

# Skeletal Injury in the Child

Third Edition

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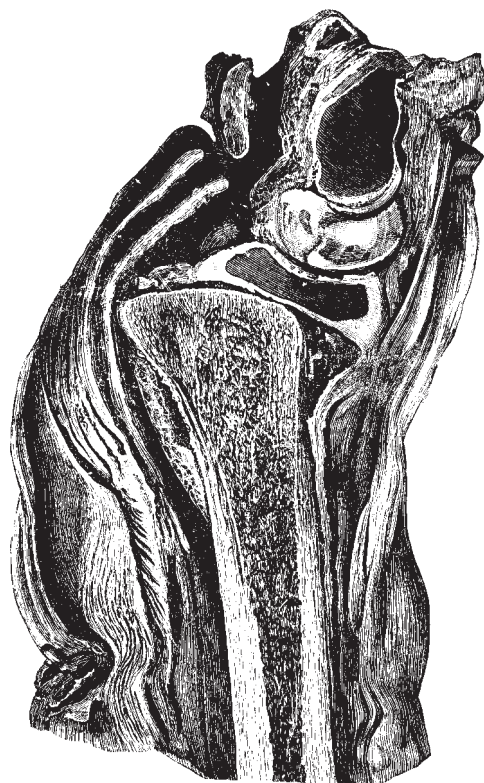
Director of Orthopaedics, Atlanta Medical Center, Consultant,  
Scottish Rite Children's Hospital, Atlanta, Georgia

# Skeletal Injury in the Child

Third Edition

With Forewords by Robert N. Hensinger, MD,  
and Newton C. McCollough, III, MD

With 1436 Figures



Springer

John A. Ogden, MD  
Director of Orthopaedics  
Atlanta Medical Center  
303 Parkway Drive, NE  
Atlanta, GA 30312, USA

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*To Dali  
who has provided immense support  
throughout the editions of this life work.*

*To Stephanie  
for providing experience in the diagnosis and treatment  
of the type 7 epiphyseal injury on her trampoline.*

*To John III  
for trying hard to get a fracture  
and leaving the space marbles on the stairs  
so that Dad could have one instead.*

*To Tyler-Davis  
for bringing up the rear and trying equally hard  
to challenge his environment.  
Perhaps you can make the next edition (hopefully not).*

*To Myke Tachdjian  
colleague and pioneer in pediatric orthopaedics,  
and most of all, a dear friend.  
You are very much missed by all of us who care for children.*

# Foreword

It is remarkable that Dr. Ogden has created a third edition of *Skeletal Injury in the Child*. It seems just a short time since the publication of the first (1982) and second (1990) editions. The previous texts have been so comprehensive that it is difficult to imagine he could add more information to the existing chapters and create additional new chapters.

One of the new chapters concerns the multiply-injured child, who presents an increasing problem in management. More children are surviving because of modern methods of emergency transportation and resuscitation. As a consequence, a significant number with extensive head and thoracoabdominal injuries are presenting to the emergency room, posing difficult problems in the coordination of care and timing of selective aspects of management. Survival rates are improving. Most of these children have concomitant musculoskeletal injury, which must be effectively treated because of the survival potential.

There is a new chapter on abnormal healing and growth plate disruption, with particular emphasis on bony bridge resection. Our ability to recognize epiphyseal bars has greatly improved. Now, we can better anticipate and recognize growth arrest before it becomes extensive. Dr. Ogden has provided many helpful suggestions on how best to document and approach these physeal injury complications.

More and more children are intensively involved in a wide variety of high performance athletics with resultant injuries. These are not limited to acute traumatic injury but include repetitive and stress-induced problems in the immature skeleton. The new chapter on the pediatric athlete covers many of these injuries. Other injuries related not only to sports but to nonathletic injury mechanisms are covered in the regional chapters.

An overview of the operative and nonoperative approaches in fracture management is introduced early in the book. For many years surgical treatment was avoided and conservative measures were recommended. More recently, surgical reduction has become extremely popular and is ready to be placed in its proper context. Dr. Ogden has had an extensive referral practice for the management of difficult children's fractures, which brings to the text an unusual assortment of injuries and fractures and their management.

A chapter deals with the variety of new diagnostic imaging technologies such as magnetic resonance imaging, computed tomography (CT), and three-dimensional reconstruction of CT scans, all of which have been incorporated throughout this wonderfully illustrated text. Dr. Ogden has also provided new pathologic material as it applies to specific anatomic regions. His selection of illustrations helps the physician focus on these problems. A unique contribution to the text is his interesting use of material from immature animals, carefully chosen to illustrate and better understand similar injuries in the young human.

This is a huge undertaking, even when it is done by a consortium of authors. It is even more so when it is done by an individual. However, Dr. Ogden has style and consistency that provides a smooth, flowing text and lack of repetition. He is a unique individual with an excellent understanding of the effect of trauma on

the immature skeleton. He has devoted his entire professional life, research, and clinical interests to the problems of skeletal injury to children, and this text continues a personal reflection of that interest and dedication.

This book is an important resource for anyone who manages musculoskeletal injuries of childhood. I think it is essential to emergency room physicians, pediatric and general orthopaedists, radiologists, pediatric residents, and students, all of whom can profit by having this text available to them. It is a wonderful correlation of anatomy, pathology, and diagnostic imaging of skeletal injury involving the child. There is no other text on fractures that has been more helpful to me or that I have found to be more comprehensive on this subject. This book is my first choice when faced with a unique or challenging problem in skeletal injury.

Dr. Ogden is to be congratulated.

*Robert N. Hensinger, MD*  
Chairman of Orthopaedics  
University of Michigan  
Past President, AAOS  
Ann Arbor, MI

# Foreword

In the third edition of *Skeletal Injury in the Child*, Dr. Ogden enlarges the scope of the immensely comprehensive second edition of this text. New chapters covering the subjects of polytrauma, growth plate disorders and their treatment, the pediatric athlete, and an overview of nonoperative and operative approaches to children's fracture care enrich this classic text even further.

Many chapters in this new edition have been enhanced by the use of new diagnostic imaging technology, especially magnetic resonance imaging and three-dimensional reconstruction of fractures. Beyond the addition of new subjects and material, each chapter includes even more examples of rare injuries and additional pathologic material.

The third edition of this monumental work will serve as an even greater resource for those involved in the care of children's fractures. The exhaustive coverage of each topic makes this book truly unique and an invaluable source of reference.

*Newton C. McCollough III, MD*  
Director of Medical Affairs  
Shriners Hospitals for Children  
Past President, AAOS  
Tampa, FLT



# Preface to the Third Edition

Childhood and adolescence are times of individual evolution. A growing mind needs to explore the external environs and to experiment with societal challenges. Taunting wildlife as a young Maasai may seem markedly different than trying to attain a 180° flip off a skateboard ramp in Atlanta; but both youngsters are responding to specific challenges provided by the conditions under which they live. These and a multitude of other opportunities, whether a recognized environmental risk or an accident, bring about the potential for injury. Such trauma frequently involves the growing skeleton.

Writing a book such as this and subsequently revising it has been a challenging endeavor each time. Revision is necessary as diagnostic methodology, treatment techniques, and further understanding of the biology of trauma to the immature musculoskeletal system evolve. Particularly, magnetic resonance imaging (MRI) and three-dimensional imaging of both computed tomography (CT) and MRI scans have become significant diagnostic tools that allow better appreciation of the extent of intraosseous and cartilaginous injury.

A single author obviously puts forth an individual concept (hardly authoritative) concerning the many and preferred methods of diagnosis and treatment. However, my written thoughts and concepts are hardly uniquely my own. I am indebted to family, friends, students, residents, fellows, teachers and colleagues throughout the planet who have provided intellectual interchange, education, philosophy, anecdotes, and unusual cases that have coalesced to create the concept of each edition of this book.

This concept had always been dual. First, there is significant emphasis on a scientific basis, namely the inclusion of developmental and pathologic (traumatic) anatomy and histology to emphasize the nuances of musculoskeletal injury prior to skeletal maturity. Techniques of reduction, whether surgical or nonoperative, must be undertaken only after considering the biologic principles and the dynamics of childhood injury. Second, a heavy emphasis on illustrative material gives an atlas-type format to the chapters, which can visually assist the physician, no matter what his or her specialty may be, when looking for a comparable case to solve an enigmatic radiograph.

Increasing trends in operative management are evident throughout this third edition. These methods often serve to control fractures more effectively, allowing quicker rehabilitation and fewer complications than “time-honored” conservative, nonoperative approaches. Many of these “older” methods, which are often acceptable, are retained, as some readers of this book do not have ready access to the equipment that allows certain diagnostic and surgical approaches. Many parts of the world still must rely on traction and casting because of limitations within the available medical system.

*John A Ogden, MD*  
Atlanta, GA

# Preface to the Second Edition

Since the publication of the first edition of this book, pediatric orthopaedics, including trauma, has grown immensely as a subspecialty. Appreciation of the anatomic and physiologic differences between children and adults has led to a proliferation of information in the pediatric and orthopaedic literature. The Shriners Hospitals for Crippled Children have supported my continued morphologic research into developmental skeletal biology. This particularly has allowed the study of pediatric chondroosseous injury in depth.

Updating concepts of cause, treatment, and biologic response to both continues the basic premise of this textbook—namely, the creation of a comprehensive, meaningful scientific rationale for the logical treatment of skeletal injury to the infant, child, and adolescent.

Accordingly, each chapter has been extensively revised to include pertinent new clinical and research information. Utilization of this expanding database should enable the physician to diagnose specific chondroosseous injury accurately, understand its natural history, treat the patient properly, and prevent common complications.

*John A. Ogden, MD*  
Tampa, FL

# Preface to the First Edition

Injury and the subsequent reparative response of the developing skeleton are frequently disparate from the mature skeleton. This book is an outgrowth of a desire to attain a morphologic understanding of the nuances of pediatric orthopaedic trauma. As clinicians, we have a tendency to focus on specific injuries, often ignoring trauma mechanisms and the relevance of underlying anatomy to both the initial injury and long-term consequences.

This book introduces the principles of diagnosis and treatment of fractures in children in a manner that first establishes a solid foundation of anatomy and pathomechanics on which treatment principles are based. Developmental anatomy is an overlooked facet of children's injuries, primarily because of the paucity of morphologic material available for use as source material. The unique opportunity to include the resources of the Skeletal Growth and Development Study Unit at Yale University allowed the inclusion of much material. In particular, I have attempted to translate the anatomic details into a form that has practical value. I believe that the emphasis on normal structure and function and the mechanisms of response to trauma is essential to good clinical practice.

Decision making in orthopaedics is experience-dependent in that it requires a proper mental set for what is normal for the given anatomic part at a particular age. Because of the lack of available anatomic material, the orthopaedist must rely on whatever resources he or she can muster for normal references for most of development. One can more readily accept the importance and significance of basic anatomic developmental changes if they are presented in close relation to current clinical situations in which the information is germane.

This work is primarily a clinical textbook, although discussions encompass aspects of skeletal developmental biology, particularly the response to trauma. My hope is that this book provides the medical student, the resident, and the practicing physician a logical and progressive plan of approach to children's fractures and allows ready storage retrieval and utilization of knowledge concerning each of the specific regions of injury. Because the study of orthopaedics must be a life-long process, this book is intended to serve both as an introduction to the study of skeletal injury and a basic text for continuing study. Hopefully, it will also have import to pediatricians, general practitioners, and radiologists. The orientation is to furnish a reference book that comprehensively covers the field of musculoskeletal trauma in the child and provides adequate information for both the specialist and the resident physician.

I have tried to develop a text for the teaching of basic and applied anatomy, mechanisms, concepts, and principles that are applicable to each area of injury in the pediatric patient. The factual and patient material has been carefully selected to support an understanding of these concepts and principles. In doing so I have attempted to integrate a scientific basis with the art of medicine. The test of the value of this book will be its effectiveness in stimulating further insight into the diagnosis and care of patients who face a lifetime of challenge. If this has been achieved, the work will have been worth the effort.

*John A. Ogden, MD*  
New Haven, CT

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As in previous editions, the morphologic and histologic studies have evolved because of the progressive support of the Carl Henze Foundation, the National Easter Seals Research Foundation, the National Institutes of Health, the AO/ASIF Foundation, the Shriners Hospitals for Children, and the Skeletal Educational Association. The opportunity to assist in orthopaedic care and to assess “natural” aspects of trauma in skeletally immature animals at Busch Gardens Zoological Park in Tampa, Florida and The Disney Corporation, Orlando, Florida is also much appreciated.

The illustrations have been accomplished by Janet Barber, Patty Barber, Deby Forrester-Gyatt, and Nina Sutherland. Appreciation is extended to the National Library of Medicine for providing microfilm of Poland’s classic treatise on epiphyseal injuries to produce the engravings used at the beginning of each chapter. The anatomic and histologic materials have been diligently prepared by Tim Ganey, PhD, Walter McAllister, and John Jacobs. Claire Keneally, Linda Pugh, and Fay Evatt have continued to compile comprehensive bibliographic material and patient databases. The multiple revisions have been tirelessly undertaken by Carolyn Massey. Pam Smith, RN, has been extremely helpful in getting patients back for follow-up studies. I also wish to thank my associates, G. Lee Cross, MD and Douglas F. Powell, MD for their sincere cooperation during the preparation of this text.

To cover the breadth of pediatric musculoskeletal injury, one can rely heavily on individual experience. However, no one orthopaedist has seen or will be likely to see every nuance of childhood fractures and dislocations. Accordingly, the illustrative cases in this book comprise not only my own patients but generous contributions from orthopaedic surgeons throughout the world. To each and every one of you I extend my sincere thanks and appreciation for those additional fracture examples that have made this volume as comprehensive as possible. If I have inadvertently failed to mention a contributor, please accept my apologies.

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Behrooz A. Akbarnia, MD  
Edward Akelman, MD  
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*John A Ogden*  
Atlanta, GA

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