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Foreword

Implant dentistry has evolved into a highly predictable clinical procedure in routine cases where the available bone is of adequate height and width. However, this condition is not met by all of our patients. Yet even patients with an inadequate bone supply to support implants now want – even expect – improved function and better esthetics.

This superb textbook presents treatment techniques both for routine cases and for some of the most difficult cases a dentist is likely to encounter.

Dr. Fouad Khoury is one of the elite clinicians in oral and maxillofacial surgery. He is a true talent. He is supremely knowledgeable about every clinical aspect of transplantation, and his approach is impeccably scientific. He is a rare blend of superb clinician and gifted teacher.

For this book, Dr. Khoury was able to enlist the assistance of a wonderful group of teachers and academics. They have done an excellent job of sharing their knowledge and experience. They have described their treatment procedures in a clear and precise manner, including extensive references at the end of each chapter. In addition, many of the chapters address the interdisciplinary aspects of treatment – which deserves particular praise, since too many clinicians tend to be locked in their own specialist's approach to their patients' problems. We should remember to take a step back now and then and look at a therapy as a unified whole, not just at a sequence of treatment steps, important as they may be.

Dr. Khoury is one of the most innovative surgeons that I know. For decades, he has been at the forefront of new and creative ideas to help his patients. He has also been kind enough to share these innovations with the rest of the world. This book is just one example of of his lifetime commitment to teaching.

He and his co-authors are to be congratulated for this outstanding effort. It is the work of lifetime put down on paper for all of us to look at, think about, and – most importantly – use in the treatment of our patients. By sharing with us their thoughts about what works and what does not, Dr. Khoury and his team has truly advanced the cause of dentistry. We are grateful and thank them for all of their hard work.

Dennis P Tarnow D.D.S.
Professor and Chairman
Department of Periodontology and
Implant Dentistry
New York University College of Dentistry

Preface

Since implant dentistry became a common prosthetic procedure in the early 1960s, the techniques and possible applications, especially in the augmentative field, have improved. Accompanied by increasing patient demands in recent years, simple functional rehabilitation has changed towards a desire for an esthetically and functionally perfect result, mimicking the original anatomical situation. Prosthetic-driven implantology is in many cases not possible without augmentative measures, which can only be successful when bone healing is undisturbed by pathogenic bacteria.

During the last 20 years, different techniques and materials have been recommended for the reconstruction of bony defects of alveolar crests, such as autogenous, allogenic or alloplastic bone grafts. Although the evolution of alloplastic and allogenic materials and guided tissue regeneration techniques has reached a high level of scientific research and clinical application, the predictable prognosis of these techniques is still limited in comparison with autogenous bone, also called the "Gold standard". Autogenous bone has additional mechanical (cortical) and osteogenic (cancellous) properties, because of graft morphology, that are unequalled by any allograft, xenograft or alloplastic material. However, biomaterials can be used today very successfully in some indications, reducing the need for second surgery to harvest bone.

It is truly remarkable to observe how much grafting techniques have evolved in recent years.

Through a better understanding of the biology of bone healing, bone regeneration and bone remodeling in combination with grafting procedures, it is possible today to treat almost every patient with implant supported restoration. We are able to rebuild a functional alveolar crest, permitting adequate implant insertion even in cases with extreme bone atrophy and bone height less than a few millimeters, and to get similar long-term results as for implantation in non-grafted bone.

There are several possibilities for augmentation of bone volume. Depending on the situation, indication and adequate diagnosis, the treatment options can be extended, from minimally invasive procedures with locally harvested bone grafts in local anesthesia, to very sophisticated grafting techniques for 3D bone reconstruction with extra oral harvested bone grafts in combination with orthognathic surgery procedures.

This book aims to present the different options of bone reconstruction. After a broad overview of the biology of bone healing, radiologic diagnosis and treatment planning, the different donor sites for harvesting autogenous bone, such as the mandible, the cranium, the tibia and the hip, are described step by step to facilitate the comprehension of the clinical procedures. The illustrations and photographs are designed to demonstrate the different grafting techniques, in all their detail. The information presented includes the underlying scientific concepts of the different augmentation methods, from bone splitting and lateral bone block grafting with mandibular bone, to 3D reconstructions of complicated vertical bone defects with intra or extra oral harvested bone grafts, GBR techniques and biomaterials, and augmentation with distraction osteogenesis, as well as detailed guidelines for practical application. A section on soft tissue management in combination with bone grafting procedures describes different incisions to enable good cover of the grafted area and to prevent flap necrosis and exposure of the grafted bone. The tunnel technique is also presented as a possibility to reduce the risk of graft exposure in high risk patients, e.g. smokers.

All these techniques are well demonstrated, outlining predictable protocols for each technique. The book provides the surgeon with basic knowledge about bone and biologic procedures of bone transplantation, allowing him to make the right choice of the augmentation procedure and material.

Each chapter offers exhaustive information on its topic, with much attention given to the underlying scientific concepts. Extensive case reports with step-by-step documentation allow readers to get an impression of what is possible today in the 3D reconstruction procedures of the alveolar crest. Important criteria for success are presented, as well as possible complications and their treatment. The book concludes with a look at the growth factors and the temporary restoration of patients with extensive bone augmentation procedures.

This book is intended for everyone who desires a comprehensive review of the clinical application of bone grafting, with a scientific background.

Finally, we would like to thank all our contributors for their excellent cooperation and the high quality of their chapters and illustrations. Special thanks to Dr. Charles Khoury for his manuscript review, probing questions, positive critical remarks and creative ideas. Thanks to Dr. Zeina Antoun for her help with the linguistics.

We would like also to thank the entire team at Quintessence Publishing for their excellent support and patience during this time.

Finally, many thanks to our families for their support and understanding.

The Editors

Editors and Contributors

Editors

KHOURY Fouad, DMD, PhD
Professor & Chairman
Privatklinik Schloss Schellenstein
Olsberg, Germany.
Department of Oral & Maxillofacial Surgery
University of Muenster, Germany

ANTOUN Hadi, DDS, CES, DU
Past Clinical Assistant
Department of Oral Implantology,
Paris 7 University
Private Practice
Paris, France

MISSIKA Patrick, DDS
Clinical Professor & Chairman
Department of Oral implantology,
Paris 7 University
Paris, France

Contributors

NEFUSSI Jean Raphaël, DDS, MS, PhD
Professor
School of Dentistry, Paris 7 University
France

CHIAPASCO Matteo, MD
Head Unit of Oral Surgey
Department of Medicine, Surgery, and Dentistry
SanPaolo Hospital †- University of Milan, Italy

CASENTINI Paolo, DDS
Unit of Oral Surgery
Department of Medicine, Surgery, and Dentistry
SanPaolo Hospital †- University of Milan, Italy

LACAN Alain, MD
TEMAN Gil, MD
SARAZIN Laurent, MD
SUISSA Mickael, MD
Radiologists
Paris, France

NEUGEBAUER Joerg, DMD
Interdisciplinary Dep. for Oral Surgery and Implantology
Dep. for Craniomaxillofacial and Plastic Surgery
University to Cologne
Cologne, Germany

TUNKEL Jochen, DMD, MOM
Periodontologist
Privatklinik Schloss Schellenstein
Olsberg, Germany.

KHOURY Charles, DDS, DES, CES, DU
Department of Prosthodontic,
School of Dentistry
St. Joseph University,
Beirut, Lebanon.

VINCI Rafaele, MD, DMD
Head of Advanced Oral Surgery Unit
Department of Dentistry
Vita-Salute University
Milan, Italy.

JAKSE Norbert, MD, DDS, PhD
Professor & Chairman
Department of Oral Surgery and Radiology
School of Dentistry
Medical University of Graz
Graz, Austria

MAIORANA Carlo, MD, DDS
Professor & Chairman
Oral Surgery and Implantology
University of Milan, Italy

ZOELLER Joachim E, MD, DMD, PhD
Professor & Chairman

LAZAR Frank C, MD, DMD
Interdisciplinary Dep. for Oral Surgery and Implantology
Dep. for Craniomaxillofacial and Plastic Surgery
University to Cologne
Cologne, Germany

MATTOUT Paul, DDS, MS, PhD
Marseille, France.

HAGE Georges, DDS, MS
Clinical Assistant, Department of Periodontology
University Paris 6
Paris, France

CHEMALY Cynthia, DDS, CES, DU
Saint-Joseph-University
Beirut, Lebanon

BESSADE Jacques, DDS, CES, DU
Paris, France

HAPPE Arndt, DMD
Oral surgeon
Muenster, Germany

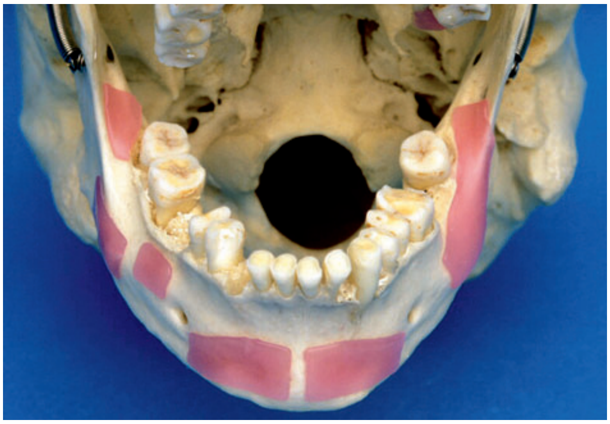

Fig 6-30 Mandibular donor sites for a block graft.

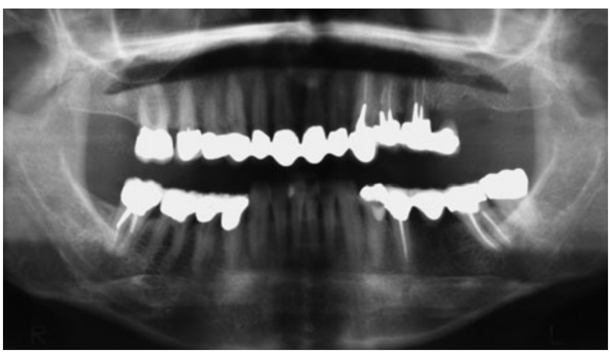

Fig 6-31 The extent of the external oblique line and the inferior dental nerve trajectory are visible on the panoramic X-ray.

Fig 6-32 Profile teleradiography is always needed in a diagnostic approach prior to harvesting a chin graft.

icillin[32] (2 g per day) is prescribed in cases where a sinus floor graft is also performed.

In all case, a chlorhexidine 0.02% mouth rinse is prescribed, in addition to analgesics three times daily for 1 week.

Harvesting of intra-oral bone for block grafting is often performed under local anesthesia in conjunction with oral or intravenous sedation. General anesthesia is indicated for large reconstructions involving multiple donor sites, as well as for surgery exceeding 3 hours.

Harvesting bone from the ramus

An inferior alveolar nerve block is usually avoided. Local vestibular and lingual infiltration with 4% articaine and 1:100,000 epinephrine (Ultracain DS forte®, Avantis) is sufficient in most cases and decreases the risk of injury to the inferior alveolar nerve. A patient who retains some sensation can inform the surgeon when he approaches the mandibular canal.

A trapeze-like incision, followed by the elevation of a mucoperiosteal flap (similar to that used for the removal of impacted wisdom teeth) is used to expose the bone at the level of the external oblique ridge to a length of 3–4 cm and 2 cm deep.

The graft is harvested with abundant saline irrigation according to a precise protocol using the MicroSaw® (Dentsply Friadent, Mannheim, Germany)[30] as described below (Fig. 6-33). The MicroSaw® technique was developed in 1984 to create a bony lid for the apical resection of mandibular molars. It consists of a thin diamond disk with a diameter of 8 mm that is mounted on an angle piece or a hand piece, with a disk protector to prevent any injuries of the soft tissue.

The volume of the block to be harvested depends on the size and extent of the external oblique ridge and the bone quantity needed for the grafting procedure (Fig. 6-34). Three osteotomies are performed with the diamond disk: two proximo-vertical (Fig. 6-35a,b) and one baso-horizontal (Fig. 6-36). The final osteotomy, on the occlusal crestal site, is achieved with a thin, 1-mm drill bur (Fig. 6-37) because of poor access to this site with the MicroSaw®. Depending on the extent of the external oblique line, the first vertical incision is performed mesially with the MicroSaw®

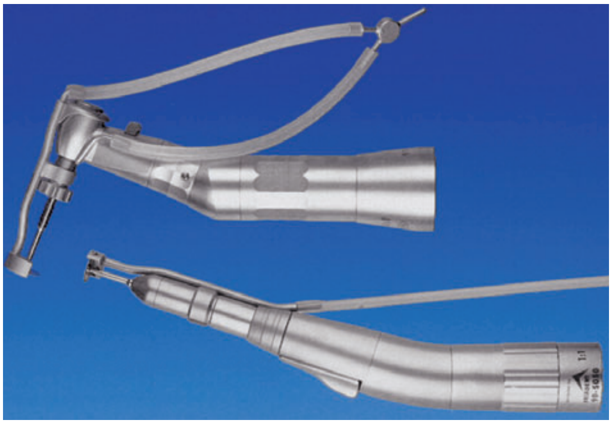

Fig 6-33 MicroSaw® special instrumentation (Friadent, Dentsply): hand piece and angle piece with diamond disc and tissue protectors.

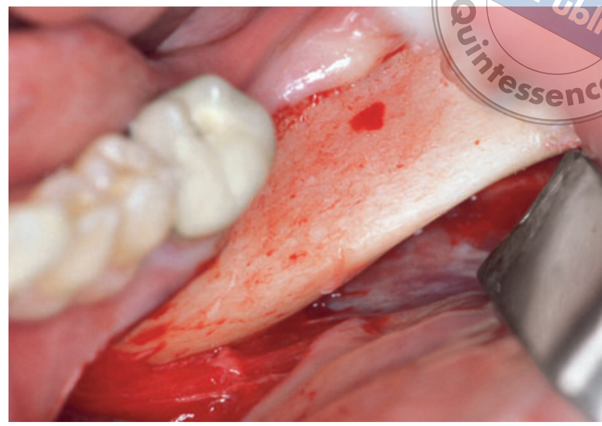

Fig 6-34 A clinical view of the external oblique line.

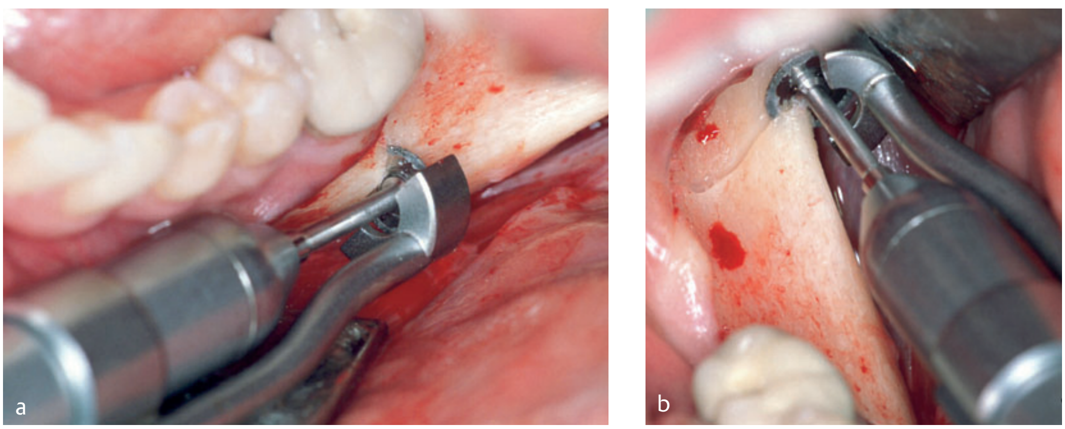

Fig 6-35a,b (*a*) Mesial vertical incision made with the MicroSaw® hand piece. (*b*) Distal vertical incision made in the same way. The disk protector reduces the risk of damage to soft tissues.

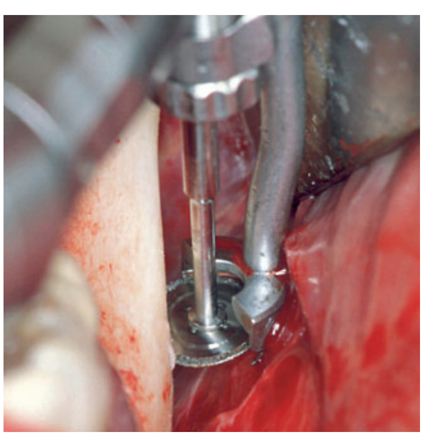

Fig 6-36 Apical connection of both vertical incisions is carried out using the MicroSaw® angle piece.

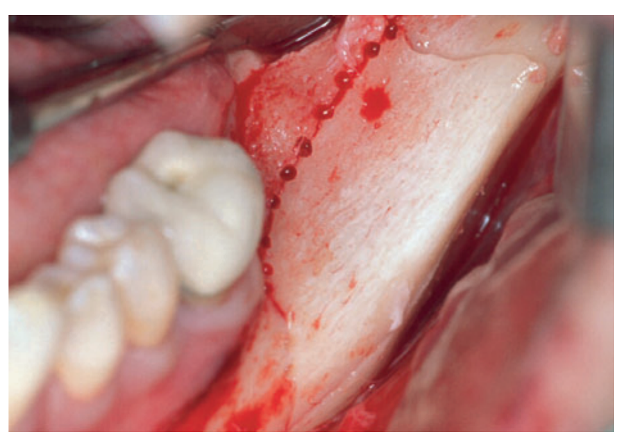

Fig 6-37 Crestal connection of both vertical incisions is performed with a drill bur.

Fig 13-11 Three-dimensional morphological structure of bioactive glass (BioGran™).

defect walls.[72] Clinical studies evaluated the use of bioactive glass combined with autogenous bone as a grafting material for maxillary sinus augmentation. By 16 months, Tadjoedin et al. found no difference in bilateral sinus grafts between autogenous bone alone and a mixture of 50% BioGran™ and 50% autogenous bone.[83] Another study suggested that a bioactive glass/autogenous bone graft combination used in one-stage sinus augmentation yields sufficient quality and volume of mineralized tissue for predictable simultaneous implant placement in patients with 3–5 mm of bone height prior to grafting.[21]

It would be interesting to evaluate implant survival results using this material alone and not combined with autogenous bone as previously reported in sinus augmentation.

Phycogene hydroxyapatite material

(courtesy of Prof. Dr. Rolf Ewers, Vienna)

Characteristics

AlgiPore®/C GRAFT™/AlgOss® (ACA) is a non-animal augmentation biological material derived from the calcium-encrusted marine algae *Corallina officinalis* (phycogene). Manufacture involves thermal treatment of the native algae and hydrothermal transformation of the calcium carbonate ($CaCO_3$) into hydroxyapatite [$Ca_5(PO_4)_3OH$]. During the production process, the organic components are completely removed. The final product consists of a minimum 98% apatite phase with an interconnecting micro-porous structure.[27]

The unique three-dimensional morphological structure of the calcite skeleton of the raw algae is maintained throughout the process until production of the final material. Details of the apatite ultrastructure can be observed by scanning electron microscopy (Fig. 13-12). The particles of the biomaterial carry a regularly arranged pore system (mean pore diameter of 10 μm) that is periodically separated (mean interval 50–100 μm) by interconnected microperforations (mean perforation diameter of 1–3 μm) (Figs. 13-13 and 13-14). The average specific pore volume of the bioceramic is 1.07 cm^3/g, while the average specific area is 32–50 m^2/g.

Human histology results

Prior to implant placement in the grafted sinus, 797 core samples were harvested, taken after different healing times, and these core samples were prepared to histology sections according to the method of Donath. From this histology, the authors were able to demonstrate the resorption kinetics of ACA. Parts of this histological work-up and the histomorphometric results had already been published by Schopper et al.[74]

At 11 months, the ACA granulate was partially resorbed and the lower pores were filled with newly formed bone (Fig. 13-15). Most of the tubuli were filled with cells or they were creeping in. The ACA biomaterial was resorbed either enzymatically or by osteoclasts (Fig. 13-16). Osteoclasts formed a huge lacuna (yellow circle). The black arrow shows the collagen fibers preceding the border of calciogenesis (black line) (Fig. 13-17). Osseointegration of the ACA particles was noted. This result was also achieved with the addition of PRP to the augmentation mixture (Fig. 13-18).

A long healing time showed almost complete formation of trabecular bone structures with remodeling processes (Fig. 13-19). Most of the ACA particles were surrounded by newly formed bone in different maturation phases, emphasizing good osseointegration due to the resorption kinetics and new bone formation (creeping substitution). Owing to the netlike connection between the particles, the newly formed bone acquires a trabecular structure comparable to the normal human spongy bone structure.

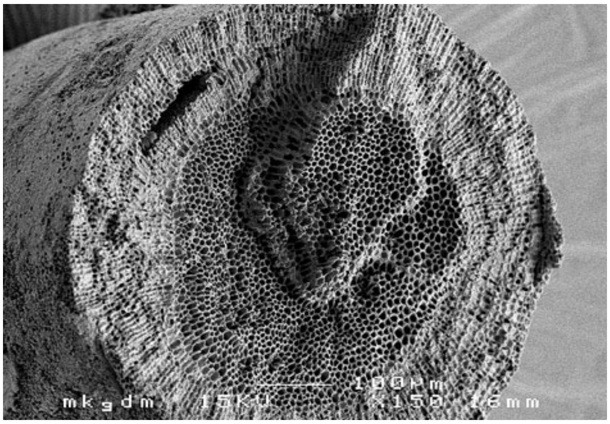

Fig 13-12 Three-dimensional morphological structure of the calcite skeleton of the raw algae is maintained from the beginning through to production of the final material (190x; white bar, 100 µm).

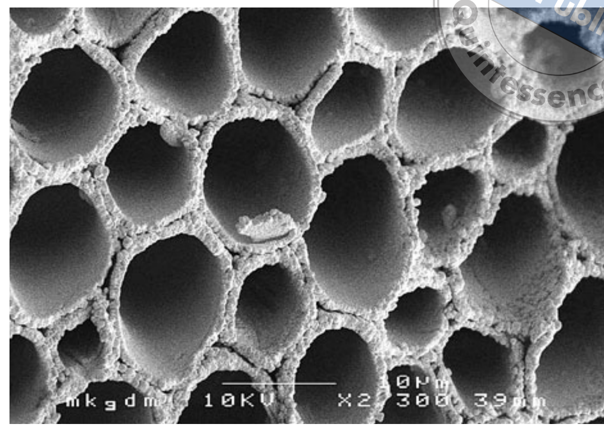

Fig 13-13 Cross-section (2300x; white bar, 10 µm).

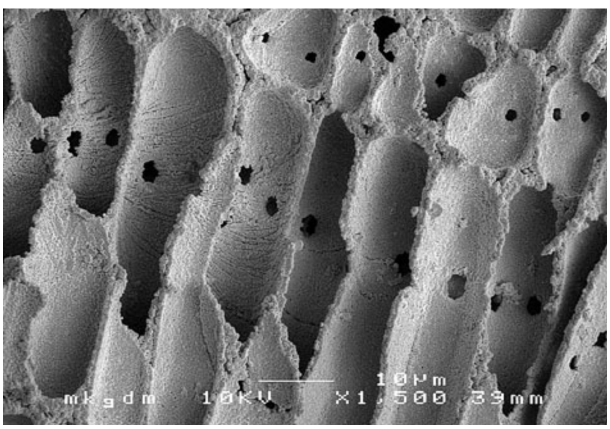

Fig 13-14 Longitudinal section. The particles of the biomaterial contain a regularly arranged pore system (mean pore diameter 10 µm) that is periodically septated (mean interval 50–100 µm) and interconnected with micro-perforations. The mean diameter of the perforations is 1–3 µm. (1500x; white bar, 10 µm).

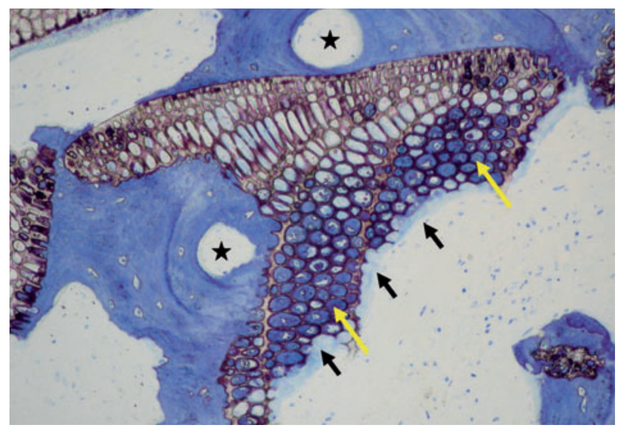

Fig 13-15 Enlargement (20x) of a histological specimen taken from a 73-year-old female after 11 months of healing. The AlgiPore®/C GRAFT™/AlgOss® (ACA) granule is partially resorbed and the lower pores are filled with newly formed bone. The two asterisks show two osteons and the bone is filled with many vital osteocytes. The lower portion of the granules is resorbing (*black arrows*) and the pores are filled with osteoid material (*yellow arrows*).

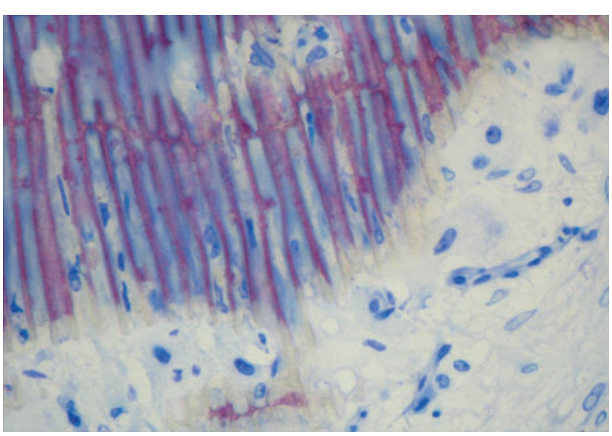

Fig 13-16 Magnification (40x) of a histological section with cellular migration from a 65-year-old female after 11 months of healing. Most of the tubuli are filled with cells, or the cells are creeping into the tubuli. The biomaterial AlgiPore®/C GRAFT™/AlgOss® (ACA) is resorbed either enzymatically or by osteoclasts.

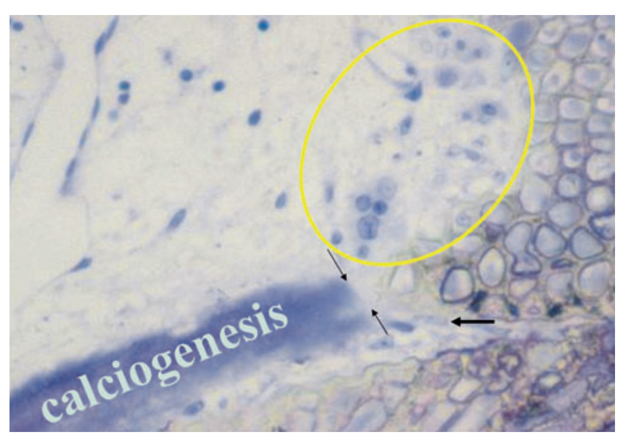

Fig 13-17 Magnification (20x) of a section taken from a 63-year-old woman after 7 months of healing, showing resorption and new bone formation induced by osteoclastic activity. The osteoclasts have formed a huge lacuna (*yellow circle*). The fat black arrow shows the collagen fibers that precede the border of calciogenesis (*thin black arrows*).