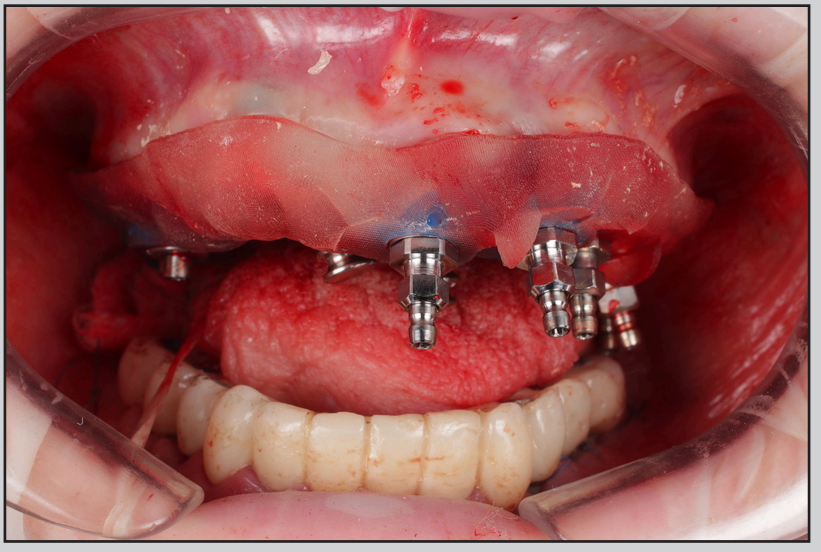

Partial Extraction Therapy: Applications in Full-Arch Dental Implant Therapy

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Partial extraction therapy (PET) is a set of surgical techniques that preserves a portion of the patient's own root structure to maintain blood supply derived from the periodontal ligament complex in order to maintain the periodontium and peri-implant tissues during restorative and implant therapy. PET includes the socket shield technique (SST), proximal shield technique (PrST), pontic shield (PtST), and root submergence technique (RST). In a traditional hybrid technique, total extraction and full-arch dental implant therapy often require significant bone reduction and palatal/lingual implant placement. In addition, postextraction preservation of the ridge architecture is a major challenge. This case series demonstrates the use of a combination of PET techniques with digital implant planning and guided implant surgery to achieve highly esthetic outcomes in full-arch implant therapy.
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Alveolar ridge resorption and tissue dimensional changes following tooth loss or dental extraction represent significant challenges for the restoration and implant rehabilitation of edentulous areas.[1] In complex cases—where patients with high esthetic expectations present with significant hard and soft tissue deficiencies in a partially edentulous anterior esthetic zone or fully edentulous arch—site development and subsequent dental implant placement can be particularly challenging.

Various strategies have been developed to reduce postextraction ridge resorption, including alveolar ridge preservation and immediate implant placement with simultaneous bone augmentation. Although these procedures are effective therapies to attenuate the dimensional reduction of the alveolar ridge that normally occurs after tooth extraction (compared to extraction alone), they do not fully prevent the resorption of the buccal plate and soft tissue architecture.[2,3]

For decades, clinicians have attempted to preserve the alveolar ridge and prevent bone loss by intentionally leaving root remnants.[4] Utilizing submerged roots to maintain the periodontal ligament (PDL) complex and stabilize the alveolar ridge associated with pontic regions of fixed dental prostheses and complete dentures has been repeatedly described since the 1960s.[5] Both the concept of

vital root submergence and nonvital endodontically treated root submergence have been applied.[6–9] In 2007, Salama et al modernized the concept root submergence to create an esthetic result in cases of adjacent multiple tooth replacement.[10] In 2010, Hürzeler et al first described in a proof-of-principle study the histologic evaluation of partial root retention in combination with immediate implant placement.[11]

Partial extraction therapy (PET) techniques have since gained significant popularity as an alternative strategy to maintaining the alveolar ridge architecture.[12] PET is a group of surgical techniques—including the socket shield technique (SST), root membrane technique, proximal shield technique (PrST), pontic shield technique (PtST), and root submergence technique (RST)—that utilize the patient's root structure to maintain the blood supply (derived from the PDL complex) to preserve the periodontium and peri-implant tissues during restorative and implant therapy.[13]

SST is the most popular PET technique with the largest scientific evidence described in the literature.[14–16] During tooth extraction, the clinician intentionally leaves behind a root section, against the buccal plate, in order to preserve the periodontal ligament and associated blood supply that helps maintain the bundle bone, thus preventing significant hard and soft tissue resorption.[11] Subsequently, an immediate implant can be placed, and the gap between the root fragment and the implant may be grafted with bone particles or filled naturally with a blood clot.[16,17] Currently, there is only one study comparing the clinical outcomes of PET performed with different graft materials in the gap. Grafting with particulate dentin or cortical tuberosity bone resulted in the most favorable outcome, leading to minimal soft tissue ingrowth between the socket shield and implant.[18]

Other PET techniques include PrST and PtST. PtST preserves the alveolar ridge at sites intended for pontic development for tooth- or implant-supported prostheses.[19] PrST preserves the inter-implant papilla when replacing a nonrestorable tooth adjacent to an implant restoration.[20] RST may be utilized to preserve the alveolar morphology to subsequently preserve the soft tissue esthetics for future pontic sites or to preserve the stability and support from a denture-bearing residual ridge.[10]

Total extraction and full-arch implant therapy often require a significant amount of bone reduction and the placement of palatal-lingual implants.[21,22] This case series uses a combination of PET techniques and minimally traumatic extraction to achieve highly esthetic outcomes for full-arch implant therapy.

Case 1: SST for Full-Arch Implants

A healthy, 61-year-old man with a smoking habit and otherwise noncontributory history presented to the general dental practice wishing to improve his current smile (Fig 1a). A radiographic examination revealed multiple teeth with root caries and/or endodontic lesions. Smile design was planned with Exoplan (Exocad), and CBCT analyses were performed in Blue Sky Plan (Blue Sky Bio) to determine possible implant positioning. The PET concept with SST was utilized in criti-cal areas—the central incisors and canines—to preserve tissue architec-ture. A novel technique involving an open guide system (chrome guide natural) was used to prepare the eight osteotomy sites for placement of the Neodent GM system (Straumann) in an immediate load fashion (Figs 1b and 1c). The temporary prosthesis was attached to straight multi-unit abutments, and temporary cylinders were fastened to the abutments. The temporary prosthesis was luted to the previously connected temporary abutments (Fig 1d). After an uneventful 3-month healing period, the definitive implant-supported prosthesis was fabricated once osseointegration was confirmed radiographically and with torque tests (Fig 1e). The definitive maxillary implant-supported zirconia prosthesis was delivered to match the previously reconstructed mandibular arch (Figs 1f and 2).

Case 2: RST for Full-Arch Implants

A healthy 64-year-old woman with no known dental allergies and a noncontributory health history presented to the prosthodontic practice desiring a fixed solution for her terminal dentition (Fig 3a). A radiographic examination revealed a heavily restored dentition with recurrent decay, root caries, and localized endodontic lesions. A thorough comprehensive workup was performed by combining facial scanning with smile-design

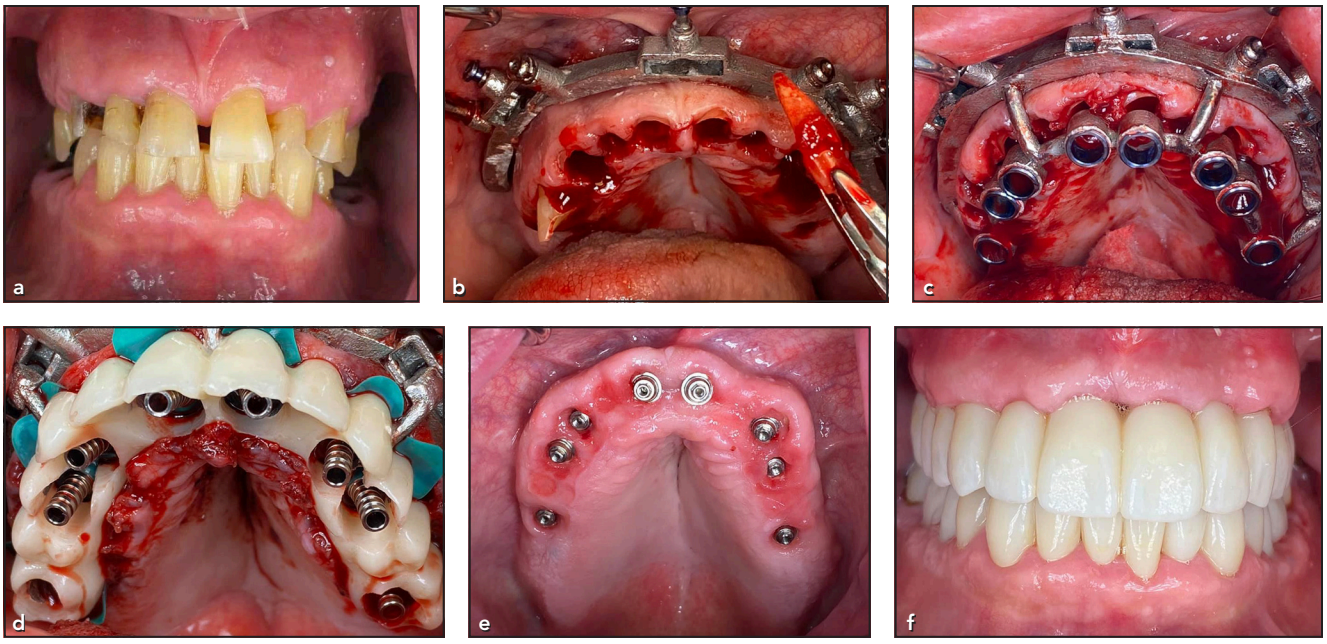

Fig 1 *Case 1: Full-arch surgical workflow combined with SST.* (a) *The patient presented with failing maxillary dentition due to numerous root caries.* (b) *Guided surgery, using the chrome guide natural concept, was utilized in the maxilla.* (c) *SST was employed on the central incisors and canines to maintain the tissue architecture.* (d) *Temporary cylinders were used for an immediate-load conversion prosthesis.* (e) *Final occlusal and* (f) *facial views show the maxillary reconstruction opposing a combination of single-tooth implants in posterior mandibular segments and single crowns in the anterior mandible.*

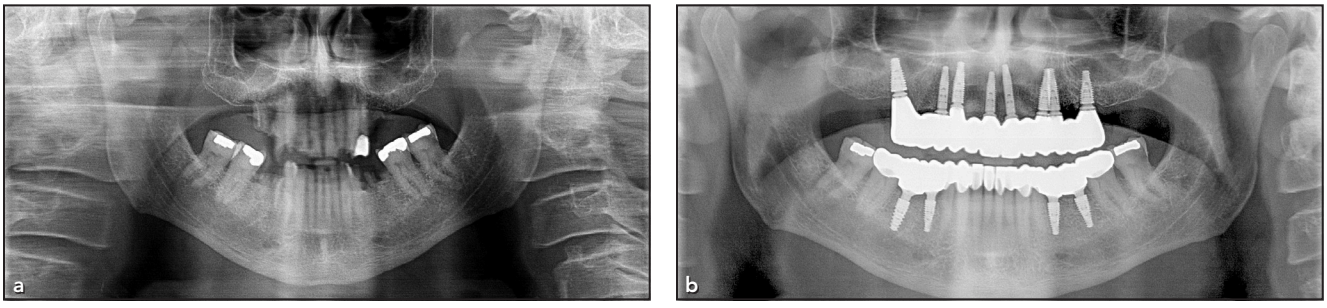

Fig 2 *Case 1.* (a) *Preoperative radiograph.* (b) *Panoramic radiograph of the final reconstruction.*

software and CBCT analysis. Potential implant sites were preoperatively determined using Blue Sky Plan software in order to fabricate 3D-printed surgical guides. Static stereolithographic surgical guides were then fabricated to prepare the osteotomy sites for placement and immediate loading of Nobel Biocare Replace CC implants **(Fig 3b).**

Prior to this, PET sites were identified using preoperative planning for SST and RST concept implementation. The canines and central incisor roots were preserved in the mandible, and the right canine root was preserved in the maxilla. Meanwhile, the maxillary anterior implants all incorporated SST placement. The temporary prosthesis was then attached to multi-unit abutments and temporary cylinders and was immediately loaded the same day. After an uneventful 3-moth healing period, the implants were fully integrated with abundant soft tissue preservation (Figs 3c and 3d). At this time, final impressions were obtained via photogrammetry to fabricate a passive splinted monolithic zirconia implant-supported restoration for both arches (Figs 3e and 4).

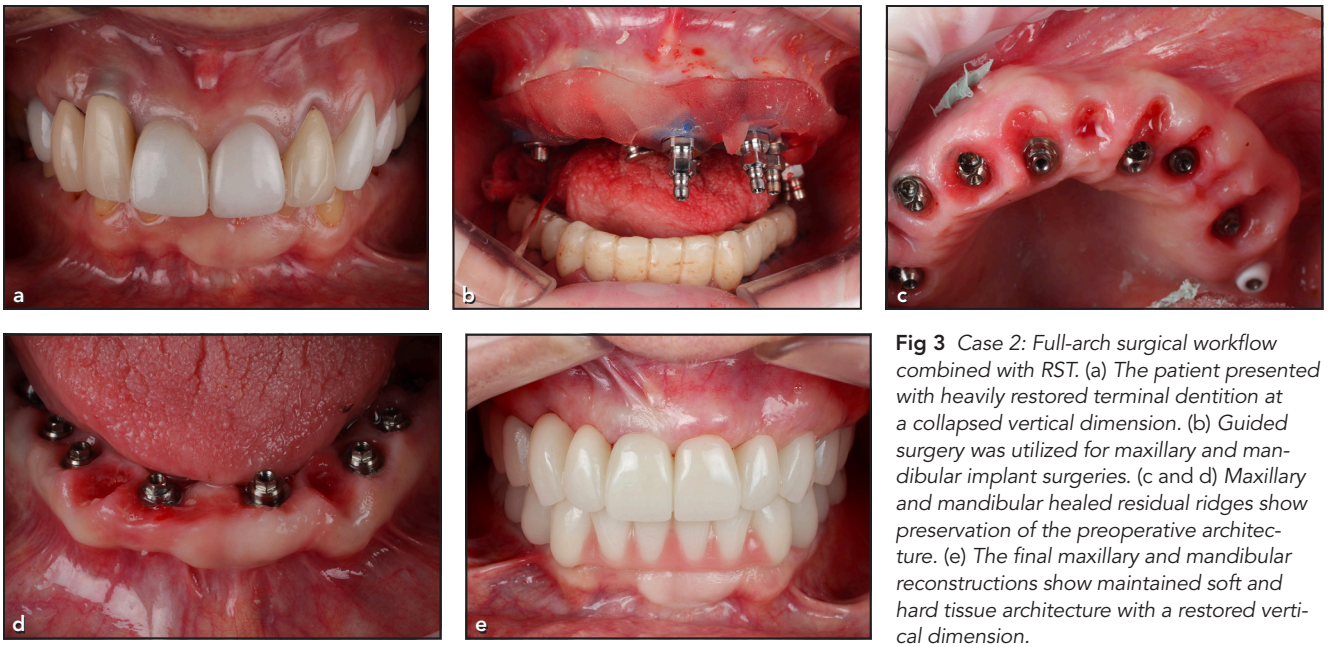

Fig 3 *Case 2: Full-arch surgical workflow combined with RST.* (a) *The patient presented with heavily restored terminal dentition at a collapsed vertical dimension.* (b) *Guided surgery was utilized for maxillary and mandibular implant surgeries.* (c and d) *Maxillary and mandibular healed residual ridges show preservation of the preoperative architecture.* (e) *The final maxillary and mandibular reconstructions show maintained soft and hard tissue architecture with a restored vertical dimension.*

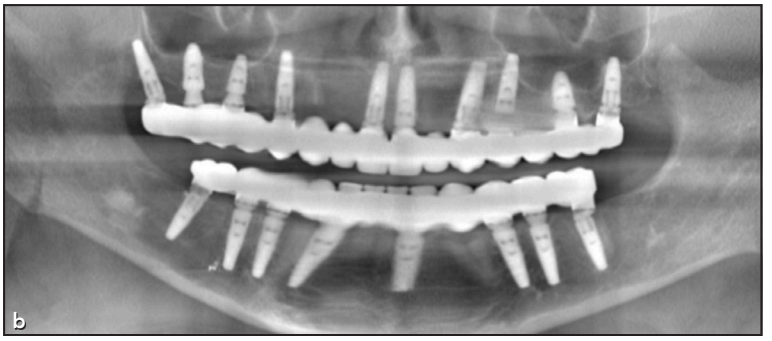

Fig 4 *Case 2.* (a) *Preoperative radiographs.* (b) *Panoramic radiograph of the final reconstruction.*

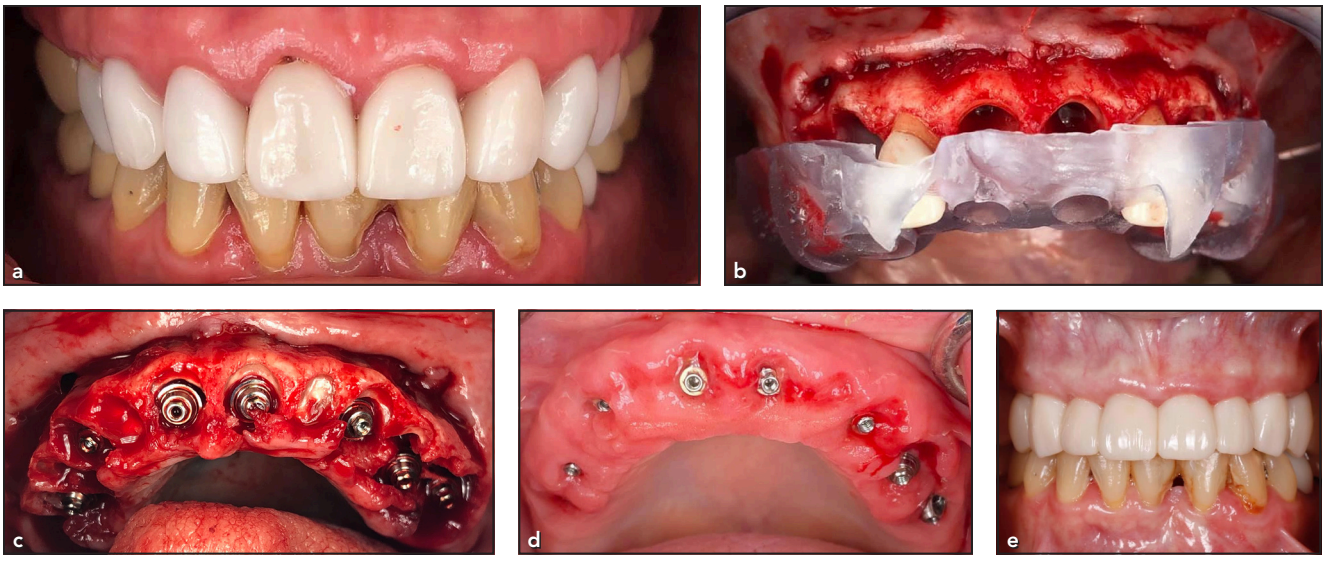

Fig 5 *Case 3: Full-arch surgical workflow combined with SST, PtST, and RST.* (a) *The patient presented with failing maxillary dentition due to medication-induced dry mouth and numerous root caries.* (b) *Guided surgery using a tooth-born guide was utilized in the maxilla.* (c) *SST was employed on the central incisors and canines to maintain tissue architecture, vital RST was utilized in the lateral incisor region, and PtST was used in the first premolar regions.* (d) *Final occlusal and facial views show that the tissue architecture was maintained using this technique.*

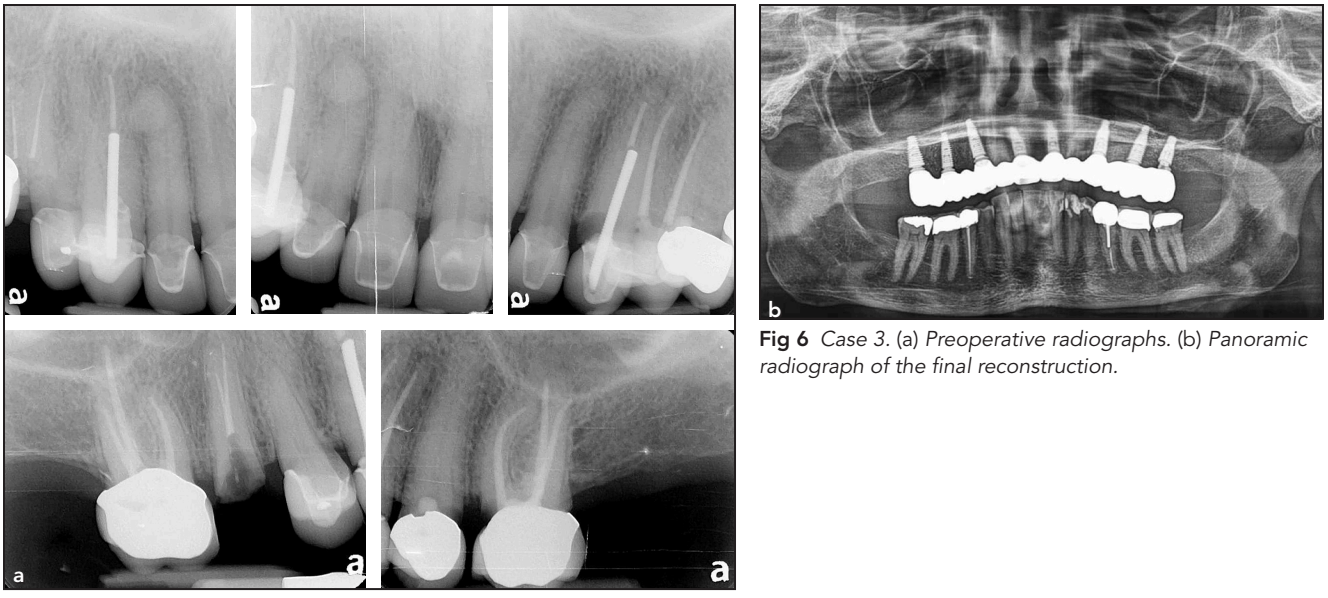

Fig 6 *Case 3.* (a) *Preoperative radiographs.* (b) *Panoramic radiograph of the final reconstruction.*

Case 3: Combination of SST, PtST, and RST for Full-Arch Implants

A healthy 62-year-old woman with a history of medication-induced dry mouth presented to the practice with complaints of maxillary sensitivity. Three years prior, she had received a combination of crown and bridge to reconstruct the upper maxilla. Due to the history of dry mouth, recurrent decay was noted beneath the crown work and required removal, as well as the possible removal of several teeth or another treatment method (Fig 5a). After discussing the available options and her present medical state, the patient opted to have the maxillary teeth removed and receive an implant-supported prosthesis. Considering her smile line and healthy existing tissue, a hybrid prosthesis design was not favored due to its

natural bulk and the bone removal required to accommodate this design. A combination of RST, PtST, and SST was employed to preserve the tissue architecture in the anterior maxilla after digital workup in Blue Sky Bio (Figs 5b and 5c). A tooth-supported guide was designed in Exoplan to place the Neodent GM implants in position and subsequently convert the supporting teeth to pontic shields sites. Finally, a palatally supported temporary restoration was used to pick up the temporary cylinders attached to the multi-unit abutments at the time of surgery. After a 3-month osseointegration period, a final monolithic zirconia bridge was placed on the eight maxillary implants (Figs 5d, 5e, and 6).

Discussion

The unique challenges of full-arch implant dentistry include the complete loss of teeth and the ability for the clinician to maintain the ridge dimen-sion following tooth loss. This is in comparison to single-tooth implant sites, where the adjacent dentition remains and is more capable of pre-serving the ridge shape from total collapse, which leads to subsequent hard and soft tissue changes. Despite what may appear as a stable result with total tooth removal, CBCT analy-sis often shows that the remaining buccal plate dimension is minimal or nonexistent (often < 1 mm thick).

In typical hybrid designs for full-arch implant dentistry, the alveolar bone is flattened to achieve an even platform of basal bone that is less susceptible to resorption. This in turn creates a thicker prosthesis in the vertical and buccolingual dimensions. Further, to minimize the proximity to the buccal plate, the implants are often placed palatally, which in turn increases the hybrid prosthesis thickness. When it comes to surgical guides, the chrome natural guide used in Case 1 was highly accurate for implant placement. This type of guide uses the existing dentition to pin the osteotomy guide and thus its accuracy is comparable to any other tooth-born guides. Additionally, because the base guide stays on throughout the procedure, placement errors or distortion can be minimized.

A benefit of utilizing PET is the ability to minimize hard and soft tissue grafting procedures, which may occur as a consequence of postextraction ridge collapse.[14,23] These cases are often managed by incorporating xenografts and/or connective tissue graft alternatives to compensate for changes in ridge dimension.[24,25] From a cost perspective, this is an extra burden on the patient, with the potential need for revision and morbidity considerations over time as the ridge dimensions continue to change.

In Case 1, the patient presented with a diastema and papilla loss on the anterior maxilla due to generalized mild periodontal disease. Although the objective of PET is to preserve tissue architecture, elongated contact points on the final restoration are often still necessary to compensate for papilla loss. In Case 3, the final results have shorter papillae than the preoperative dentition. This is often a consequence of raising a full-thickness flap in full-arch cases, which leads to tissue recession.

Consideration for alternatives to total tooth extraction therapy must be considered during full-arch implant therapy. Given that implant treatment may need future revisions and/or corrections, ridge preservation techniques such as PET allow for tissue preservation.[14,16] In cases of bone atrophy and the subsequent need for future treatment, revisions often require major grafting and/or zygomatic ptyergoid approaches to treatment, which present their own challenges.[26–28] Another alternative to immediate loading of full-arch implant cases is the use of serial extractions to allow certain abutment teeth to support temporary bridges while implant osseointegration occurs. In the present cases, because an adequate 35-Ncm torque was achieved, the implants were selected for immediate loading to minimize the number of patient surgeries.

Finally, numerous clinical studies have demonstrated the benefits of PET.[14,15,17] Complications can occur but are largely manageable.[16,17,29] Typical management involves shield reduction to the bone crest and extraction of the shield if it is found to be mobile. In Case 1, a small shield exposure was noted in the canine site of the maxillary left quadrant. This is classified as an internal shield exposure and is sometimes caused by excessive pressure from the temporary prosthesis.[30] The exposure is managed by trimming the exposed area with a high-speed round burr to allow for tissue epithelialization. It is also important to undersize the temporary restoration in this region to allow the tissue space needed for clot formation.

In cases with a thin biotype or a large root fragment exposure, options such as autogenous connective tissue grafts from the palatal or tuberosity donor sites can be used after reduction of the exposure to ensure full coverage.

Conclusions

The present three cases show an alternative to ridge preservation techniques, with highly esthetic outcomes, that may be used in appropriate case selections. Future considerations for PET include a fully guided approach to make the segmental cuts prior to the guided implant procedure.

Acknowledgments

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