Bone Graft Substitutes

Edited by
Cato T. Laurencin, M. D., Ph. D.

Chair, Department of Orthopaedic Surgery
University Professor and Lillian T. Pratt Distinguished Professor of Orthopaedic Surgery
Professor of Biomedical Engineering and Chemical Engineering
University of Virginia

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This book is dedicated to my wife Cynthia and our children, Tiberius, Michaela, and Victoria.
Contributors

C. Mauli Agrawal, Ph.D., P.E.
Professor of Orthopaedics and Engineering
Director, Center for Clinical Bioengineering
The University of Texas Health Science Center
Houston, TX

Mohamed Attawia, M.B.B. Ch.
Senior Product Development Engineer,
Osteobiologics
DePuy AcroMed, a Johnson & Johnson Company
Raynham, MA

Mark D. Borden, Ph.D.
Senior Product Development Scientist
Interpore Cross International
Irvine, CA

Barbara D. Boyan, Ph.D.
Price Gilbert, Jr. Chair in Tissue Engineering
Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University
Institute of Bioengineering and Bioscience
Georgia Institute of Technology
Atlanta, GA

Scott P. Bruder, M.D., Ph.D.
Worldwide Vice President, Orthobiologics
DePuy Orthopaedics, DePuy AcroMed, and Mitek Worldwide, a Division of Ethicon Inc., Johnson & Johnson Companies
Raynham, MA

Robert W. Bucholz, M.D.
Professor and Chairman
Department of Orthopaedic Surgery
University of Texas Southwestern Medical School
Dallas, TX

Emilie V. Cheung, M.D.
Orthopaedic Surgical Resident
Department of Orthopedic Surgery
Drexel University School of Medicine
Philadelphia, PA

Kim Fitzgerald, B.S.
Senior Product Director
DePuy AcroMed, a Johnson & Johnson Company
Raynham, MA

Sergio J. Gadaleta, Ph.D.
Manager, Regulatory Affairs
Mitek Worldwide, a Division of Ethicon Inc., a Johnson and Johnson Company
Norwood, MA

Warren O. Haggard, Ph.D.
Vice President of Research
Wright Medical Technology, Inc.
Arlington, TN

Scott Hofer, D.O.
Major, United States Army Medical Corps
Orthopaedic Surgery Service
William Beaumont Army Medical Center
El Paso, TX

Joshua J. Jacobs, M.D.
Crown Family Professor of Orthopaedic Surgery
Rush Medical College
St Luke's Medical Center
Chicago, IL

David M. Joyce, B.S.
Case Western Reserve University
Cleveland, OH

Michael J. Joyce, M.D.
Orthopaedic Surgeon: Cleveland Clinic Foundation
Past-President (1997-1999) American Association of Tissue Banks
Associate Clinical Professor of Orthopaedic Surgery: Case Western Reserve University
Cleveland, OH

Sudha Kadiyala, Ph.D.
Director, Bone and Spinal Technologies
DePuy AcroMed, a Johnson & Johnson Company
Raynham, MA

Dhirendra S. Katti, Ph.D.
Assistant Professor of Orthopaedics and Biomedical Engineering
University of Virginia
Charlottesville, VA
Yusuf Khan, M.S.
Research Fellow
Center for Advanced Biomaterials and Tissue Engineering
Drexel University
Philadelphia, PA

John S. Kirkpatrick, M.D.
Associate Professor, Division of Orthopaedic Surgery
University of Alabama at Birmingham,
Chief, Division of Orthopaedic Surgery,
Birmingham Veterans Administration Medical Center
Birmingham, AL

Karl H. Kraus, D.V.M.
Professor
Orthopedic Research Laboratory
Tufts University School of Veterinary Medicine
North Grafton, MA

Joseph M. Lane, M.D.
Professor of Orthopaedic Surgery
Assistant Dean, Medical Students
Weill Medical College of Cornell University
Chief, Metabolic Bone Diseases and Orthopaedic Surgery
Hospital for Special Surgery
New York, NY

Cato I'. Laurencin, M.D., Ph.D.
Lillian T. Pratt Distinguished Professor and Chair, Department of Orthopaedic Surgery
University Professor
Professor of Biomedical Engineering and Chemical Engineering
University of Virginia
Charlottesville, VA

Jack Lemons, Ph.D.
Professor and Director of Laboratory Surgical Research
Division of Orthopaedic Surgery
University of Alabama at Birmingham
Birmingham, AL

Seth S. Leopold, M.D.
Associate Professor
Department of Orthopaedics and Sports Medicine
University of Washington Medical Center
Seattle, WA

Jay R. Lieberman, M.D.
Associate Professor
Department of Orthopaedic Surgery
David Geffen School of Medicine at UCLA
Los Angeles, CA

Treena Livingston Arinzeh, Ph.D.
Assistant Professor
Department of Biomedical Engineering
New Jersey Institute of Technology
University Heights
Newark, NJ

Christoph H. Lohmann, M.D
Department of Orthopaedics, University of Texas Health Science Center at San Antonio
San Antonio, TX
Department of Orthopaedics, University of Hamburg-Eppendorf
Hamburg, Germany

Marc Long, Ph.D.
Project Manager, Bone Graft Substitute Team, Research Projects
Smith & Nephew, Inc.
Memphis, TN

Jacquelyn McMillan, M.B.B.Ch., F.R.C.S.Ed., F.R.C.S. (Trauma & Orthopaedics)
Research Fellow
Georgia Tech/Emory Center for the Engineering of Living Tissues
Institute of Bioengineering and Bioscience
Georgia Institute of Technology
Atlanta, GA

Jack E. Parr, Ph.D.
Chief Scientific Officer
Wright Medical Technology, Inc.
Arlington, TN

Ashley R. Poynton M.D., F.R.C.S.I., F.R.C.S. (Trauma & Orthopaedics)
Spine Fellow
Hospital for Special Surgery
Weill-Cornell University Medical College
New York, NY

Don M. Ranly, D.D.S., Ph.D.
Principal Research Scientist
Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University
Institute of Bioengineering and Bioscience
Georgia Institute of Technology
Atlanta, GA

A Hari Reddi, Ph.D.
Lawrence J. Ellison Professor of Orthopaedic Research
Center for Tissue Regeneration and Repair
Department of Orthopaedic Surgery
University of California at Davis
Sacramento, CA
Kelly C. Richelsoph, M.S.
Senior Project Engineer
Wright Medical Technology, Inc.
Arlington, TN

Randy N. Rosier, M.D., Ph.D.
Professor and Chairman
Department of Orthopaedic Surgery
The University of Rochester
Rochester, NY

T. Kuber Sampath, Ph.D.
Vice President
Orthopedic Research & Development
Cell and Protein Therapeutic Division
Genzyme Corporation
Framingham, MA

Zvi Schwartz, D.M.D, Ph.D.
Professor
Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University
Institute of Bioengineering and Bioscience
Georgia Institute of Technology
Atlanta, GA

Edwin C. Shors, Ph.D.
Vice President, Research and New Technology
Interpore Cross International
Irvine, CA

Robert Talac, M.D., Ph.D.
Research Fellow
Departments of Orthopedic Surgery and Bioengineering
Mayo Clinic
Rochester, MN

William W. Tomford, M.D.
Professor of Orthopedic Surgery
Harvard Medical School
Massachusetts General Hospital
Cambridge, MA

Peter G. Whang, M.D.
Resident Physician
Department of Orthopaedic Surgery
David Geffen School of Medicine at UCLA
Los Angeles, CA

Michael J. Yaszemski, M.D., Ph.D.
Associate Professor of Orthopedic Surgery and Biomedical Engineering
Director, Tissue Engineering and Polymeric Biomaterials Laboratory
Departments of Orthopedic Surgery and Biomedical Engineering
Mayo Clinic
Rochester, MN
Foreword

In 1997, the leadership of the American Society for Testing and Materials (ASTM International) Committee F04 on Medical and Surgical Materials and Devices created a broad-based standards development activity in Tissue Engineered Medical Products (TEMPs). This was a proactive initiative borne out of the realization that in the near future a large number of medical products will be introduced into the marketplace that are fundamentally different from the current generation of products fabricated from conventional engineering materials. These new products will be based on some combination of cells, growth factors, human tissue and biologic or non-biologic biodegradable scaffoldings. Unlike previous standards development activities, the TEMPs standards initiative is occurring prior to or concurrent with the commercial introduction of the vast majority of the products to be covered by the standards. This situation provides a unique opportunity for consensus standards to accelerate the product development phase and regulatory processes (by virtue of the establishment of a common nomenclature and standardized test methods) in order to bring these promising treatment modalities to the patient in an expeditious fashion.

To produce the most relevant and useful standards, it is critical that the best science and the latest scientific developments are brought to bear. Thus, ASTM Committee F04 regularly conducts workshops and scientific symposia in targeted areas where the science is rapidly evolving and the need for standards is pressing. This volume entitled "Bone Graft Substitutes," edited by Dr. Cato Laurencin represents, in large part, the proceedings of a workshop held in November 2000 in Orlando, FL during ASTM committee week activities. Dr. Laurencin organized this workshop with help from Dr. Mohamed Attawia and recruited an impressive array of speakers, most of whom are recognized as leaders in their respective scientific, clinical and regulatory fields. The symposium organization effort was a cooperative endeavor between ASTM Committee F04 and the American Academy of Orthopaedic Surgeons Biological Implants Committee, and Biomedical Engineering Committee.

Bone defects resulting from traumatic, neoplastic, degenerative, inflammatory and congenital diseases are commonly seen in the clinical arena. Autologous bone grafting remains as the "gold standard" in treating such defects. In addition, autologous bone grafting is widely used to promote bone healing in the absence of bone defects in arthrodesis (fusion) procedures and in the treatment of delayed fracture healing. Unfortunately, only limited quantities of bone autograft are available and the harvesting of the graft can be associated with substantial morbidity. Thus, there is a great need for autologous bone graft substitutes—a need that can be filled by allograft tissue, synthetic bone graft substitutes, tissue-engineered bone products or a combination of the three. In this volume, the state of the art and science of bone grafting is presented in the context of the role of standards in the development, manufacturing, processing, testing, and regulation of bone graft substitute materials.

This monograph is divided into three sections. The first section presents a summary of the clinical use of bone allografts and allograft-based bone graft substitutes. This section
includes a chapter on allograft tissue banking and safety and a chapter on potential areas of standards development. The second section addresses the use of cells and growth factors as bone graft substitutes. Representatives from academia, industry, and the regulatory communities present their perspectives on the exciting opportunities and formidable challenges involved in bringing scientific advances in the field of bone tissue engineering to the patient care arena. The final section addresses the use of synthetic materials, including polymers and ceramics, for bone graft substitutes. As in the other two sections, there is a chapter addressing the regulatory and standards issues involved. All sections begin with an overview by some of the leading authorities in the field.

Overall, this is a unique monograph exploring not only the clinical and scientific aspects of bone grafting, but also the practical issues of bringing promising new bone graft substitutes to the marketplace in a fashion which insures their safety and efficacy. Dr. Laurencin, the editor of this book, is to be commended for his tireless efforts in bringing this project to fruition. He has assembled an accomplished multidisciplinary panel of authors who collectively have produced a comprehensive and authoritative summary of a complex field. This volume will serve as a foundation for future standards development activities in this area.

Joshua J. Jacobs, M.D.
Chairman, ASTM Committee F04

Jack Lemons, Ph.D.
Past Chairman, ASTM Committee F04
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Preface

In November 2000 a workshop sponsored by the American Society for Testing and Materials (ASTM International) brought together individuals from academia, industry, and regulatory bodies to examine important issues surrounding the development of Bone Graft Substitutes for Clinical Use. The effort, co-sponsored by the American Academy of Orthopaedic Surgeons (AAOS) achieved unprecedented success, and with the backing of ASTM International and AAOS a monograph largely based on the proceedings of that workshop has been produced. As with the workshop, the monograph provides various perspectives on the variety of bone graft substitutes currently available, and proposed for use. There is a special emphasis on outlining the challenges in the development, evaluation and use of these materials, along with analyses of regulatory and standards development concepts.

There are a number of individuals whose efforts in producing this monograph must be acknowledged. Dr. Barbara Boyan was the first individual I called, and came at her own expense to the workshop to provide a lead lecture. Not surprisingly, she was the first to answer the call for manuscripts for the book. I am indebted to her. Dr. Joseph Lane and Dr. Kuber Sampath also gave lead lectures and provided outstanding manuscripts for the book, while Dr. Arnold Kaplan re-routed a trip around the world to participate in the workshop. Drs. Jack Lemons and Joshua Jacobs, the leadership of ASTM International, were the catalysts for the workshop, and encouraged the production of this monograph, while Dr. Mauli Agrawal provided significant support in his roles as ASTM International publications committee liaison and section leader for the book. In addition, the production staff at ASTM must be commended for their work. Led by Ms. Kathy Dernoga, their diligence and professionalism made this book a reality. On the Academy side, Dr. Randy Rosier, Chair of the Biological Implants Committee and Ms. Jeanne Kennedy must be thanked for their encouragement throughout the development of the workshop and monograph.

I must thank the inner circle of individuals who helped me on this project. This includes my good friends and colleagues Dr. Mohamed Attawia and Dr. Dhirendra Katti who were active in all phases of the work. Finally I must thank my clinical mentors, Dr. Henry Mankin, Dr. Charles Epps, and Dr. Augustus White and especially my research mentor Dr. Robert Langer who taught me science, and who has been the guiding light for my career.

To all who have helped in producing this monograph, I give thanks.

Cato T. Laurencin, M.D., Ph.D.