Biomaterials in Orthopaedic Surgery

Federico Ángel Rodríguez-González

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About the image on the title page:
The three sets of circular lines symbolize the main components that contribute to advancements in biomaterials: the atom, the continuous search for improvements, and the scientific evolution of newer biomaterials.
To my wife, my four sons, and my daughter for their understanding, patience and support.

To the memory of two outstanding and brilliant surgeons:
  Professor Ángel Martinez-Villarreal, M.D.
  Professor Carlos de la Garza-Páez, M.D.

To my Professors of The University of Texas at Austin:
  Professor Robert N. Little, Ph.D., D.Ed
  Professor Stephen J. Gage, Ph.D.
  Professor Kenneth M. Ralls, Sc.D.
  Professor William R. Upthegrove, Ph.D.
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Foreword

Being invited by Dr. Federico Ángel Rodríguez to contribute the foreword to his book is an honor. It is greatly appreciated, since this work represents the culmination of his dreams and his many years of hard work and research.

Biomaterials are the keystone of our time; a “dreamed matter.” Matter because they are handled and felt on a daily basis, and dreamed because we expect them to be magical structures that will fulfill and resolve all of our needs. Much advancement has been achieved and many dreams have come true in recent times. A brief look at what has happened in the last century shows how the new materials have contributed to surgery and to the well-being of many people.

Knowledge of biomaterials is fundamental to their appropriate use in medicine. How many times the profession traumatology has been compared to that of a carpenter or a hardware dealer!

Orthopaedic surgery and traumatology have been marked by the instruments of the profession. Luminaries such as Danis, Kuntscher, Charnley, Müller, and so many others have contributed greatly to the field, and their names are associated with specific designs and materials. I am referring to skeletal biomaterials, but their importance in heart surgery, general surgery, urology, and in many other medical specialties should not be forgotten.

Biomechanics is also concerned with the study of biomaterials; for that reason it is important to review some of the basic concepts; as it is done in this book. The technical principles for the application of biomechanics are inherent in the results of mechanical tests. Much has been learned about the possibilities of a material when looking at results as well as failures.

Failures, such as fracturing and corrosion, have helped surgeons improve their techniques and engineers improve their designs. The path has always been walked along with patients who have agreed to try out new designs believed to improve upon the previous ones.

At the end of the nineteenth century, ivory implants were used. Later on screws and metallic plates were implanted with a basic and insufficient
anesthesia, with low quality materials, without mechanical principles that supported their placement, and with a high risk of infections. Those factors eliminated many brilliant ideas. The improvement of anesthesia techniques, the understanding of mechanics applied to biology, and the incorporation of advanced metals, metallic alloys, polymers, ceramics, and composites, on top of safer antibiotic therapies are the factors that have made orthopaedic surgery move forward.

We now have resistant materials to replace bones, and elastic materials capable to act as soft tissue substitutes. Stainless steels, commercially pure titanium, titanium base alloys, cobalt chrome alloys, polyethylene or methyl-methacrylate are essential items in orthopaedic surgery and traumatology.

Also, the establishment of bone and tissue banks has contributed to extend the possibilities of biomaterials. Bone or ligament grafts are organic biological materials with an inert structure similar to the one to be replaced and with the same integration problems as the rest of the biomaterials. Research and the observation of the established rules for the tissue banks allow having grafts of all kinds and probably, in a near future will allow a fast integration of grafts coming from other species, obtained \textit{in vivo}, to be implanted.

We are in the world of coatings, metals combined with biological substances in search of a better incorporation to the organism. In addition, we are experiencing a new period with reabsorbable materials that fulfill their function during a period of time and then gradually undergo reabsorption. Intelligent biomaterials are another emerging possibility.

Nowadays, an interesting period has begun involving materials implanted with cellular cultures. A material should no longer be only inert or active, but may require that cells adhere to the surfaces and differentiate and proliferate in the interior. Growth factors that stimulate cellular differentiation can be incorporated to the material to be considered live material.

The world of biomaterials, after years of sustained knowledge increase, is showing a new impulse and many possibilities are open; many investigations are needed. All this will be possible if history of the development of the different materials is spread, and if we have the basic knowledge offered by books like this one. This book has been written by Professor Federico Ángel Rodríguez thanks to his educational activity and a lifetime dedication to the mechanical study of materials. Professor Rodríguez has been studying biological integration of biomaterials in the organism, and he has been transmitting and shaping his knowledge in a didactic way, as the reader may note.

This book aims to satisfy the knowledge of doctors and engineers who, after finishing their professional studies, would like to enter their neighbor world and continue developing new implants.
Implantation of new materials will benefit patients and will contribute to solve some of the exciting challenges that many branches of surgery currently have.

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Preface

*Biomaterials in Orthopaedic Surgery* is directed to residents entering the specialty in orthopaedics and traumatology as well as to those professionals who wish to update their knowledge in the very extensive field of application of biomaterials in orthopaedics.

This book will be useful to professionals associated with orthopaedic devices, especially those involved in their design and manufacture.

Surgical practice in orthopaedics requires a strong interaction of different disciplines of science, such as biology, biomechanics, metallurgy, materials science, chemistry and, quite recently, biotechnology and nanotechnology.

The structure of the table of contents in this book is intended to help the reader obtain, through his learning process, a strong and firm grasp of the fundamental principles of biomechanics and biomaterials; both are essential to the study and comprehension of joint physiology and the issues dealing with their application in orthopaedic surgery.

This book will also help the reader have a clear frame of reference regarding the current state of science and infer the future direction of research needed to solve some of the remaining problems of biomaterials that are strongly linked to orthopaedics.

Every chapter except Chapter 8, “Clinical Cases,” has a number of bibliographic references, a list of books for further reading, and an enumerated set of educational objectives that serve as a teaching tool and are aimed to reinforce the content presented in each chapter.

The creation of this book was possible only with the support and help from many people. I wish to thank and acknowledge the following colleagues for their support and valuable assistance:

* Professor Carlos de la Garza-Páez M.D., former Chairman of the Orthopaedics and Traumatology Service of the Dr. José E. González University Hospital and of the Faculty of Medicine of the Universidad Autónoma de Nuevo León, for his extraordinary and enthusiastic support throughout the writing of the book.
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I also value the assistance received from many other distinguished orthopaedic surgeons that collaborated with their very extensive experience in the clinical cases.

Equally appreciated is the assistance of Professors Guillermo Elizondo-Riojas M.D. and José Bernardo Gutiérrez-Sánchez M.D., Ph.D., radiologists of The University Center for Diagnostic Images, for their revision and comments to the manuscript for the section “Artifacts of Metallic Implants in Magnetic Resonance Imaging (MRI)” presented in Chapter 9.

This book has been developed from the notes for a series of lectures given at the Dr. José E. González University Hospital. I want to express deep gratitude to the orthopaedic surgeons at the University Hospital.

Also, I wish to thank the ASM International publishing staff, including Mr. Scott Henry, Mr. Charles Moosbrugger, Ms. Pam Brown, Ms. Ann Britton, and Ms. Madrid Tramble, for their valuable assistance before and during the printing process of the book. My great appreciation to the reviewers for giving me critical advice of a constructive nature, I am also very grateful to individuals, institutions, and organizations that gave permission to use their data and illustrations, including ASTM International, The Hip Society, and the American Association of Tissue Banks. Full credit is given to the appropriate sources.

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Dr. Rodríguez has presented papers related with his research work in national and international forums. He has also been a consultant for several industrial companies.

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