SECOND EDITION

# 20 Years of GUIDED BONE REGENERATION in Implant Dentistry

Edited by

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# Contents

To the pioneers of
guided bone regeneration

L. A. Hurley
C. A. L. Bassett
P. J. Boyne
T. P. Rüedi
T. Karring
S. Nyman
C. Dahlin
R. K. Schenk

# Foreword

To be provided with the opportunity to write a foreword for a significant new textbook represents both a true honor and privilege, but certainly also a genuine responsibility toward the authors. The work at hand not only represents a definite landmark in clinical dentistry but also has been carefully edited and in part written by my close friend of many years. The text comprehensively surveys 20 years of a fundamental and ever-growing field in implant dentistry and defines the current state of the art in guided bone regeneration. At the end of the first decade of the new millennium, guided bone regeneration and peri-implant contour augmentation are well established and inseparably connected to successful clinical implant dentistry. In fact, the knowledge of what techniques, procedures, and associated biomaterials are available today, linked to indispensable scientific documentation, provide the clinician with the basis for appropriate clinical decision making and—according to the practitioner's education and competence—subsequent treatment. In this context, the SAC concept, which objectively differentiates between straightforward (S), advanced (A), and complex (C) clinical situations, has particular importance and therefore has been strongly promoted by the author. Furthermore, as the title of this textbook suggests, guided bone regeneration, although an independent discipline, is strongly and primarily connected to implant dentistry, which now promotes prosthetically driven implant placement, rather than the antiquated bone-driven approach. The authors, all of them highly qualified and considered experts in the field, guarantee both the impressive quality of this work and its completeness in covering all the various aspects involved. Oral surgeons, periodontists, prosthodontists, general practitioners, and dental students are certain to find information that is relevant to their unique goals and perspectives. This textbook is destined to quickly reach the level of a true standard and long-standing reference.

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# Preface

The use of barrier membranes for the regeneration of bone defects has significantly changed implant dentistry in the past 20 years. This principle, often called *guided bone regeneration* (*GBR* or *GBR technique*), was first described in 1959 by Hurley and colleagues for experimental spinal fusion treatment. In the 1960s, the research teams of Bassett and Boyne tested microporous cellulose acetate laboratory filters (Millipore) for the healing of cortical defects in long bones and for osseous facial reconstruction, respectively. The authors used these filters to establish a suitable environment for osteogenesis by excluding fibrous connective tissue cells from bone defects. However, these pioneering studies did not immediately lead to a broad clinical application of barrier membranes in patients. The clinical potential of the membrane technique was not recognized until the early 1980s, when the research team of Karring and Nyman systematically examined barrier membranes in various experimental and clinical studies for periodontal regeneration. A few years later, barrier membrane techniques were tested in experimental studies on bone regeneration. Based on promising results in these studies, clinical testing of membranes began in implant patients in the late 1980s.

In 1994, after 5 years of intensive experimental and clinical work, the first edition of this textbook, *Guided Bone Regeneration in Implant Dentistry*, was published and generated a high level of interest among those in the field of implant dentistry. Since that time, the GBR technique has continued to evolve, necessitating an updated analysis of its scientific basis and clinical applications. The result is in your hands—the second edition of the GBR book, *20 Years of Guided Bone Regeneration in Implant Dentistry*.

This book is again written for the clinician with interest and experience in implant dentistry. The first four chapters focus on the basic science of GBR in implant dentistry. These chapters help the reader to understand the biologic and biomaterial background of this well-documented and well-established surgical technique in implant dentistry—essential knowledge for the use of barrier membranes in patients. As an introduction to the topic of the book, chapter 1 discusses the development of the GBR technique over the past 20 years. In this chapter, the four factors important for a successful regenerative outcome are described. Chapter 2 covers the biologic basis of bone regeneration and presents a scientific update on bone formation and remodeling. It features excellent histologic images obtained using undecalcified sections over the course of more than 30 years of experimental orthopedic research. Chapter 3 describes the characteristics, advantages, and disadvantages of nonresorbable and bioresorbable barrier membranes used in implant dentistry. Chapter 4 contains information about the various types of bone grafts and bone substitutes routinely used in combination with barrier membranes. These bone fillers not only provide support and thus help prevent membrane collapse but also influence new bone formation and bone remodeling in the defect area. The various characteristics of bone fillers, such as their osteogenetic and osteoconductive potential and substitution rates, are presented based on various experimental studies.

Chapters 5 through 9 focus on the clinical applications of GBR. Each chapter presents specific indications and describes the criteria for patient selection, the step-by-step surgical procedure, and aspects of postoperative treatment. Emphasis is placed on incision technique, flap design, the handling and placement of barrier membranes, the combination of membranes with autogenous bone grafts and low-substitution bone fillers, and approaches to wound closure. These five clinical chapters reflect the immense progress of GBR in the past 10 to 15 years and the current clinical status of GBR in implant dentistry.

As editor, I cordially thank all the authors and coauthors for the great amount of time and effort they contributed to the realization of this textbook. It has been a very intensive but satisfying experience to collaborate with colleagues of such quality. I also thank Ms Jeannie Wurz for her excellent work in editing and checking all manuscripts prior to submission to the publisher. Last but not least, I thank the staff of Quintessence Publishing for their excellent collaboration in completing this book and again providing superb quality in their work and printing.

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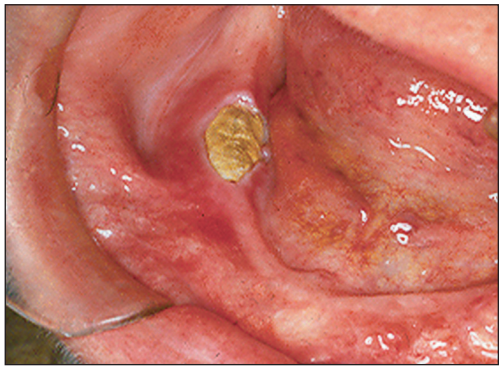

**Fig 4–14** Mucosal dehiscence of a coral-derived xenogeneic block 4 years after augmentation of an edentulous mandible. (Courtesy of Dr N. Worsaae, Copenhagen University Hospital, Denmark.)

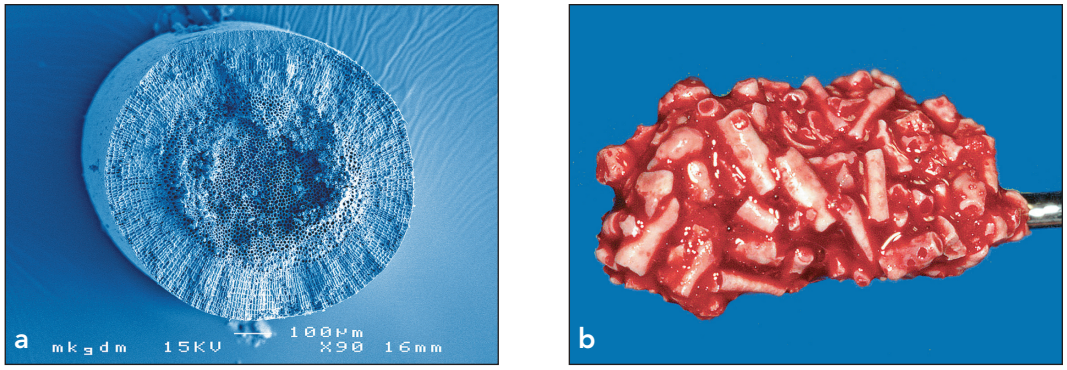


**Fig 4–15** Xenogeneic HA derived from calcifying algae. *(a)* Scanning electron microscopic image. *(b)* Algae-derived xenograft mixed with blood just before clinical application.

There is also a group of marine algae that consists of a calcified exoskeleton made of calcium carbonate. The natural material is converted into fluorhydroxyapatite through an exchange reaction with ammonium phosphate at around 700°C. The morphologic structure is built up of pores arranged in parallel with a mean diameter of 10 µm and connected through microperforations (Fig 4-15). The pore configuration is thus not ideal for vascular ingrowth, but cellular invasion of the pores and bone deposition directly on the material surface have been documented.[46,47] Neovascularization is instead expected to take place between the bone substitute particles. In contrast to coralline HAs, phycogenic fluorapatite undergoes slow resorption by enzymatic and cellular degradation but at a lower rate than autografts.[46]

## Animal-derived bone minerals

Xenografts derived from natural bone sources have been extensively investigated in multiple experimental and clinical studies. In particular, cancellous bovine bone has been used as a source for these bone substitute materials because of its close simi-

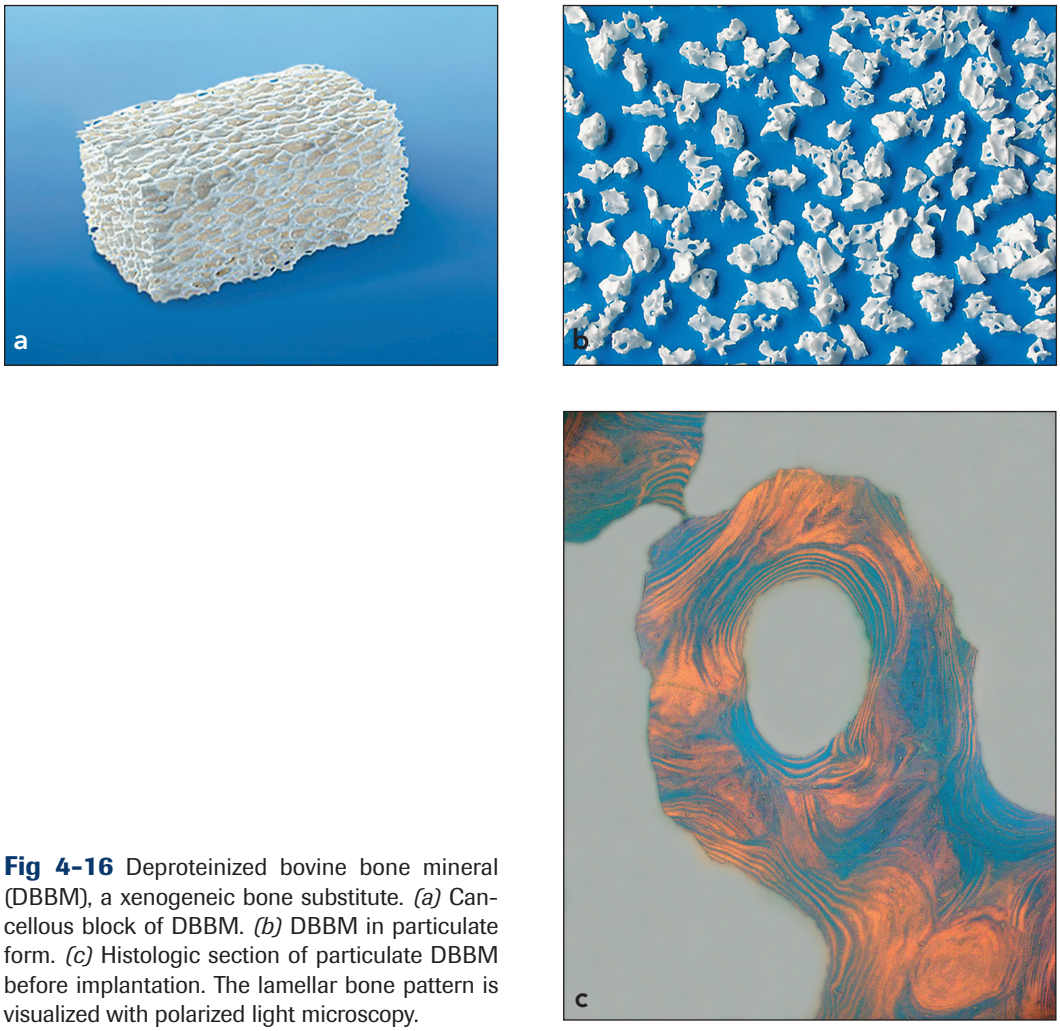


**Fig 4-16** Deproteinized bovine bone mineral (DBBM), a xenogeneic bone substitute. *(a)* Cancellous block of DBBM. *(b)* DBBM in particulate form. *(c)* Histologic section of particulate DBBM before implantation. The lamellar bone pattern is visualized with polarized light microscopy.

larity to cancellous human bone (Fig 4-16). The organic component is removed by heat treatment, by a chemical extraction method, or by a combination of the two to eliminate the risk of immunologic reactions and disease transmission. Since the first reports of bovine spongiform encephalopathy, there has been a particular focus on the ability of these extraction methods to completely eliminate all protein from the bovine bone source.[48,49] However, despite the hypothetical risk of organic remnants in bovine bone substitutes, there have been no reports of disease transmission from these materials. In contrast, a few cases of transmission of human immunodeficiency virus and hepatitis related to allogeneic materials have been reported.[50]

Deproteinized bovine bone minerals (DBBMs) are in general known to be biocompatible and osteoconductive, although the production methods have a strong impact on their biologic behavior. Two bovine bone substitutes derived from bovine cancellous bone, one deproteinized by high temperatures and the other mainly by chemi-

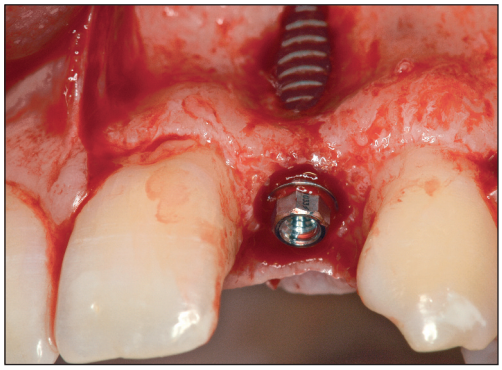

**Fig 6–11f** A narrow-neck implant has been placed with a correct three-dimensional position and axis, resulting in an apical fenestration defect.

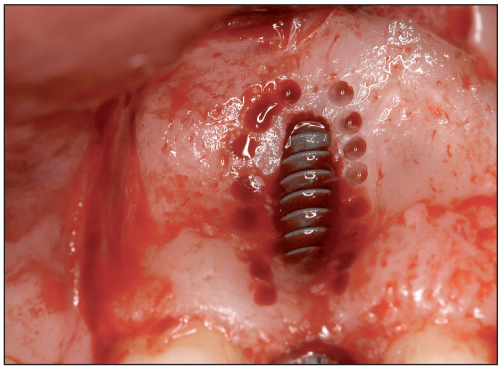

**Fig 6–11g** The peri-implant bone surface is cortical. Numerous drill holes are prepared to open the marrow cavity and cause bleeding in the defect area.

The crest width was sufficient to allow implant placement, but it also had a significant facial undercut. The implant bed was prepared with round burs, spiral and profile drills of increasing diameter, and copious cooling with sterile, chilled saline. This standardized low-trauma surgical approach helps to minimize trauma to the implant site.[47] The implant was inserted in a correct three-dimensional position and in an appropriate axis to allow placement of a screw-retained crown with a transocclusal access hole in the cingulum area.

This implant position and implant axis resulted, as expected, in a significant apical fenestration defect (Fig 6-11f). The surrounding bone structure was mainly cortical and required the perforation of the cortex with a small round bur to open the marrow cavity and to provoke spontaneous bleeding in the defect area (Fig 6-11g). Next, autogenous bone chips were harvested within the same flap at the nasal spine using a flat chisel, mixed with the patient's own blood, and applied to cover the exposed implant surface (Fig 6-11h). The autografts were covered with a second layer of DBBM granules to accomplish the contour augmentation (Fig 6-11i). These granules clearly overcontoured the local anatomy to serve as supporting anatomical structure for pleasing soft tissue esthetics (Fig 6-11j).

The augmentation material was covered with a collagen membrane using a double-layer technique (Figs 6-11k and 6-11l). This allowed good stabilization of the membrane serving as a temporary barrier. In addition, the membrane also helped to keep applied bone fillers in place. As a rule, collagen membranes can extend into the sulcus of adjacent teeth without causing any problems during healing. The surgery was completed with tension-free primary wound closure following the incision of the periosteum on the facial aspect. The wound margins were carefully adapted and secured in place with several interrupted single sutures (Fig 6-11m).

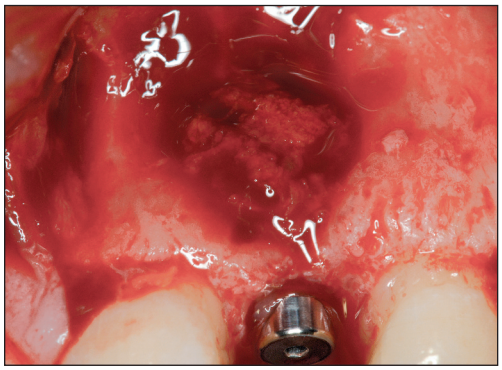

**Fig 6-11h** Locally harvested bone chips are applied to cover the exposed implant surface. These osteogenic autografts are supposed to speed new bone formation at the bone-implant interface.

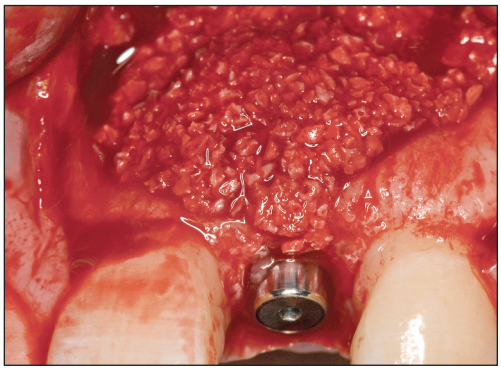

**Fig 6-11i** A second layer of DBBM particles is applied in the implant site. The granules are soaked in blood to facilitate application.

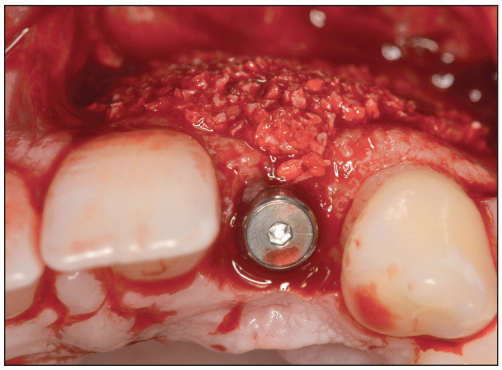

**Fig 6-11j** The occlusal view demonstrates the contour augmentation. The low-substitution bone filler is supposed to optimize the esthetic outcome and to provide a stable volume in the implant site.

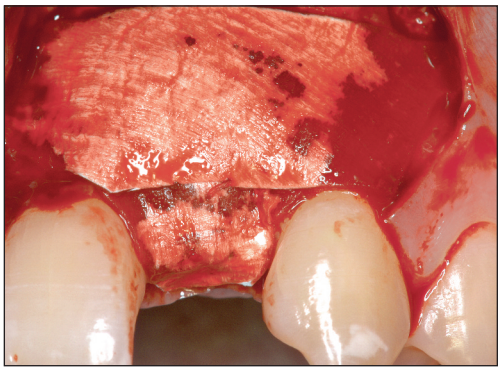

**Fig 6-11k** Application of a collagen membrane with a double-layer technique. The hydrophilic membrane is easy to manage as soon as it is moistened with blood.

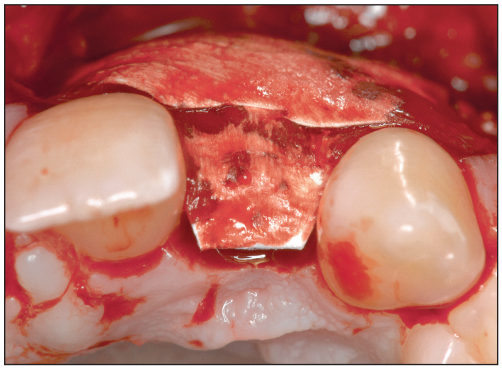

**Fig 6-11l** The membrane not only provides a temporary barrier function but also stabilizes the applied bone fillers.

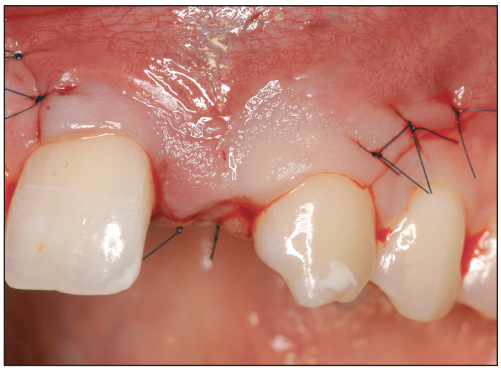

**Fig 6-11m** Following the release of the periosteum, tension-free primary wound closure is achieved with interrupted single sutures.