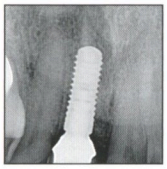
Implant Site Development Using Ti-Mesh and Cellular Allograft in the Esthetic Zone for Restorative-Driven Implant Placement: A Case Report



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This article presents a case report of implant site development in a healthy, nonsmoking 62-year-old man using titanium mesh (Ti-mesh) in conjunction with human cellular allograft for ridge augmentation of a type 4 alveolar ridge defect. The patient presented initially with a severely periodontally abscessed maxillary right central incisor probing to the apex. The tooth was extracted, and after 8 weeks a bone reconstructive procedure was completed using a well-stabilized Ti-mesh and cellular allograft that was covered with a quickly resorbing collagen matrix. After 7 months of undisturbed healing, cone beam computed tomographic evaluation demonstrated a horizontal bone increase of 7 mm and a vertical bone increase of 2.3 mm. This case report demonstrates the benefits of predictable regenerative space maintenance using Ti-mesh in conjunction with a cellular allograft to allow for prosthetically driven implant placement in the esthetic zone.
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Predictable augmentation of alveolar bone in both a horizontal and a vertical dimension is one of the most challenging surgical procedures in implant site development.[1] It is also a key determinant in obtaining a long-term esthetic and functional result. One of the risk factors evaluated presurgically that can affect final esthetic result is inadequate bone volume in three dimensions. In such cases placement of a dental implant is more complicated and less predictable. To compensate for the inadequate bone, the implant is frequently placed in a palatal or apical position. This can negatively affect the ability to achieve long-term health, function, and esthetics. Ideally, a minimum of 2 mm of buccal bone wall is necessary once the implant osteotomy has been prepared in a healed site to ensure proper soft tissue support and to avoid complete resorption of the buccal bone during healing or following restoration.[2-4] This becomes very important in esthetically demanding areas such as a patient's esthetic zone, where bone loss and the potential for recession or periimplantitis can negatively affect patient satisfaction.

Implant treatment in the esthetic zone is challenging and requires comprehensive preoperative planning and precise surgical execution based on a restorative-driven

approach. The prevention of esthetic complications should be a primary objective. The Esthetic Risk Profile (ERP) is a pretreatment assessment tool that uses clinical precursors to determine the risk of achieving an esthetic result based on known surgical and restorative approaches in given clinical situations.[5] As part of the ERP, horizontal (medium risk) and vertical (high risk) bony deficiency of the planned implant site is evaluated at the initial consultation visit. Minor amounts of horizontal augmentation can be accomplished readily with a wide variety of treatment modalities. However, in situations where more significant bone augmentation is necessary, the problem becomes more challenging. Distraction osteogenesis, autogenous onlay block grafts, ridge splitting, and tenting screws with barrier membranes (with or without titanium struts) have been described in the literature as techniques capable of producing significant amounts of bone augmentation. However, each technique carries concerns related to predictability, patient morbidity, or postoperative complications.[1]

The use of epithelium-excluding barrier membranes for guided bone regeneration (GBR) has been demonstrated in the literature to be a successful treatment approach. However, complications related to early exposure and early removal of the barrier membrane make this technique less predictable when significant regeneration is required. Boyne et al introduced the concept of a titanium mesh (Ti-mesh) scaffold with advantages that include the ability to offer enhanced space maintenance and graft revascularization from the periosteum with less concern about failure if exposure occurs.[6] Numerous studies have since reported on the success of this technique in achieving significant osseous regeneration in implant site development and simultaneous implant placement procedures.[7–21] A variety of newer regenerative materials are now available that employ either cellular or molecular enhancement features. Cellular allografts were first shown to be effective in dental implant reconstructive procedures with a series of sinus augmentations that showed consistent histologic evidence of greater than 30% new bone area formation at only 4 months.[22] A larger, multicenter, bilateral sinus study confirmed these results and showed superiority when compared to mineralized allograft without cells.[23] Additional studies have shown cellular allograft to work well in a variety of additional applications, such as alveolar ridge augmentation,[24] periodontal defects,[25] ankle fusion,[26] and spinal fusion.[27] The following case report demonstrates the techniques to treat a single severe buccal ridge defect in the esthetic zone presenting with a type 4 defect (knife-edge alveolar ridge)[28] using a well-stabilized Ti-mesh with a cellular allograft.

Patient presentation

A healthy, nonsmoking, 62-year-old man was referred to the primary author (R.A.L.) with a chief complaint of pain, mobility, and esthetics of the maxillary right central incisor. Root canal therapy had been completed 20 years prior on this tooth. A clinical exam revealed generalized moderate with localized advanced periodontitis; probing depths ranged up to 8 mm in the mandibular left and right posterior sextants and locally 12 mm at this tooth. Digital intraoral photographs were taken along with an initial periapical digital radiograph. The patient's ERP, reviewed chairside with him at the end of his initial exam, was noted as a low-medium esthetic risk. He had not seen a dentist in over 5 years (Figs 1 to 3).

The following comprehensive treatment plan was proposed and accepted by the patient:

1. Emergency care: Fabrication of a transitional removable partial denture (TRPD) by the patient's restorative dentist to replace the maxillary right central incisor
2. Extraction of tooth with thorough debridement of the remaining socket walls; placement of the TRPD
3. Phase 1 periodontal therapy: Full-mouth scaling and root planing (ScRP) (in two visits) with plaque control reinforcement in conjunction with 1 week of oral antibiotic therapy (amoxicillin and metronidazole) upon completion[29]
4. Two months postextraction: Large defect reconstruction using a cellular allograft with Ti-mesh scaffold
5. Site-specific cone beam computed tomography (CBCT) scan taken at 6 to 8 months to evaluate bone healing in three

Fig 1 *Esthetic Risk Profile (ERP) was low to medium.*

Patient Robert M. (10/18/13) **IMPLANT ESTHETIC RISK PROFILE**

Esthetic risk factors	Low	Medium	High
Medical status	Healthy patient and intact immune system		Reduced immune system
Smoking habit	Non-smoker	Light smoker < 10 Cig/D	Heavy smoker > 10 Cig/D
Patients esthetic expectations	Low	Medium	High
Lip line	Low	Medium	High
Gingival biotype	Low scalloped Thick	Medium scalloped Medium thick	High scalloped Thin
Shape of tooth crowns	Rectangular	Slightly triangular	Triangular
Infection at implant site	None	Chronic	Acute
Bone level at adjacent teeth	≤ 5mm to contact point	5.5 to 6.5mm to contact point	7mm to contact point
Restoration status of neighboring teeth	Virgin		Restored
Width of edentulous span	1 tooth ≥ 7mm	1 tooth ≤ 7mm	2 teeth or more
Soft tissue anatomy	Intact soft tissue		Soft tissue defects
Bone anatomy of alveolar crest	No bone deficiency	Horizontal bone deficiency	Vertical bone deficiency

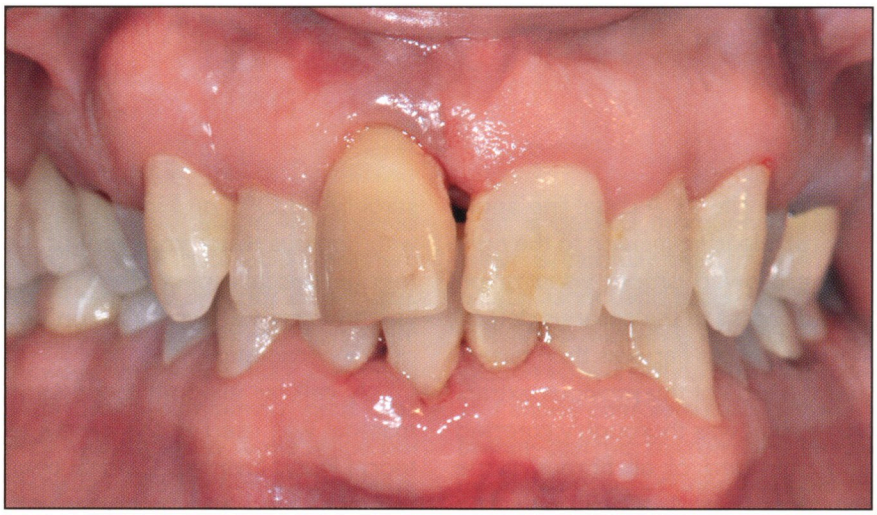


Fig 2 *Clinical view of maxillary right central incisor, which showed Class III mobility and was in buccal version.*

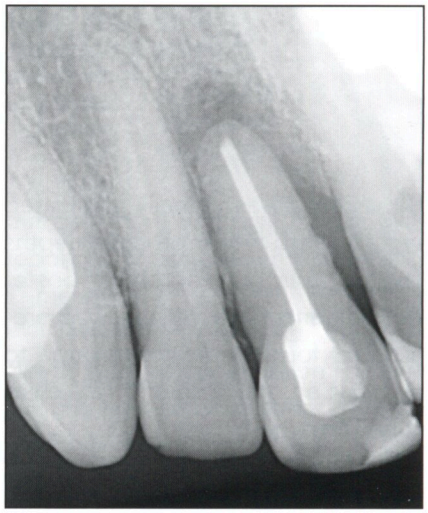


Fig 3 *Nonrestorable maxillary right central incisor as a result of advanced periodontal attachment loss to the apex of the tooth.*

dimensions prior to implant placement
6. Fabrication of an anatomically correct surgical guide template (ACSGT)
7. Prosthetically guided implant placement with evaluation for contour augmentation and soft tissue augmentation
8. Prosthetic completion of crown with mesial composite bonding to left central incisor
9. Periodontal maintenance every 3 months alternating between surgical and restorative offices with evaluation for periodontal pocket reduction therapy as needed in posterior sextants

Bone reconstruction materials and methods

The patient presented for the bone reconstruction visit 2 months post–tooth extraction allowing for complete soft tissue closure over the extraction site. His periodontal status was stable, as bleeding

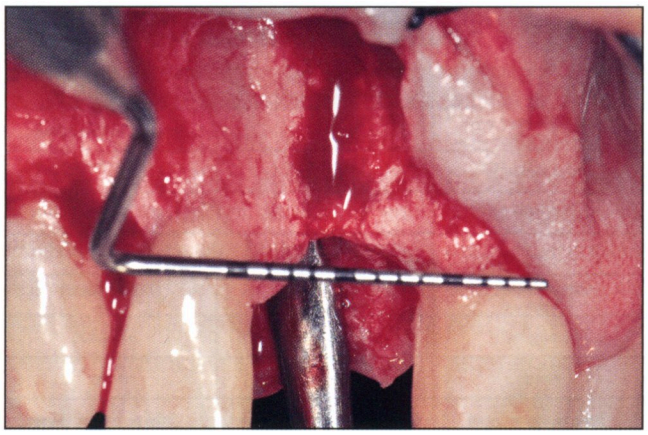


Fig 4 *Surgical reentry to perform Ti-mesh GBR procedure at 2 months postextraction. Note the bone loss on the mesiobuccal surface of the right lateral and the mesial surface of the left central incisor.*

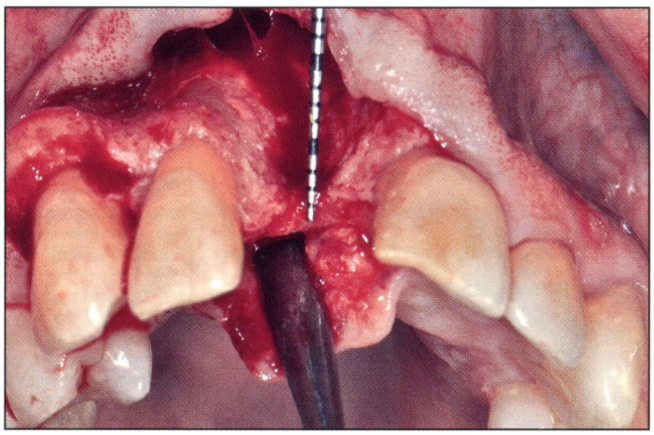


Fig 5 *Palatal residual ridge width was recorded at 1 mm. A significant buccal concavity was noted due to loss of the tooth past the apex. A distobuccal releasing incision at the right canine enabled good access to treat the bony defect. A deep vestibular periosteal release was completed to fully mobilize the buccal flap to aid in tension-free closure over the Ti-mesh.*

on probing was virtually eliminated with isolated 5-mm probing depths remaining in his mandibular posterior sextants. The patient was prescribed four medications prior to surgery: an oral rinse of 0.12% chlorohexidine gluconate to be started 1 day prior to surgery, twice daily for 2 weeks; amoxicillin 500 mg started on the morning of the surgery and taken for 1 week (qid); NSAID therapy started the morning of surgery and continued for 4 to 5 days as needed; and a methylprednisolone dose pack started the morning of surgery and used until completed.

The Ti-mesh surgical technique used in this case report was previously described by Levine et al.[18,19] Sulcular incisions were made from the right canine to lateral incisor with papillary sparing between the right lateral and site 11 and crestal incisions over site 11. A distal line-angle vertical releasing incision to the right canine allowed proper visualization of and access to the osseous defect. A full-thickness flap was then raised, and the area of the previous extraction socket was thoroughly curetted and debrided of all fibrous tissue remnants (Figs 4 and 5), revealing the large residual bony ridge defect. At the crestal aspect of the ridge a 1-mm thickness of palatal bone remained, but all aspects of the facial plate were missing to the apex. A deep vestibular periosteal release was completed to provide flap mobility and ensure tension-free suturing over the Ti-mesh. A single 7-mm tenting screw (BioMet 3i) was placed midbuccal to help in maintenance of the regenerative space under the Ti-mesh and followed by multiple intraosseous penetrations (Piezosurgery tip OP5 on highest setting with copious water irrigation) of the residual buccal aspect of the palatal wall to improve vascularization and graft incorporation.

A cellular allograft bone graft material was used in this case (Osteocel Plus, Nuvasive). Cortical bone was separated and processed into demineralized bone particles. The selective immunodepletion, through a series of washes, removed unwanted cells from the remaining cell-rich cancellous bone (osteoprogenitor and mesenchymal stem cells). Broad-spectrum antimicrobial treatment was performed on every lot to eliminate any potential bacterial contamination. The bone graft containing a minimum of 250,000 cells/cc was shipped to the office on dry ice and prepared as per the manufacturer's recommendation. Because the graft

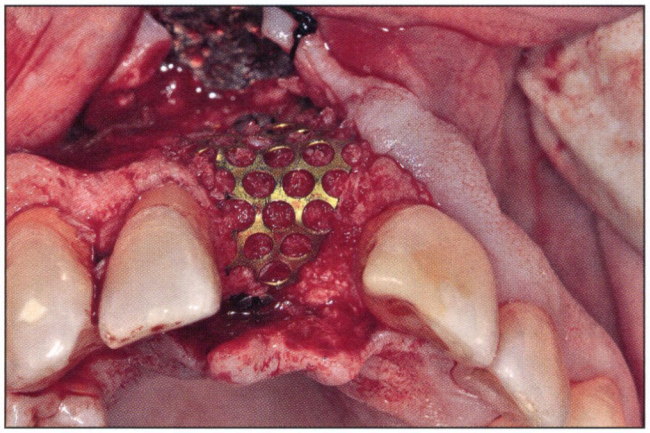


Fig 6 *The Ti-mesh was secured palatally with one 3-mm bone screw. Note the over bulking facially of the graft-Ti-mesh complex. A space of 1 to 2 mm is necessary interproximally from the mesh to the adjacent teeth. All sharp edges of the mesh are turned toward the osseous surface so as not to cut the overlying soft tissues and to further stabilize the mesh.*

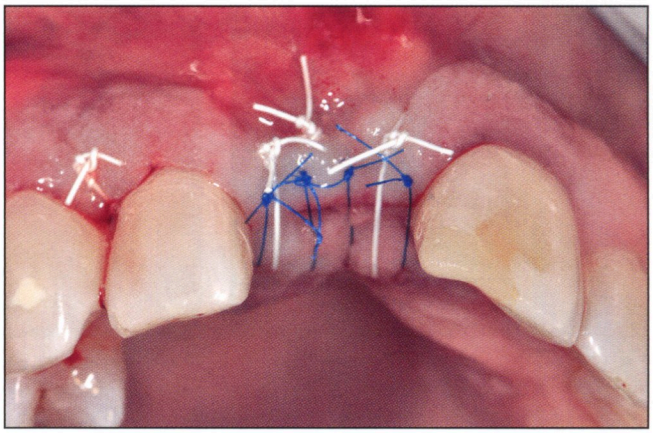


Fig 7 *Tension-free closure with high-density PTFE and 6-0 polypropylene. To close the vertical releasing incision distal to the right lateral incisor, 6-0 plain gut sutures were used.*

contained vital cells, it was thawed using a water bath at a maximum temperature of 37°C for 20 minutes. After the cryopreserved cells were thawed, the liquid was decanted and the cell-containing graft was kept hydrated with sterile saline until ready to be implanted. The large particle size (1 to 3 mm) was carefully reduced with rongeurs to reduce the particle size.

The Ti-mesh (0.2 mm, Johnson & Johnson) is customized outside of the mouth with clinical try-ins to ensure that the mesh is properly extended both apically and palatally as well as at least 1 to 2 mm away from the interproximal tooth surfaces. Special attention is paid to make sure that the Ti-mesh is secure starting with the facial aspect to create a facial wall against which the allograft material can be packed. Once the graft is packed thoroughly, the Ti-mesh is carefully bent over to the palatal aspect and secured with one to two additional 3- to 5-mm bone fixation screws (Johnson & Johnson). This allows complete stabilization to ensure that no micromovement of the mesh occurs during the healing phase. The rigid securing of the Ti-mesh by bone screws stabilizes the graft and the underlying blood clot, which provides a better reconstructive outcome[15,17–19] (Fig 6). Once the Ti-Mesh was secured, a collagen quick-resorbing membrane (CollaTape, Zimmer Dental) was placed over it. Disruption of the periosteal cells to the regenerative site was intentionally avoided in this case. The surgical goal was to have the Ti-mesh act as a protective scaffold to maintain the regenerative space and facilitate bone ingrowth without being cell occlusive, similar to a report by Misch[15] with rhBMP-2 and Ti-mesh.

The surgical site was then sutured with a combination of 5-0 d-PTFE horizontal mattress (Osteogenics Biomedical) and 5-0 d-PTFE and polypropylene (Prolene, Ethicon) interrupted sutures (Fig 7). This combination of suture materials enables close adaptation of the flap and interproximal papillae during the early healing phase. Postoperative care was then reviewed with the patient.

A CBCT scan was taken after 6 months of healing (Fig 8). It demonstrates significant regeneration of the facial plate, which will allow the implant to be placed in an ideal prosthetic position. The scan measured a horizontal ridge width of 8 mm (7 mm gained), and 2.3 mm of

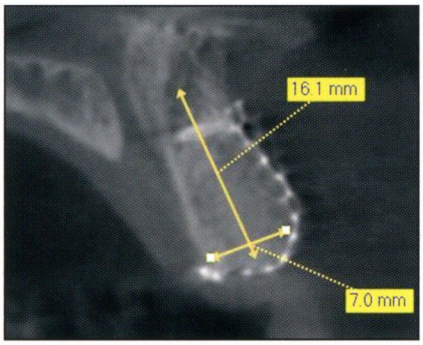


Fig 8 *CBCT scan taken at 7 months confirmed excellent bone healing.*

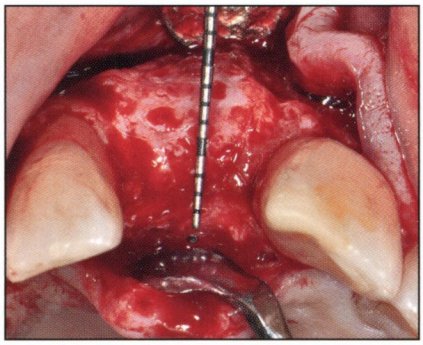


Fig 9 *Reentry at 7 months confirmed excellent bone healing for prosthetically driven implant placement. A horizontal gain of 7 mm and a vertical gain of 2.3 mm were recorded on the preoperative CBCT scan and confirmed clinically.*

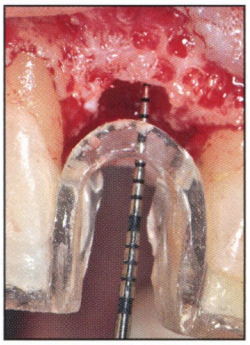
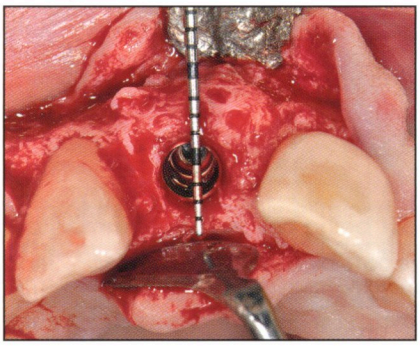


Fig 10 *An anatomically correct in situ surgical guide template was used to determine the bone scalloping necessary prior to implant placement to provide an adequate prosthetic emergence profile of 3 to 4 mm from the implant shoulder to the anticipated crown.*



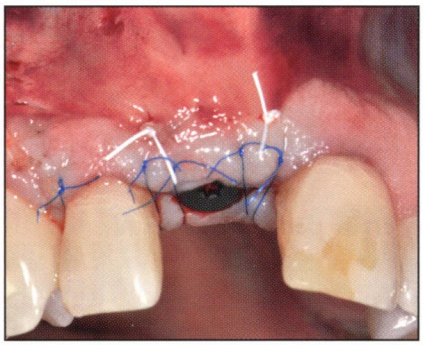


Fig 11 (left) *A Straumann 4.1-mm RC SLActive implant in place with 3 mm of bone buccal to the placed implant and 2 mm palatal to it.*

Fig 12 (right) *A palatal connective tissue graft (10 × 10 × 2 mm) was harvested and sutured to the undersurface of the buccal flap with 6-0 chromic gut. A Straumann RC tapered healing abutment was significantly bevelled facially so as to not place pressure on the buccal soft tissues during initial healing, to be replaced by a normal RC tapered healing abutment at 2 months of healing to stretch the tissues.*

vertical gain. The restorative dentist then saw the patient for study models to fabricate a laboratory-made ACSGT. The patient was scheduled for implant surgical placement 7 months after the original Ti-mesh procedure. Soft tissue healing at the implant placement visit was excellent, with no clinical signs of Ti-mesh exposure. Crestal incisions were made over the edentulous ridge at the implant site extending to the distal line angle of the right lateral incisor with a vertical releasing incision, and full-thickness flaps were raised for access to remove the Ti-mesh and bone screws (Fig 9). The bone was noted to be type 3 quality during osteotomy preparation. The implant osteotomy was positioned with the aid of the ACSGT (Fig 10), and a 4.1 × 12-mm Straumann Bone Level (BL) Regular Connection (RC) implant was placed with excellent primary stability (> 35 Ncm insertion torque). A view of the final implant in situ clearly demonstrates 3 mm of bone reconstruction buccal to the implant, which corresponds with a total of 7 mm of horizontal ridge reconstruction (Fig 11). A palatal connective tissue graft was placed under the buccal flap and sutured with resorbable plain gut to provide an improved posttreatment esthetic result with the appearance of a root convexity (Fig 12). Figures 13 and 14 show the 1-year digital periapical and clinical results.

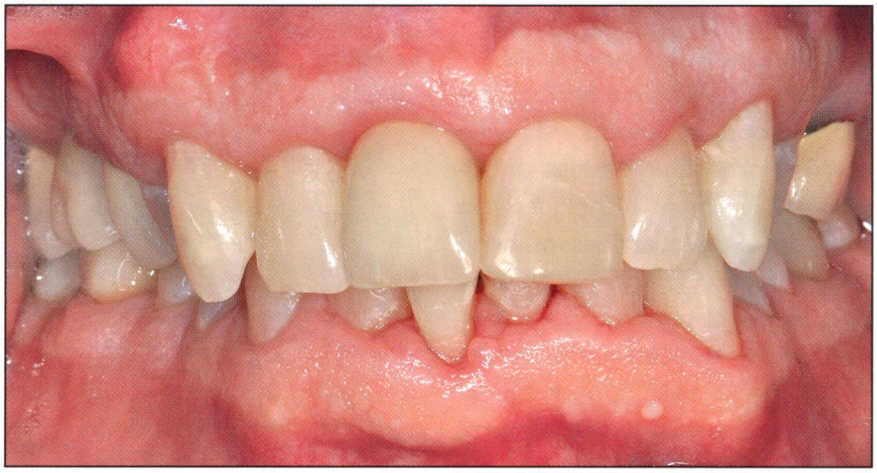


Fig 13 *Buccal view of the final cement-retained crown, 1 year postinsertion. Papillae embrasure closure was noted between the adjacent teeth. Buccal convexity is noted from hard and soft tissue healing. Probing depths were all normal (1 to 3 mm) with no bleeding on probing. Composite bonding was completed mesial to the left central incisor.*

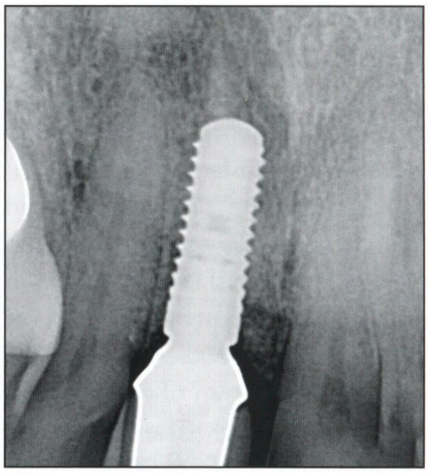


Fig 14 *The final digital periapical radiograph 1 year postinsertion showed stable osseous healing.*

Discussion

The dental implant literature includes numerous studies and case reports on the successful use of Ti-mesh for implant site development in the treatment of severely atrophic ridges using autogenous bone alone, autogenous bone mixed with bovine bone mineral (BBM), or particulate allograft with or without growth factors. The authors point to the many benefits of Ti-mesh, including easy handling and shaping, biocompatibility, excellent mechanical properties for rigid stabilization of the graft material, and allowing treatment of all types and sizes of large three-dimensional bony defects.[7–21,24] The rigidity of Ti-mesh prevents contour collapse, mucosa compression, and graft displacement while protecting the graft from external trauma and nonfunctional loading forces and allowing excellent integration of the bone graft into the recipient site. Ti-mesh is easily contoured outside of the mouth or prior to surgery on sterilized study casts or stereolithic bone models.[17,20] In addition, if there is exposure of the mesh after an initial 2 to 6 weeks of healing the soft tissue dehiscences seen are generally well tolerated. This is because the soft tissue migrates under the mesh, protecting the graft from infection, which limits the amount of resorption and does not appear to have a significant negative influence on implant placement.[7,8,10,12,14,17] Ti-mesh exposure after soft tissue dehiscence is documented to range from 10.5% to 80% in studies having from 7 to 24 patients enrolled.[8–10,13,14,16,17,20] The large variance in exposure rates is related to surgical technique, transmucosal loading under a transitional removable appliance, width and thickness of keratinized tissue at the recipient site, periodontal tissue biotype, and the volumetric reconstruction preoperatively planned.[26]

Proussaefs and Lozada, in their study of 17 patients using Ti-mesh (50% autogenous bone, 50% BBM), measured 2.56 ± 1.32 mm and 3.75 ± 1.33 mm vertical and horizontal reconstruction, respectively.[9] Roccuzzo et al, in 18 patients using Ti-mesh (and autogenous bone blocks), measuring only vertical height changes, recorded a mean of 4.8 mm (range: 4 to 7 mm) in vertical bone height augmentation.[7] Pieri et al measured, in 16 patients, 3.71 ± 1.24 mm and 4.16 ± 0.59 mm in vertical and horizontal change using Ti-mesh (70% autogenous, 30% BBM).[13] Corinaldesi et al in 24 patients measured 4.5 ± 1.16 mm of vertical bone gain (using autogenous mandibular bone chips) with Ti-mesh.[14] Funato et al recorded 8.6 ± 4.0 mm measuring only

vertical height in 19 patients using Ti-mesh and autogenous bone mixed with either 1:1 or 4:1 BBM and recombinant human platelet-derived growth factor BB.[17] The Ti-mesh technique provides a mean vertical gain (using various bone grafting materials) of 2.56 to 6 mm with both Funato et al[17] and Louis et al[11] reporting as outliers with means of 8.6 and 13.7 mm of vertical gain, respectively.[7,9,12–14] The horizontal bone gain of 7 mm reported in the present case report using Ti-mesh and a cellular allograft containing adult mesenchymal stem cells was greater than the mean of approximately 4 mm seen in other studies measuring horizontal bone gain with Ti-mesh.[6,11–13,21] The clinical use of cellular allograft, with its additional fees for the patient, may be considered when large volumetric bony defects are to be reconstructed, which is how it is recommended for use in the medical literature.[26,27] The patient in the present study was successfully rehabilitated with a dental implant, allowing him to be restored to health, function, and esthetics.

A recent systematic review of six selected articles documented an overall success rate of 98.86% for the Ti-mesh reconstructive procedure.[21] The overall survival and success rates of implants placed were 100% and 93.2%, respectively. It was concluded that the survival and success of implants placed using this procedure were comparable to those of implants placed in native bone, nonregenerated bone, and bone regenerated using nonresorbable and resorbable membranes.[21]

Conclusions

This case presentation adds to the growing body of literature showing how Ti-mesh with molecular or cellular enhancement techniques can result in large quantities of bone augmentation. The authors are in the process of performing a larger-scale study evaluating the results of 81 consecutive Ti-mesh procedures in 66 patients (122 implants) in private periodontal practice with different cellular and molecular enhancement techniques.

Acknowledgments

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