Istvan Urban

Vertical 2

THE NEXT LEVEL

OF HARD AND SOFT TISSUE AUGMENTATION

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Preface

It has been almost 5 years since the publication of my first book, *Vertical and Horizontal Ridge Augmentation: New Perspectives* by Quintessence Publishing in 2017. That book has enjoyed great success and has been translated into 12 languages, helping the guided bone regeneration (GBR) technique to be practiced successfully worldwide.

The reader might expect this book to be a second edition. It is not. I had a lot more to share, and this book delves more into the details where the devil lives. I anticipate that you will read this book armed with the knowledge from the first book as regards the anatomy, principles of mandibular surgery, anterior maxillary defect types and their treatment options, and soft tissue reconstruction after bone grafting. It is important that you please review this information from the first book before reading this new one.

Parts of this book are like watching a surgical video with me, where I stop the video at the most important parts (sometimes frame by frame) and discuss with you, the reader, what I am thinking and doing at that step, and what my next step will be. At the same time, I discuss the reason for each of these steps.

In addition, the greatly appreciated 'Lessons learned' sections are again included in this book. I consider these sections to be very important, since one can always identify a part of the procedure that one could have done better. These sections also help to emphasize the most important learning objectives of the case.

Please note that one could describe this book as a kind of atlas, a 'show-and-tell,' so to speak, where in many places the images, drawings, radiographs, charts, and tables tell the story. For this reason, some chapters contain a minimum of text, and the figures are not always 'called out' in the text in a way you may be accustomed to. The idea was to keep things as clear and simple as possible; the figure legends always explain exactly what is going on.

The section on the mandible is more detailed in this book than it was in my first book; also, it focuses on larger defects as well as different surgical steps in native, fibrotic, and scarred tissue types around the mental nerve during flap advancement. The section on the posterior maxilla will hopefully help to solve many issues such as the management of complications of sinus grafting and the lack of buccal, crestal or nasal bony walls of the posterior maxilla before bone grafting.

This book sheds light on the detail in treating the anterior maxilla that has not been published previously. You are finally getting the 'complete package,' including treatment options such as the fast track, the safe track or the technical track of soft tissue reconstruction in conjunction with bone grafting. Questions are answered such as: What options do I have when there are multiple implants in regenerated bone and I would like to reconstruct the papilla? The Ice-cube and Iceberg connective tissue graft techniques are the best options, but how do I actually do them, and how do I choose between the two techniques?

I have great expectations for this book, and I really wish that I had had this knowledge two decades ago. I could have had the most perfect cases today. That is what I am expecting for you, dear reader – to make the most perfect cases based on the principles described in this book.

At the same time, as I have said elsewhere, I like to keep procedures simple, repeatable, and biologically sound. The techniques presented here are not overcomplicated – they are simple treatment strategies with lower complication rates and more predictability in the final outcome. Therefore, I would like to welcome you and thank you for reading this book, and remind you of a quote by Leonardo da Vinci: "Simplicity is the ultimate sophistication."

Some of the cases in this book were not finalized by the time of publication. For additional material and to see the final clinical outcomes of these cases, please scan the QR code on the right or go to the following link: https://www.quint.link/vertical2mat

Acknowledgments

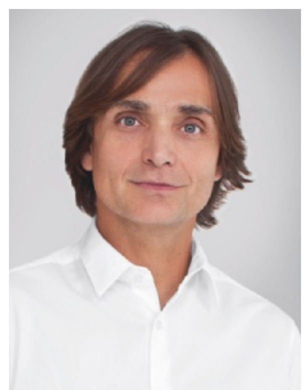
I would like to thank my family for their love and endless support, and our two sons, Isti and Marci, for their existence, spirit, and positive outlook on life. You make our life complete. As a child (and ever since), my parents never interfered in any of the decisions I made, as they believed in the development of the individual with only minimal guidance. I believe they were right, and I thank them for that.

My teachers, who were my teachers during my training, continue to be my teachers and will remain my teachers. Special thanks to Dr. Henry Takei for his inspiration and unsurpassed qualities as a humanitarian, both as an educator and as a periodontist. Special thanks also to Dr. Jaime Lozada for his belief in me as a student at Loma Linda University and his confidence that I would go on to do vertical ridge augmentation. I would also like to thank Dr. Sascha Jovanovic for introducing me to performing GBR in a biologically sound way. Thanks also to Dr. Joseph Kan, Dr. Perry Klokkevold, Dr. Anna Pogany, Dr. Bela Kovacs, and Dr. Lajos Patonay, and to all my other teachers. Without meeting all of you and being your student, there would be much less to say in this book.

I would like to express my appreciation to Quintessence Publishing, specifically to the management, Horst Wolfgang Haase and Christian Haase.

I would like to express my gratitude to Ms. Krisztina Szample for creating the schematic drawings, and to Denes Doboveczki for assisting in the photography for this book.

I would also like to thank Ms. Jacqueline Kalbach of The Avenues Company for her support in the preparation of my manuscripts, and of this book.



Istvan Urban
2021

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Ultimate esthetics

1 The biology of vertically and horizontally augmented bone

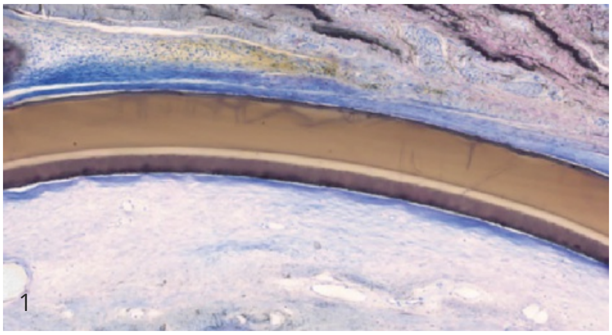
Vertical bone growth is very challenging, both biologically and technically. A recent meta-analysis by Urban et al[1] found that, regardless of the technique, about 4.5 mm of vertical bone gain was achieved in the included studies. However, complications occur least frequently when the guided bone regeneration (GBR) technique is used. The results of this study indicate the advantage of using GBR. The technical challenge of GBR is discussed extensively in this book, while the biologic challenge that may play a role in limiting vertical bone gain is discussed in this chapter. Based on the author's experience, the amount of vertical bone gain is not limited by biology, but more by the clinician's abilities.

The biologic background of vertical bone gain was investigated by the author in preclinical settings.

The histology of polytetrafluoroethylene (PTFE) membranes in an in vivo setting

The mucogingival tissue is primarily characterized by a moderate vascularized fibrotic reaction that surrounds the PTFE membrane. The membrane is usually internally and externally surrounded by connective tissue that is rich in fibers and poor in cells, with the fibers oriented parallel to the membrane. Membrane pores, if present, show the presence of a highly vascularized matrix of connective tissue and a dense network of collagen fibers that penetrates across the pores to fix on the internal side of the membrane or, in some cases, to the newly formed bone.

The inner layer, which is composed of expanded PTFE (e-PTFE), is always placed against the bone of the lingual and buccal sides. A slight number of macrophages admixed with a few lymphocytes, polymorphonuclear cells, giant cells/osteoclasts, and plasma cells were observed around the membrane. Deep at the lingual side of the ridge, the



Figs 1-1 and 1-2 Parallel-oriented fibers around the membranes.

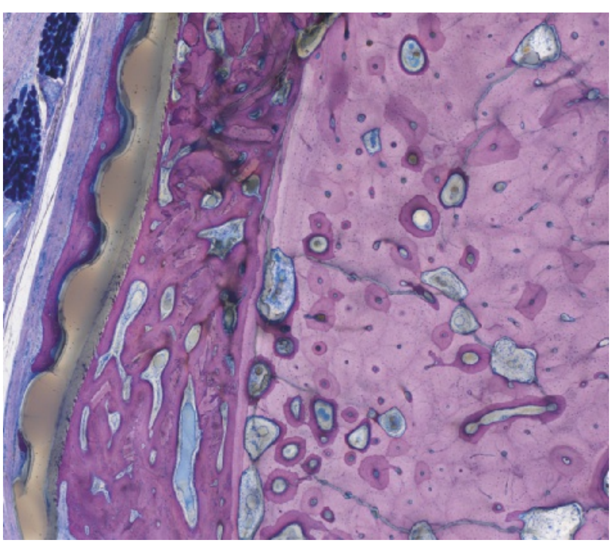


Fig 1-3 The membrane shows signs of osseointegration on both sides. Note the excellent biocompatibility of the polytetrafluoroethylene (PTFE) membrane.

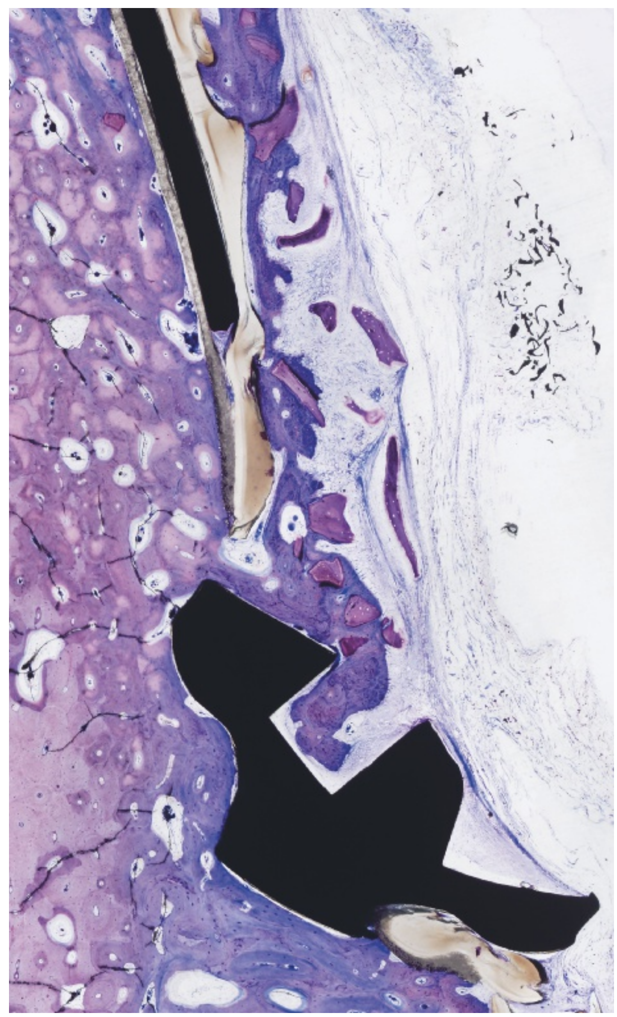
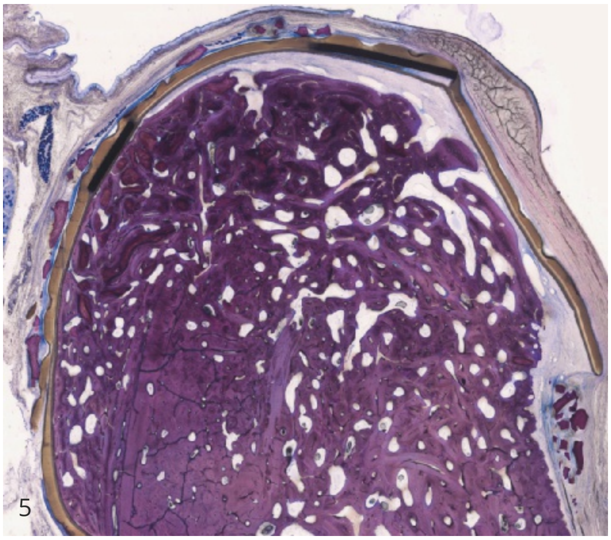
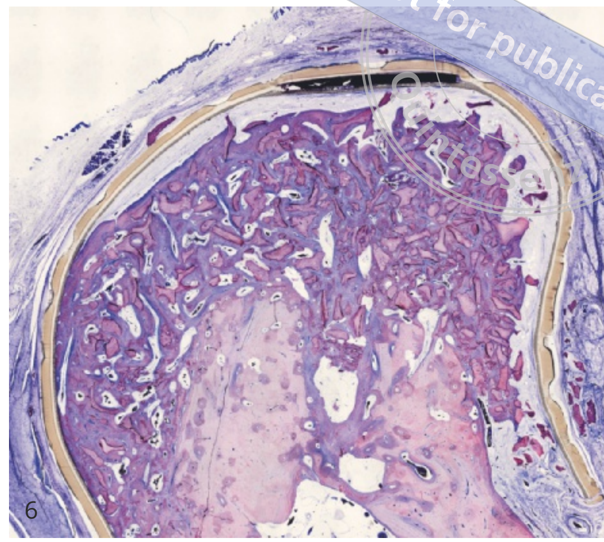


Fig 1-4 When compared with titanium, the PTFE-membrane demonstrated similar biocompatibility.

Figs 1-5 and 1-6 Histologic results of vertical augmentation. Note the excellent new bone formation and the well-incorporated xenograft particles.

membrane was often in direct contact with the bone tissue, even showing slight signs of osteointegration (Figs 1-1 to 1-4).

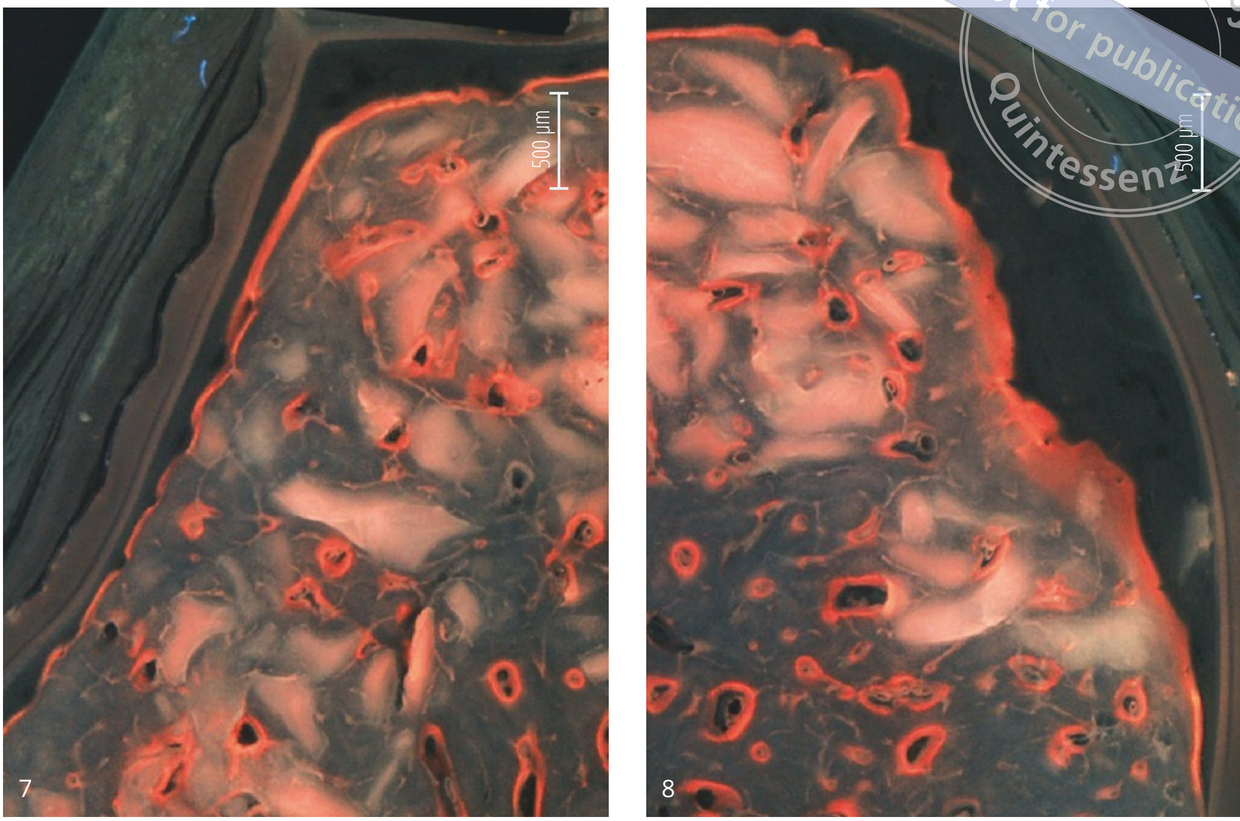
Bone growth using a xenogenic bone graft

In a preclinical in vivo setting, a chronic vertical defect was treated using a xenograft. After 17 weeks of healing, the following was found: Emerging from the defect bed, the bone growth of a moderate to marked amount showed similar signs of remodeling, resulting in significant vertical ridge augmentation. The bone filler was markedly osteointegrated, showed slight signs of degradation, and demonstrated definite signs of osteoconduction (bone growth on the surface of the granules). The newly formed bone harbored numerous osteoblasts (Figs 1-5 and 1-6).

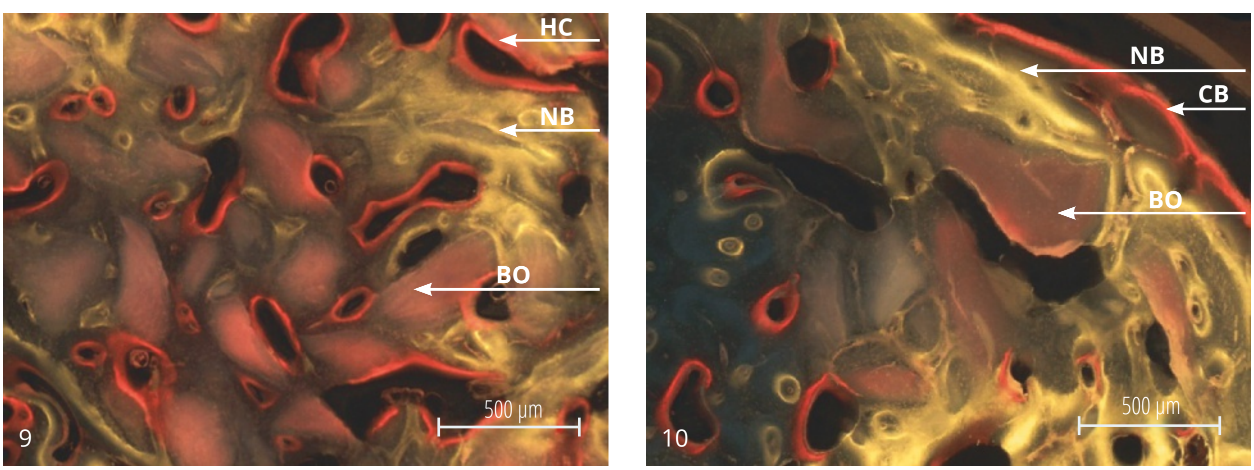
The epifluorescence analysis showed a marked grade of mineralization activity at different time points (OTC and XO), respectively. The signs of mineralization activity were visible at the newly formed and remodeled harversian systems (numerous concentric labeled rings). The outer circumferential bone lamellae were not fully formed, as is shown by their irregular shape. Two distinct and spaced lines of labeling (first OTC, then XO) indicated a marked vertical bone growth (Figs 1-7 to 1-10).

Figures 1-9 and 1-10 show that the xenograft particles are well incorporated in the newly formed trabecular bone. These images also demonstrate the phases of bone formation and maturation.

In the first phase, the newly formed ridge is present, but the cortical bone and the lacunae are not fully developed. This is referred to as 'baby bone' (Figs 1-11 and 1-12).



Figs 1-7 and 1-8 Epifluorescence analysis of a well-developed and mature bone after vertical augmentation.



Figs 1-9 and 1-10 Epifluorescence analysis demonstrating the haversian canals and the cortical bone formation of the newly formed bone. The images demonstrate the incorporation of a biomaterial into the newly formed bone and the different time points of bone maturation. BO: anorganic bovine bone mineral; HC: haversian canal; NB: new bone; CB: cortical bone.

In the next phase, the bone starts to further mature and corticalize, after which the outer layer becomes smooth and gains its final shape. Although the bone was good enough for the placement of implants, it would need about 3 more months to fully develop.

The healing time was 6 months (Figs 1-13 and 1-14). The implants were placed about a millimeter subcrestally. A tissue level implant placed into the bone with the polished collar 1 mm into the bone would be an excellent choice in the posterior region. The same patient had the other side grafted

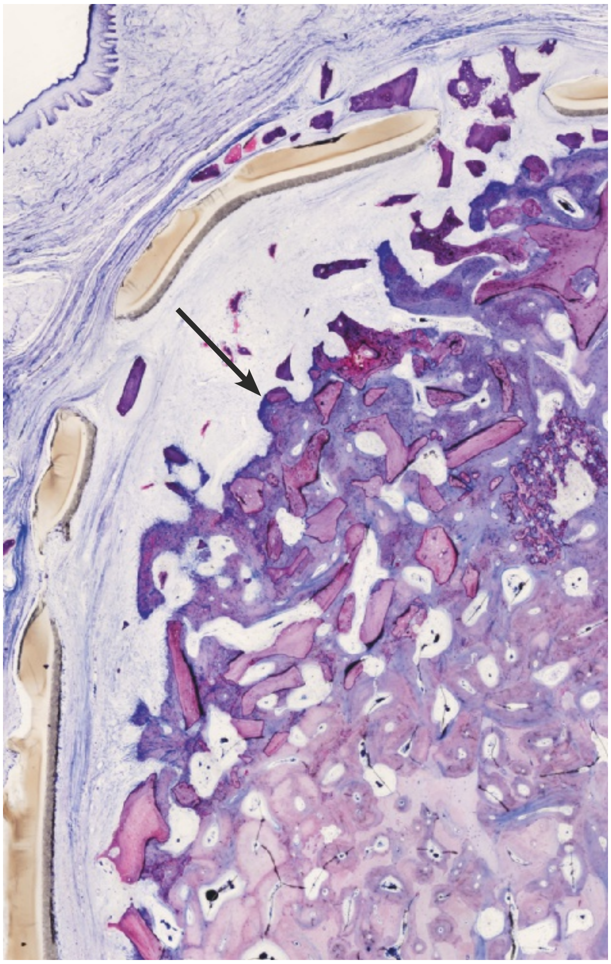


Fig 1-11 The outer surface of the 'baby bone' demonstrating irregularity and less maturity than the inner layer of the newly formed bone. This outer layer, referred to in this book as the 'smear layer' (see arrow), is about 1.5 mm in width. It will be remodeled and 'shredded off' during maturation.

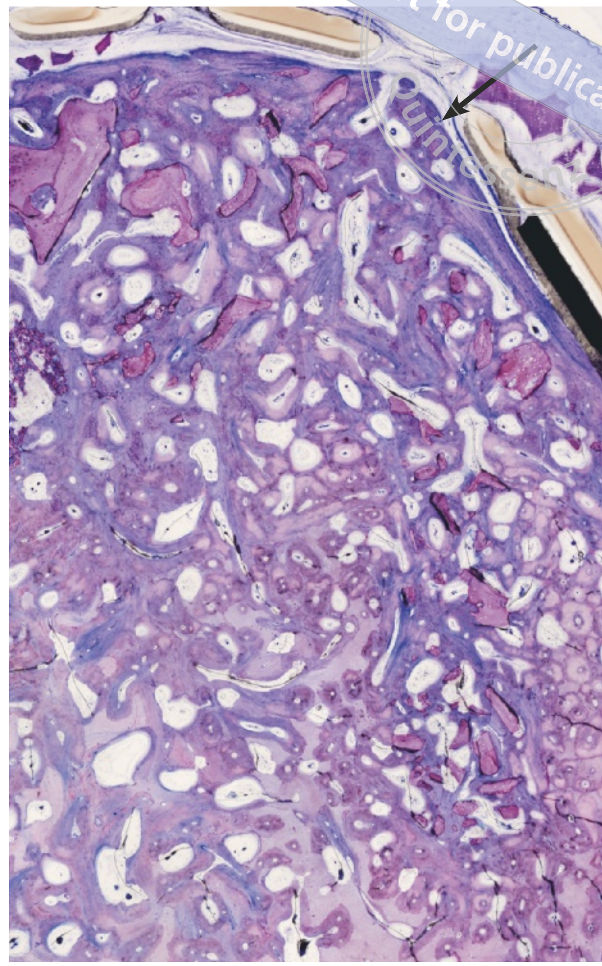
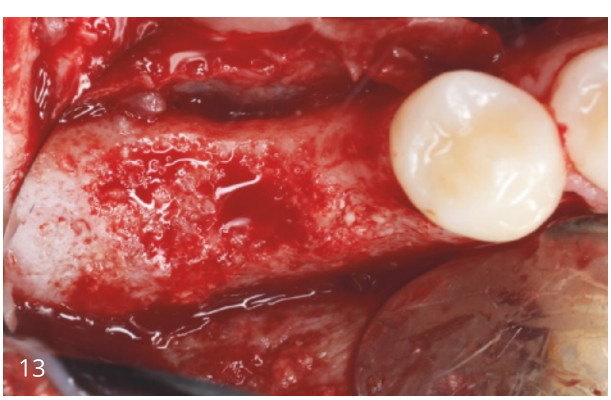
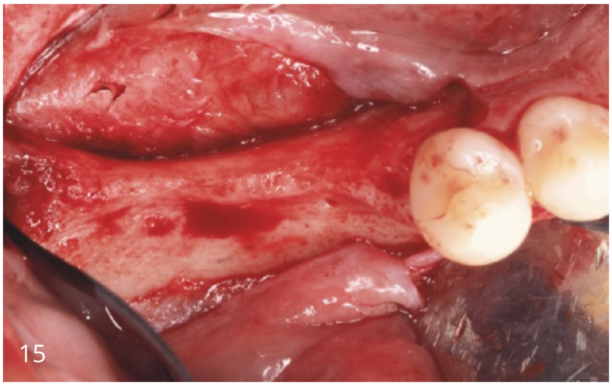
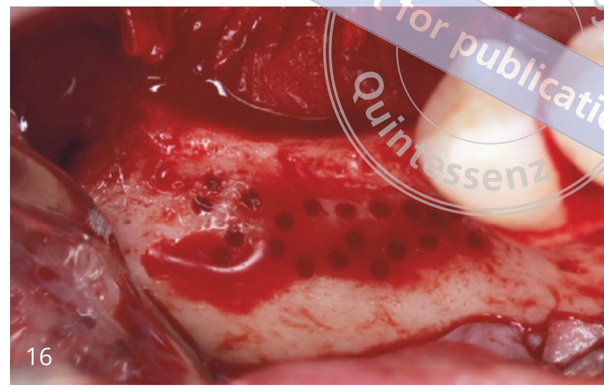


Fig 1-12 Image showing an area where corticalization has begun.

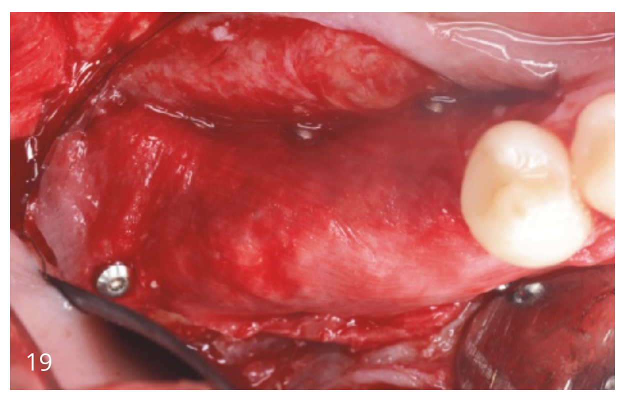


Figs 1-13 and 1-14 Clinical example of a posterior mandibular ridge augmentation using the Sausage technique. Note that some of the area is corticalized, whereas other parts are still in maturation.

Figs 1-15 and 1-16 Occlusal and labial views of a narrow posterior mandibular ridge.

Fig 1-17 Labial view of the graft consisting of a 1:1 ratio of autogenous bone mixed with anorganic bovine bone mineral (ABBM).

Figs 1-18 and 1-19 Labial and occlusal views of the fixated and stretched collagen membrane in place.

10 months earlier. Due to scheduling issues, one side healed for longer than the other, but now the two phases of maturation can be compared. The ridge defects were similarly narrow (Figs 1-15 to 1-21).

In this book, the smear layer will be highlighted, especially in the anterior maxilla chapters where it will be modified and preserved using the Mini Sausage technique as a secondary bone graft protecting the newly formed ridge.

The clinician should bear in mind that the smear layer will be either lost or modified. In most posterior cases, it is allowed to be shredded off, placing the implants deeper into the bone, whereas in the esthetic region, the Mini Sausage technique is used to prevent its resorption. These clinical procedures are exciting, and knowing the biology and dynamics of bone formation is essential to success.

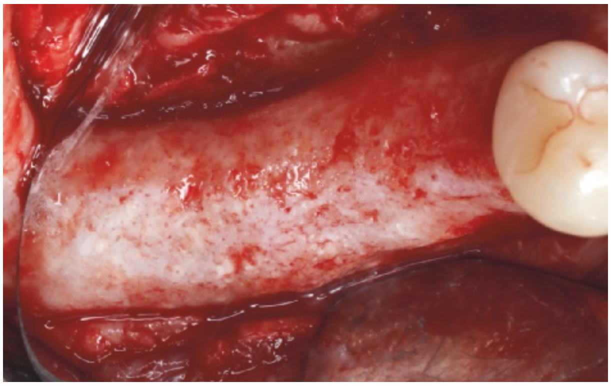


Fig 1-20 Occlusal view of the mature, corticalized, newly formed ridge.

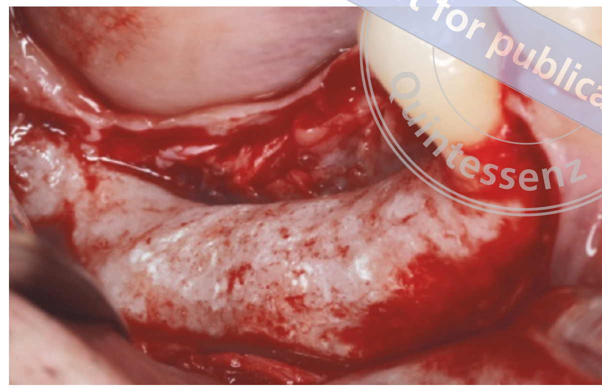


Fig 1-21 Note the excellent cortical bone formation.

Dense versus perforated membrane

The use of a membrane in GBR has been evaluated successfully for decades in multiple clinical and preclinical investigations. The role of the membrane has been determined to exclude competing cells such as fibroblasts. The clinical experience demonstrated that an important role of the membrane is to stabilize the bone graft. This has been well demonstrated in the Sausage technique using a collagen membrane and titanium pins for immobilization. In the author's experience, the Sausage technique has resulted in the best bone quality and is usually faster and better than PTFE membranes. The native collagen membrane allows transvascularization and a possible accumulation of osseoinductive stimuli from the periosteum. In addition, the fast resorption of the collagen may also play a part in the maturation of the graft, since the periosteum holds vessels as well as mesenchymal cells that can turn into bone-forming cells. Therefore, a perforated membrane might help in bone formation. The goal is to develop 'sausage-like' bone quality faster.

One idea was to perforate PTFE membranes to allow faster bone maturation. In several preclinical investigations, different aspects of this idea were investigated, as is shown in the following subsections.

I. Dense vs perforated membrane using bone morphogenetic protein-2 (BMP-2) as a graft

The osseoinductive action of BMP-2 depends on the presence of mesenchymal cells. The question is: How important are these types of cells in the periosteum versus the bone surface and the blood clot?

Dense versus perforated membrane was compared in a chronic vertical defect (Figs 1-22 to 1-24). The results demonstrated significantly more bone fill when using the perforated membrane. The non-perforated membrane usually demonstrated appositional bone formation from the host bone with a lack of bone formation under the membrane (Figs 1-25 to 1-27). These results demonstrated that the communication with the periosteum might be important when a graft containing BMP-2 is being used, such as autogenous particles.

II. Perforated vs non-perforated membranes using an osteoconductive graft material

This experiment focused on the vascularization and bone formation activity of the newly formed bone. A xenogenic bone graft was used without any growth factors or autogenous bone. The perforated membrane was used with and without a collagen mem-

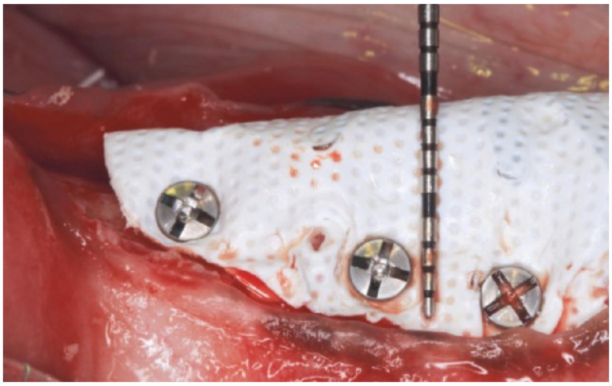


Fig 1-22 Labial view of a dense membrane fixated around a chronic vertical defect.

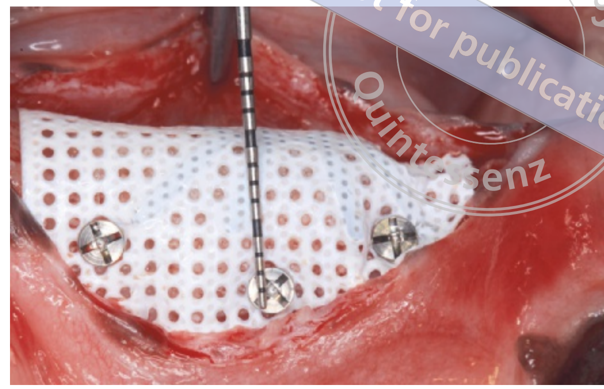


Fig 1-23 Labial view of a perforated membrane fixated around a chronic vertical defect.

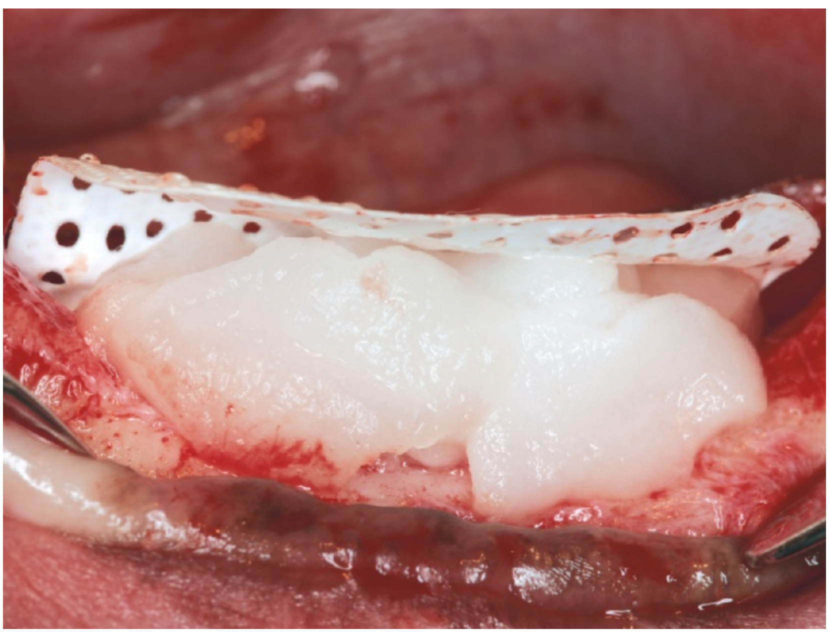
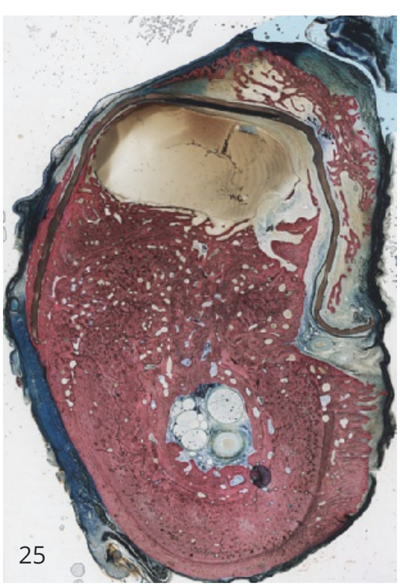


Fig 1-24 Bone morphogenetic protein-2 (BMP-2) is bound into a collagen carrier. No other graft is used.



Figs 1-25 and 1-26 Cross-sectional views showing bone formation in both groups just below the periosteum and above the membrane.

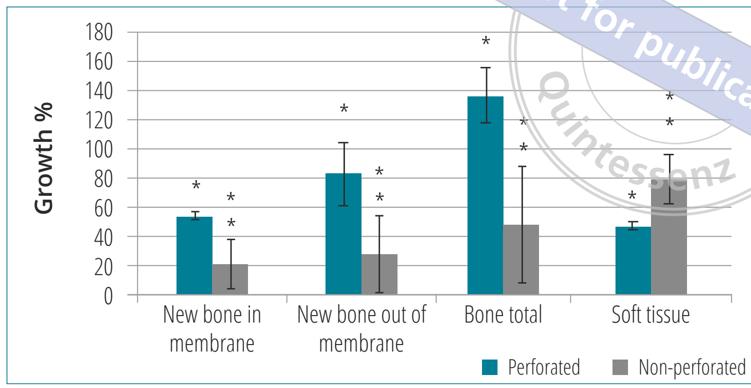


Fig 1-27 Graph showing bone growth of the perforated and non-perforated sites. The perforated membranes demonstrated significantly more bone growth.

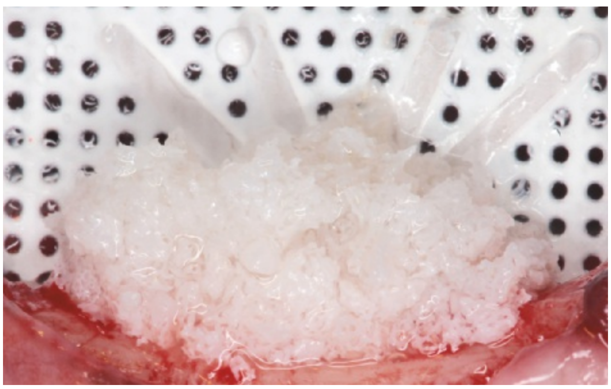


Fig 1-28 Labial view of a xenograft placed on a chronic vertical defect.

Fig 1-29 Labial view of a fixated dense membrane.

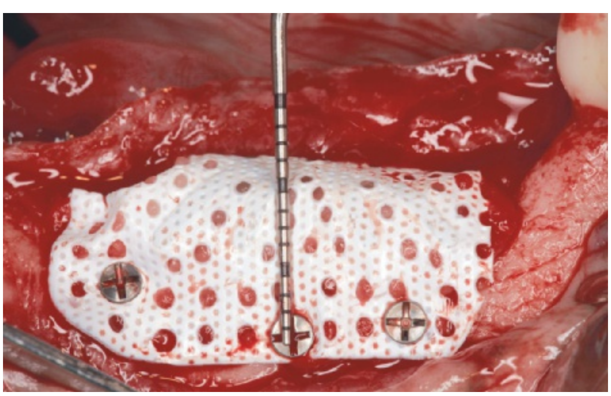


Fig 1-30 Labial view of a perforated membrane.

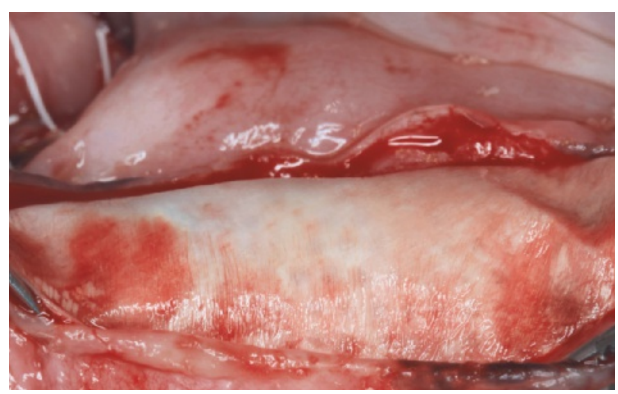
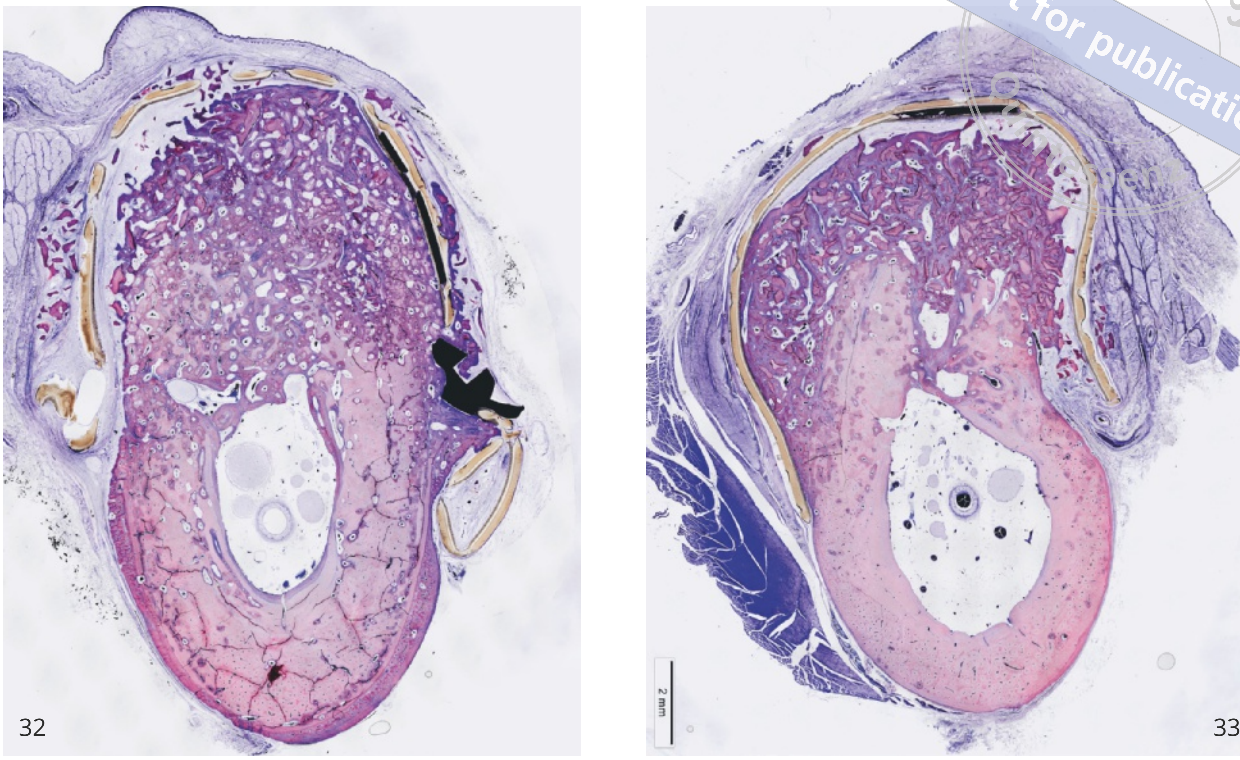


Fig 1-31 Labial view of a perforated membrane covered with a collagen membrane.

brane covering the non-perforated membrane (Figs 1-28 to 1-31). Each group demonstrated a similar amount of bone formation as well as soft tissue invagination (Figs 1-32 to 1-34). However, when the vascularized area of the regenerated ridge was examined, the perforated group demonstrated a tendency toward better vascularization (Fig 1-35 and Table 1-1).

The tendency of having less pseudoperiosteum formation has been seen in well-adapted sites, even in cases of perforated membranes (Figs 1-36 and 1-37). Since membrane adaptation seems to be important, a hybrid design PTFE mesh/membrane was tested clinically (Fig 1-38).



Figs 1-32 and 1-33 Cross-sectional views of the histologies of the regenerated bone after vertical ridge augmentation in this study.

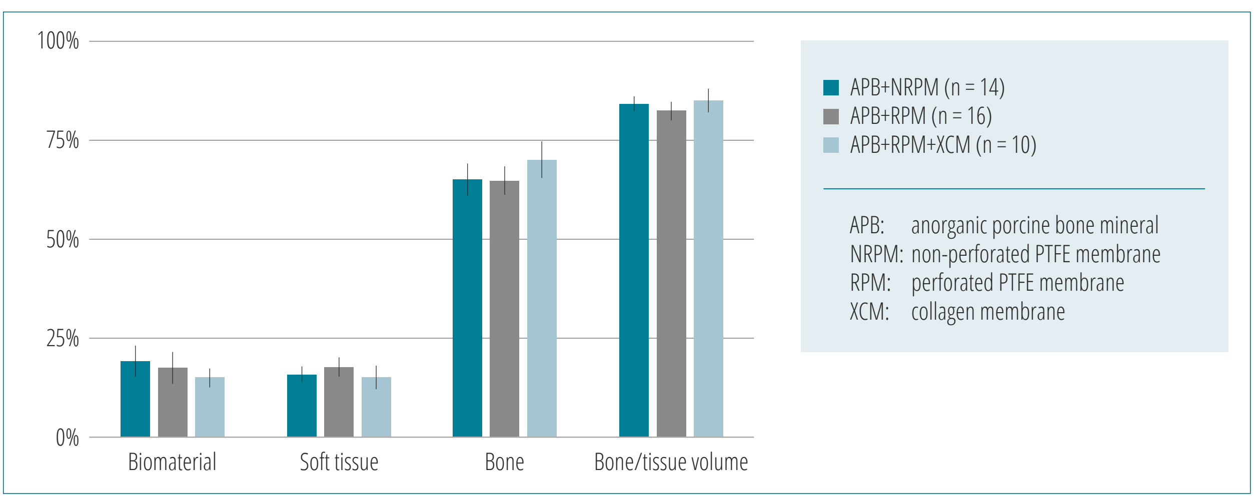


Fig 1-34 Graph showing the bone formation of the three groups. No statistically significant differences were found.

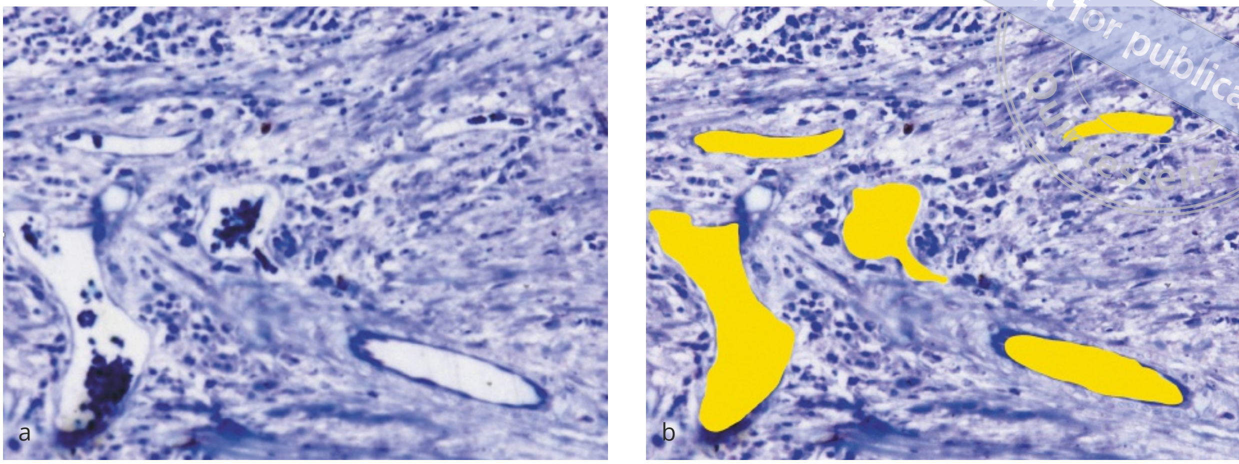
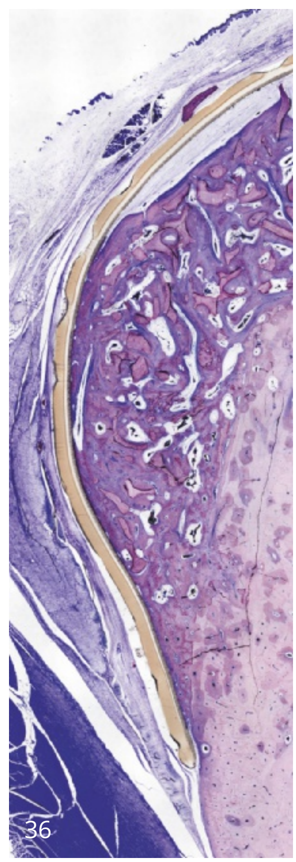
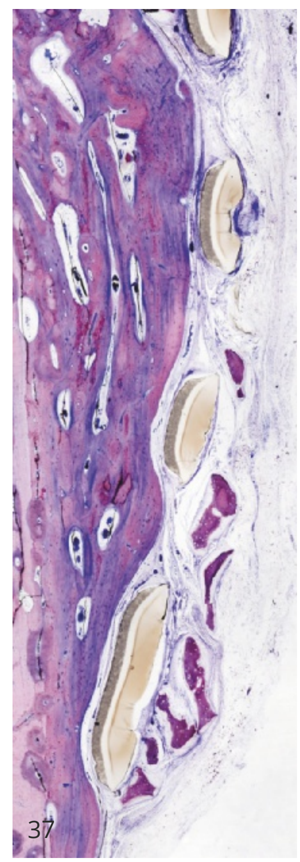


Fig 1-35a and b The perforated group demonstrated a tendency toward better vascularization.

Solid	Perforated	Perforated, covered with collagen
2.44	8.33	7.93
7.22	8.41	4.40
2.77	11.26	6.58
13.83	12.41	5.54
4.76	5.64	2.48
2.30	3.62	4.24
7.07	10.62	5.77
3.58	6.87	1.89
5.50	8.40	4.85

Table 1-1 Table showing the tendency toward a better vascularized surface of the perforated group.





Figs 1-36 and 1-37 A well-adapted dense and perforated membrane showing minimal soft tissue ingrowth.

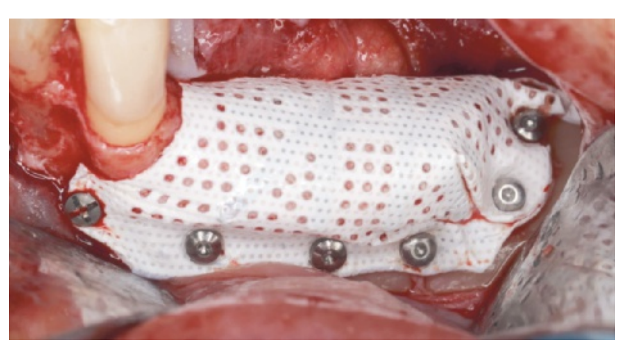


Fig 1-38 The membrane showed excellent performance in terms of clinical results as well as adaptability and retrievability.

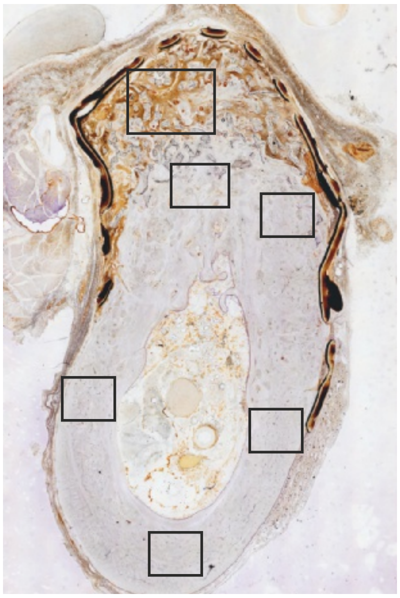


Fig 1-39 Cross-sectional view of the osteocalcin (OCN) marker. The squares demonstrate the regions of interest (ROIs) that were investigated.

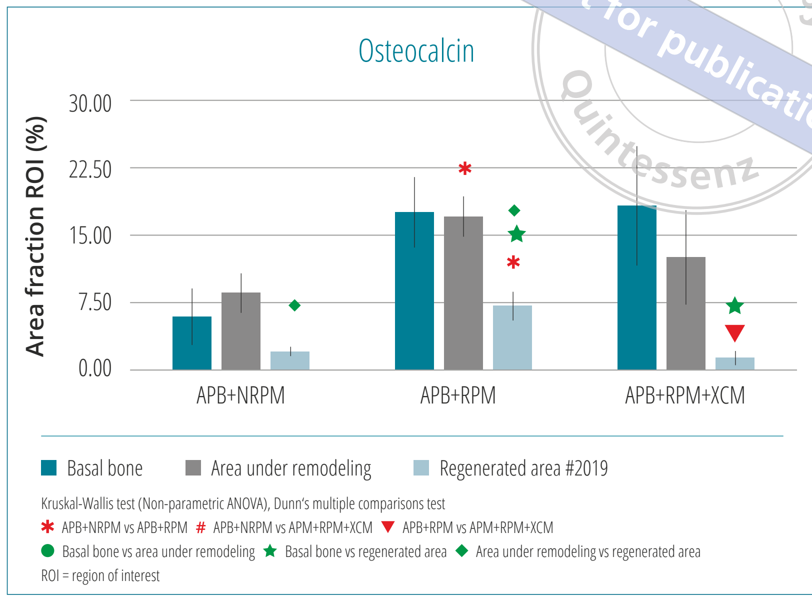


Fig 1-40 Graph showing the results of the OCN marker for the three groups investigated.

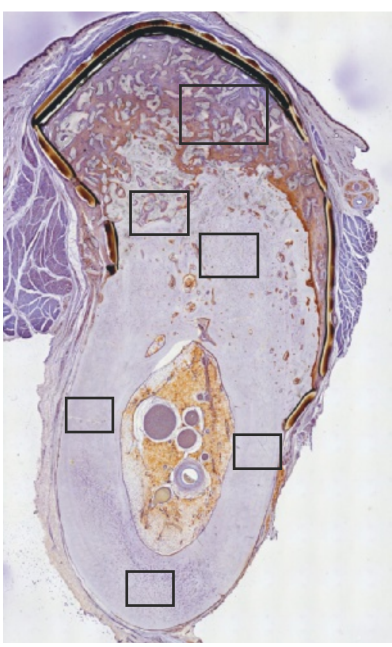


Fig 1-41 Cross-sectional view of the alkaline phosphatase (ALP) marker. The squares demonstrate the ROIs that were investigated.

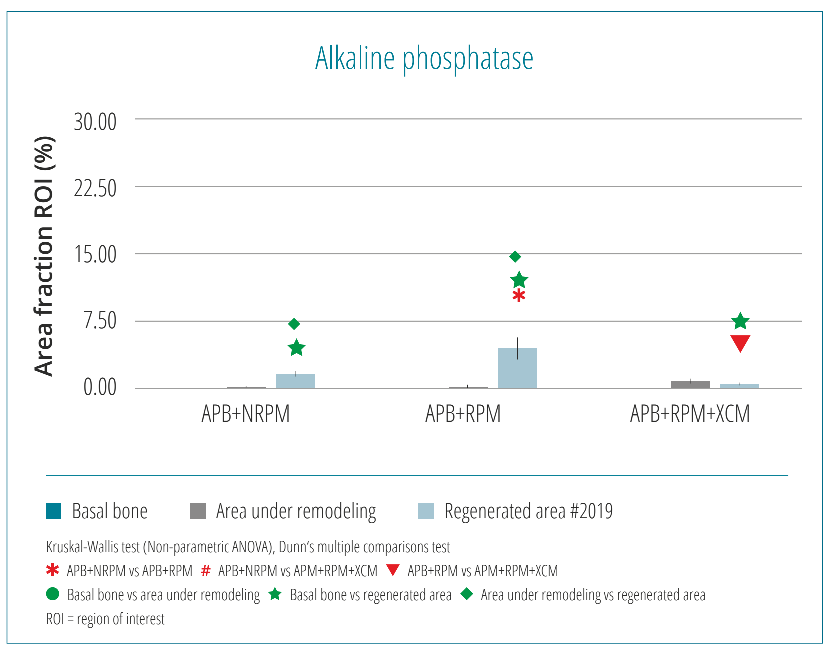
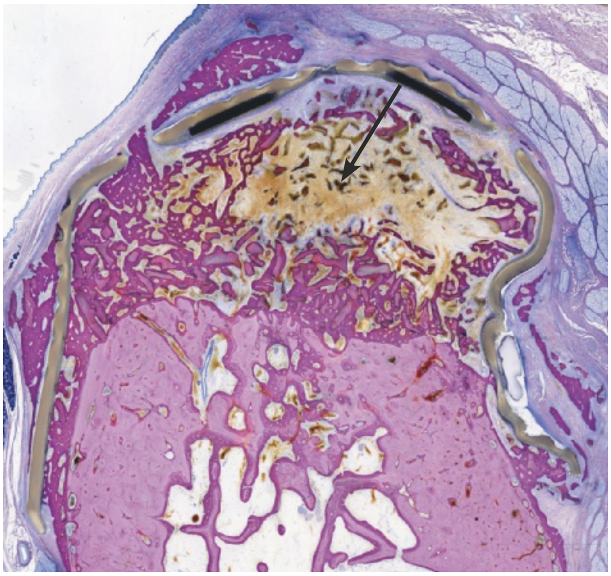


Fig 1-42 Graph showing the results of the ALP marker for the three groups investigated.

Immunohistochemistry was also performed, looking at different markers. Of these markers, two demonstrated significantly better results. Osteocalcin (OCN – a marker for osteoblastic activity and level of mineralization) and alkaline phosphatase (ALP – a marker for osteoblastic activity and bone formation) had a significant presence (Figs 1-39 to 1-42).



Figs 1-43 BMP-2/xenograft: Sandwich configuration showing how the BMP-2 is sandwiched inside the xenograft particles (arrow).

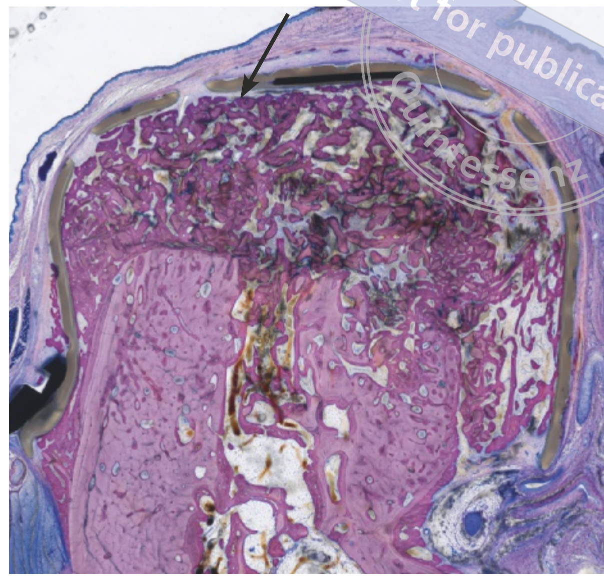


Fig 1-44 BMP-2/xenograft: Lasagna configuration showing how the BMP-2 is layered on top of the graft and just below the perforated PTFE membrane (arrow).

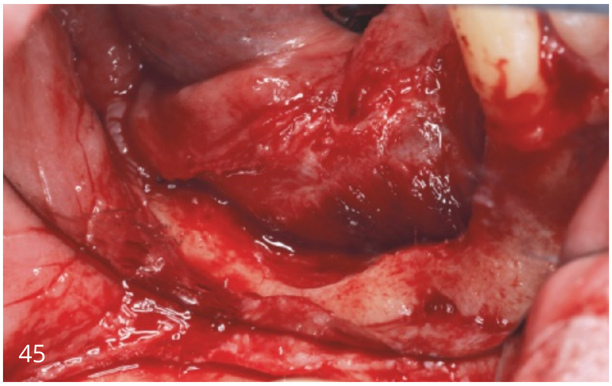
These results indicate that the perforated group is more vascularized and has a more active formation. However, the collagen membrane coverage did not seem to be a prerequisite. In fact, the collagen membrane group demonstrated slightly worse results than the group without coverage. This was due to the collagen membrane of choice producing some inflammatory response. It is very likely that the other native type of collagen membranes could help in reducing soft tissue ingrowth. For this reason, the author uses a collagen membrane in conjunction with a perforated PTFE membrane.

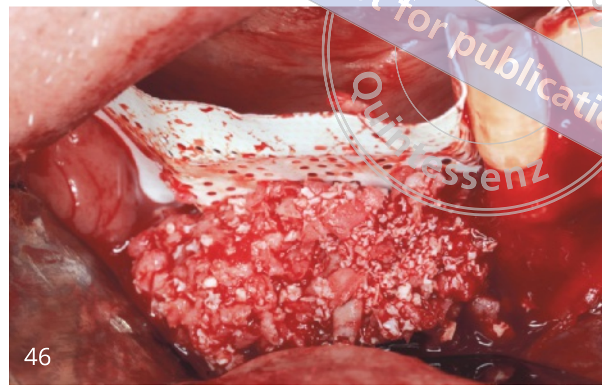
III. The effect of the use of a microdose of BMP-2 in combination with an osteoconductive xenograft

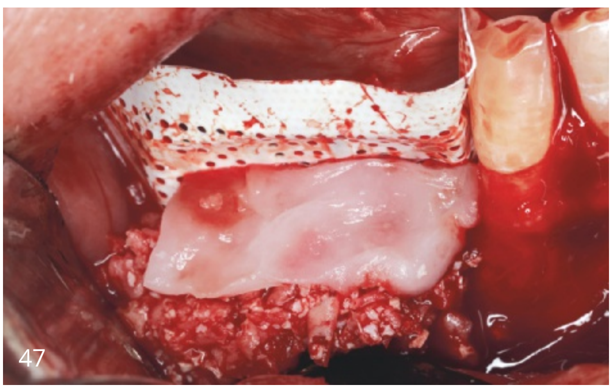
This investigation looked at whether the use of a perforated membrane could result in faster and better bone formation with a microdose of osseoinductive stimuli.

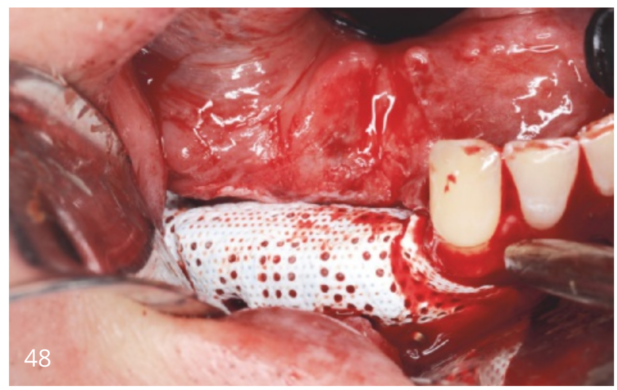
In these cases, < 100 µg BMP-2 was used, either inside the graft or just simply placed on top of the graft. The former is called the Sandwich technique and the latter the Lasagna technique. A pure xenogenic bone graft was used. The layered BMP-2 (Lasagna) developed excellent bone formation, which was better than the internally placed BMP-2 (Sandwich) graft, which failed to form a complete ridge (specifically in the middle of the ridge). Even though the Lasagna configuration only had BMP-2 placed on top of the graft, the bone was more evenly formed throughout the entire new ridge. This investigation again demonstrated the importance of the periosteal connection, especially with a growth factor. Note that the Lasagna configuration resulted in excellent new ridge formation throughout the entire ridge (Figs 1-43 and 1-44).

The final case demonstrates the Lasagna technique, where a low dose of BMP-2 was used on top of the graft to improve and accelerate the bone formation (Figs 1-45 to 1-49). Note the complete vertical bone regeneration and the excellent bone quality with minimal smear layer that was regenerated.









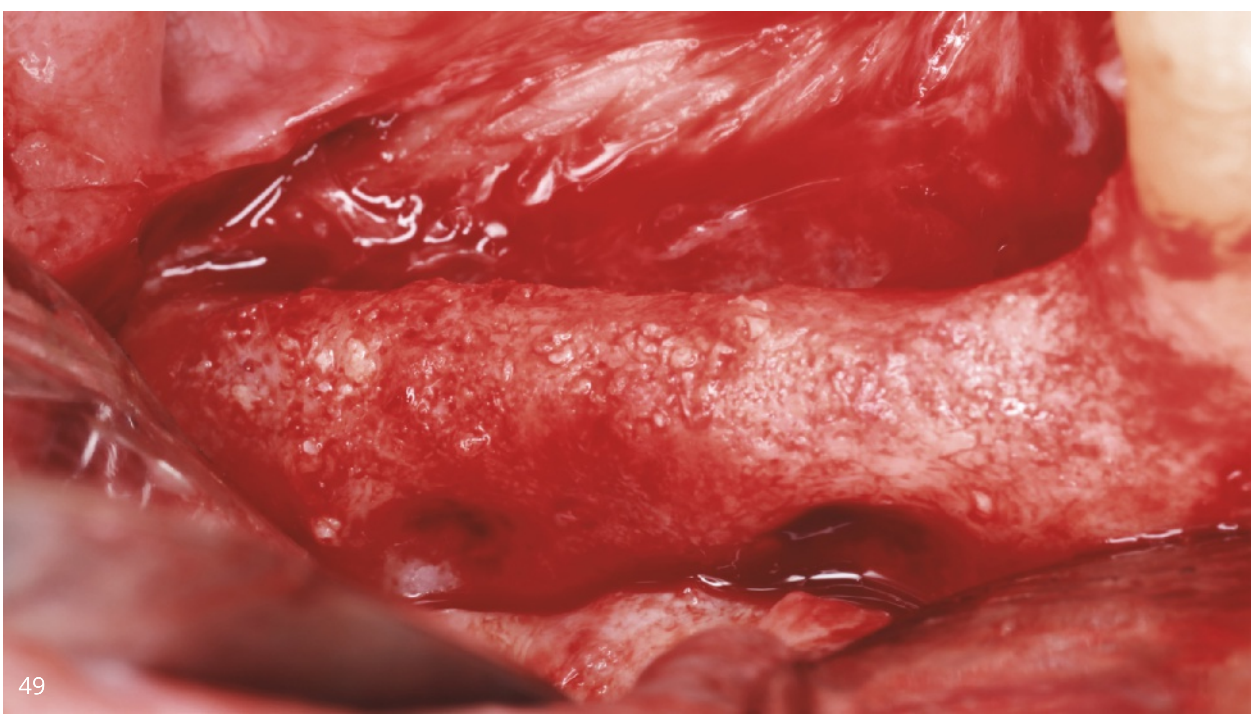


Fig 1-45 Labial view of an advanced vertical defect.
Fig 1-46 A 1:1 ratio of autogenous bone mixed with ABBM is used.
Fig 1-47 A BMP-2–infused collagen membrane is layered on top of the graft (Lasagna technique).
Fig 1-48 A perforated dense PTFE (d-PTFE) membrane is used to immobilize the graft.
Fig 1-49 Labial view of the ridge after 9 months of uneventful healing.

Conclusion

The perforated membrane shows that the clinician may expect better bone quality and faster bone formation. It also sheds light on how to use growth factors. Autogenous particulated bone has several growth factors such as BMP-2 and transforming growth factor beta 1 (TGF-B1), hence these results can likely be applied to the autograft/xenograft mixture that is used throughout this book. In some cases, the author has used the Lasagna type of graft with excellent results.

It is also clear that the periosteum should not be blocked, and if a collagen membrane is used, it should be a native collagen membrane that resorbs as rapidly as possible. Crosslinked collagen membranes should not be used over perforated PTFE membranes. Also, particulated bone chips may release more BMP-2 than an autogenous cortical block.

Reference

1. Urban IA, Montero E, Monje A, Sanz-Sánchez I. Effectiveness of vertical ridge augmentation interventions: a systematic review and meta-analysis. J Clin Periodontol 2019;46(suppl 21):319–339.

Additional reading

1. Urban I, Baczko L, Parkany I, Coelho P, Tovar N, Nagy K. Dense versus perforated PTFE membranes using BMP-2 grafting [in progress].
2. Urban I, Farkasdi S, Munoz F, VIgnoletti F, Varga G. Dense versus perforated PTFE membranes using a xenogenic graft material [in progress].
3. Urban I. Dense versus a novel form of stable collagen membrane using a xenogenic graft material [in progress].
4. Urban I, Farkasdi S, Bosshard D, Owusu S, Wikesjo U. Perforated PTFE membranes using a microdose of BMP-2 in conjunction with a xenogenic graft material [in progress].

3 Reconstruction of the extreme posterior mandibular defect: surgical principles and anatomical considerations

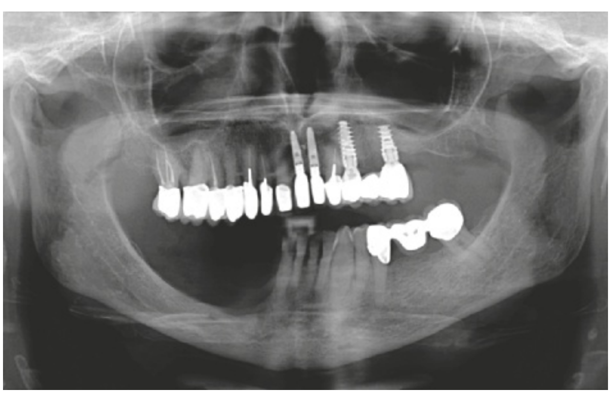


Fig 3-1 Panoramic radiograph of the defect.

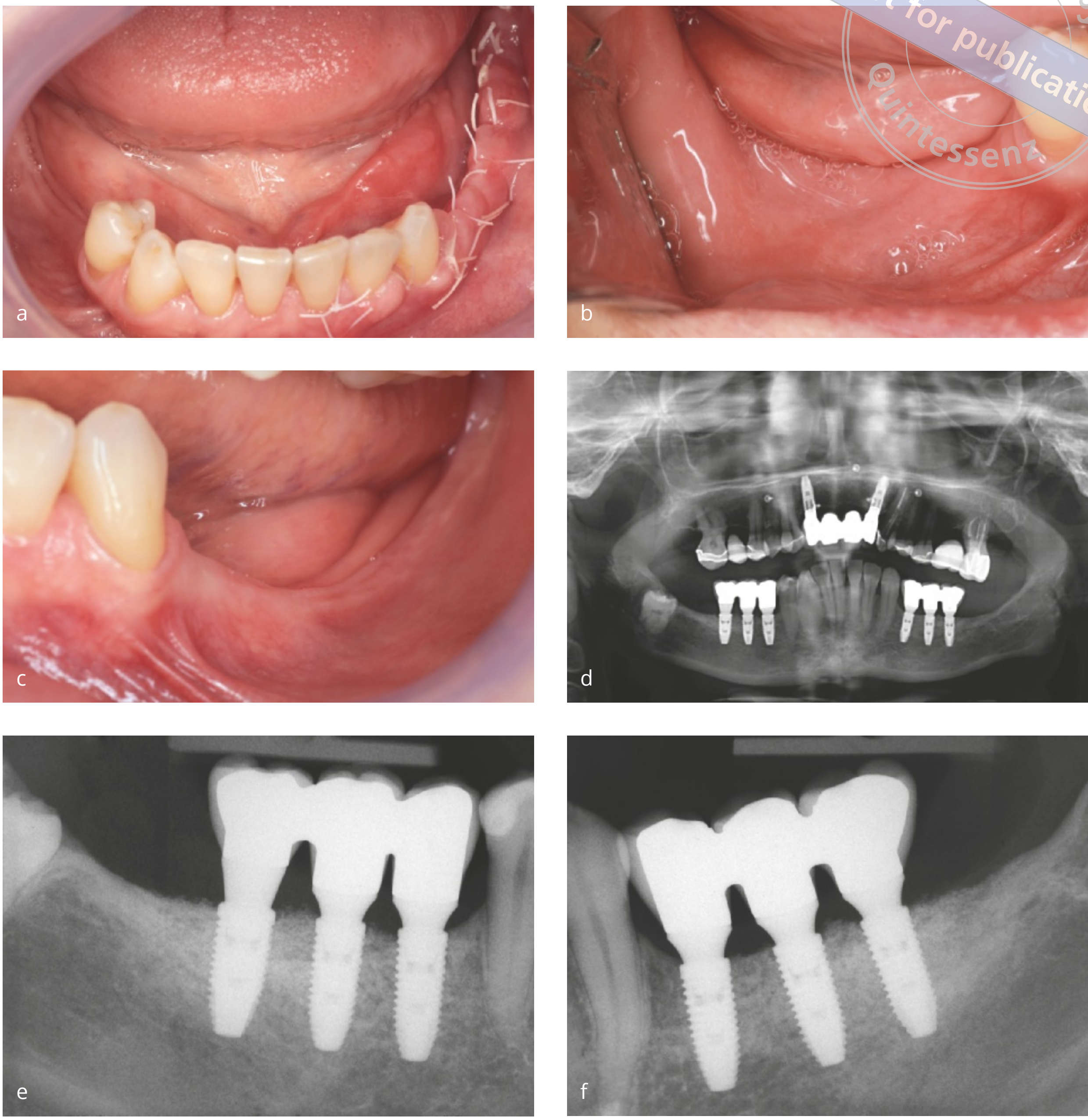
Fig 3-2 Anterior view of the defect.

Introduction

This chapter details a patient case that is a representative example of an extreme vertical defect that required regeneration. The first question we need to answer in cases such as these is whether the defect requires regeneration or whether alternative treatments would be appropriate.

It is necessary to justify this particular treatment for each patient. Alternative treatment options and potential compromised outcomes have to be evaluated and presented to the patient. Regenerating a defect may not be necessary if it is possible to place implants in other adjoining areas by using short implants for well-selected cases or by using pink ceramic restorations if longer clinical crowns have to be made. In this specific example (Figs 3-1 and 3-2), short implants were not a possibility due to the close proximity of the neurovascular bundle.

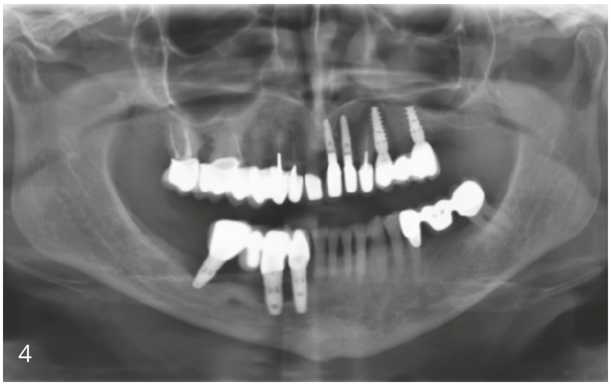
Another alternative and frequent choice of treatment is extraction of all the anterior teeth and interforaminal implant placement. Not only is this treat-



Figs 3-3 (a to c) Anterior and labial views of the patient with sound anterior teeth and a bilateral vertical ridge deficiency. **(d)** Panoramic radiograph demonstrating stable crestal bone after 5 years in function. **(e and f)** Detail of panoramic radiograph.

ment simpler, it has less morbidity, is highly successful, and has a significantly faster overall treatment time. However, there may be cases in which healthy teeth are sacrificed in the interests of a faster treatment. A good example can be seen in Figure 3-3a to c. This patient received a bilateral ridge augmentation instead of interforaminal implants. However, another practice recommended extraction of all the teeth, which is considered by this author to be a poor choice for this patient.

In the particular situation shown in Figures 3-4 and 3-5, extraction of all the teeth would have been a viable alternative. The reason for the defect developing was untreated peri-implantitis.



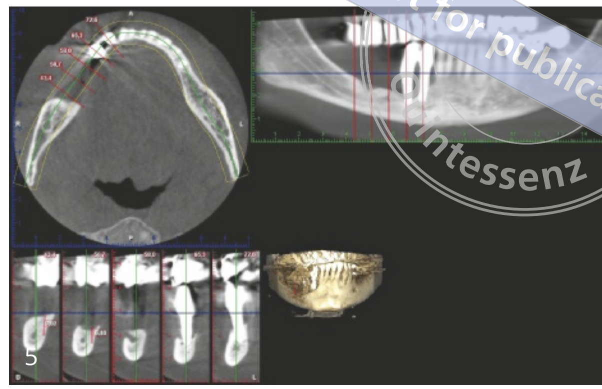


Fig 3-4 Panoramic radiograph demonstrating the vertical defect.

Fig 3-5 Panoramic and cross-sectional CBCT images demonstrating the vertical defect.

Fig 3-6 Note the extreme ridge atrophy.

This patient did not opt for extraction of all her teeth and the placement of intraforaminal implants. She felt that such a treatment would mean losing all her teeth due to previous implants. This author thinks that she was right. In fact, we frequently have this same debate due to implant failures that create such advanced defects. The question is: Why would the regenerated bone serve the new implants better than the native bone that previously existed in the same place? It is our responsibility to provide a treatment alternative that will support function and health over time. This patient, a healthy 67-year-old nonsmoker, was very motivated not to lose all her teeth due to three previous implants.

To resolve this case, the soft tissue quality and quantity was evaluated as well as the defect intraorally (Fig 3-6).

In addition, there was significant attachment loss of the canine tooth that may have required its extraction. Although there was a limited amount of keratinized tissue, its quality appeared to be good. However, it should be borne in mind that this patient had at least one prior surgical procedure that might have altered the nature of the periosteum, and this was not visible from the outside. It is very important to note that in the middle of the defect there were no bony walls that could help in regeneration. The bone would have had to grow from the bottom without any help from the side, which made this case very difficult.

Anatomically, the difficulty was that there was very little soft tissue to mobilize. This is especially true of the area of the mental nerve. Figures 3-7 to 3-9 show cross-sectional views of an anatomic specimen with atrophic mandible, which demonstrate the following:

1. The mylohyoid muscle is attached very close to the crest. Our goal was not to disturb this attachment (please review Chaps 5 and 6 in the author's first book – see Preface). Therefore, the lingual tissue quantity is limited.
2. The mental foramen was close to the crest. Since we did not want to disturb the nerve and did not

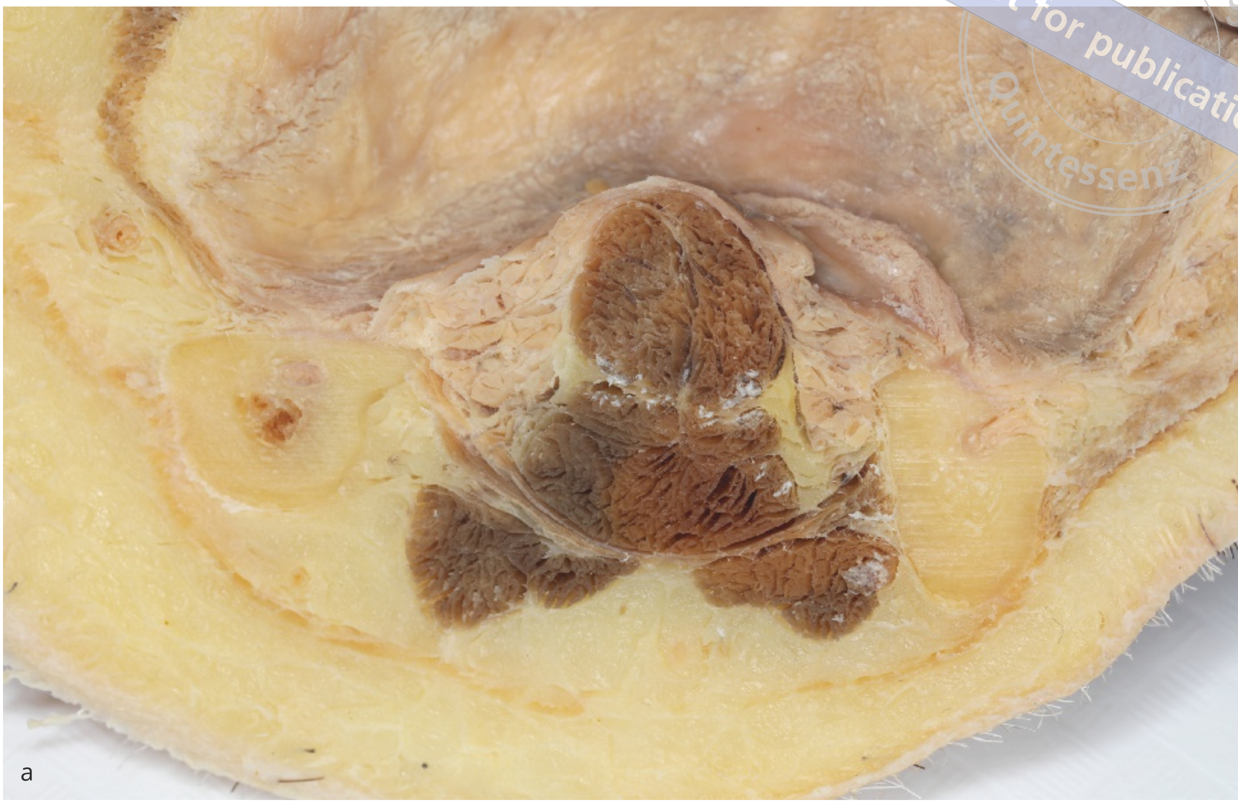
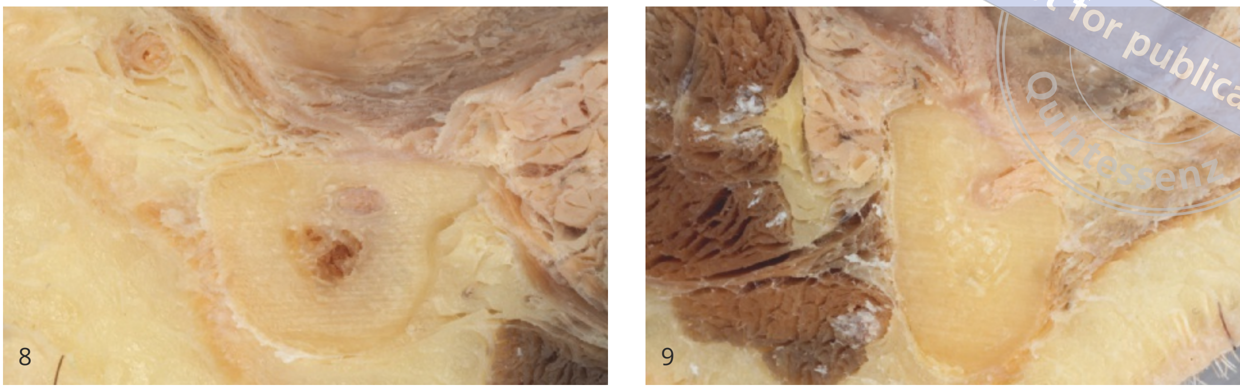


Fig 3-7a and b Cross-sectional and schematic views of the anatomy of the floor of the mouth.



Figs 3-8 and 3-9 Close-up images demonstrating that the bone is very cortical, which is typical for these types of defects. This made this case a challenge biologically, as it would be difficult to revascularize this graft from its cortical base.

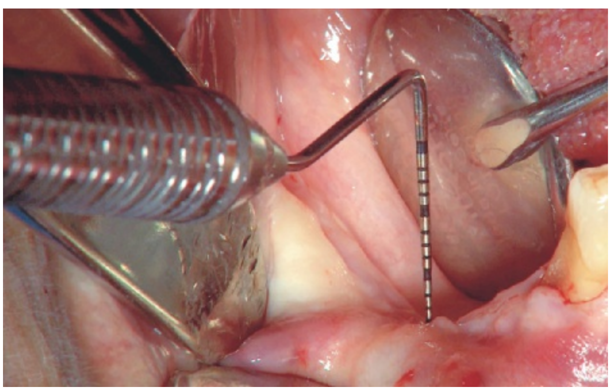


Fig 3-10 Labial view of the defect after the administration of local anesthesia. Note the puffiness of the tissue from the anesthetic injected into the site.

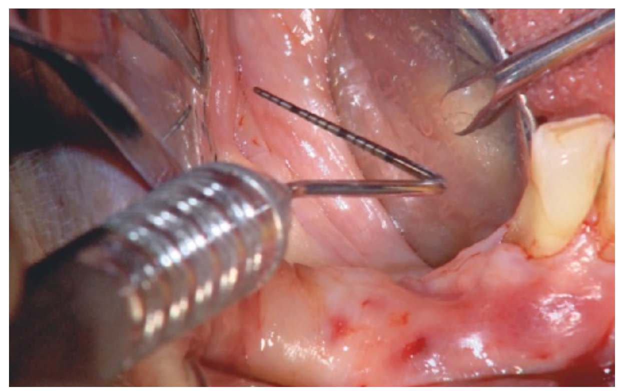


Fig 3-11 Periodontal probe demonstrating the ideal tissue level. This level might not have been possible or necessary to achieve.

recommend reflecting the flap apically to the nerve, we had a limited amount of soft tissue to advance in this area. It could be estimated that there was only about 6 mm of soft tissue.

3. We considered it possible to utilize a technique that would advance the flap sufficiently to achieve primary closure on top of the membrane.

Based on the above, we concluded that the extreme vertical defect was both biologically and technically very challenging. This should be borne in mind before one starts to treat a case such as this, regardless of the technique utilized.

After appropriate patient preparation (please see Chap 2 of the author's first book), which included the elimination of any potential source of infection, including a thorough cleaning and presurgical scraping of the tongue, the surgical procedure was performed (Figs 3-10 and 3-11).

Our plan was to place 8- to 10-mm implants 2 mm above the nerve. Therefore, about 10 mm of vertical gain was needed. The goal was to elevate a full-thickness flap that was completely uninjured after flap elevation (referred to as the super-full–thickness flap). This type of flap elevation depends on the primary incision, which comprises three steps. Figures 3-12 to 3-16 demonstrate the flap design as well as the primary incision.

A 'safety flap' was created, which included a crestal incision starting from the retromolar pad (RP). The primary incision entailed three steps: first, a No. 15C blade (Swann-Morton, Sheffield, UK) was utilized in a 'floating' manner. This means that the blade touches gently and only explores the crest.

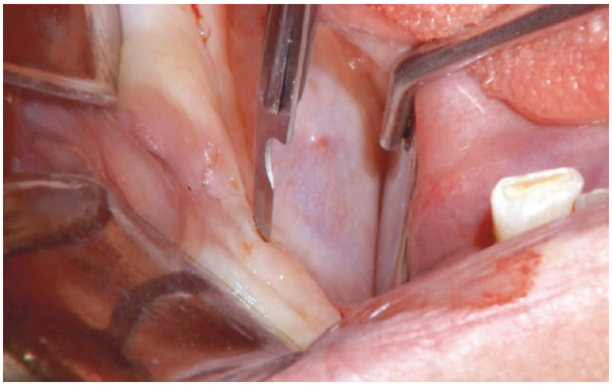


Fig 3-12 Lateral view of the crestal incision.

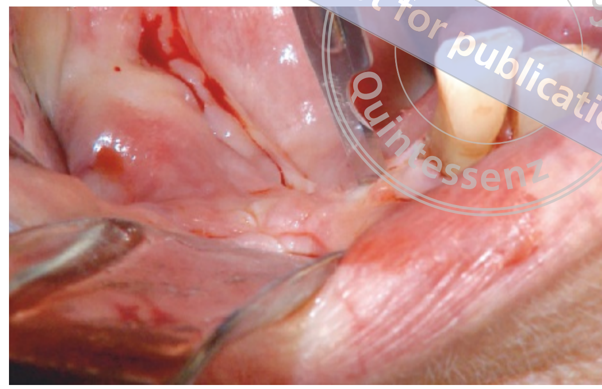


Fig 3-13 Lateral view of the completed crestal incision.

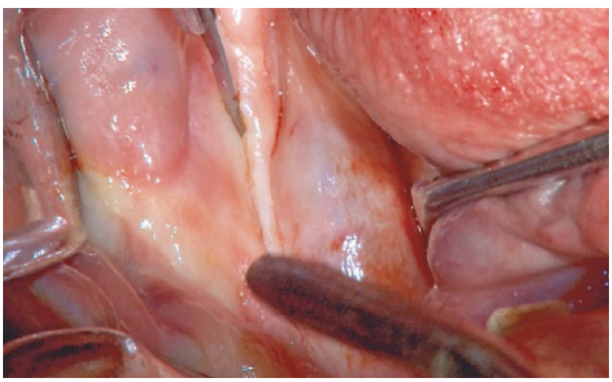


Fig 3-14 Occlusal view of the incision bypassing the retromolar pad laterally.

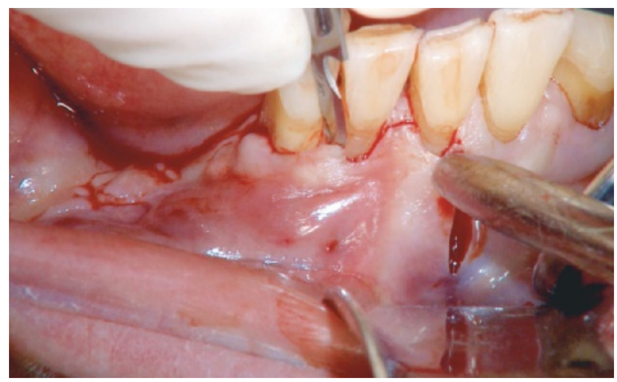


Fig 3-15 A vertical incision is placed mesiobuccally at least one tooth, but preferably two teeth, away from the surgical site. In this case, the vertical incision is placed three teeth away, since the canine was to be extracted.

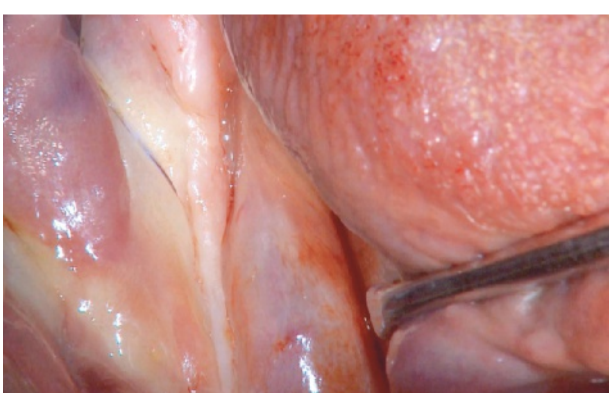


Fig 3-16 Occlusal view of the retromolar pad.

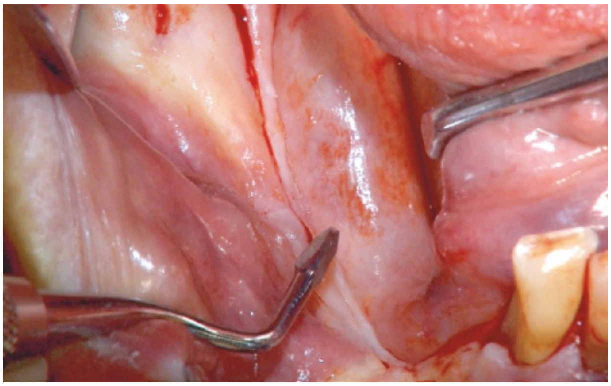


Fig 3-17 A ball scaler is used on the crest to eliminate any uncut tissue. This step concludes the initial incision.

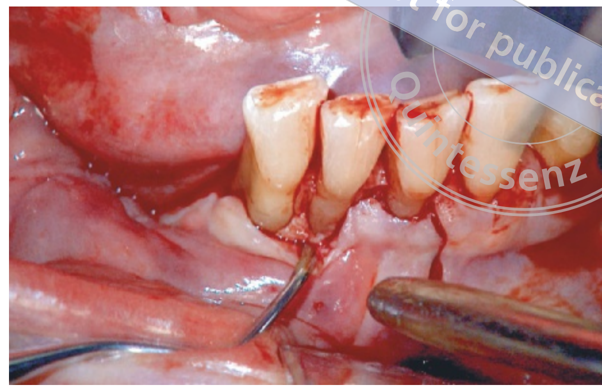


Fig 3-18 A universal curette is also used at the marginal area to initiate the flap elevation.

In a second step, this incision was reinforced with a new No. 15 blade, cutting through the periosteum to the crest (see Fig 3-15). Mesiolingually, a short, 3- to 4-mm incision was placed at the mesiolingual line angle of the most distal tooth in front of the defect. The primary incision was continued toward the coronoid process, avoiding the RP.

The third step utilized a scaler or curette to score down to the bone crest. This step ensured that there were no remnants of soft tissue attachments in the incision that would have made it difficult to elevate the flap, as this difficulty usually results in tissue damage. This third step is demonstrated in Figures 3-17 to 3-24.

The mental foramen was thereby exposed. Note, however, that the flap was elevated more apically at its mesial and distal parts, and the soft tissue was not tunneled apically of the mental nerve. This is an important part of the procedure, as tunneling the flap apically makes the nerve more vulnerable to injury during flap retraction. The author thinks that tunneling is not even necessary when the nerve is very close to the crest, as it was in this case.

The next step was to place (mesiolingually) a short 3- to 4-mm incision at the mesiolingual line angle of the most distal tooth in front of the defect. In this case, this meant two teeth mesially, since it was planned to extract the canine due to the apparent attachment loss (Figs 3-25 and 3-26). The lingual flap was then elevated (Fig 3-27). A typical error occurs when the clinician starts to elevate at the distolingual aspect of the last tooth, and this results in a small accidental tear at this location, making the final closure more complicated.

Since, anatomically, the mylohyoid attachment was deeper mesially than the region of the second premolar, the depth of flap elevation did not follow the location of the muscle (Fig 3-28). Instead, it was carefully prepared slightly deeper than the elevation of the molar region, corresponding with the muscle attachment.

In this case, an arteriola, which is a rare anatomical finding, was identified (Fig 3-29). Previous investigators have found (as has the author in his clinical experience) that these arteriolas have an average diameter of 0.8 mm. Injury of these vessels does not present a high risk of hemorrhage, as compared with injury of more deeply running sublingual arterial branches. In this case, the arteriola was gently reflected and 'pulled out' from the mandible, with minimal bleeding. In cases where a larger arteriola is found, the clinician might choose to use a ligature before the pullout.

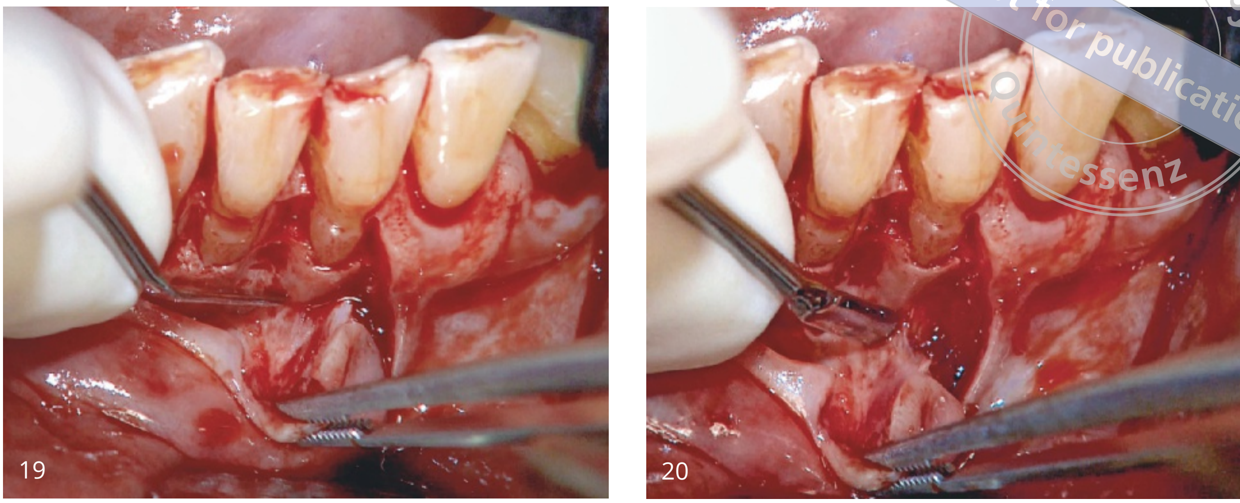
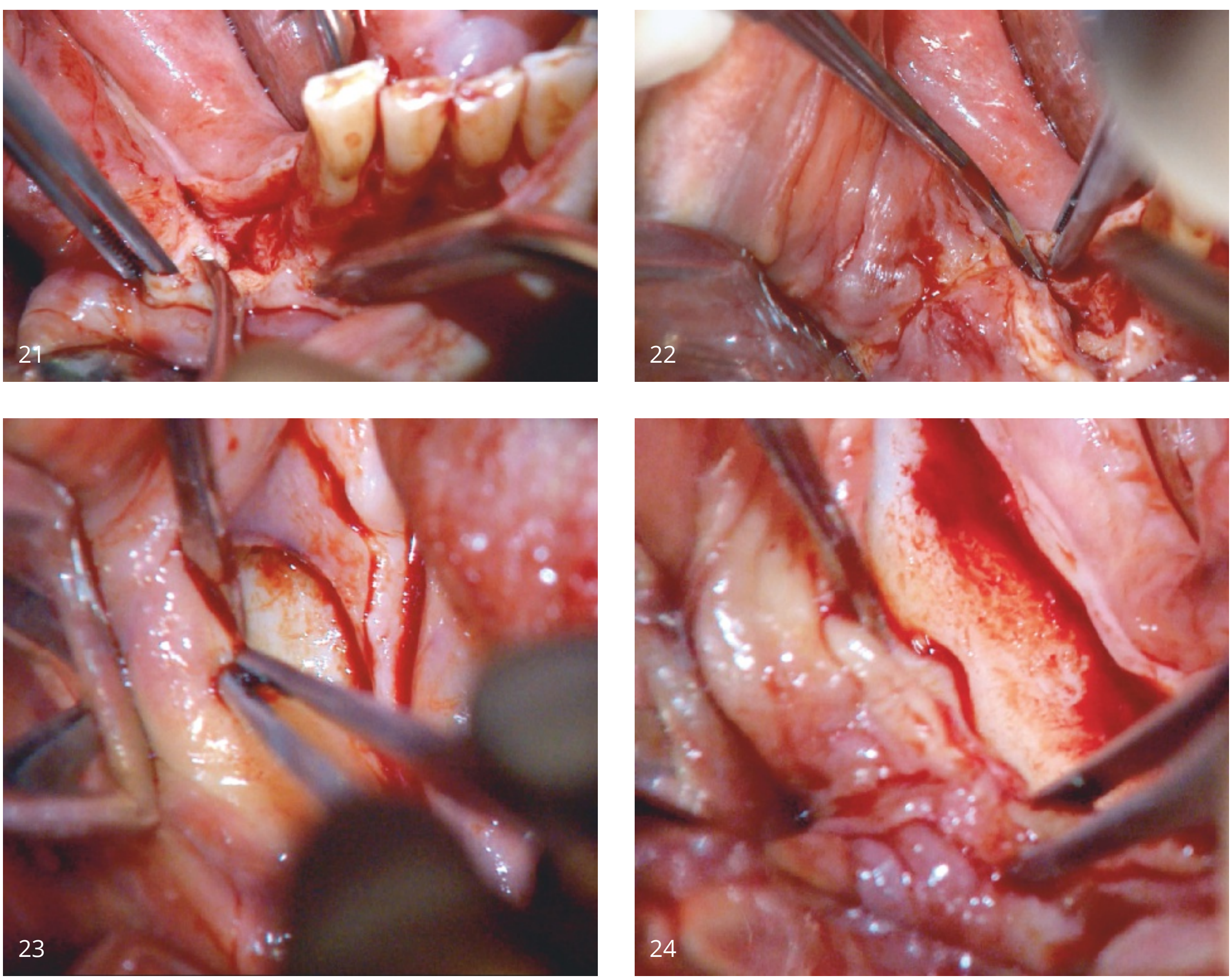
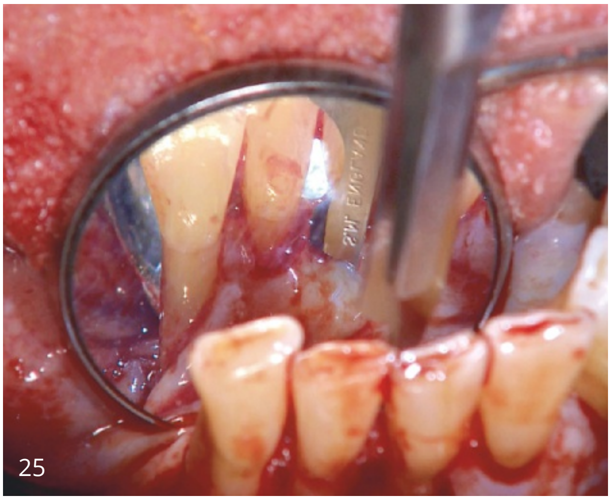
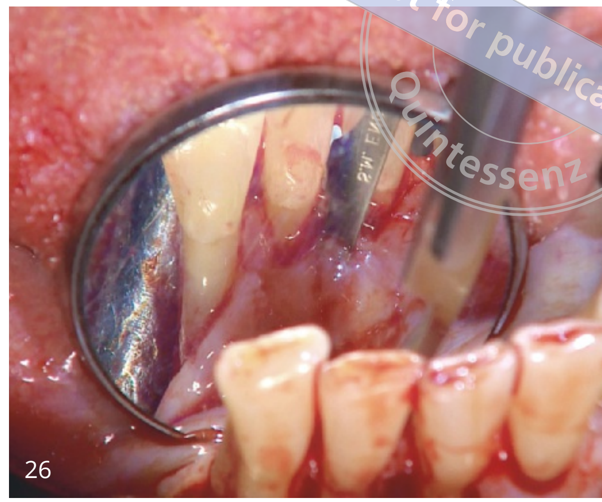


Fig 3-19 and 3-20 The flap elevation is then continued using a Mini Me microsurgical tissue elevator, beginning at the mesial vertical incision.



Figs 3-21 to 3-24 The crestal part of the flap is initiated using a narrow chisel and is continued apically using a periosteal elevator until the mental foramen is exposed.





Figs 3-25 and 3-26 The attachment loss is clearly visible in these images.

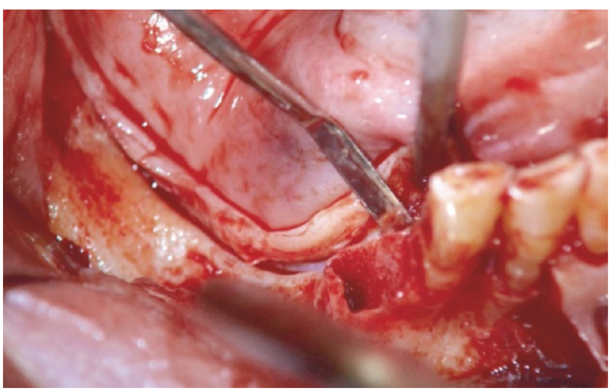


Fig 3-27 The lingual flap is elevated, beginning at the vertical incision.

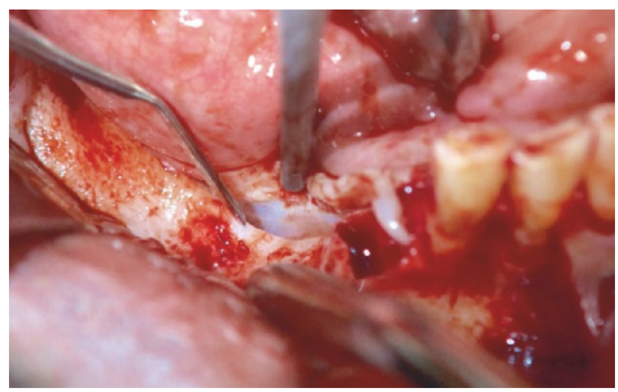


Fig 3-28 The lingual flap is continued distally and is elevated to the mylohyoid line, where the attachment of the fibers of the mylohyoid muscle are identified.

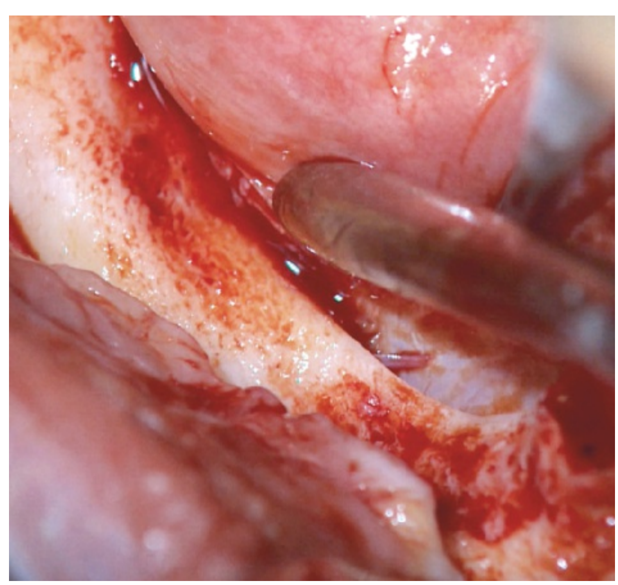


Fig 3-29 An arteriola arising from the sublingual artery and perforating the mandible.

Fig 3-30 Superior view of the sublingual artery in relation to the lingual nerve and the Warton's duct. This is the classic anatomical variation.

Fig 3-31 Superior view of the lateral lingual groove after the body of the mandible has been rotated facially. This region is of key interest when posterior mandibular ridge augmentation is performed. In about 30% of cases, the main blood supply to the floor of the mouth comes from the perforating branch of the submental artery, as is seen in this specimen. Note the multiple small-diameter arteriolas arising from the sublingual artery.

Fig 3-32 Superior view of the sublingual anatomy. Note the small-diameter arteriola perforating the lateral mandible (cross). This is the type of anatomical configuration seen in the current clinical case, demonstrated in Figure 3-30. This clinical situation should be managed as described in the text.

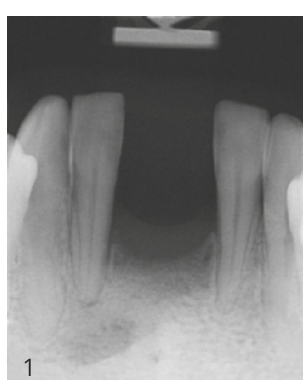
For a review of vascularization, some anatomical samples follow (Figs 3-30 to 3-32), and the reader is again referred to Chapter 5 of the author's first book for anatomical details.

In order to properly achieve primary closure, minimize the occurrence of complications, and maximize long-term regenerative outcomes, adequate release of both the buccal and lingual flaps is required.

In recent years, various lingual flap management techniques for bone augmentation in the posterior mandible have been proposed in the literature. However, the level of evidence is limited to technical descriptions and case series studies. Additionally, these 'classic' techniques have limitations associated with complete or partial detachment of the mandibular insertion of the mylohyoid muscle, which may lead to serious postoperative complications. Hence, a more conservative and predictable approach was developed, consisting of the advancement of the lingual flap via blunt preparation in three different anteroposterior zones, while preserving the entire mylohyoid muscle attachment. The technique, developed by the author and his coworkers, is called the 'modified lingual flap advancement technique,' 9

Reconstruction of the advanced anterior mandibular defect: considerations for soft tissue reconstruction and preservation of the regenerated bone

This chapter describes a representative patient case of a bone graft and implant failure in the anterior mandible. The patient, a healthy, 47-year-old, non-smoker male, experienced the failure of a bone graft that used an autogenous bone block from the chin. The patient was very keen to find a better solution. The labial flap was type II moderately scarred tissue (see Chap 4 for description of different tissue types). There was severe interproximal bone loss around the two lateral incisors.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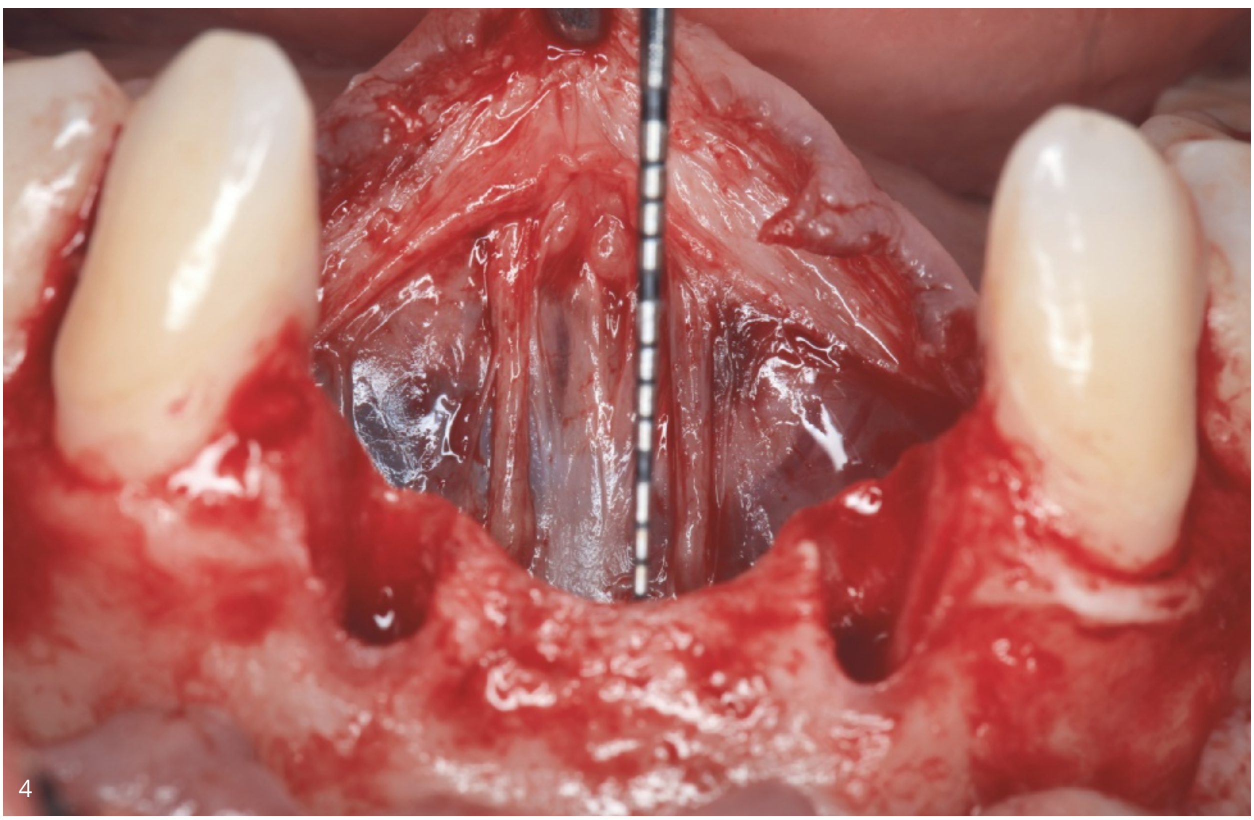
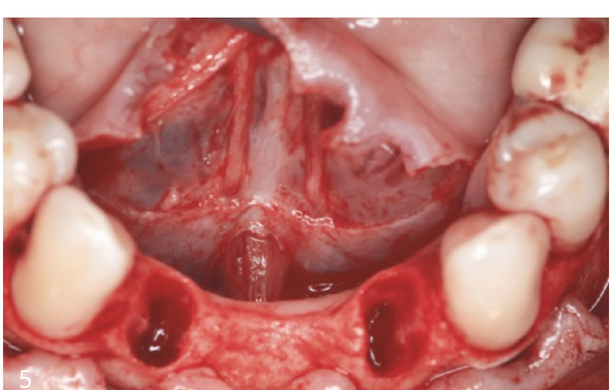
Figs 9-1 and 9-2 Periapical radiograph and CBCT image demonstrating a vertical defect in the anterior mandible.

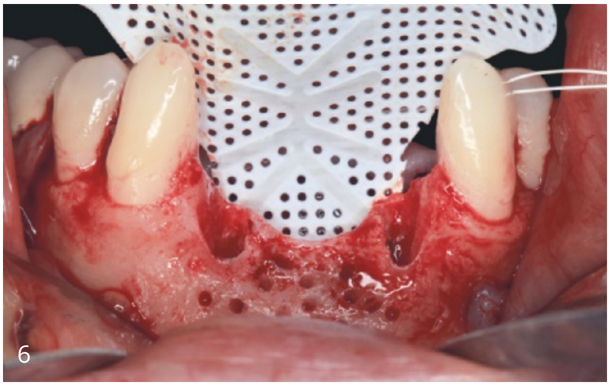
Fig 9-3 Labial view of the edentulous area. The interproximal bone loss is evident.

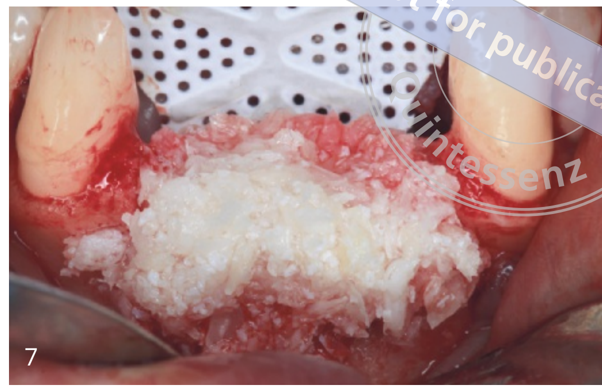
Figs 9-4 and 9-5 Labial and occlusal views of the site after lingual flap advancement. The genioglossus muscle and the two end branches of the arteries are identified during flap elevation. The two lateral incisors have been extracted.





The author prefers to harvest bone from the ramus in anterior mandibular cases instead of the chin for several reasons: the flap becomes too extensive, and there is usually more hematoma formation, which could lead to more complications.





Figs 9-6 and 9-7 Labial views of the fixated perforated dense polytetrafluoroethylene (d-PTFE) membrane. A 1:1 ratio of autogenous bone and anorganic bovine bone mineral (ABBM) is utilized.

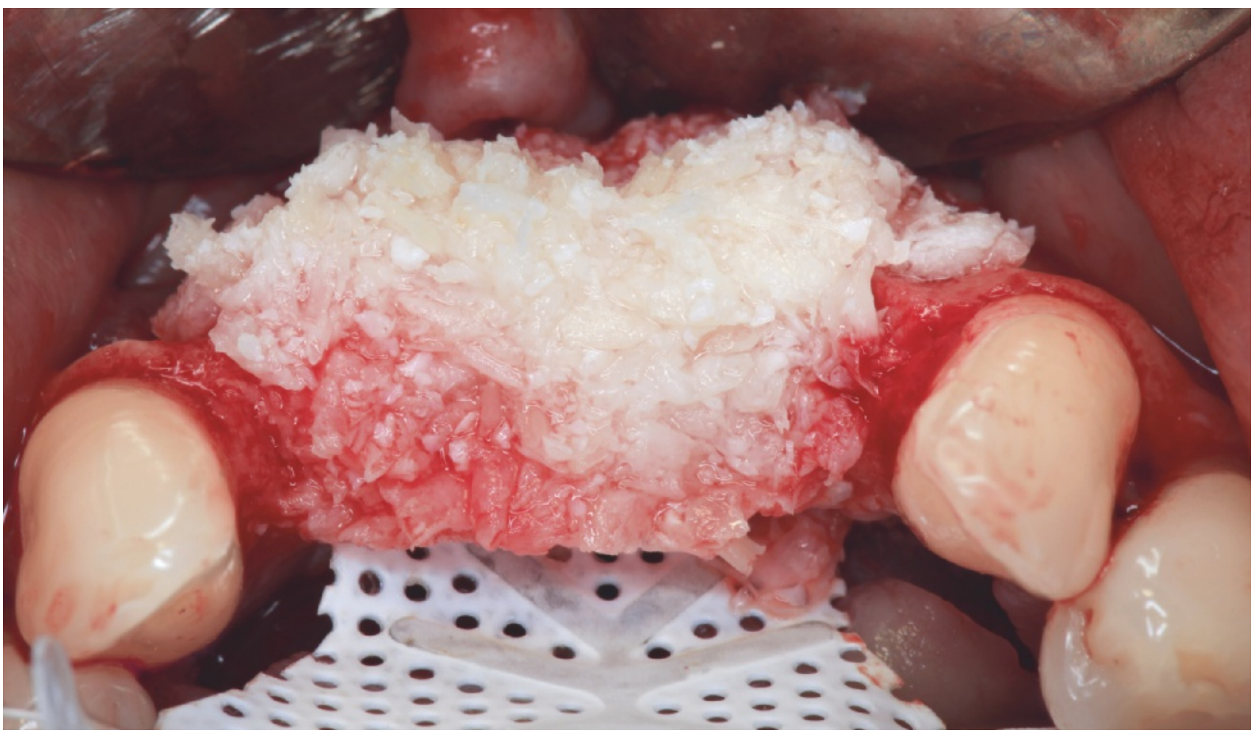


Fig 9-8 Occlusal view of the graft in place.

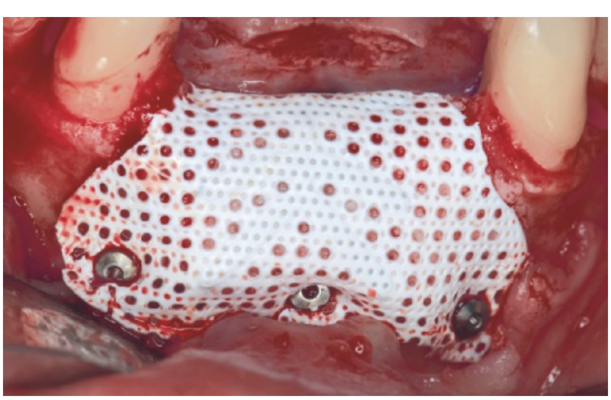


Fig 9-9 Labial view of the membrane in place.

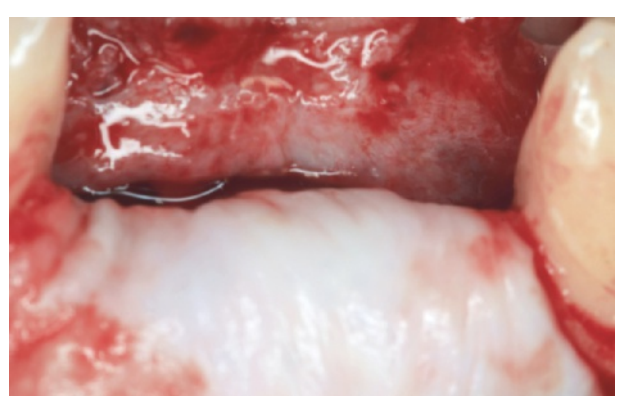


Fig 9-10 A native collagen membrane placed on top of the perforated PTFE membrane.

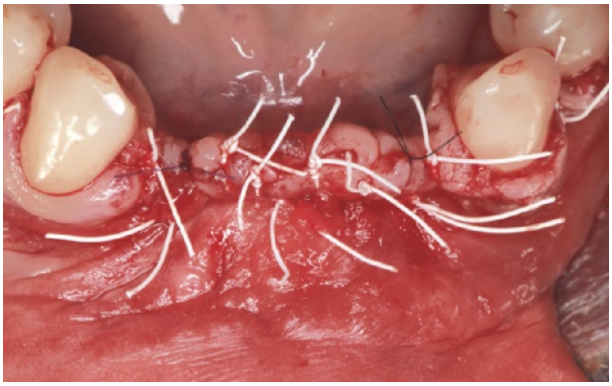
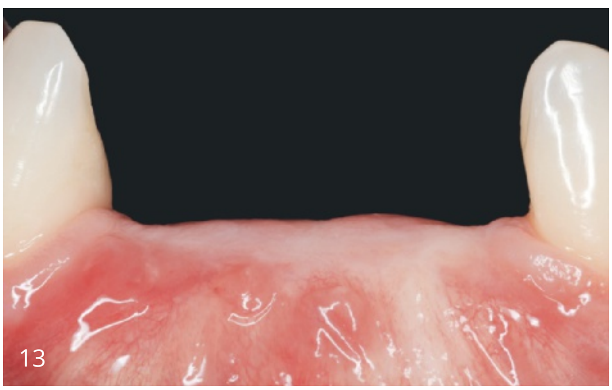
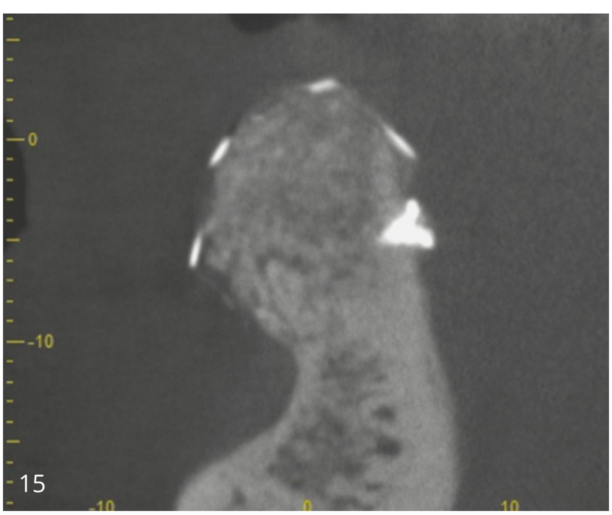


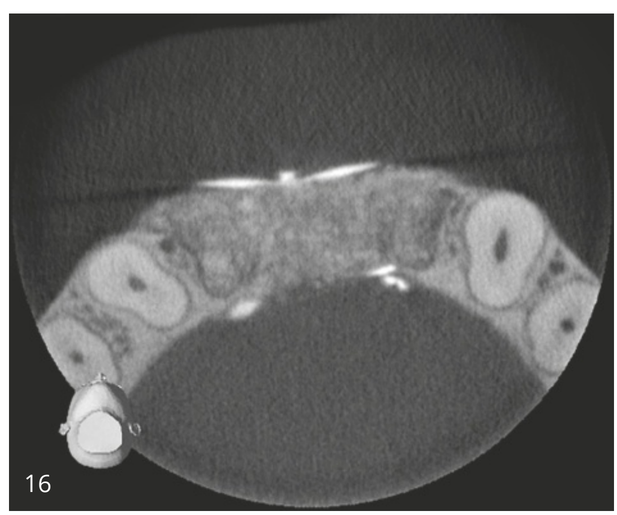
Fig 9-11 Labial view of primary closure at the end of surgery.

Fig 9-12 Labial view after 2 weeks of uneventful healing.

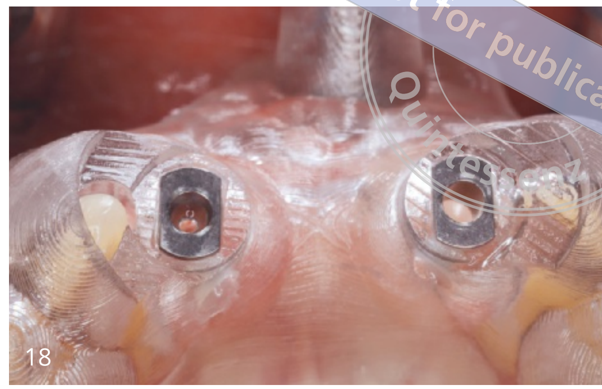


Figs 9-13 and 9-14 Labial and occlusal views of the site after 9 months of uneventful healing.

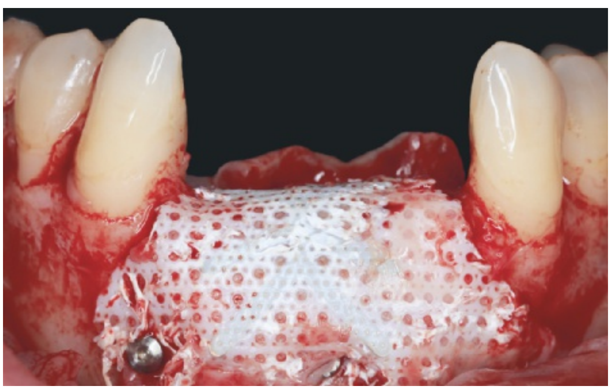




Figs 9-15 and 9-16 CBCT images demonstrating good bone incorporation.



Figs 9-17 and 9-18 Labial and occlusal views of the anatomical and digital surgical guides that were created.



Figs 9-19 Labial view of the membrane at the time of removal.

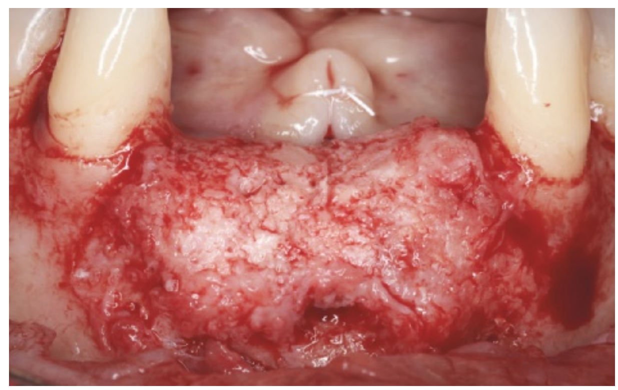
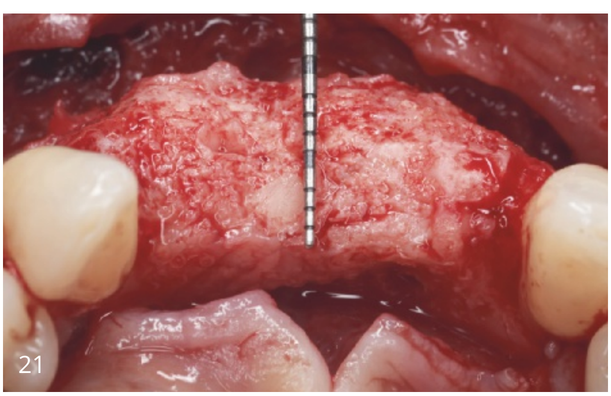


Fig 9-20 Labial view of the regenerated vertical bone.



Figs 9-21 and 9-22 Occlusal and labial views of the horizontal bone gain at the site after implant placement.

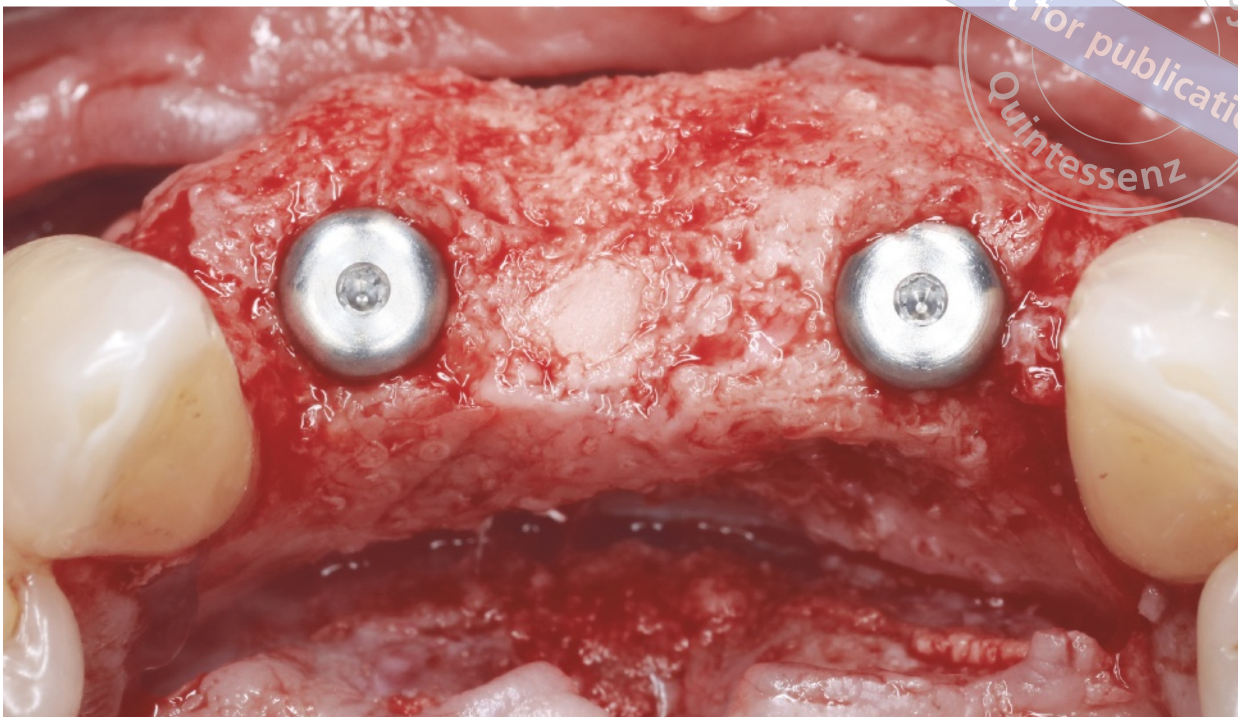
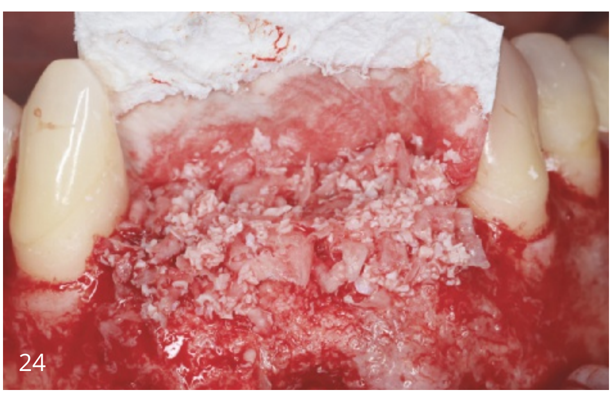
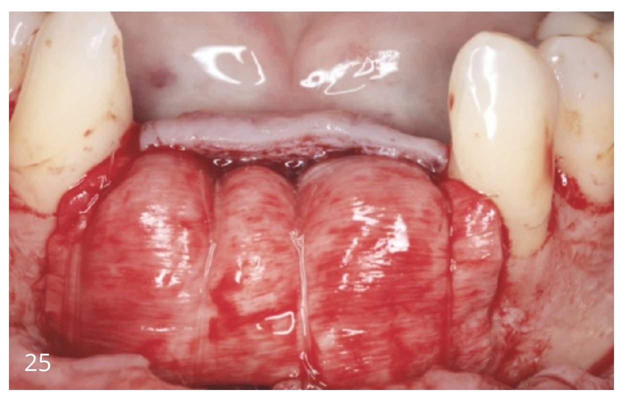
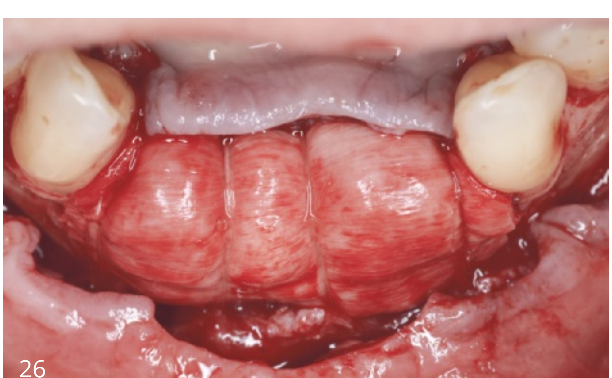


Fig 9-23 Occlusal view of the site after implant placement. Note the good buccal and lingual bone width around the implants.

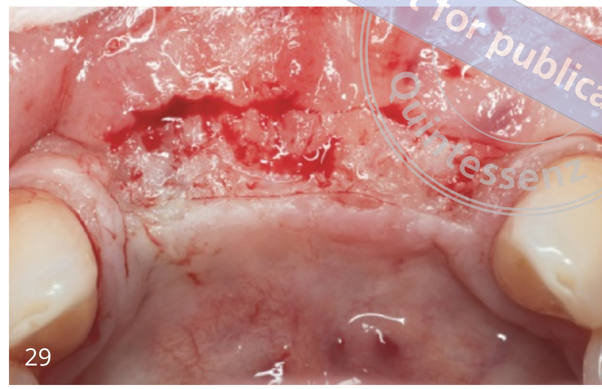




Figs 9-24 and 9-25 Labial and occlusal views of the Mini Sausage. The native collagen membrane is fixated with sutures. In most cases, the author uses pins for fixation. This case was an exception.



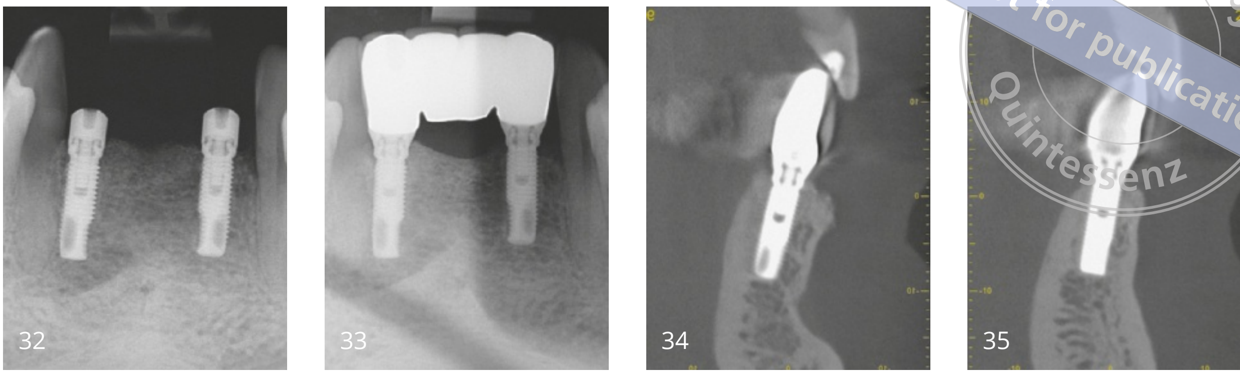
Figs 9-26 and 9-27 Labial views of the site after healing demonstrating the lack of keratinized tissue (KT).



Figs 9-28 to 9-30 The KT was missing, so a partial-thickness flap was prepared and a strip gingival graft was fixated to the site. Care was taken to have enough KT also on the lingual side.

Figs 9-31 Lingual view of the final clinical outcome after 2 years demonstrating a narrow zone of KT. This helps the patient to keep the implants clean.

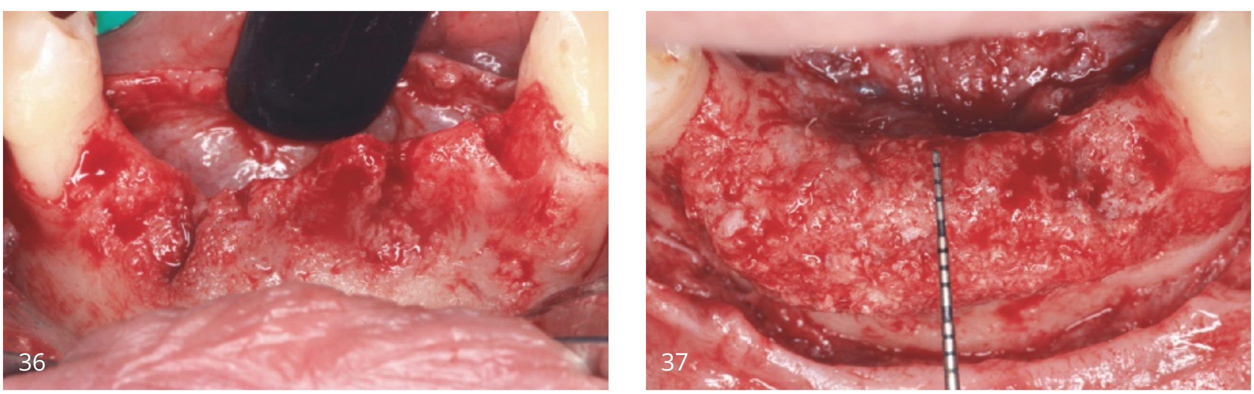
It was demonstrated in Chapter 9 (case 9-13) of the author's first book (see Preface) that peri-implantitis around anterior implants due to the lack of lingual KT makes it very difficult for the patient to keep the area clean. In the present case, these implants have a very favorable prognosis.



Figs 9-32 to 9-35 Periapical radiographs and CBCT images demonstrating an excellent bone level after 2 years of loading.

Lingual soft tissue grafting

The following case demonstrates the lingual soft tissue graft technique.



Figs 9-36 and 9-37 Labial and occlusal views of an anterior mandibular defect before and after reconstruction.

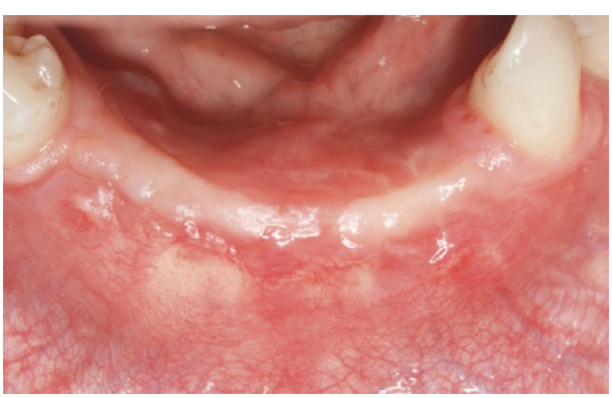


Fig 9-38 Occlusal view of the narrow band of KT.

Fig 9-39 The mucosal tissue on the lingual side of the KT is gently de-epithelialized, creating a partial-thickness flap and at the same time making sure that there is no potential damage of the lingual anatomical landmarks.

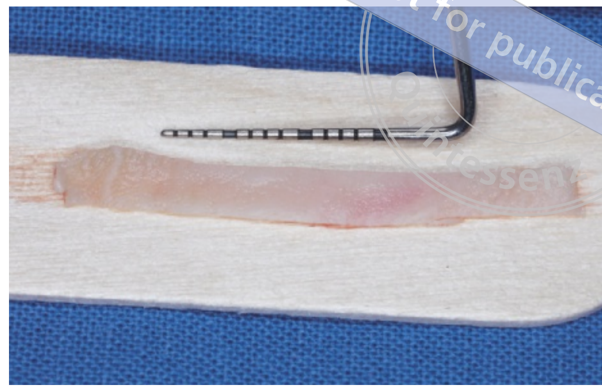


Fig 9-40 A wide strip graft that was harvested from the palate. It was secured using a 7-0 suture (Resolon, Resorba).

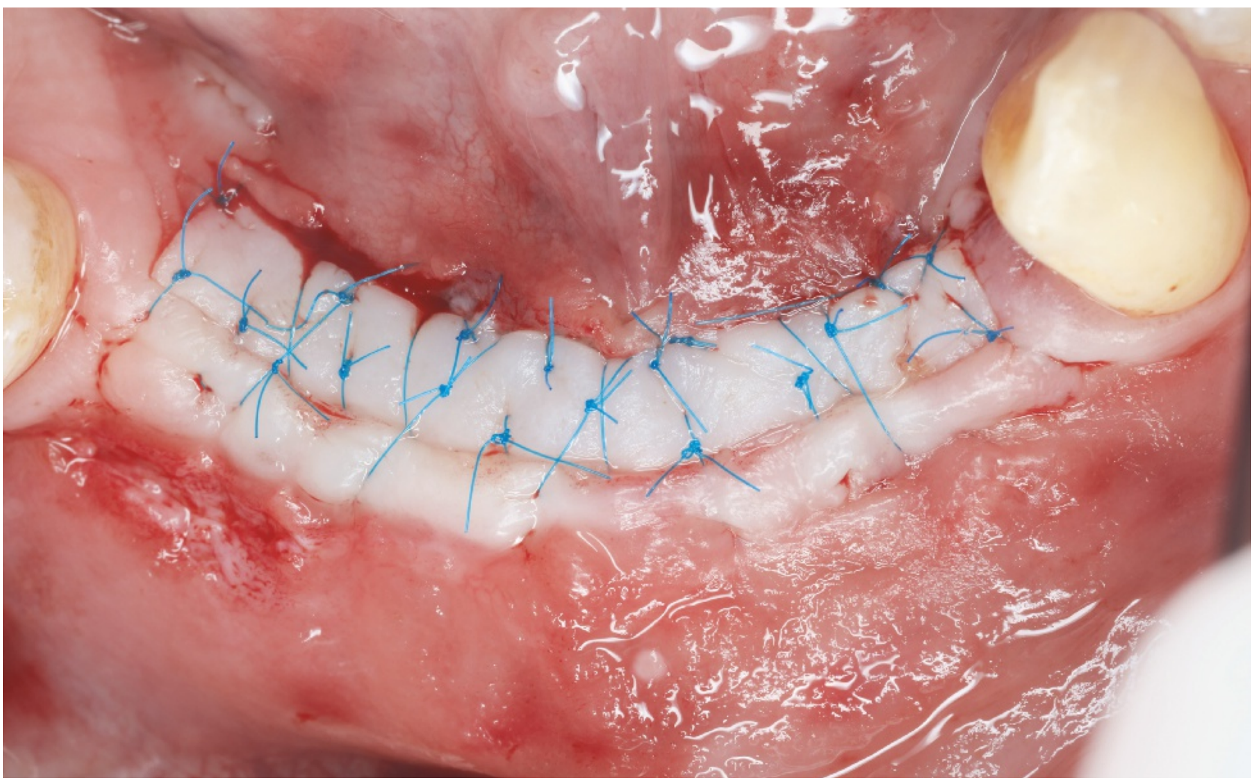
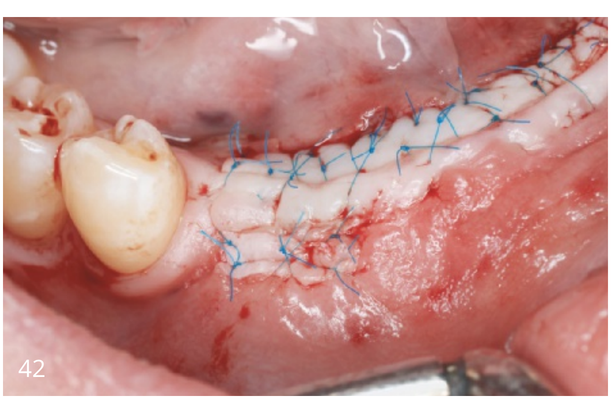
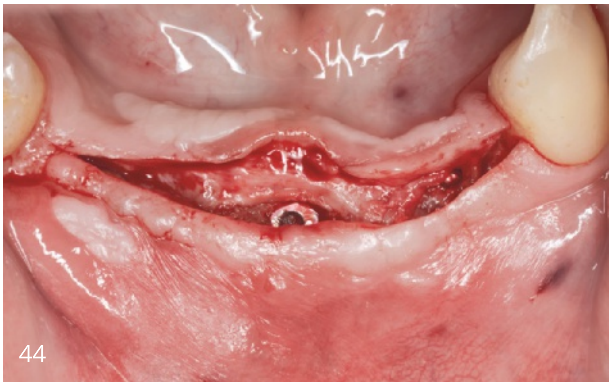
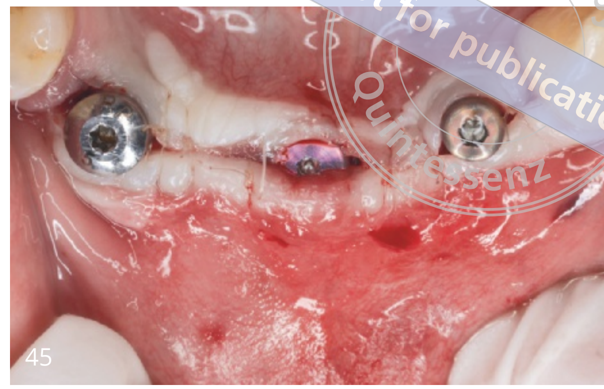


Fig 9-41 First, single sutures are used to secure the corners and the mid-section of the graft. Subsequently, cross mattress sutures are used to completely immobilize the graft.



Figs 9-42 and 9-43 Labial views of the graft and the healed site after 1 week of uneventful healing. Note that a small strip graft was also placed on the buccal right corner.





Figs 9-44 and 9-45 Occlusal views of the healed KT during uncovery of the implants. The healing time allowed was 2 months. Note the wide band of lingual as well as buccal KT.

Figs 9-46 and 9-47 Labial views of the final reconstruction in place. Note the healthy peri-implant mucosa around the implants.

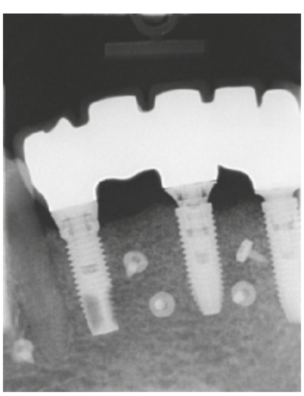


Fig 9-48 Periapical radiograph demonstrating good crestal bone stability.

Lessons learned

1. Mandibular anterior soft tissue management results in predictable outcomes.
2. Sufficient vertical height and adding enough horizontal bone are both essential for long-term success.