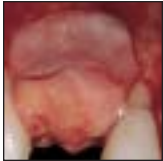




Papilla Reformation at Single-Tooth Implant Sites Adjacent to Teeth with Severely Compromised Periodontal Support



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Reformation of the lost interdental papilla remains one of the most challenging goals for clinicians. When a single tooth is replaced with an implant, the papilla between the tooth and the implant can often be maintained or predictably reformed as long as the adjacent tooth's periodontal attachment and bone are preserved. However, if the periodontal support is compromised on the neighboring natural tooth, the papilla will often be deficient or missing. The cases presented herein demonstrate long-term follow-up of successful reformation of periodontal/peri-implant tissue contours, including reconstruction of lost interproximal bone and papilla at periodontally compromised sites using a combined hard and soft tissue surgical approach. Int J Periodontics Restorative Dent 2017;37:9–17. doi: 10.11607/prd.2818

The interdental papilla is an extremely important aspect of anterior esthetics that must be considered when replacing teeth with implants. While replication and replacement of missing tooth structure with a natural-appearing implant-supported prosthesis is predictable, regeneration of lost interdental papilla is a significant esthetic problem that is often difficult to solve. The black triangle that presents when soft tissue does not completely fill the interproximal space is unsightly and can be devastating for patients. Regeneration or reformation of lost interdental papilla remains one of the most challenging and least predictable goals for clinicians.

In the natural dentition, papillae are supported by the presence of interdental alveolar bone, a network of gingival connective tissue fibers, and a long junctional epithelial attachment. The quality or thickness of the tissues (ie, the periodontal biotype) also influences the fullness of the interdental papilla.^{1–4} When a single tooth is replaced with an implant-supported crown, the papilla between the tooth and the implant can often be maintained or predictably reformed as long as the adjacent tooth's periodontal attachment and bone are preserved at a normal level.⁵ However, if the periodontal support is compromised by bone

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and periodontal attachment loss, the papilla will often be deficient or missing.

Critical dimensions of interproximal spaces between natural teeth that are conducive to complete papilla fill have been described. Tarnow et al found that the papilla completely fills the interdental space when the vertical distance between the contact point and the interproximal bone crest height is ≤ 5 mm, while the papilla is less likely to fill the space when the distance is > 5 mm.⁶ Cho et al found that the presence of a full interdental papilla was also influenced by the horizontal distance between teeth, and that as the interdental space increased the vertical distance from contact point to bone crest had less influence on the presence of papilla.⁷ In other words, when the horizontal dimension increased beyond a certain dimension, papilla were not full even if the distance from contact to bone was ≤ 5 mm. Similarly, Martegani et al found that the horizontal dimension between natural teeth is important, suggesting that interdental spaces > 2.4 mm resulted in a higher likelihood of black triangles.⁸ When an implant is used to replace a missing single tooth between natural teeth, the critical dimensions for papilla are similar to those for adjacent natural teeth. Grunder concluded that for single-tooth implants, the presence of the papilla is determined by the interproximal bone level on the neighboring natural tooth and not the bone level adjacent to the implant.⁹

The black triangle problem presents around a single-tooth im-

plant when the adjacent tooth has lost bone and periodontal attachment. Most approaches to correct lost or deficient interdental papilla have been surgical,¹⁰ which is understandable given that the goal is to increase the volume of living tissue. A number of surgical techniques have been proposed to preserve, restore, and regenerate the interdental papilla, including papilla preservation procedures,^{11,12} hard and/or soft tissue augmentation,¹³ guided tissue regeneration,^{11,14} injections,^{15,16} microsurgical approaches,¹⁷ and modified suturing techniques.¹⁸

This article presents the long-term follow-up for two single-tooth implant cases in the anterior esthetic zone that use a regenerative approach (bone and soft tissue augmentation) to reform the lost interdental papilla adjacent to teeth with severely compromised periodontal support.

Materials and methods

Case 1

A healthy, 45-year-old woman presented for an evaluation of her maxillary left central incisor. The tooth had a history of trauma 2 months earlier (Fig 1a). Clinical examination revealed a pocket probing depth of 9 mm between the maxillary left central and lateral incisors, with bleeding and purulent exudate (Fig 1b). The left central incisor, which was endodontically treated, demonstrated increased mobility and appeared to be fractured. The periapical radiograph revealed severe

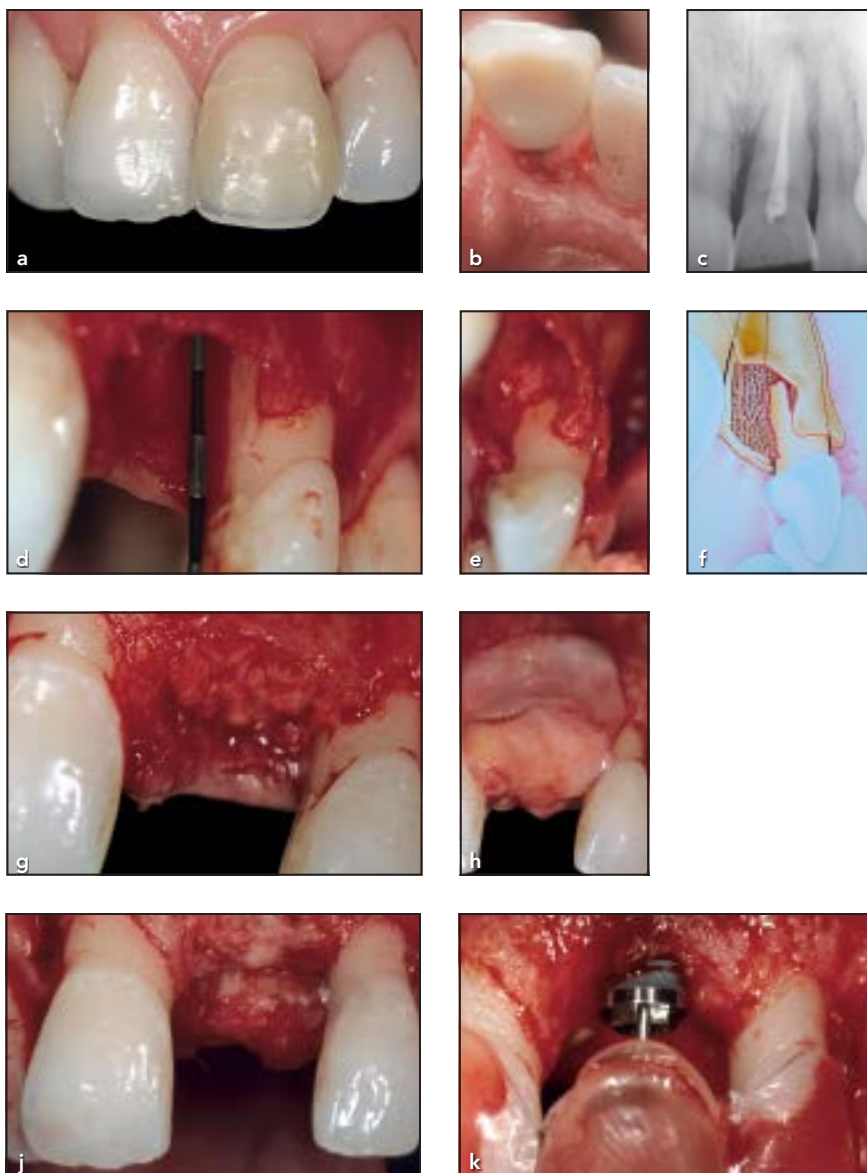
loss of the inter-radicular bone between the maxillary left central and lateral incisors (Fig 1c). The left central incisor was deemed hopeless. Since the patient desired a fixed restoration, a single-tooth implant was planned to replace it. The severely compromised periodontal support on the mesial surface of the left lateral incisor posed a significant concern for reformation of the interdental papilla.

Surgical phases

Extraction and socket grafting

On extraction, a longitudinal root fracture was observed along the distal proximal surface of the maxillary left central incisor that resulted in severe loss of bone from the mesial surface of the left lateral incisor (Figs 1d to 1f). Since this tooth revealed no pathologies, the bone loss was attributed to the ongoing infection caused by the fractured left central incisor. A full-thickness flap was elevated on the buccal side with two divergent vertical releasing incisions at the distal line angles of the neighboring teeth. The palatal tissue remained intact (ie, no flap was reflected). Bone loss on the mesial surface of the left lateral incisor extended to the apical third of the root. The exposed root surface was carefully root planed, and the defect was grafted with autogenous particulate bone (Fig 1g). The socket was covered with a collagen membrane and a connective tissue graft (Fig 1h). The flap was repositioned and sutured with an expanded polytetrafluoroethylene suture (Gore-Tex CV-5 Suture, W.L. Gore & Associates).

Figs 1a to 1k (a) Labial and (b) occlusal views of a maxillary left central incisor that underwent trauma 2 months prior to the patient's first visit. Note that the papilla exists around the fractured tooth. (c) Periapical radiograph demonstrating missing inter-radicular bone between maxillary left central and lateral incisors. (d, e) Oblique views of the exposed root of the maxillary left lateral incisor after extraction of the central incisor. (f) Schematic drawing demonstrating the osseous architecture. Note that this is a three-wall defect. (g) After careful root planning, autogenous bone was packed into the socket. (h) A collagen membrane and a connective tissue graft were used to cover the socket graft. (i) Labial view after 6 months of uneventful healing. Note the now-damaged papilla mesial to the left lateral incisor. (j) Labial view at 6 months demonstrating good incorporation of the bone graft with tight connection to the previously denuded root. Note that the mesial bony peak of the lateral incisor is still missing. (k) Labial view of the implant in place. Note that some dehiscence exists on the implant.



Implant placement and papillary bone and connective tissue graft

Following 6 months of uneventful healing, the papilla remained deficient on the maxillary left central incisor (Fig 1i). A full-thickness flap was elevated using the same flap design as the initial procedure. The palatal flap was elevated using two vertical incisions on the distal line angles of the adjacent teeth. Good bone re-

generation was observed, and the previously exposed root surface of the left lateral incisor was completely covered with bone. There was only a slight vertical deficiency at the crest (Fig 1j).

A standard-diameter Brånemark TiUnite implant (Nobel Biocare) was placed using a prefabricated surgical guide. There was a 2-mm dehiscence on the labial sur-

face of the implant after reaching an optimal prosthetic position (Fig 1k). Autogenous particulated bone was used not only to graft the buccal dehiscence but also to augment the interproximal missing bone in a vertical direction (Figs 1l and 1m). A collagen membrane (Bio-Gide, Geistlich) was placed to protect the graft. Additional soft tissue grafting was performed to enhance the soft



Figs 1l to 1o (l, m) Labial and occlusal views of a particulated autogenous bone graft to regenerate the dehiscence and the missing bony peak. (n) A papillary connective tissue graft was also used after covering the bone graft with a collagen membrane. (o) Schematic drawing illustrating the hard and soft tissue augmentation to regenerate the interproximal hard and soft tissues.



Figs 1p to 1u (p) Labial view after 6 months of uneventful healing. Note the improved soft tissue architecture. (q) Labial view of the final restoration in place. Note the completely regenerated papilla. (r) Labial view of the final restoration after 9 years of loading. Note the preservation of the papilla. (s) Periapical radiograph at implant uncover. (t) Periapical radiograph at 2 years of loading. (u) Periapical radiograph at 9 years of loading. Note that no changes in the regenerated interproximal bone occurred between uncover and 9 years of loading. Also note the clear mark of the apical end of the root planing on the radiograph. The left lateral incisor is vital.



tissue architecture. A subepithelial connective tissue graft (CTG) was harvested from the palate. The free CTG was secured interdentally in an inverted position to cover the denuded proximal root surface (PCTG) of the maxillary left central incisor with a 6-0 resorbable monofilament suture (PDS-II, Ethicon) (Figs 1n and 1o). The flap was advanced and sutured in two layers to achieve good

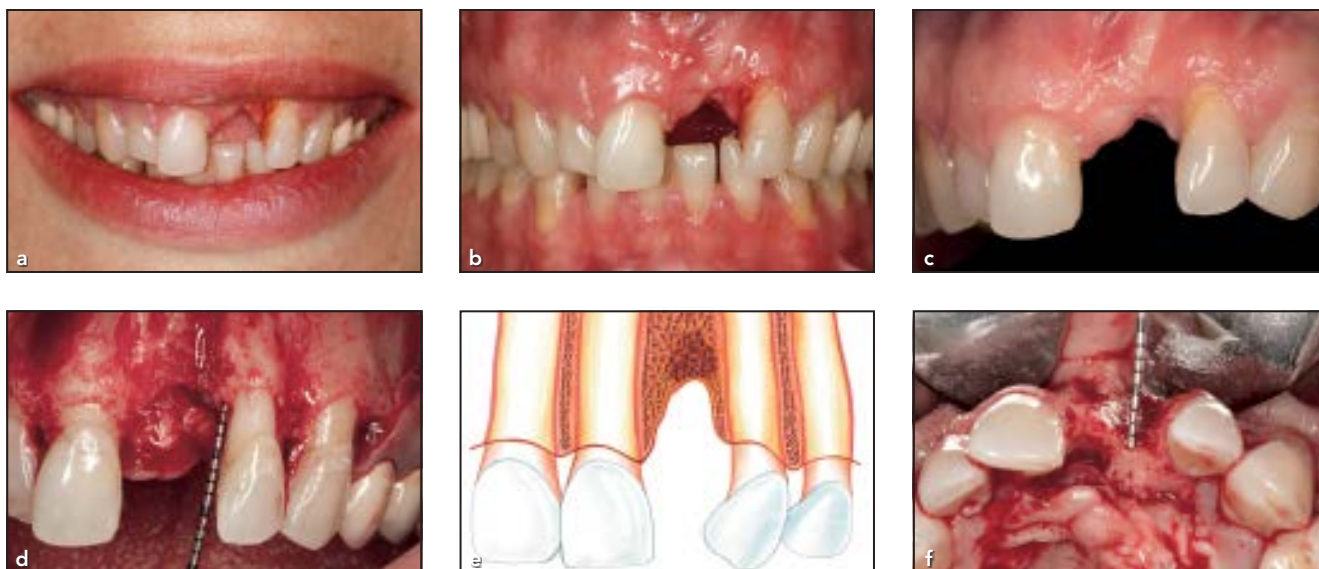
primary closure above the connective tissue graft.

Restorative phase

The implant was left to heal for an additional 6 months (Fig 1p). After implant exposure, a provisional implant crown was fabricated within 2 weeks.^{19,20} The provisional restoration was kept in place for 6 months while the tissue matured. Subsequently, a

zirconia abutment and crown were fabricated and delivered (Fig 1q).

The patient was followed for 9 years after loading, and good bone and soft tissue stability were seen (Fig 1r). The regenerated interproximal bone remained stable throughout the follow-up period. The maxillary left lateral incisor remained stable without any symptoms (Figs 1s to 1u).



Figs 2a to 2f (a, b) Labial view of a 25-year-old woman presenting with a failed bone graft. The patient has a severe papillary deficiency. Note that a piece of bone graft is exfoliating at the papilla area of the distal side of the defect. (c) Labial view of the site after the exfoliating pieces of failing bone graft were cleaned out. Note the severe defect at the papilla and at the crest. (d) Labial view of the vertical defect. A periodontal probe is demonstrating the mesial bone loss at the maxillary left lateral incisor. (e) Schematic drawing of the defect. (f) Occlusal view of the severe horizontal component of the defect.

Case 2

A healthy, 25-year-old woman presented for an evaluation after implant and bone graft failure of the maxillary left central incisor (Fig 2a). The site had a history of simultaneous implant placement and bone grafting that developed an infection and subsequently loss of the implant and the graft 6 months prior to the visit. Clinical examination revealed a severe defect involving the distal papilla with purulent exudate and exfoliating graft particles (Fig 2b). The interproximal root surface of the maxillary left lateral incisor became denuded. The patient was distraught about the appearance and sought help to solve the esthetic problem. A decision was made to remove the implant and reconstruct the hard and soft tissue architecture for esthetics

with a plan to place a new implant for a single-unit restoration.

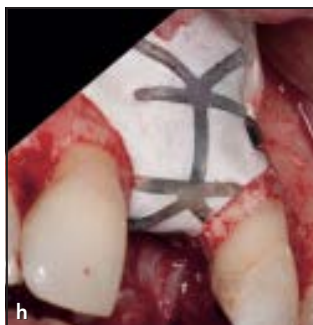
Site preparation, vertical ridge augmentation, and papillary hard and soft tissue reconstruction

The exfoliating pieces of bone graft were removed with curettes and the tooth was thoroughly root planed (Fig 2c). The site was repeatedly debrided, and after 8 weeks of soft tissue healing the regenerative surgery was performed.

A full-thickness midcrestal incision was made in the keratinized gingiva on the alveolar crest. Two divergent vertical incisions were made at the mesial line angle of the maxillary right canine and the distal line angle of the maxillary left first premolar to achieve adequate surgical access. Periosteal elevators were used to reflect a full-thickness flap

beyond the mucogingival junction and at least 5 mm beyond the bone defect.

When the flap was reflected, a periodontal and vertical ridge combination defect became evident (Fig 2d). In addition to the vertical and horizontal ridge deficiency, about 2 mm of interproximal bone was missing on the mesial side of the maxillary left lateral incisor (Figs 2e and 2f). Using a small round bur, the recipient bony bed was prepared with multiple decorticalization holes to expose the medullary space and promote bleeding. Autogenous bone was then harvested from the right ascending ramus and particulated in a bone mill (R. Quétin Bone-Mill, Roswitha Quétin Dental Products, Leimen, Germany). An appropriate size titanium-reinforced expanded polytetrafluoroethylene



Figs 2g to 2i (g) Labial view of the composite bone graft consisting of a combination of autograft and anorganic bovine bone matrix in place. (h) Oblique view of an e-PTFE-TR membrane in place. Note that a bone graft was placed on the denuded root. (i) A native collagen membrane was placed over the papillary bone graft.



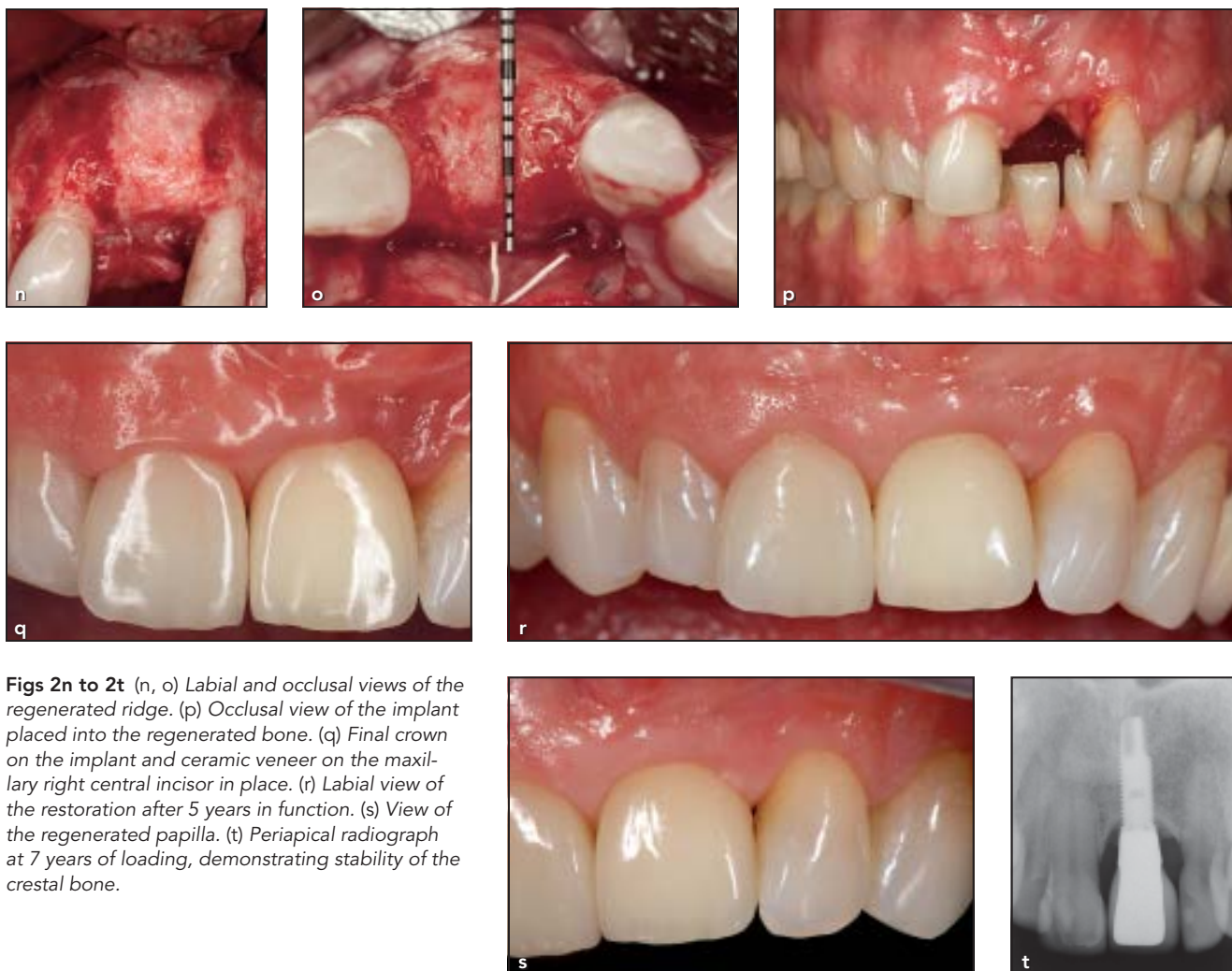
Figs 2j to 2m (j, k) Labial and occlusal views of a thick connective tissue graft sutured in place. Note that 6-0 resorbable monofilament sutures were used. (l) Labial view of uneventful healing at 9 months. Note the interproximal gain of soft tissue covering the previously denuded area. (m) Labial view of the titanium-reinforced membrane and the soft tissue thickness demonstrated by a periodontal probe. Note the horizontal line of soft tissue demonstrating the regenerated papilla.

membrane (e-PTFE-TR) (Gore-Tex, W.L. Gore & Associates) was selected and trimmed with consideration given to graft volume. The membrane was fixed first on the palatal side using multiple titanium pins (Master-Pin-Control, Meisinger) (Fig 2g). A combination of autogenous bone and anorganic bovine bone-derived mineral (ABBM) (Bio-Oss, Geistlich) was used to graft the ridge defect. The e-PTFE-TR membrane was cut 2 mm short of the maxillary left lateral incisor and the space was

grafted with autogenous bone chips touching the denuded root (Fig 2h). This exposed area was covered with a collagen membrane (BioGide, Geistlich) (Fig 2i). A papillary connective tissue graft using a thick piece of connective tissue was performed as described in the previous case (Figs 2j and 2k). The flap was mobilized to permit tension-free primary closure and sutured in two layers using horizontal mattress sutures and single interrupted sutures (Gore-Tex CV-5 Suture, W.L. Gore & Associates).

Implant placement

After 9 months of uneventful healing, the site was reentered after raising the same flap, and the e-PTFE-TR membrane was removed (Figs 2l and 2m). Complete vertical and horizontal augmentation was evident, including a small (1 mm) vertical bone gain on the mesial aspect of the maxillary left lateral incisor (Figs 2n and 2o). A standard-diameter Brånemark TiUnite implant (Nobel Biocare) was placed using a prefabricated surgical guide (Fig 2p).



Figs 2n to 2t (n, o) Labial and occlusal views of the regenerated ridge. (p) Occlusal view of the implant placed into the regenerated bone. (q) Final crown on the implant and ceramic veneer on the maxillary right central incisor in place. (r) Labial view of the restoration after 5 years in function. (s) View of the regenerated papilla. (t) Periapical radiograph at 7 years of loading, demonstrating stability of the crestal bone.

Restorative phase

The implant was left to heal for an additional 6 months.¹⁹ After implant exposure, a provisional implant crown was fabricated and delivered within 2 weeks.^{20,21} The properly contoured provisional restoration was kept in place for 6 months while tissues matured (Fig 2q).²² Then, a zirconia final abutment and crown were fabricated and placed. A ceramic veneer was also fabricated and delivered for the maxillary right central incisor (Fig 2r).

The patient was followed for 7 years after loading with good bone and soft tissue stability. Crestal and regenerated interproximal bone remained stable throughout the follow-up period (Figs 2s and 2t).

Discussion

The cases presented here demonstrate successful reformation of periodontal/peri-implant tissue contours, including reconstruction of

lost interproximal bone and papilla at periodontally compromised sites, using a combined hard and soft tissue surgical approach. Reports on simultaneous ridge augmentation and periodontal regeneration are scarce and limited to short-term case reports.²³ The cases presented here illustrate that with a detailed application of regenerative techniques, a combination of ridge and periodontal regeneration is possible. The long-term follow-up and good tissue stability in these cases is

encouraging. Admittedly, it can only be speculated whether true periodontal regeneration was achieved, since no histologic proof is available. Nonetheless, the clinical and radiographic findings are consistent with stable, healthy regenerated tissues, suggesting that periodontal regeneration may be possible. At the least, the results demonstrate periodontal stability with improved attachment levels.

There is a biologic limit to papilla tissue height that is dictated by the level of periodontal attachment and bone support. Studies have shown that predictable papilla fill adjacent to a natural tooth is approximately 5 mm from the interdental bone height to the contact point.⁶ When the distance from the bone crest to the contact point is > 5 mm, achieving a full papilla is unlikely. Therefore, reconstruction of the missing interdental bone was essential to achieving papilla reformation. The regenerated interdental bone did not quite reach the level of the contralateral side, yet it did not have a negative effect on the final papillary height as the papillae were clearly symmetric. It appears that periodontal bone regeneration, along with the connective tissue grafting used here, had a significant effect on the reformation of the papilla.

These cases included the use of autogenous bone chips placed in contact with denuded root surfaces. Although clinical studies have reported ankylosis and root resorption caused by autogenous bone

grafted adjacent to root surfaces, this was not observed in the present study.²⁴ Another important distinction may be that the former report of ankylosis and root resorption was attributed to autogenous bone from the iliac crest, not from intraoral bone sites. The radiolucency observed at the apical termination of the regenerated tissue (case 1) is most likely the result of scaling and root planing. The results of these cases are in agreement with a recent preclinical study that concluded particulated autogenous bone may be implanted safely into periodontal defects without significant healing aberrations such as root resorption and ankylosis.²⁵

Conclusions

The use of growth factors such as PDGF could be considered in conjunction with the bone grafts in similar cases. PDGF-BB has demonstrated favorable outcomes on periodontal regeneration even when combined with vertical ridge augmentation.^{23,26} These cases are challenging and require multiple surgeries and extended healing times. Therefore, careful patient selection and patient preparation for surgery is strongly recommended. The clinician should recognize that the techniques presented here, however encouraging, should be investigated in randomized, multicenter clinical trials before they are recommended into routine clinical practice.

Acknowledgments

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