Modified IVAN Technique: Long-Term Follow-Up of 20 Cases Over 2 to 11 Years

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When natural teeth fail, frequently there is a loss of hard and soft tissue. This may complicate subsequent dental implant placement by creating insufficient bone to house the implant. This also occurs when the tooth has been missing for an extended period, especially in the premaxilla, where the bone is less dense and often lacks sufficient volume of facial bone. Site reconstruction to accommodate implant placement often requires both hard and soft tissue augmentation. The modified interpositional vascularized augmentation neogenesis (mIVAN) technique achieves the desired treatment goals in both delayed and immediate placement scenarios. The technique will be discussed as well as the long-term follow-up on 20 cases.

Key Words: extraction socket, delayed implant placement, interpositional vascularized augmentation neogenesis, IVAN, socket fenestration, buccal dehiscence

INTRODUCTION

Frequently, when a natural tooth fails in the maxillary anterior area, both hard and soft tissues are lost. Soft tissue and facial bone loss limits the ability for immediate implant placement and may complicate eventual implant placement, even at healed sites. The premaxilla's "triangle of bone"[1] frequently has a thin layer of facial bone overlying the roots of teeth. A natural dehiscence is not uncommon, even though a healthy dentition is present.[2,3] Frequently, the facial plate is absent as a result of vertical root fracture(s). Endodontic failure further complicates what remains of a thin facial plate at the root's apex.[4] Grafting and a delayed implant placement approach may be required to provide sufficient bone to encompass and support the implant. Grafting needs may involve not only bone replacement but may also require soft tissue augmentation to achieve proper site closure. During the healing phase, additional soft tissue coverage is often necessary to contain the hard tissue augmentation. Soft tissue augmentation may also provide adequate attached gingiva for long-term periodontal health.

Classification of the extraction socket determines what approach will be performed when an implant is planned for a site. Extraction sockets have been classified into 3 types based on the facial/buccal bone and soft tissue position.[5]

A Type I socket is defined as having intact facial bone (no perforation, dehiscence, or loss of crestal height) with an appropriately positioned gingival margin. These are the easiest and most predictable sites to treat, especially when the soft tissue biotype is thick. Excellent esthetics can normally be achieved with this socket type, and immediate implant placement can be accomplished without the need for grafting of the socket walls.[6] Using partial extraction therapies with a retained buccal aspect of the root (socket shield approach) will often result in almost complete maintenance of the ridge and soft tissue dimensions.[7]

Type II sockets can be deceptive, especially for an inexperienced clinician and are oftentimes difficult to diagnose. Type II sockets present with dehiscence; therefore, they are subdivided into 3 categories. Type II-A presents with a dehiscence involving the coronal one-third of the labial bone plate. The defect is roughly 5 mm to 6 mm from the free gingival margin (FGM). Type II-B presents with a dehiscence defect involving the middle one[third of the labial plate, approximately 7 mm to 9 mm from the FGM. In Type II-C, the dehiscence defect involves the apical one-third of the labial osseous plate and is 10 mm or greater from the FGM.

Type II sockets result in the largest number of esthetic problems. These esthetic problems often result from improper treatment of the defect. Frequently, treatment of soft tissue recession may occur, especially when an immediate implant placement is performed.[8] Additionally, dehiscence or fenestration of the implant may lead to the eventual loss of the implant due to a lack of sufficient osseous support surrounding the implant. These may be misidentified when the extraction socket is not explored to verify whether the facial plate is intact. Various procedures have been recommended for treatment of Type II sockets.[9–12]

Type III sockets are described as a midfacial recession defect of the facial soft tissue and labial bone plate. These are, however, very difficult to treat and require soft tissue augmentation with connective tissue grafts or connective tissue grafts with osseous grafting in a staged approach to rebuild the lost hard and soft tissues. Such patients often present with an associated soft tissue recession and labial bone plate loss before tooth extraction. Sockets in this classification

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require a very high degree of surgical experience, skill, and time commitment to achieve esthetic success.

Treatment of these clinical situations has been addressed by various methods when a defect presents on the facial/buccal aspect of the ridge. Treatments include the use of a collagen membrane in the extraction socket for the purpose of limiting soft tissue ingrowth that could compromise the bone graft placed into the socket. This procedure was termed the "ice cream cone" technique because the collagen membrane is formed into an ice cream cone shape before insertion into the extraction socket and placement of the osseous graft material.[13] However, this method does not address soft tissue deficiencies.

Immediately placed implants into sockets with a missing labial bone wall has been reported.[14] In 2013, da Rosa et al[15] reported a novel technique, called "immediate dentoalveolar restoration" (IDR), for treating compromised extraction sockets that calls for augmenting hard and soft tissue around immediately placed and loaded implants. The patient in the case reported was followed for 36 months, and the treatment was deemed a clinical success. In 2014, da Rosa et al[16] further reported a modification to IDR that was designed to treat soft tissue recession. At a 3-year follow-up, this technique demonstrated a predictable esthetic outcome with soft and hard tissue stability.[17]

In 2008, Fagan et al[18] were the first to report on the simultaneous augmentation of hard and soft tissues in preparation for implant placement.[18] Fagan et al[19] reported on 37 patients treated using the interpositional vascularized augmentation neogenesis (IVAN) technique. They postulated that :this technique is effective when used in conjunction with the immediate or delayed placement of dental implants in the maxillary anterior segment."

This article will focus on the modified IVAN (mIVAN) technique for Type II and III sockets and ridges with horizontal atrophy that presents a simultaneous soft and hard tissue grafting approach. This report follows 20 patients treated with the mIVAN technique over a 2 to 11 years and reports on the clinical success and negative sequela that arose during the observation period. The patients were treated on an as-needed basis in the private clinical practice of the primary author (S.P.). When the diagnosis and treatment planning required both hard and soft tissue grafting for the placement of an implant in the anterior maxilla, the mIVAN technique was used.

IVAN

Simultaneous reconstruction of the soft and hard tissue of the extraction socket is difficult due to poor blood flow in the overlying soft tissue graft. To circumvent this complication, a vascularized interpositional periostal connective tissue flap was developed. This consists of an anteriorly based pediculated tissue of the palatal submucosa to overlie the simultaneously placed hard tissue graft of the extraction socket or placed implant.[5] The repositioned pedicle graft has its blood supply maintained, therefore, allowing graft survival on the poorly vascularized or nonvascularized hard tissue augmentation that was placed during the same surgery.[20] The technique, termed "IVAN" consists of hard tissue grafts, various barrier membranes, and closure with a pediculated connective tissue graft (PCTG). The advantage if this technique over one that does not advance a coronal flap on the labial is that there is no loss of labial keratinized gingiva and it preserves the proximal papilla.

Materials and Methods

Identifying a Type II or III extraction socket (missing facial osseous plate) and when an implant treatment is planned for q site (either at the time of extraction or once there is a healed extraction socket) is crucial for eventual success (Figure 1a). Following are the treatment steps.

- Step 1: A split-thickness incision is made with a scalpel at the crestal-facial aspect of the socket.
- Step 2: An envelope flap is elevated (without use of vertical releasing incisions) (Figure 1b). This helps preserve the adjacent papilla.
- Step 3: With scissors, a piece of long-term collagen membrane is trimmed into an ice cream cone shape wide enough for the cone portion (apical aspect) to cover the entire facial width of the socket and the top or broad (ice cream) portion is placed to completely cover the coronal aspect of the socket.
- Step 4: The cone-shaped collagen is inserted into the socket on the facial aspect to act as a barrier for the hard tissue graft that will be placed (Figure 1c).
- Step 5: Xenograft (bovine bone) is placed as a layer along the lingual aspect of the collagen (cone) membrane in the extraction socket, acting as a barrier to prevent resorption of the autogenous bone placed as a filling into the socket (Figure 1d).
- Step 6: Autogenous bone particles are then placed, filling the remainder of the socket and compacting it against the previously placed xenograft that is against the resorbable membrane (Figure 2a).
- Step 7: Additional autogenous bone is placed to completely fill the socket to the crest (Figure 2b).
- Step 8: The top portion (ice cream portion) of the collagen membrane is folded over the bone graft placed at the site; this further contains the bone graft within the socket (Figure 2c).
- Step 9: An incision is made with a scalpel on the palate starting at the mesial aspect of the first molar and running from posterior to anterior, 2–3 mm apical to the gingival margin of the teeth. Making the incision in this manner avoids entry into the lingual gingival sulcus. The incision is carried anteriorly to the mesial side of the extraction socket as a single incision (Figure 2d).
- Step 10: Next, the connective tissue layer in the medial aspect of the incision (toward the palatal midline) is dissected from the overlying epithelium with a scalpel; the connective tissue must maintain attachment to the overlying tissue in the anterior area and thus create the pedicle graft.
- Step 11: The pedicle graft is released from the bed and rotated over the grafted extraction site; it is important to keep its attachment to the palate in the anterior area to maintain the pedicle graft blood supply (Figure 3a).

- Step 12: A suture needle with resorbable suture material is passed through the soft tissue in the labial vestibule apical to the mucogingival line and through the partial-thickness envelope flap (previously created) and looped through the end of the pedicle graft.
- Step 13: The suture is then reintroduced through the envelope flap and out through the labial vestibular soft tissue a few millimeters from where the suture initially passed into the tissue (Figure 3b).
- Step 14: The suture is pulled to move the pedicle graft over the socket and into the envelope flap (to augment the soft tissue on the facial aspect of the site).
- Step 15: The suture is then tied on the vestibule, thereby fixing the pedicle graft covering the resorbable membrane and further containing the underlying hard tissue graft (Figure 3c).
- Step 16: The donor site is then closed with crisscross sling sutures, using the teeth to help stabilize the flap margin.

Sutures need to provide compression to the soft tissue palatal flap to prevent hematoma formation (Figure 3d). This completes the soft and hard tissue grafting of the socket, and the mIVAN procedure is finished. The technique is further illustrated by the an actual case as reported by the authors.[21]

Surgical Case Example

A patient presented with pain in the upper right anterior that was restored with splinted crowns on the lateral and central incisors (teeth 7 and 8) (Figure 4). Radiographically, a fracture was noted on the lateral incisor (tooth 7) at the cervical region. After administration of local anesthetic, the splinted crowns were gently removed, and the coronal portion of the lateral incisor was in the crown. Periodontal probing confirmed the presence of a root fracture, and the tooth was deemed nontreatable. The root was atraumatically extracted, and exploration of the extraction socket identified a facial dehiscence (Figure 5). The palatal incision was made, and the connective tissue layer was separated from the overlying keratinized layer, leaving it attached in the anterior aspect to maintain its blood supply (Figure 6). The trimmed ice cream cone–shaped resorbable collagen membrane was inserted into the extraction socket to cover the dehiscence (Figure 7). A xenograft was packed in the socket against the membrane; the remainder of the socket was filled with autogenous bone that was gathered by scraping the palate following connective tissue graft elevation, and the membrane was folded over the graft-filled socket (Figure 8). The previously mobilized palatal connective tissue was rotated over the socket to cover the collagen membrane (Figure 9). Sutures were placed to close the palatal incision and cover the extraction socket graft (Figure 10). The old splinted crowns were temporarily luted as a cantilever bridge during the healing phase. The patient returned 2 weeks after surgery for suture removal, wherein the cantilever bridge was removed to facilitate suture removal. The site demonstrated coverage of the extraction socket with keratinized non-inflamed soft tissue, so hard tissue healing could progress before implant placement (Figure 11).

Results

The primary author (S.P.) treated 20 patients with the mIVAN technique over an observation period of up to 11 years (Table 1). Per standard of care, a cone bean computerized tomography (CBCT) (Figures 12 through 16) was taken before surgery to evaluate facial bone volume and the anatomy of the planned surgical site. Treatment results were evaluated by 3 independent clinicians to eliminate bias.

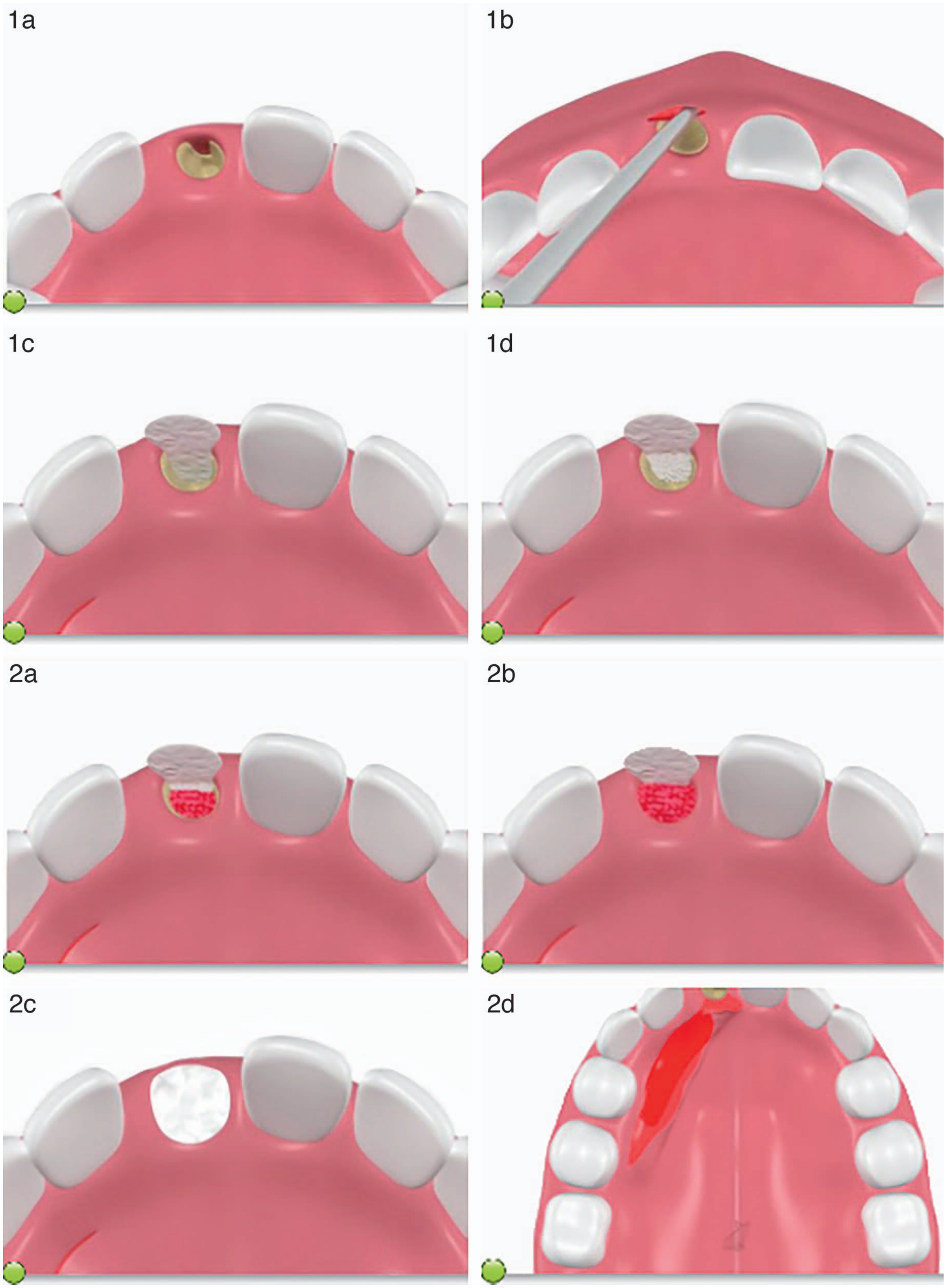
For socket Types II and III, buccal bone was found to be missing and periapical-deficient areas were often noted. Those sites, due to insufficient bone for implant placement, required a 2-step surgical approach, with mIVAN being performed to develop the site for implant placement and subsequent implant placement after healing of the osseous graft material. As the implant sites were grafted with autogenous (scraped) bone particles, only the buccal outer contour used xenografts. The implants placed in maxillary sites consisted principally of D2 quality bone after graft healing and were similar to the proximal native bone. Insertion torque at implant placement ranged from 25 to 40 N. Postloading evaluation of the implants and prosthetics was performed with radiographs and periodontal probing during clinical examinations. Regarding probing depths of the study patients, no pathologic probing was noted, and results were within normal limits (1–4 mm) with no bleeding on probing reported. Soft tissue stability was measured by visual examination and photographic documentation; no gingival recession was noted during the study period. Each evaluator determined the pink esthetic score (PES) for the 20 patients from 0 to 10. Table 2 shows the 3 evaluators' average score per patient and average total per evaluator.

The average PES for the 20 patients studied was 9.46.

Minor complications were noted in a few patients with no loss of implant. Those complications ranged from esthetic issues with the prosthetics (4 patients) to fracture of the zirconia abutment (1 patient). A surgical complication was partial necrosis of the PCTG for 1 patient (Table 1, patient 11). This patient was reevaluated 5 years after treatment and restoration were completed, with gingival probing depths within normal limits and no bleeding (Figure 17, left), and CBCT cross-section demonstrated maintenance of facial bone over the implant (Figure 17, right),

Discussion

Various methods have been proposed for simultaneous hard and soft tissue augmentation of extraction sockets, whether at the time of extraction or for defects resulting from prior extraction sites. As advocated by da Rosa et al,[22] IDR uses an autogenous hard tissue graft taken from the patient's tuberosity, but it may not be possible to harvest sufficient bone volume from the tuberosity as this is dependent on what bone is present in this area on the particular patient. The IDR technique requires immediately placed implants with immediate provisionalization. Depending on apical defects and sagittal root position, primary implant stability may not be achieved in all patients. This may be overly risky as it relates to the lack of a



Figures 1 and 2. Figure 1. (a) Patient presents with either a prior extraction site with a missing facial plate or a facial plate is lacking after extraction of the tooth and an implant is planned for the site. (b) A split-thickness incision is made at the crest on the facial aspect and an envelope flap is elevated without use of vertical releasing incisions. (c) An ice cream cone–shaped piece of collagen membrane is inserted into the site from inside the socket to act as a barrier for the hard tissue graft to be placed. (d) Xenograft (bovine bone) is placed as a layer over the resorbable membrane in the extraction socket to act as a barrier to prevent resorption of the autogenous bone to be placed

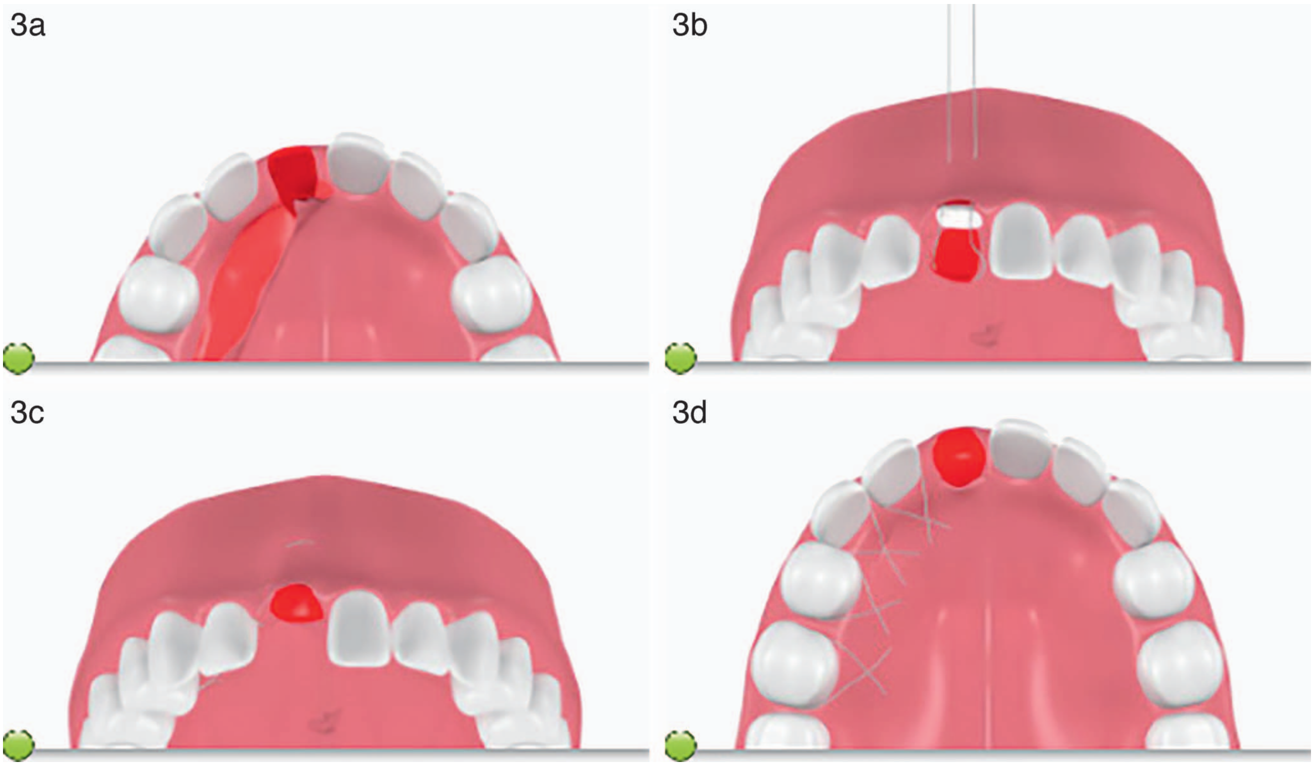


Figure 3. (a) The pedicle graft is released from the bed and rotated over the site keeping its attachment to the palate in the anterior. (b) The pedicle graft is sutured over the extraction site with emergence of the suture into the vestibule after passing under the facial soft tissue. (c) The suture is tied to fix the pedicle graft covering the resorbable membrane and contain the underlying hard tissue graft. (d) The donor site is closed with crisscross sling sutures using the teeth to help stabilize the flap margin and compress the tissue to prevent hematoma formation.

sufficient socket in contact with the implant, especially when a wide area of buccal or labial bone is missing.

The mIVAN for socket Types I and II is a flapless technique with no incision involving the periosteum. The gingiva and papillae are not detached, so swelling and hematoma formation are kept to a minimum. Since gingival fibroblasts are not disrupted, there is no trigger for bone resorption, and host bone is not lost during the healing phase; which is often observed when a flap is elevated.[23] As no coronal flap advancement is performed, the mucogingival junction and frenum are not displaced, and the width or position of the keratinized gingiva is not altered.

When horizontal atrophy of the ridge is present, the mIVAN uses a lingual flap elevated to augment the site. Because there is no labial coronal flap advancement, the disadvantages reported with repositioning a labial flap to a more coronal position are not observed. Part of the PCTG is left exposed to bridge the socket opening and, therefore, primary closure is achieved covering the crestal aspect of the socket.

Treatment of Type II and III sockets with the mIVAN technique is flapless and involves hard tissue augmentation with autogenous bone that prepares the site for future implant placement surrounded by soft tissue. Creating the labial soft tissue tunnel and then placing the PCTG into this labial tunnel has the advantage of additional labial soft tissue grafting. This results in a natural gingival appearance with texture, color, and stippling at the treatment site that blends nicely with the adjacent natural unaltered tissue on the adjacent healthy teeth.

The mIVAN technique allows preparation of the site for subsequent implant placement after soft tissue healing and hard tissue graft incorporation with the host bone; this resulted in quality bone to house the implant circumferentially in Type II and III sockets (Figures 12 and 13). When extractions are preformed without socket maintenance at the time of tooth loss and a delayed implant placement approach is used (either due to need for site healing or the patient's financial decisions), this often leads to horizontal bone loss plus a defect on the buccal aspect of the ridge. The mIVAN technique may be used to treat and prevent further tissue deficiencies. The clinician may also be able to achieve simultaneous implant placement (Figures 14 through 16).

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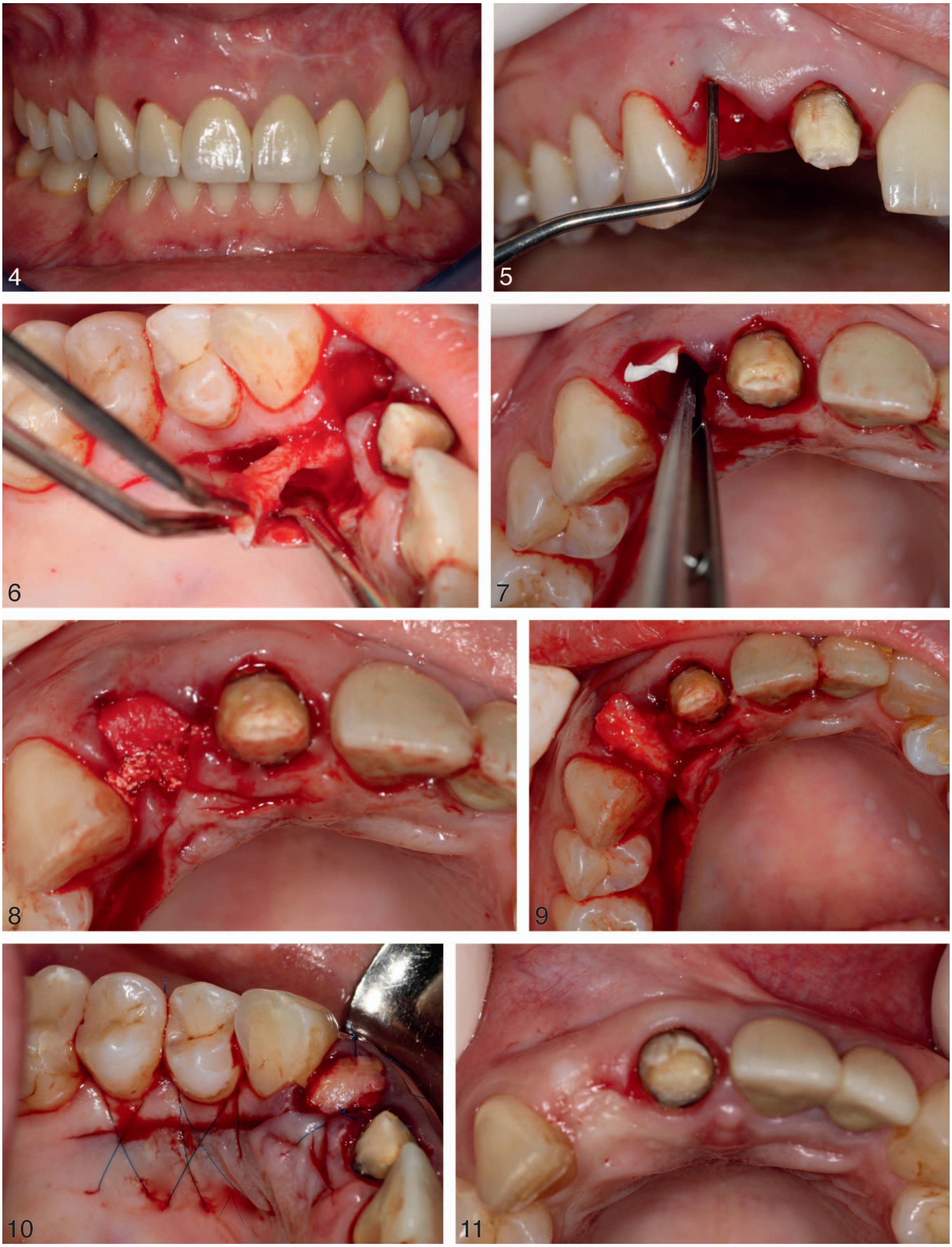
filling the socket. **Figure 2.** (a) Autogenous bone particles is placed to fill the remainder of the socket against the xenograft just placed and compacted into the site. (b) The socket is completely filled to the crestal level with additional autogenous bone previously collected. (c) The top portion of resorbable membrane is folded over the hard tissue graft placed at the site helping to contain it in the socket. (d) An incision is made on the palate starting at the mesial aspect of the first molar 2–3 mm apical to the gingival margin (to avoid entry into the lingual gingival sulcus) of the teeth and carried anteriorly to the extraction socket in a single incision.



Figures 4–11. Figure 4. Patient presented with pain on the right lateral incisor under 2 splinted crowns. **Figure 5.** Dehiscence noted on the facial aspect after extraction of the root. **Figure 6.** Connective tissue is mobilized on the palatal aspect, maintaining attachment in the anterior for continuous blood supply to the tissue. **Figure 7.** Ice cream cone–shaped collagen membrane is inserted into the extraction socket against the facial aspect of the socket. **Figure 8.** Xenograft and autogenous bone have been placed into the socket and the collagen membrane folded over it coronally). **Figure 9.** The previously mobilized connective tissue is rotated over the grafted extraction socket. **Figure 10.** The palatal incision and socket are secured with sutures. **Figure 11.** At suture removal 2 weeks after surgery demonstrating coverage of the socket with keratinized tissue.

Table 1

Data for the 20 patients treated using modified interpositional vascularized augmentation neogenesis followed over the 2- to 11-year observation period

Patient No.	Site	Sex	Year Treatment Ended	Year of Follow-up	Period of Observation	Age (y)	Socket Type II	Socket Type III	Horizontal Ridge Atrophy	Implant System	Additional Details
1	Right lateral incisor	Female	2011	2018	7	31	1			Astra	
2	Left central incisor	Female	2014	2017	3	32	1			Astra	
3	Right lateral incisor	Female	2011	2017	6	30	1			Astra	Apicoectomy on adjacent tooth
4	Right central incisor	Female	2016	2018	2	28	1			BEGO	
5	Left central incisor	Female	2013	2018	5	48	1			Astra	New crown for esthetic reason in 2018
6	Left central incisor	Female	2013	2019	6	29	1			Astra	Apicoectomy on adjacent tooth; new crown as a result of trauma.
7	Left lateral incisor	Male	2012	2019	7	34	1			Astra	Spacing with contact opening; new crown in 2017
8	Left central incisor	Female	2015	2017	2	41	1			BEGO	
9	Right central incisor	Female	2014	2017	3	29	1			BEGO	Zirkon abutment fracture; new crown
10	Left central incisor	Male	2012	2017	5	28			1	Astra	
11	Right canine	Male	2014	2019	5	40		1		BEGO	Partial pediculated connective tissue graft necrosis.
12	Right lateral incisor	Male	2011	2017	6	29		1		Astra	
13	Right central incisor	Female	2011	2018	7	55			1	Astra	Postextraction implant on adjacent tooth; new crown
14	Right central incisor	Female	2013	2017	4	41			1	Astra	New crown for esthetic reason
15	Left lateral incisor	Female	2015	2019	4	56			1	Astra	
16	Left central incisor	Female	2006	2016	10	27			1	Straumann	New crown (patient's wish)
17	Left central incisor	Female	2011	2019	8	28			1	Astra	
18	Right central incisor	Female	2013	2018	5	29			1	Astra	
19	Left central incisor	Male	2017	2019	2	28			1	BEGO	
20	Right central incisor	Female	2005	2016	11	52			1	Straumann	

Table 2

Pink esthetic score (PES) values as rated by the 3 evaluators, the average score per patient, and the average total per evaluator*

Patient No.	Average PES Score GP	Average PES Score OS	Average PES Score Periodontist	Overall Average PES Score
1	10	10	10	10
2	10	10	10	10
3	9	9	9	9
4	9	10	9	9.33
5	10	9	10	9.66
6	10	10	10	10
7	9	10	10	9.66
8	10	10	10	10
9	9	10	9	9.33
10	9	10	10	9.66
11	8	10	7	8.33
12	9	9	9	9
13	9	9	9	9
14	9	9	10	9.33
15	9	9	10	9.33
16	10	10	10	10
17	9	9	8	8.66
18	9	10	9	9.33
19	10	10	10	10
20	9	10	10	9.66
Average total score per evaluator	9.3	9.65	9.45	9.46

*GP indicates general practitioner; OS, oral surgeon.

The mIVAN technique (as reported by the authors in a previously published article) addresses the shortcomings of the previous techniques that have been advocated.[21] The mIVAN technique can provide predictable results while affording simultaneous hard and soft tissue grafting. This technique may be used for (1) hard and soft tissue augmentation in extraction sockets with missing labial bone or (2) hard/soft tissue augmentations with simultaneous implant placement for ridges demonstrating horizontal atrophy in the esthetic zone. The 20 patients presented in this study demonstrated long-term success with stable soft and hard tissue and preservation of esthetics.

Conclusion

Extraction of teeth in the maxillary anterior area frequently presents an insufficient volume of bone for implant placement as it relates to the angulation of the premaxilla and often results in fenestration or dehiscence of the natural tooth. Proper implant placement becomes more complicated when there is associated bone loss from periodontal or endodontic pathologies. These comorbidities often necessitate osseous grafting to fully house the implant. Soft tissue deficiencies are often present due to previous recession, inadequate available keratinized gingiva or a combination of both. Various techniques have been suggested to treat these situations with mixed results.

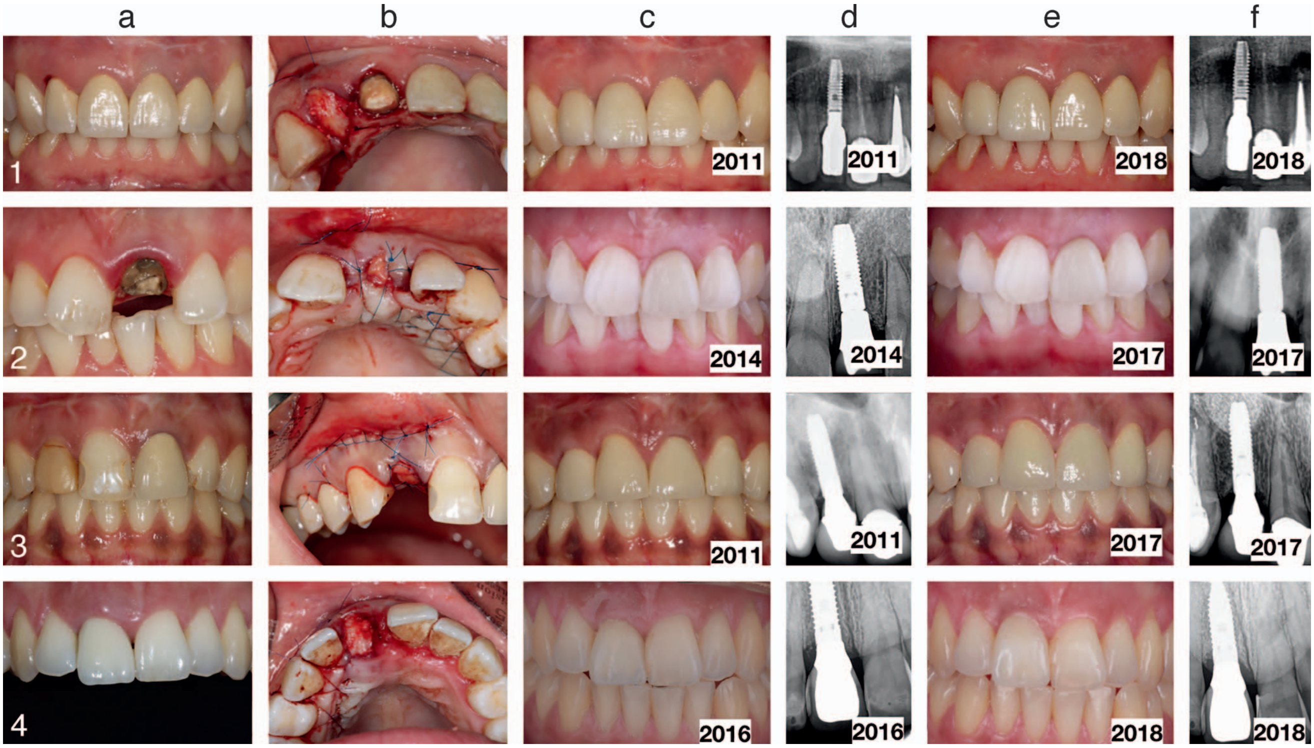


FIGURE 12. Patients 1–4, who were treated by modified interpositional vascularized augmentation neogenesis (mIVAN) for socket Type II hard and soft tissue augmentation showing the condition (a) before treatment, (b) after mIVAN, (c) after restoration healing, (d) radiographically at restoration, (e) at the end of the observation period showing soft tissue stability, and (f) radiographically demonstrating crestal bone stability.

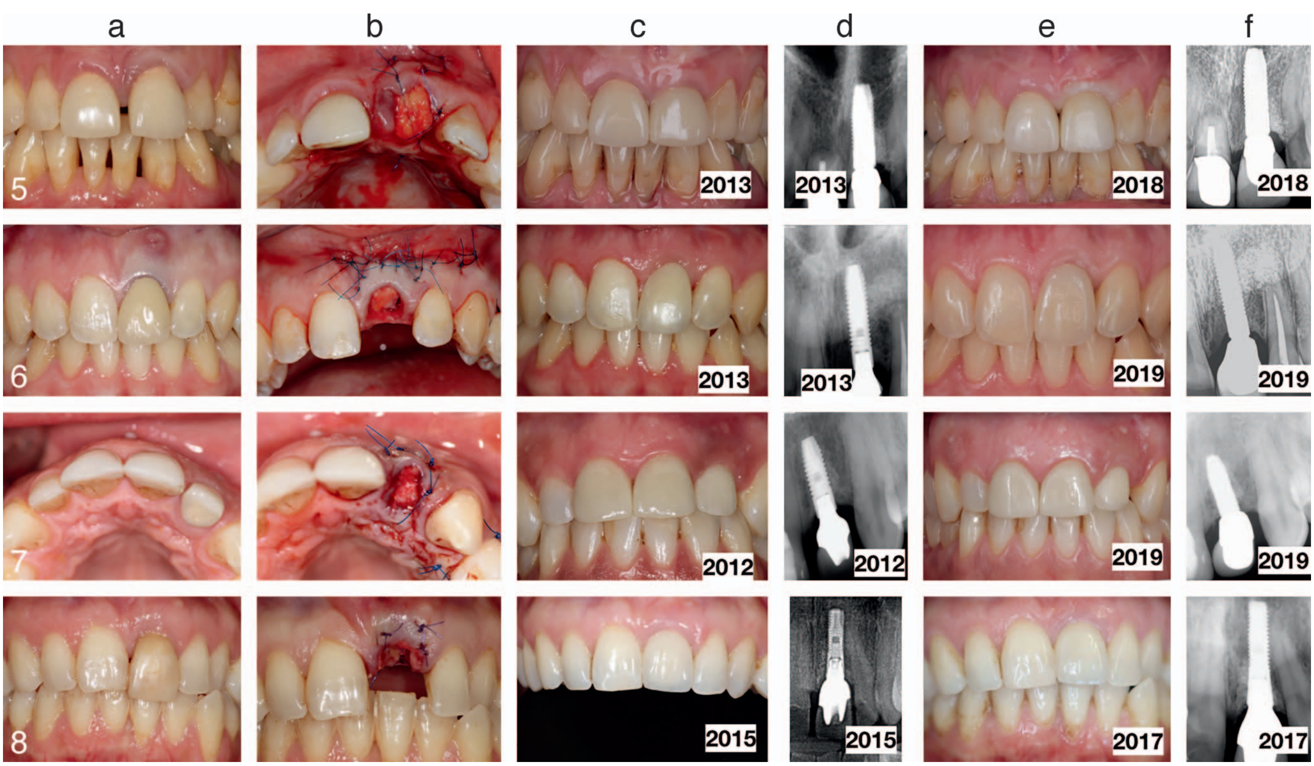


FIGURE 13. Patients 5–8, who were treated by modified interpositional vascularized augmentation neogenesis (mIVAN) for postextraction socket in Type II sockets showing the condition (a) before treatment, (b) after mIVAN, (c) after restoration healing, (d) radiographically at restoration, (e) at the end of the observation period showing soft tissue stability, and (f) radiographically demonstrating crestal bone stability.

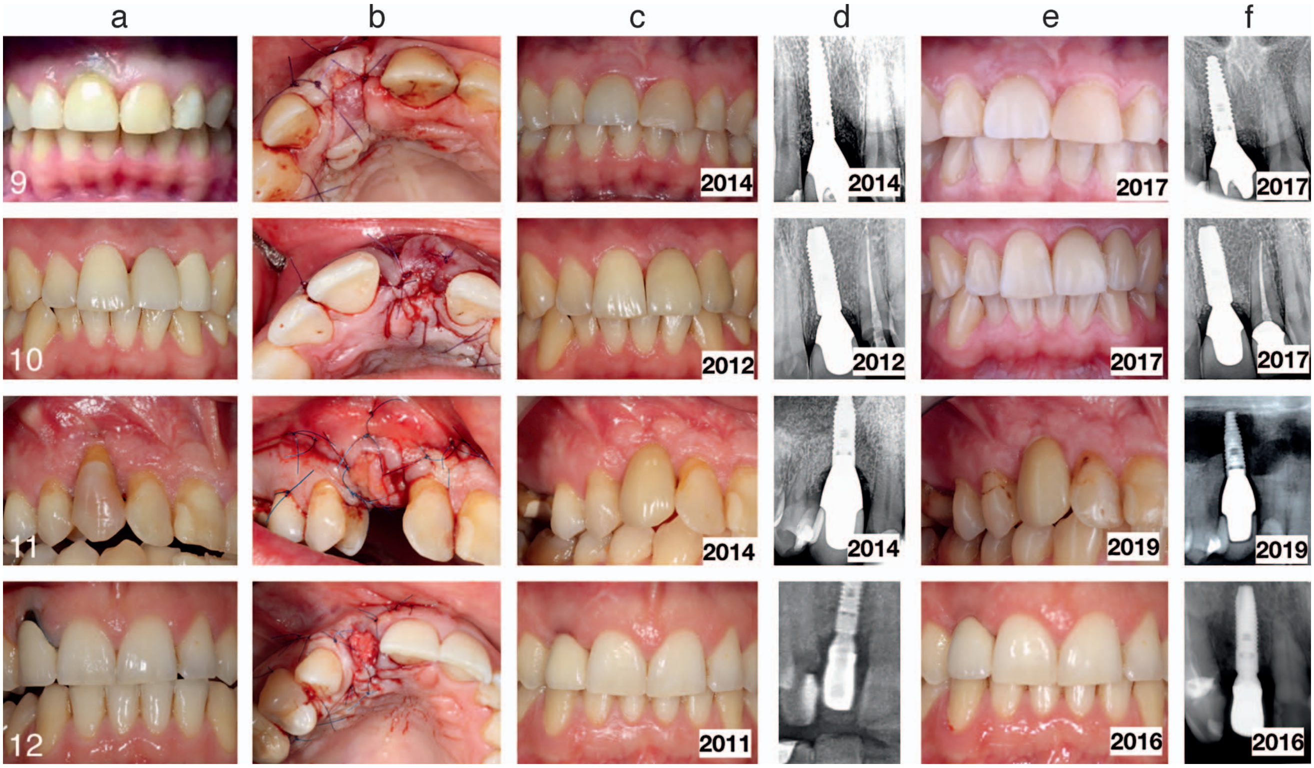


Figure 14. Patients 9 and 10, who were treated by modified interpositional vascularized augmentation neogenesis (mIVAN) for postextraction socket in Type II sockets, and patients 11 and 12 with Type III socket showing the condition (a) before treatment, (b) after mIVAN, (c) after restoration healing, (d) radiographically at restoration, (e) at the end of the observation period showing soft tissue stability, and (f) radiographically demonstrating crestal bone stability.

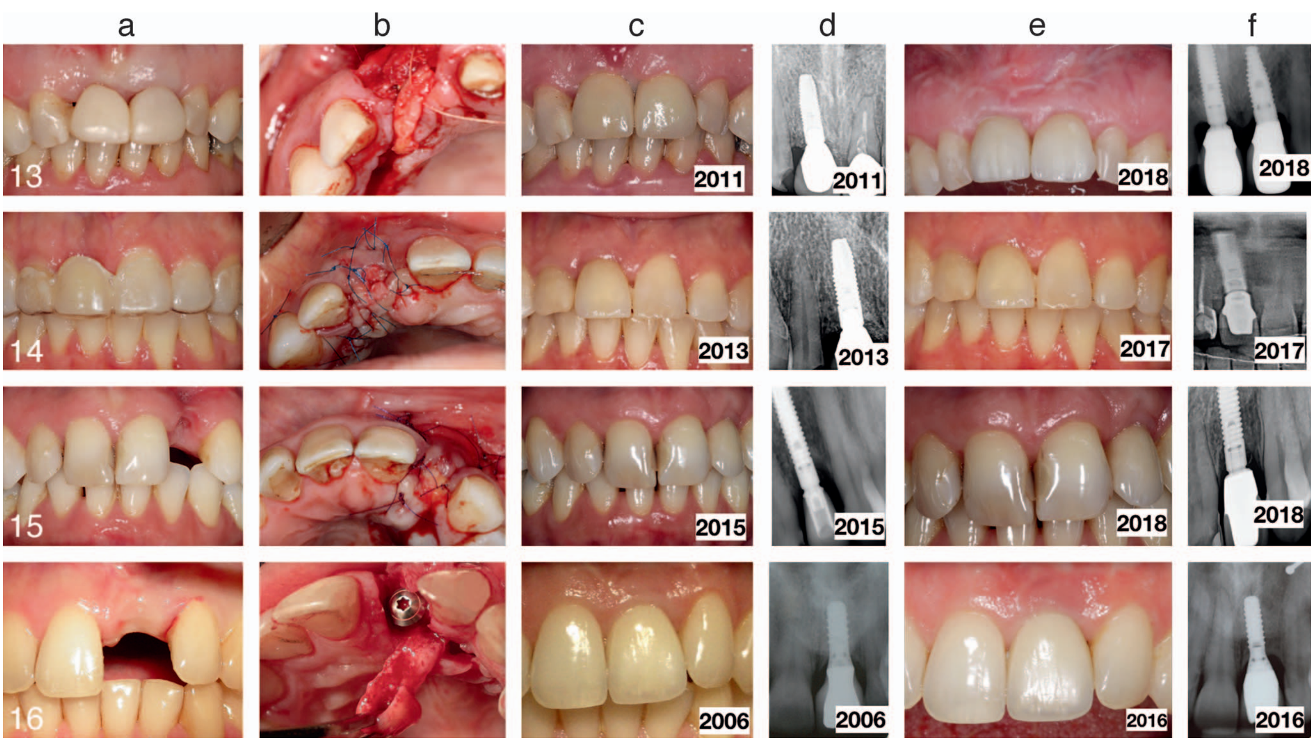


Figure 15. Patients 13–16, who were treated by modified interpositional vascularized augmentation neogenesis (mIVAN) for the ridge with horizontal atrophy showing the condition (a) before treatment, (b) after mIVAN with simultaneous implant placement, (c) after restoration healing, (d) radiographically at restoration, (e) at the end of the observation period showing soft tissue stability, and (f) radiographically demonstrating crestal bone stability.

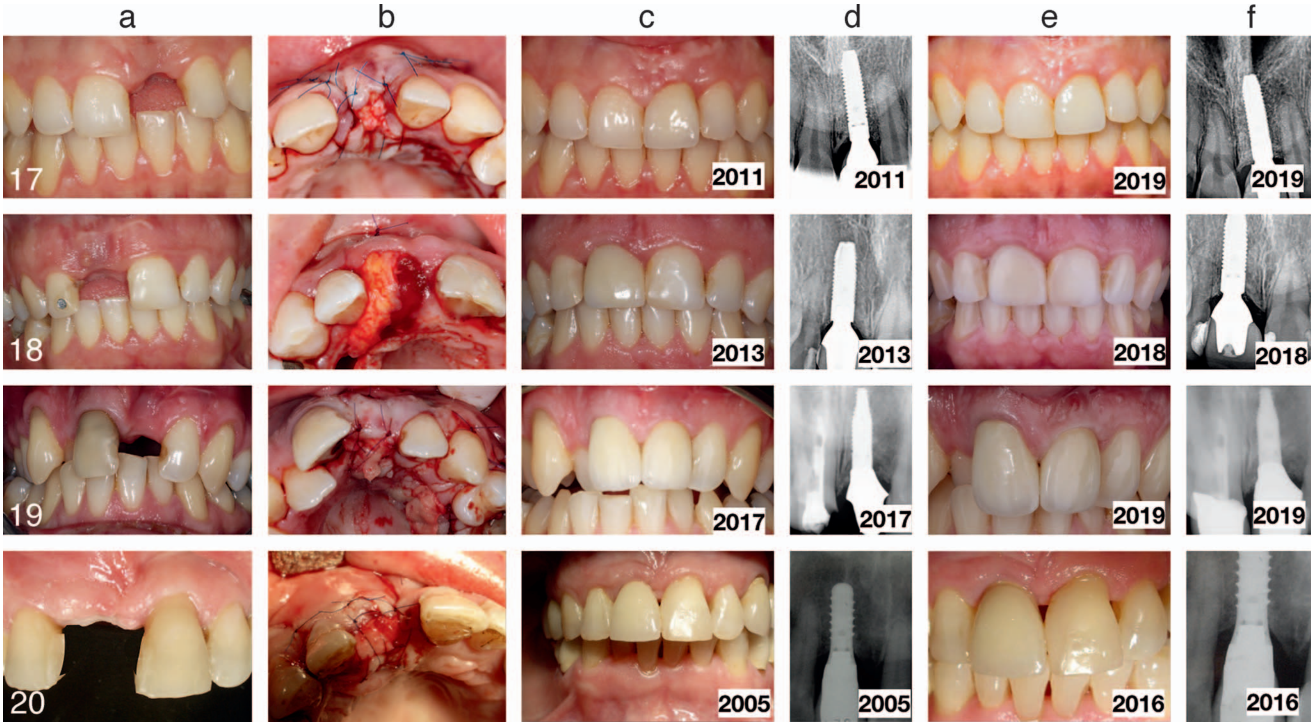


FIGURE 16. Patients 17–20, who were treated by modified interpositional vascularized augmentation neogenesis (mIVAN) for the ridge with horizontal atrophy after prior tooth extraction showing the condition (a) before treatment, (b) after mIVAN, (c) after restoration healing, (d) radiographically at restoration, (e) at the end of the observation period showing soft tissue stability, and (f) radiographically demonstrating crestal bone stability.

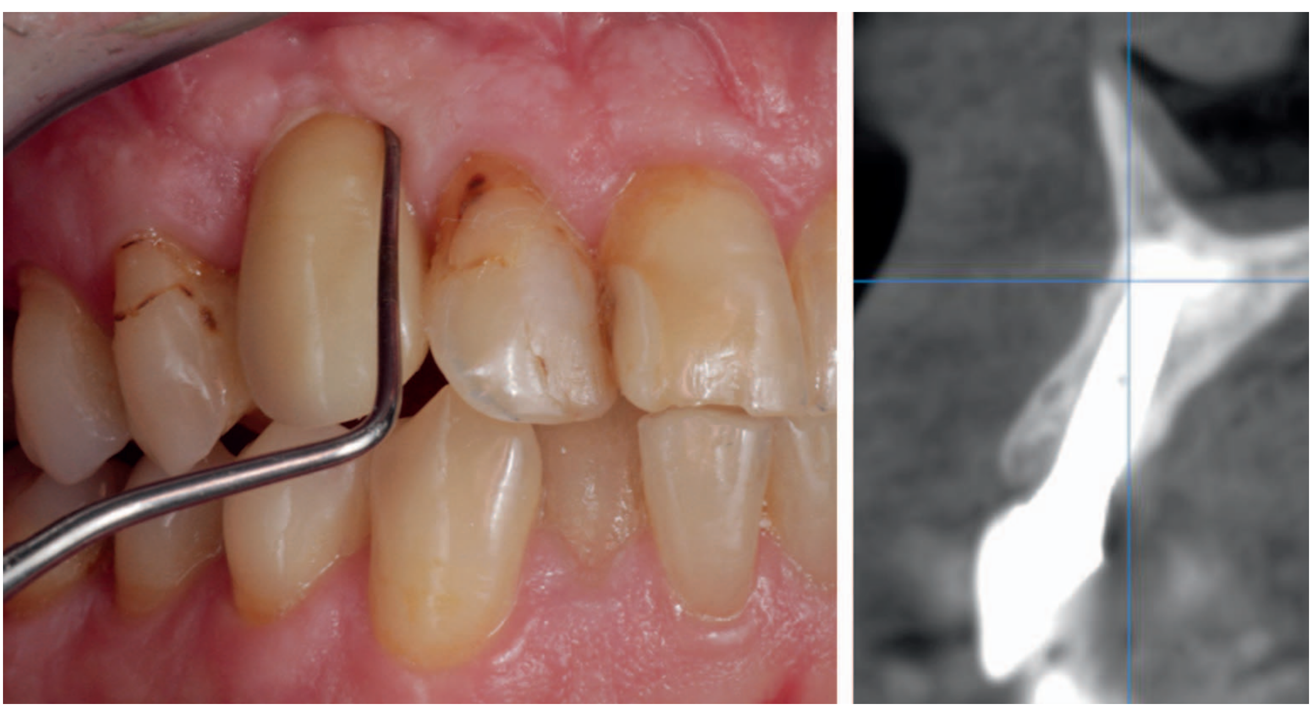


FIGURE 17. Patient evaluated 5 years after completion of treatment and restoration, with probing within normal limits and no bleeding (left) and cone beam computerized tomography cross-section demonstrating maintenance of the facial bone over the implant (right).

Abbreviations

CBCT: cone beam computerized tomography
IDR: immediate dentoalveolar restoration
IVAN: interpositional vascularized augmentation neogenesis
mIVAN: modified interpositional vascularized augmentation neogenesis
PCTG: pediculated connective tissue graft
PES: pink esthetic score

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