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Vertical Ridge Augmentation in the Anterior Maxilla Using a Dual-Texture e-PTFE Membrane and Autogenous Bone: A 2- to 5-Year Retrospective Case-Series Study

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ABSTRACT

Objectives: To evaluate a novel protocol for vertical ridge augmentation with titanium-(Ti)-reinforced dual-texture expanded polytetrafluoroethylene (e-PTFE) membranes, 100% autogenous bone, and 12 months of bone healing in the anterior maxilla.

Material and Methods: This retrospective study included 14 consecutive patients treated between 2016 and 2021. Large defects, including both vertical and horizontal components, were treated with autogenous bone grafting and non-resorbable Ti-reinforced dual-texture e-PTFE membranes. Implants were placed in the augmented bone after 12 months. All clinical and radiographical parameters were retrieved from patient records.

Results: The case series included 14 patients treated with 15 e-PTFE membranes. The mean initial vertical defect size was 7.5 ± 5.1 mm (range: 3–23 mm). All membranes remained unexposed during the entire healing period (12.6 ± 1.2 months). No complications that needed intervention occurred. Complete bone fill was achieved, that is, regenerated bone filled the entire volume created by the membrane, in all treated defects. Twenty-three implants were placed. The survival rate was 100% and the mean marginal bone level was 0.08 ± 0.11 mm after up to 5 years.

Conclusions: Excellent vertical augmentation outcomes can be achieved in the anterior maxilla using a non-resorbable Ti-reinforced e-PTFE membrane and an autogenous bone graft, followed by 12 months of healing before implant placement. The implants demonstrated stable marginal bone levels after loading. This case series has limitations, mainly the retrospective nature and small sample size, but it indicates that the proper choice of methods, materials, and healing times during GBR results in a predictable clinical outcome.

1 | Introduction

Guided bone regeneration (GBR) (Buser et al. 2023; Dahlin et al. 1989) has been in clinical use for over three decades and is currently the most reliable technique in terms of bone stability, with minor resorption and a low complication rate and morbidity (Alotaibi et al. 2023; Elnayef et al. 2017). The biological principle of GBR relies on the placement of a membrane that acts as a barrier and prevents the ingrowth of non-osteogenic cells, maintaining adequate biological space for the regeneration of bone tissue.

Resorbable collagen membranes are most frequently used but lack mechanical stability and can be challenging to implement, especially in the treatment of extensive vertical deficiencies. Non-resorbable membranes are superior for vertical defects

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due to their superior ability to maintain regenerative space during the healing period (Soldatos et al. 2017).

The first-generation non-resorbable PTFE membranes were expanded polytetrafluoroethylene (e-PTFE) membranes, with an open fibrous structure. They have the longest published follow-up data and are considered the gold standard in the augmentation of advanced defects (Omar et al. 2019; Qasim et al. 2023). The use of dense PTFE (d-PTFE) membranes has also been introduced in the clinical setting (Ronda et al. 2014). The dense structure makes them better at withstanding bacterial penetration at exposure, but it also leads to less tissue interaction with the membrane surface (Turri et al. 2024). To increase tissue interaction with the d-PTFE membranes, a mesh version has been introduced (Cucchi, Bettini, et al. 2024; Urban et al. 2021). The most recent type of PTFE membranes is a dual texture e-PTFE that has a fibrous structure like the first-generation but is occlusive to bacteria (Felice et al. 2024; Trobos et al. 2018; Zeller et al. 2024).

Marginal bone loss (MBL) after GBR has been evaluated in several studies. Results indicate that some resorption of the augmented site is expected over time. A recent systematic review reported a mean MBL of 1.12 mm at medium-term follow-up (24–60 months) and 1.13 mm at long-term follow-up (≥ 60 months) for GBR using different membrane types including both resorbable and non-resorbable membranes (Cucchi, Maiani, et al. 2024). This is in line with another literature review that concluded that an average bone loss of about 1 mm is expected after the first year of loading, and stable marginal bone levels could be assumed after this period (Urban et al. 2023). More specifically related to this study, the medium-term MBL when using e-PTFE membranes ranged from 0.5 to 1.0 mm (Fontana et al. 2015; Merli et al. 2014; Urban et al. 2009), and 0.7 to 1.3 mm when using d-PTFE membranes (Cucchi et al. 2023; Pistilli et al. 2020).

The use of bone substitute materials has been indicated to minimize the extra invasiveness of a second site for graft harvesting. A recent systematic review showed that treatment success, as measured by the survival rate of implants placed in augmented bone, was comparable for bone substitutes (97.4%), autogenous bone (98.6%), and mixtures of the two (100%). However, they did not report on the stability of the augmented bone over time (Al-Nawas and Schiegnitz 2014). Other studies have shown that the medium-term MBL when using PTFE membranes and 100% autogenous bone ranged from 0.5 to 1.0 mm (Merli et al. 2014; Urban et al. 2009), and 0.7 to 1.3 mm when using PTFE membranes and a mixture of autogenous bone and bone substitute materials (Cucchi et al. 2023; Fontana et al. 2015; Pistilli et al. 2020).

The aim of this retrospective case series was to evaluate a novel protocol for vertical ridge augmentation with dual-texture PTFE membranes, 100% autogenous bone, and 12 months of bone healing in order to increase the stability of regenerated bone and to reduce the MBL around implants.

2 | Material and Methods

This retrospective study consisted of all consecutive patients ($n = 14$) treated between September 2016 and March 2021 in a private office in Murcia, Spain (Clinica Ortoperio) that met the inclusion criteria:

- Patients with alveolar defects with a combination of horizontal and vertical atrophy in the anterior maxilla, where the vertical component was ≥ 3 mm.
- Treatment with dual-texture e-PTFE membranes (NeoGen Ti-Reinforced PTFE Membrane; Neoss AB, Gothenburg, Sweden) and 100% autogenous bone grafts.

All patients received preoperative information and provided informed consent prior to treatment. The study was approved by the Ethics Committee of HM Hospitales (24.09.2378-GHM). It was conducted in accordance with the World Medical Association Declaration of Helsinki and the STROBE guidelines for observational studies.

2.1 | Surgical Protocol

The patients were treated according to the routine treatment protocol at the clinic as illustrated in Figures 1–3. They received amoxicillin 2 g (Normon, Madrid, Spain) 1 h prior to surgery and amoxicillin 500 mg three times daily for 7 days postoperatively. Local anesthesia with Ultracain (epinephrine 40 mg/mL + 10 micrograms/ml; Normon, Madrid, Spain) was administered at the surgical sites.

A full-thickness crestal incision was performed and extended mesially and distally to involve the adjacent teeth. Diverging releasing incisions were added buccally, and full-thickness mucoperiosteal flaps were elevated. The bone surface in the augmentation area was carefully debrided to remove all remnants of soft and granulation tissue. The buccal bone plates in the defect areas were perforated using a spiral bur with a diameter of approximately 1 mm.

Autogenous bone was harvested from the retromolar region via a vestibular incision and exposure of the lateral wall of the ramus. Multiple bone biopsies were harvested using a 4 mm trephine bur (Meisinger, Neuss, Germany) under rigorous cooling with saline. The bone biopsies were crushed into 1–2 mm pieces using a bone mill (Meisinger, Neuss, Germany). Additional bone graft material was harvested with a bone scraper from the surgical site. The augmentation procedure was initiated by securing a trimmed dual-textured e-PTFE membrane (NeoGen; Neoss) to the palatal flap using two horizontal 5-0 PTFE mattress sutures (WL Gore & Ass, Flagstaff, Arizona, USA). The autogenous graft material was placed in the defect area, and the membrane was fitted to cover the graft material and secured buccally using titanium tacks (Neoss AB, Gothenburg, Sweden). Tension-free soft tissue closure was achieved by a careful periosteal releasing incision, and the flaps were sutured in two layers using 5-0 PTFE sutures (WL Gore & Ass, Flagstaff, Arizona, USA) for horizontal mattress suturing, followed by the closure of the mucosal incision with 6-0 Polinyl nonabsorbable sutures (Sweden&Martina, Due Carrare, Italy).

The patients were instructed to rinse with chlorhexidine 1 mg/mL (GlaxoSmithKline Consumer Healthcare AS, Bröndby, Denmark) twice daily until suture removal 2–3 weeks postoperatively. The patients were not allowed to wear any removable dentures for 1 month postoperatively.

The treatment sites were allowed to heal for 12–14 months before reentry, membrane removal and implant placement, and subsequent

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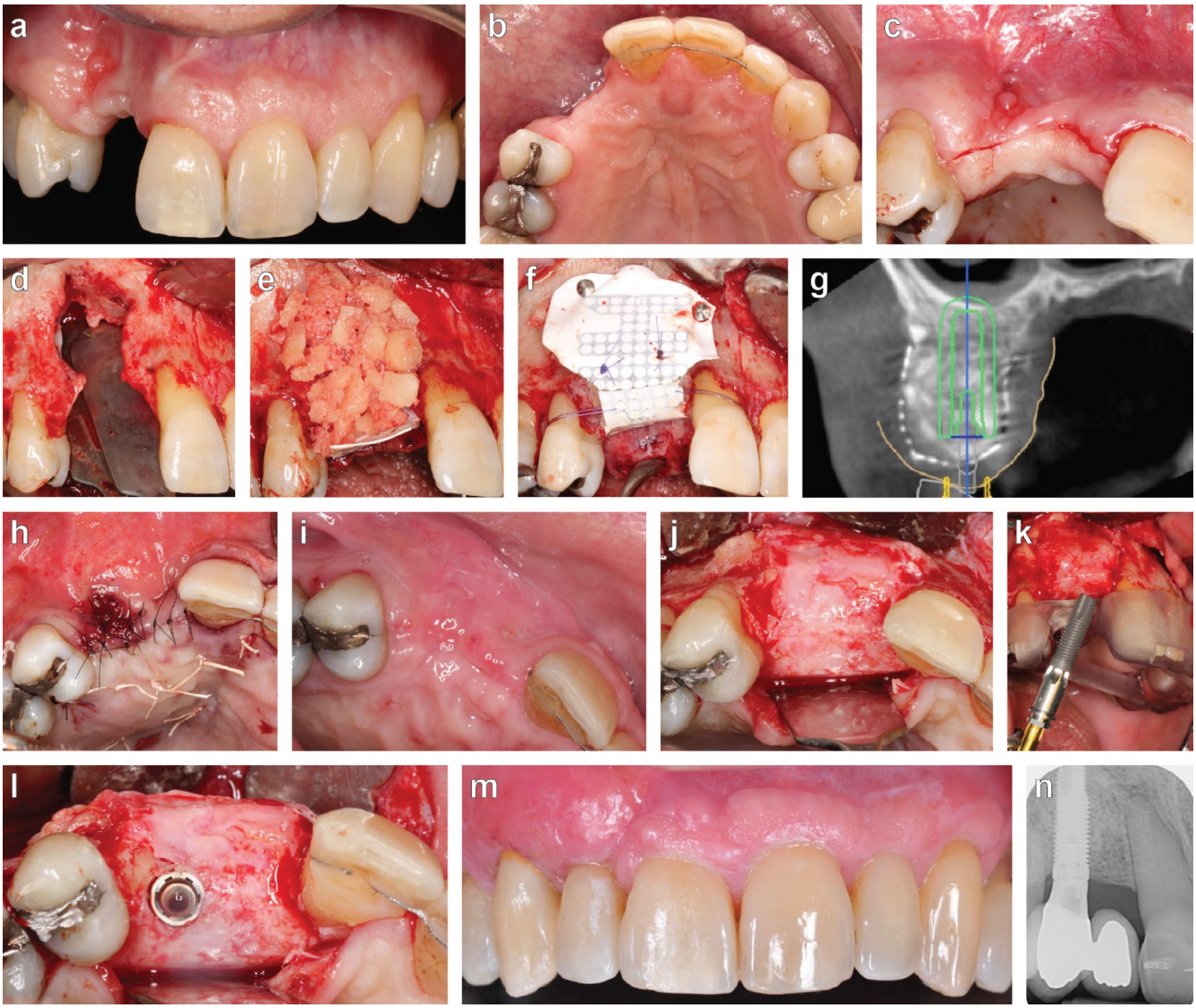

FIGURE 1 | Images depicting the steps in the treatment protocol. (a, b) The initial clinical situation, (c) crestal incision, (d) defect exposed, (e) autogenous bone grafting, (f) membrane placed, (g) CBCT of augmented site with planned implant position, (h) suturing to achieve tension-free closure; also note the deep palatal sutures for membrane fixation, (i) soft tissue healing, (j) augmented bone at membrane removal; a thin pseudoperiosteum can be noted at the center of the augmented area, (k) guided implant placement, (l) implant in place, (m) definitive crown in place, (n) radiograph 5 years after loading.

prosthetic restoration. A subepithelial connective graft was placed at the time of implant placement to improve the quality of the soft tissue. Two to three months later, after raising a split-thickness flap, a free subepithelial connective tissue graft was placed on the buccal aspect of the alveolar ridge to reposition the mucogingival line.

2.2 | Clinical Evaluation

Study data were collected through a retrospective chart review. Clinical parameters, radiographs, clinical photographs, and all available information on adverse events and complications were collected from the patient files. No additional treatments were performed as part of this study. The clinical parameters were patient sex and age, defect position, vertical component of the defect before and after augmentation, healing and follow-up times, and implant survival.

The vertical component of the defect was measured using a standard periodontal probe (UNC-15; Hu-Friedy, Chicago, USA) from the most apical point of the defect to a line connecting the bone attachment levels on the neighboring tooth roots using two periodontal probes, as seen in Figure 4. The change in vertical height was defined as the difference in vertical component between baseline (time of augmentation) and reentry (time of membrane removal and implant installation).

2.3 | Radiographic Evaluation

Marginal bone levels around the implants were assessed using intraoral radiographs. The radiographs were projected on a large screen, and the measurements were performed manually by a single observer, who was blinded to the patient demographics. The observer had been calibrated prior to the analysis. The reference

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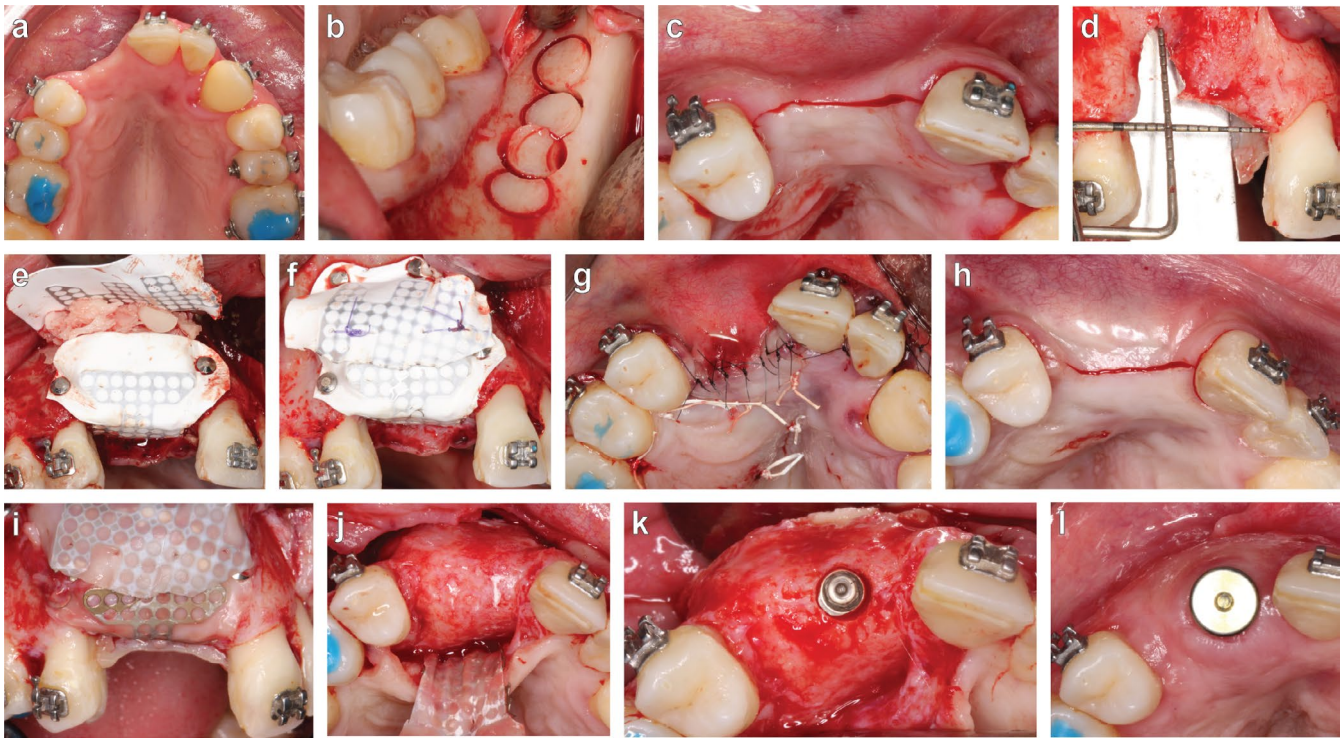

FIGURE 2 | Images depicting the steps in the treatment protocol. (a) The initial clinical situation, (b) autogenous bone donor site, (c) crestal incision, (d) defect exposed, (e) autogenous bone grafting, (f) membrane placed, (g) suturing to achieve tension-free closure; also note the deep palatal sutures for membrane fixation, (h) crestal incision at reentry, (i) membrane before removal, (j) augmented bone at membrane removal. (k) implant in place, (l) soft tissue healing with healing abutment.

point used for measurements was the implant-abutment interface. Distances from the reference point to the first bone contact on both the mesial and distal aspects of the implants were measured. A mean value for each implant was calculated. The impact of the status of the adjacent site (tooth, implant, pontic, or cantilever) on the marginal bone levels was also evaluated.

2.4 | Histological Analysis

During osteotomy preparation in conjunction with implant placement in two patients, a 3 mm bone biopsy was removed en bloc from the augmented area. The specimen was immediately fixed in 10% neutral buffered formalin and sent to the Department of Biomaterials, University of Gothenburg (Gothenburg, Sweden) for analysis. After dehydration, it was embedded in plastic (LR white; London resin company Ltd.), transaxial sections were prepared using a microtome (EXAKT Apparatebeu GmBH & company). Ground sections, 15–20 μm in thickness, were stained with 1% toluidine blue to visualize cellular structures. For the descriptive histomorphometric analysis, an optical microscope (Nikon Eclipse 600; Nikon Instruments, Tokyo, Japan) was used. Images were captured using imaging software (NIS-Elements; Nikon).

2.5 | Statistics

Descriptive statistics were used for the main study parameters. A sub-analysis was performed to explore possible correlations between the marginal bone level at the regenerated site and the tooth/implant status of the adjacent site. Due to the pilot nature of this sub-analysis, it was assumed that each measurement was independent even though they were from the same patient and implant site. Normal distribution could not be assumed for the sub-analysis; therefore, statistical testing was performed using the nonparametric Kruskal–Wallis rank sum test. A significance level of $p = 0.05$ was used. All analyses were performed using StatXact (Version 12; Cytel Inc., Cambridge, USA).

3 | Results

The retrospective chart review identified 84 patients with alveolar defects with a combination of horizontal and vertical atrophy in the anterior maxilla treated between September 2016 and March 2021. The augmentations were done using either split bone block (Khoury's) technique or GBR with PTFE membranes and different ratios of autogenous bone, allografts, and xenografts. Of the 84 patients, 14 were treated with NeoGen PTFE membranes and 100% autogenous bone grafts and therefore were included in the study.

The study consisted of 14 patients (nine females, five males; mean age 41 ± 15 years, range: 20–64 years) presenting with 15 edentulous sites in the anterior upper jaw. The mean initial vertical component of the defects was 7.5 ± 5.1 mm (range: 3–23 mm). Clinical photographs of all defects are presented in Figure 4.

In all 15 treated sites, NeoGen PTFE membranes were placed, and the defects were grafted with 100% autogenous bone. The mean

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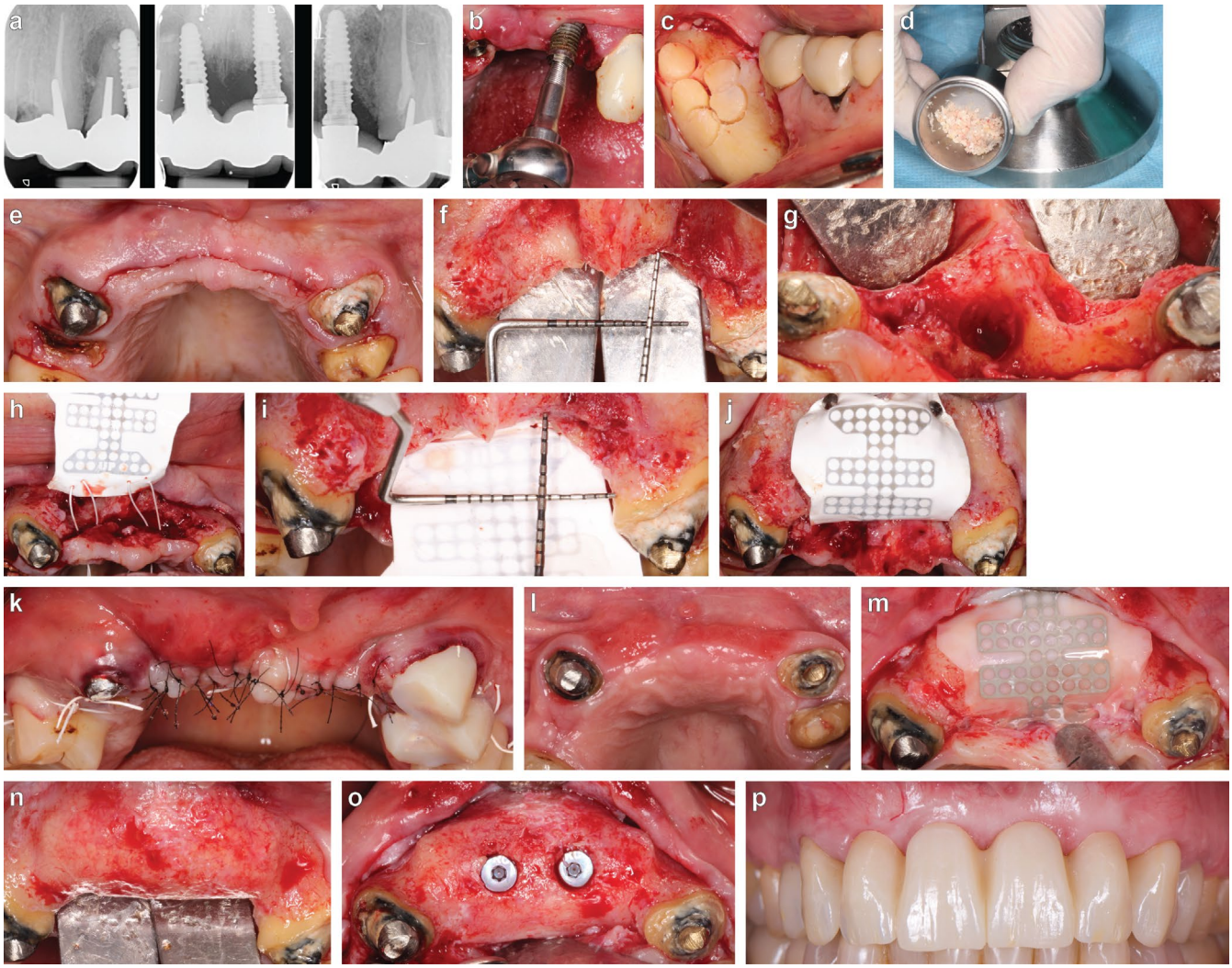

FIGURE 3 | Images depicting the steps in the treatment protocol. (a) Failing implants in the anterior maxilla, (b) implant removal, (c) autogenous bone donor site, (d) particulate bone chips after milling, (e) crestal incision, (f, g) defect exposed, (h) membrane secured using palatal sutures, (i, j) membrane placed, (k) suturing to achieve tension-free closure, (l) soft tissue healing, (m) membrane before removal, (n) augmented bone after membrane removal. (o) implants in place, (p) implants restored.

healing time was 12.6 ± 1.2 months (range: 10–14 months). Clinical photographs of all augmented sites are presented in Figure 5.

All treated sites healed uneventfully, and all membranes remained unexposed during the entire healing period. No adverse events that needed attention were identified in the patient records. The dimensions of the regenerated defects and regenerative outcomes are presented in Table 1. All defects demonstrated 100% bone fill at the time of membrane removal, that is, the regenerated bone filled the entire volume created by the membrane. The mean vertical gain was 7.5 ± 5.1 mm. In most cases, a thin, soft tissue layer could be identified partly covering the newly formed bone (Figure 5). There were no clinical signs of inflammation. All sites were classified as Type 1 (no pseudoperiosteum or a layer of soft tissue thinner than 1 mm) according to Cucchi et al. (2019).

The histological analysis of the biopsies, as shown in Figure 6, revealed a mature lamellar bone, quite dense in its character. Osteocytes embedded in the bone surrounded previous cutting cones, indicating a mature status of the newly formed bone. Secondary osteons with active cutting cones, both in transversal and longitudinal aspects, were found, indicating an ongoing remodeling of the created bone. The collagen fibers were structurally organized around the Haversian canals and not in a random manner. No remaining autogenous bone graft particles could be identified in the specimen, indicating a complete remodeling and maturation of the bone.

A total of 23 implants were placed in the augmented sites. All implants placed in the regenerated areas were integrated and were subjected to clinical loading and subsequent follow-ups. The implants were followed for a mean of 48.6 ± 12.0 months (range 25–62 months) after implant loading. No implant failures occurred during the follow-up period, resulting in a survival rate of 100%.

Based on the radiological evaluation, the mean marginal bone level around the implants at follow-up (48.6 ± 12.0 months after loading) was 0.08 ± 0.11 mm; see Table 2. Follow-up radiographs for all 14 patients are presented in Figure 7.

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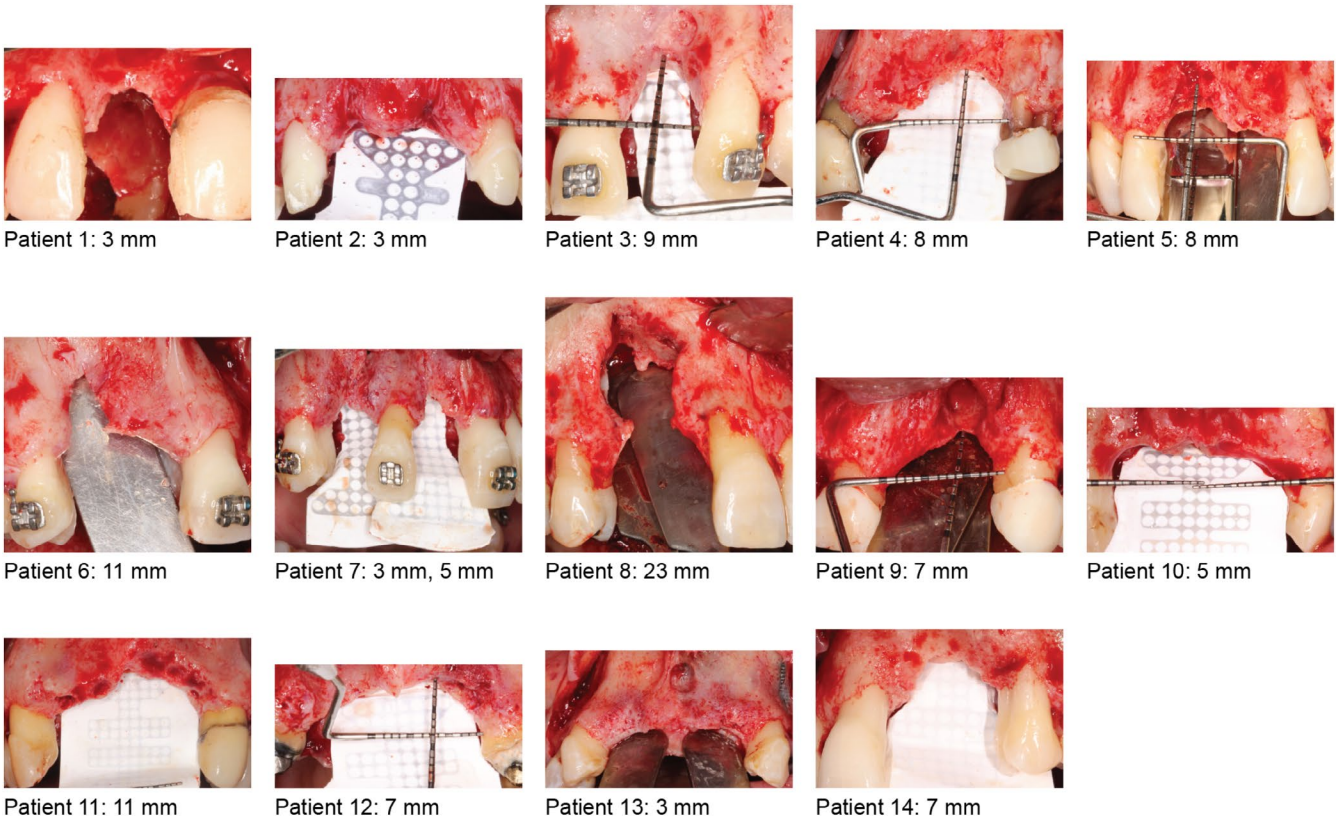

FIGURE 4 | Clinical photographs of all defects before augmentation. The number indicates the vertical component of the defect.

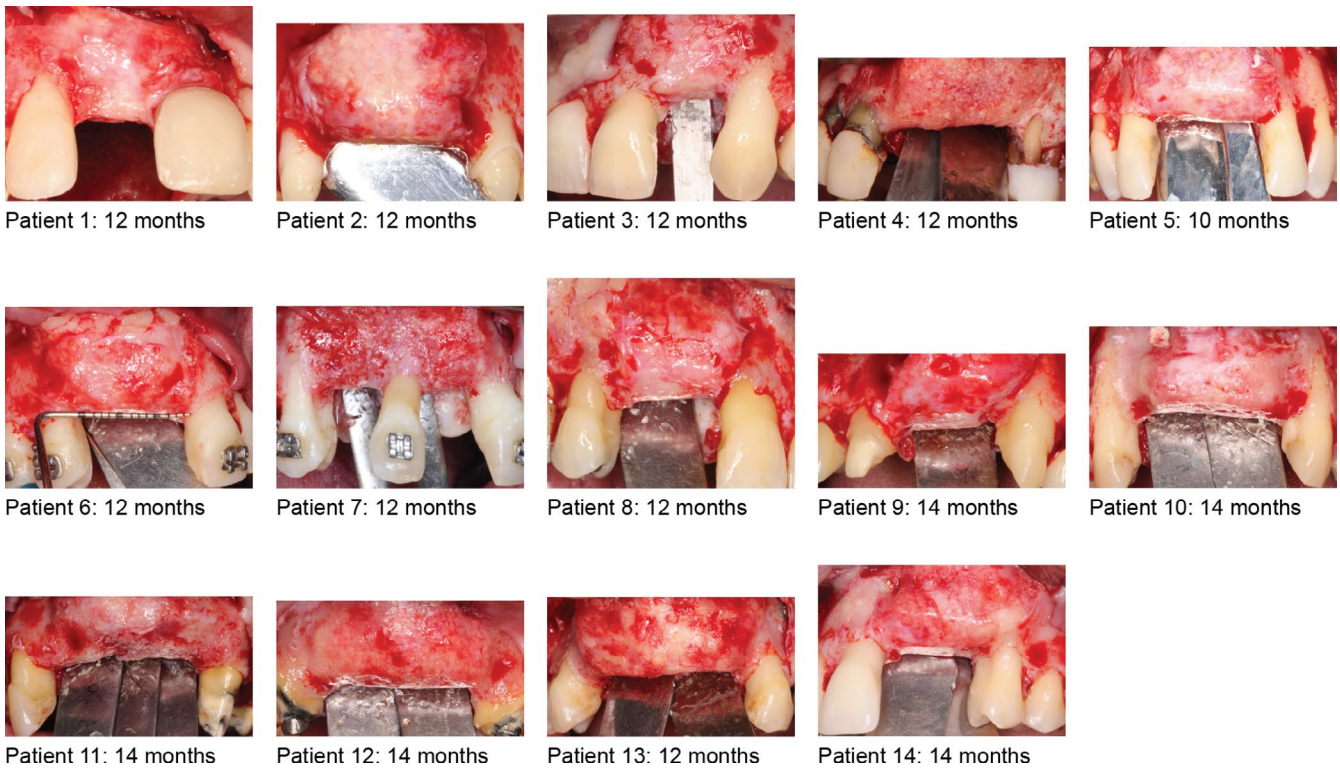

FIGURE 5 | Clinical photographs of all augmented sites after membrane removal. Time indicates the number of months of healing before membrane removal.

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TABLE 1 | Augmentation outcomes.

	Vertical defect before augmentation		Remaining defect		Vertical bone fill	
Mean	7.5 mm		0 mm		7.5 mm	
SD	5.1 mm		0 mm		5.1 mm	
n	15		15		15	
	n	**%**	***n***	**%**	***n***	**%**
0.0–5.0	4	26.7	15	100	4	26.7
5.0–10.0	8	53.3	0	0	8	53.3
10.0–15.0	2	13.3	0	0	2	13.3
15.0–20.0	0	0	0	0	0	0
20.0–25.0	1	6.7	0	0	1	6.7

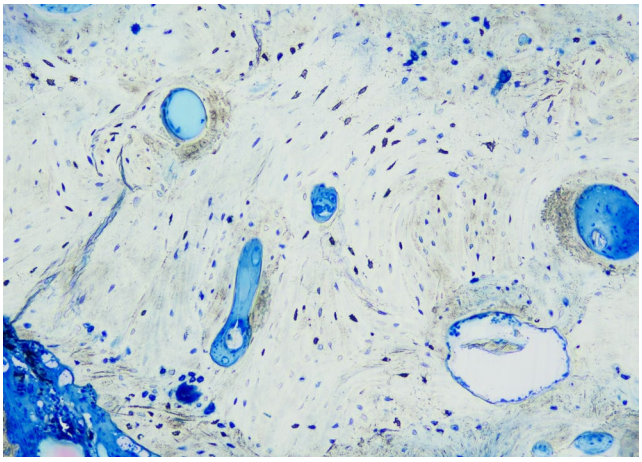

FIGURE 6 | Histological specimen, toluidine blue stain. Mature lamellar bone with embedded osteocytes around previous cutting cones. Collagen fibres are structurally organized around the Haversian canals. No remaining autogenous bone graft particles are identified in the specimen.

The effect of neighboring sites on marginal bone levels was evaluated in a sub-analysis. As shown in Figure 8, implant margins facing the pontics and cantilevers showed a tendency for less bone remodeling than implant margins facing another implant or a tooth. However, no significant differences were found between the sites ($p = 0.445$).

4 | Discussion

This retrospective clinical study included 14 patients, who underwent vertical and horizontal GBR augmentation to treat advanced bone atrophy in the anterior maxilla. The defects comprised both a vertical and horizontal component, with a mean vertical defect size of 7.5 mm across the treated sites. The augmentations were performed using a combination of dual-texture e-PTFE membranes and 100% autogenous bone grafts. All treated defects demonstrated 100% bone fill. When reentering the augmented sites, a thin pseudo-periosteum could be noted between the newly formed bone and the membranes (Figure 5). This is a finding that is well described in the literature. In a histological study by Dahlin et al. (1998), this intervening soft tissue layer underneath an e-PTFE membrane was characterized as a multiple cell layer that resembled the anatomical appearance of a normal periosteum; however, it was somewhat thicker. They also found low numbers of macrophages in the tissue, indicating a slight foreign body response, and suggested that micro movements in the tissue could lead to a volume increase of the tissue layer. Lee et al. (2024) examined the pseudo-periosteum during GBR after different healing times and found that the tissue layer changed appearance over time; in premature bone, an osteogenic layer with osteoblasts and blood vessels was found, whereas upon maturation this layer disappeared, leaving only

TABLE 2 | Marginal bone levels at follow-up, 25–62 months after loading.

Patient	Follow-up time (months)	Implant position	Mean marginal bone level (mm)
1	55	11	0.10
		21	0.09
2	59	11	0.00
		21	0.00
3	62	22	0.15
4	57	21	0.10
		23	0.00
5	52	11	0.12
		21	0.08
6	42	11	0.00
7	47	11	0.22
		13	0.43
8	58	13	0.00
9	60	21	0.16
10	53	11	0.00
		21	0.00
11	45	11	0.00
		21	0.00
12	39	11	0.00
		21	0.00
13	25	11	0.14
		21	0.17
14	26	22	0.00
Mean	48.6		0.08
SD	12.0		0.11
Range	25–62		0.0–0.43

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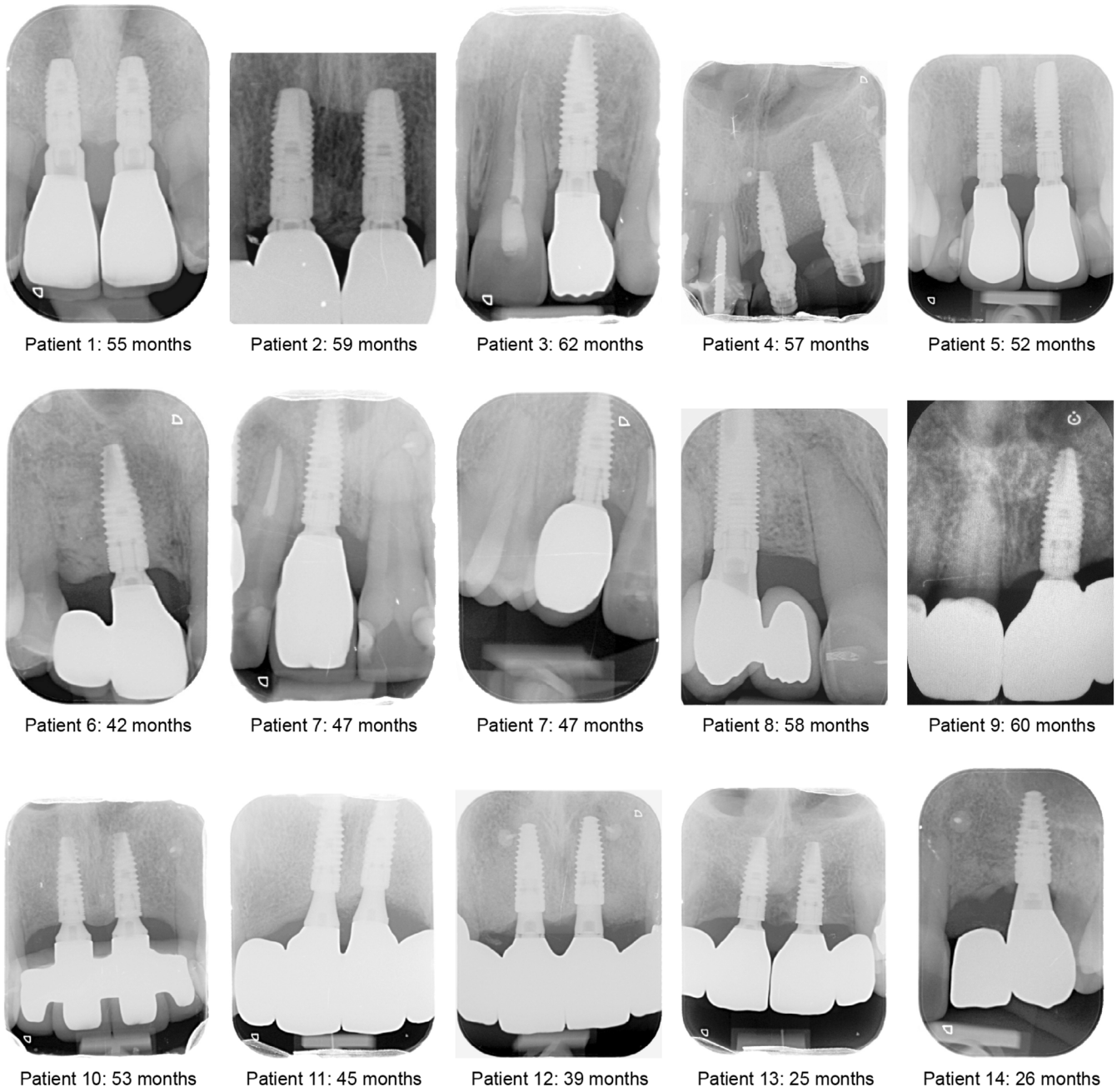

FIGURE 7 | Radiographs of all study patients at the time of the latest radiographic follow-up. Time indicates the number of months after implant loading.

a thin fibrous layer in place. The thin tissue layers found in the current study suggest a mature bone formation under a stable membrane.

A positive clinical outcome was the lack of complications during the healing period. All membranes remained unexposed during the entire healing period of approximately 12 months. This finding contrasts with the frequent reports of membrane exposure in the literature (Alotaibi et al. 2023; Donos et al. 2023; Lim et al. 2018). It has been speculated that the use of a nonporous d-PTFE membrane, compared to e-PTFE, could better prevent bacterial perforation and subsequent infection (Carbonell et al. 2014). Nevertheless, one study by Ronda et al. (2014) comparing the regenerative outcome using e-PTFE and d-PTFE did not identify any clinical differences. The current literature has primarily evaluated first-generation e-PTFE membranes that have a solid fibrillar structure and are not occlusive to bacteria. In the present study, a dual texture e-PTFE membrane with a dual texture configuration was used. This membrane features different inner and outer layer microstructures. The *outer* layer, which clinically interfaces with the soft tissue, has a 'semi-open' structure to maintain a barrier function against soft tissue ingress and bacterial penetration, whereas the *inner* layer, which faces the bone, has a more "open" structure to enhance cell interactions with the membrane (Trobos et al. 2018). These functional properties have been demonstrated in a recent study that identified a significant upregulation of soft tissue-specific markers (e.g., TGF-2) in conjunction with the dual texture e-PTFE

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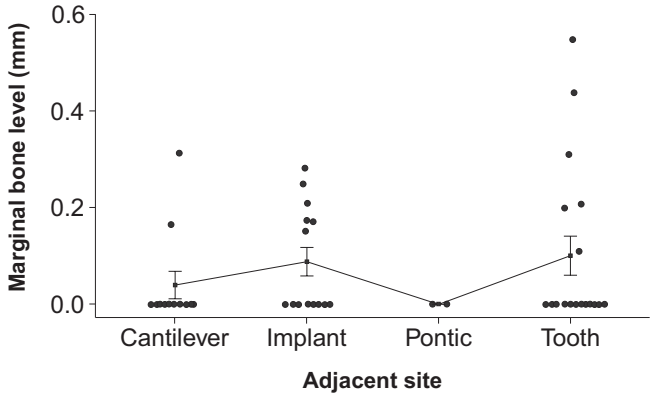

FIGURE 8 | Marginal bone levels at the time of the latest follow-up grouped by the status of the adjacent site (cantilever, implant, pontic, or tooth). Each dot represents an individual measurement. Line represents mean ± SD.

membrane (Turri et al. 2024). In contrast to the first-generation e-PTFE membranes, the dual texture e-PTFE material is completely occlusive to bacterial penetration similar to d-PTFE membranes (Trobos et al. 2018).

The use of non-resorbable PTFE membranes is considered technique sensitive. Primary wound closure, angiogenesis, space, and stability of the clot are requirements for a good clinical outcome (Wang and Boyapati 2006). One may speculate that the dual texture e-PTFE membrane can optimize the soft tissue response, and hence, primary wound closure.

Autogenous bone is used as a graft material based on its osteogenic properties (Buser et al. 1998). This has been well described both in clinical and experimental studies (Asparuhova et al. 2018; Buser et al. 2023; Rocchietta et al. 2016). However, due to patient morbidity and the need for an extra surgical site to harvest bone, allograft and xenograft materials are often used. The use of these materials has also been reported to result in lower bone resorption over time (Jensen et al. 2006). Current state of the art is to use barrier membranes and autogenous bone chips either as a standalone, as in the present study, or in combination with demineralized bovine bone matrix (DBBM) (Buser et al. 2023).

Interestingly, in the current study, minimal volume changes and MBL were found. The bone levels remained stable over time; the mean marginal bone level was within 0.1 mm from the implant-abutment interface from 25 to 62 months after prosthetic loading. This is less than reported in the literature. A recent systematic review (Cucchi et al. 2019) reported a mean MBL of 1.12 mm at medium-term follow-up (24–60 months) after GBR procedures. What differs the surgical protocol from the available literature is the extended healing period (12 months) prior to implant installation. The recommended healing period for bone augmentation using PTFE membranes is up to 9 months (Buser et al. 2023). Several other studies have promoted healing periods between 5 and 9 months for vertical ridge augmentation (Cucchi et al. 2023; Fontana et al. 2015; Merli et al. 2014; Pistilli et al. 2020; Urban et al. 2009), whereas a limited number of studies report on healing times up to 12 months (Simion et al. 2001; Todisco 2010). We hypothesize that the prolonged healing time allows a complete maturation of the newly formed bone, protected by the dual texture e-PTFE membrane during the remodeling phase. Hence, an optimal environment for implant placement and integration is achieved. This was also confirmed in the histological evaluation of the biopsies taken at implant sites in conjunction with the osteotomy preparation. As demonstrated in Figure 6, the regenerated bone was quite dense in its character. This likely increased stability of the marginal bone around the implants subjected to clinical function and loading, thus contributing to the high implant survival.

A possible drawback of using 100% autogenous bone is the need for an extra surgical site for harvesting the autogenous graft material and the associated donor site morbidity and additional surgical time. Despite the increased invasiveness of the procedure, there were no clinical complications reported.

A limitation of the present retrospective study was the single-center design, in which a single surgeon performed the treatment. To assess the generalizability of the results, it would be of great clinical interest to evaluate the concept in a multicenter setting.

Another possible limitation of the study was the diversity in implant brands, placement depth, restoration types, and prosthetic protocols. This is explained by the study clinic being a referral clinic, and the cases were planned together with the referring dentists who also restored the implants. However, since all cases presented minimal bone loss, the prosthetic diversity did not seem to affect the outcome.

The current study stands in contrast to most previous reports due to the relatively long healing period. Horizontal and vertical augmentation using the GBR principle is technique sensitive and presents a biological challenge from a healing perspective. This, in combination with a demand for shorter treatment periods for the patients in general, might jeopardize clinical outcomes. With the extended healing period incorporated in the present study, sufficient time was allotted for the maturation of regenerated bone; consequently, providing a more optimal environment for implant placement and integration.

5 | Conclusions

The results of this retrospective study show that excellent augmentation outcomes can be achieved in the anterior maxilla with the combined use of a dual texture e-PTFE non-resorbable membrane and autogenous bone grafting, along with a sufficient healing period (12 months) prior to implant placement. The installed implants demonstrated stable marginal bone levels after clinical loading, confirming that predictable clinical outcomes can be achieved with the proper choice of methods, materials, and healing times during GBR.

Author Contributions

David González: conceptualization, methodology, writing – review and editing, investigation. **Herman Sahlin:** writing – original draft, writing – review and editing, formal analysis, visualization, data curation.

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Christer Dahlin: writing – original draft, writing – review and editing, validation, supervision, funding acquisition.

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Ethics Statement

This study was approved by the Ethics Committee of HM Hospitales (24.09.2378-GHM) and conducted in accordance with the World Medical Association Declaration of Helsinki.

Consent

All patients provided informed consent prior to treatment.

Conflicts of Interest

David González declares no conflicts of interest. Herman Sahlin is an employee of Neoss AB. Christer Dahlin has received consultant and lecture fees from Neoss AB and the Osteology Foundation and lecture fees from the Swedish Dental Society, American Academy of Periodontology, Dentsply AB, Italian Society of Osseointegration, and the Dental Trauma Group.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

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