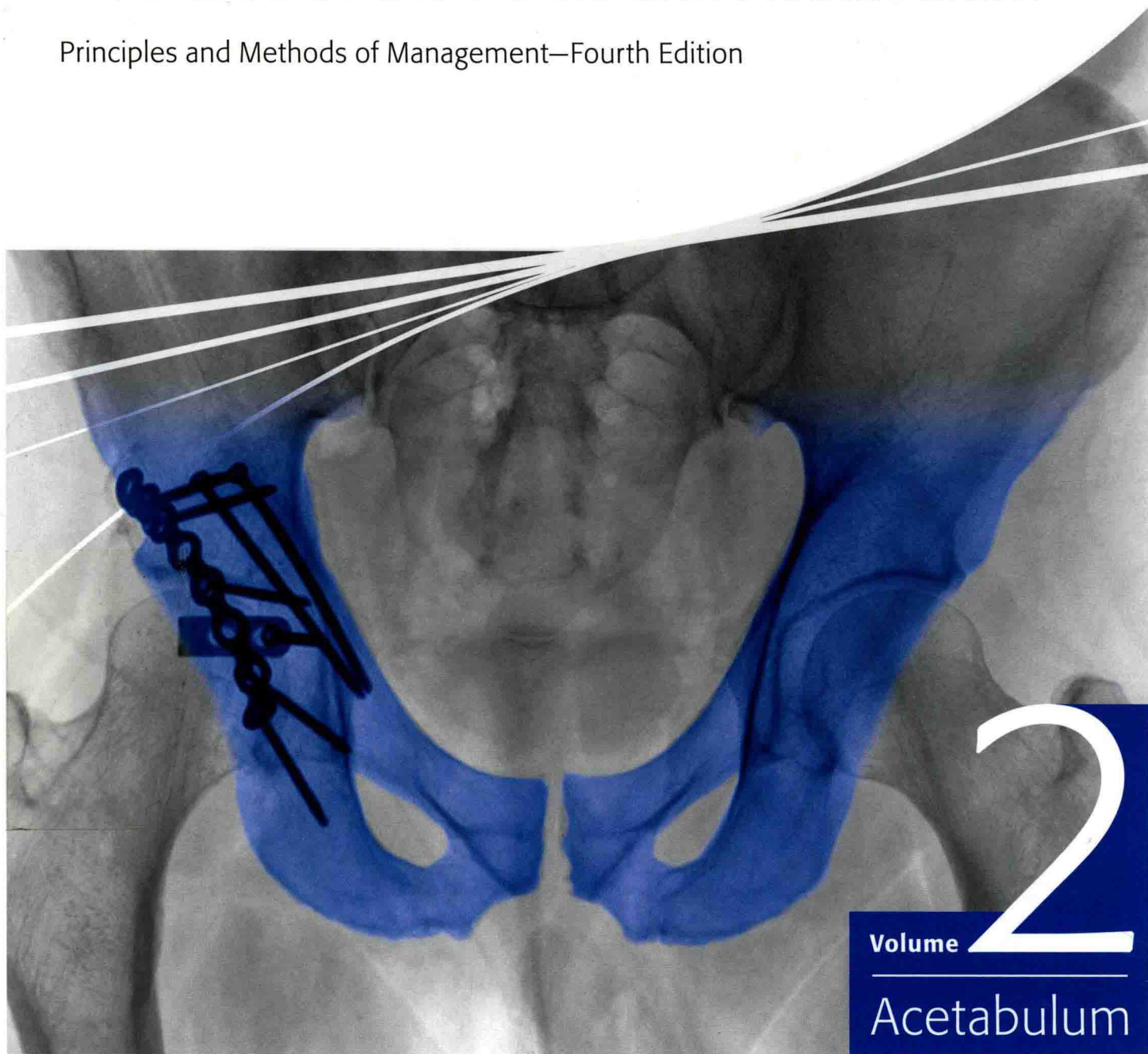


Marvin Tile | David L Helfet | James F Kellam | Mark Vrahas

Fractures of the Pelvis and Acetabulum

Principles and Methods of Management—Fourth Edition



Volume

2

Acetabulum

Marvin Tile | David L Helfet | James F Kellam | Mark Vrahas

Fractures of the Pelvis and Acetabulum

Principles and Methods of Management—Fourth Edition

Volume 2

Acetabulum



1377 illustrations/images

Hazards

Great care has been taken to maintain the accuracy of the information contained in this publication. However, the publisher, and/or the distributor, and/or the editors, and/or the authors cannot be held responsible for errors or any consequences arising from the use of the information contained in this publication. Contributions published under the name of individual authors are statements and opinions solely of said authors and not of the publisher, and/or the distributor, and/or the AO Group.

The products, procedures, and therapies described in this work are hazardous and are therefore only to be applied by certified and trained medical professionals in environments specially designed for such procedures. No suggested test or procedure should be carried out unless, in the user's professional judgment, its risk is justified. Whoever applies products, procedures, and therapies shown or described in this work will do this at their own risk. Because of rapid advances in the medical sciences, AO recommends that independent verification of diagnosis, therapies, drugs, dosages, and operation methods should be made before any action is taken.

Although all advertising material which may be inserted into the work is expected to conform to ethical (medical) standards, inclusion in this publication does not constitute a guarantee or endorsement by the publisher regarding quality or value of such product or of the claims made of it by its manufacturer.

Legal restrictions

This work was produced by AO Foundation, Switzerland. All rights reserved by AO Foundation. This publication, including all parts thereof, is legally protected by copyright.

Any use, exploitation or commercialization outside the narrow limits set forth by copyright legislation and the restrictions on use laid out below, without the publisher's consent, is illegal and liable to prosecution. This applies in particular to photostat reproduction, copying, scanning or duplication of any kind, translation, preparation of microfilms, electronic data processing, and storage such as making this publication available on Intranet or Internet.

Some of the products, names, instruments, treatments, logos, designs, etc referred to in this publication are also protected by patents and trademarks or by other intellectual property protection laws (eg, "AO", "ASIF", "AO/ASIF", "TRIANGLE/GLOBE Logo" are registered trademarks) even though specific reference to this fact is not always made in the text. Therefore, the appearance of a name, instrument, etc without designation as proprietary is not to be construed as a representation by the publisher that it is in the public domain.

Restrictions on use: The rightful owner of an authorized copy of this work may use it for educational and research purposes only. Single images or illustrations may be copied for research or educational purposes only. The images or illustrations may not be altered in any way and need to carry the following statement of origin "Copyright by AO Foundation, Switzerland".

Check hazards and legal restrictions on www.aofoundation.org/legal

Copyright © 2015 by AO Foundation, Clavadelstrasse 8, 7270 Davos Platz, Switzerland

Distribution by Georg Thieme Verlag, Rüdigerstrasse 14, 70469 Stuttgart, Germany, and Thieme New York, 333 Seventh Avenue, New York, NY 10001, USA

ISBN: 978-3-13-200631-7

e-ISBN: 978-3-13-200671-3

1 2 3 4 5 6



Preface

I began writing the first edition of this book, *Fractures of the Pelvis and Acetabulum* in 1982 and it was published in 1984, 30 short years ago. That first edition was a labor of love; an attempt to summarize the pioneering work of my mentor, Dr George Pennal on pelvic ring disruption and the work of Robert Judet and Emile Letournel on acetabular trauma. Along with the summary of the pioneering work in this field, new thoughts on classification, biomechanics, and treatment of these injuries was formulated. This was the adolescent phase of knowledge in this important and growing field of pelvic trauma.

By the time of the second edition in 1995, this field had come of age, and by the third edition in 2003, it had become a mature subspecialty of orthopaedic traumatology. This new fourth edition was deemed necessary because of significant advances in diagnosis and treatment, primarily using new technology.

This new fourth edition is published by AOTrauma. Almost all the chapters have been extensively rewritten. All the chapter authors, including the new ones, are internationally renowned and all have made substantial contributions to our pelvic knowledge base. The section on minimally invasive techniques using image guidance has also been expanded.

The drawings have been skillfully redone, and many new cases added. Also included are new in-depth videos of surgical approaches and reduction and fixation techniques by world renowned experts.

The chapters on outcomes of care have been rewritten and include an extensive bibliography.

The editors believed that with all the updated materials, the expanded edition should be divided into two volumes. Dr Mark Vrahas has joined with Dr James Kellam as coeditors of volume 1, *Pelvis*, and Dr David Helfet has remained as editor of volume 2, *Acetabulum*.

The first edition published 30 years ago was a small, single volume, largely single author, deeply personal book. Although the book has evolved in this fourth edition to a two-volume multiauthored text, with new videos, new illustrations, and extensive rewriting of the text, I am proud, along with my coeditors, that the basic philosophy of care of the severely injured patient has remained; care based on a careful assessment of the personality of the injury including both patient and fracture factors. Although our technology is rapidly changing, this philosophy will remain as the hallmark of exemplary patient care.



Marvin Tile, CM, MD, BSc(Med), FRCS(C)

Acknowledgments

Marvin Tile, MD

To my wife and companion, Esther, for her continuing love and support during our 60 years of marriage together.

To my growing family, Gary, Rosemary, Katy and her partner David Albert; Sari and her partner, Jacob Diskin, and Noah Tile; Stephen and his partner Helene, David, Rachel, and Abby Tile; Steve, Deborah, Ian and his wife Samantha, and Annie Cass; Andrew Tile and his partner, Candy Ramberansingh; Caya and Keeley Tile for their love and devotion and for bringing balance and joy to my life.

To my associate, Shirley Fitzgerald, whom I have known and worked with for 50 years, for her loyalty and friendship, and for helping so much with the first three editions of this book.

In addition to those acknowledged in the first and previous editions of this book, I am indebted to the following individuals for their support, dedication and hard work in bringing this fourth edition to completion:

I welcome Mark Vrahas as my coeditor along with David Helfet and Jim Kellam, and thank them for their role as section editors and in the reorganization of this edition into two volumes:

Volume 1

Pelvis—James Kellam and Mark Vrahas

Volume 2

Acetabulum—David Helfet

To Jim Kellam for leading the production of the excellent videos which are an essential part of this publication.

To all the authors who contributed to previous editions as well as this one, and all the new authors for their contributions to this fourth edition, which required much work in rewriting the chapters.

To the staff of the AO Education Institute, led by Urs Ruetschi for taking on the task of publishing the fourth edition of this book.

To Vidula H Bhoyroo, who took over as managing editor of this project, and with her very hard work, personality and intellect, and with the dedicated help of Jessada Mahatthananchai, Amber Parkinson, Jecca Reichmuth, and Roger Kistler brought this new edition to fruition. I and my coeditors are eternally grateful.

James F Kellam, MD

To my family, Lynda, Lindsay, Patrick as well as Stephanie and her husband Chris and our grandson Hudson for their support and understanding and adding enjoyment to my life.

To my patients who without their trust would never have allowed me to achieve the expertise and skill to be a compassionate and knowledgeable physician and surgeon.

We are grateful to Drs Michael D Stover, Keith Mayo, David Stephens, Stephen Sims, and Mark Reilly for producing the material for the surgical approach videos. Robin Green and Sergei Nikokoshev have done an excellent job in producing and editing the surgical approach videotapes. Our thanks to Urs Rüetschi and Kathrin Lüssi who had the vision and courage to start this project as well as Cristina Lusti. Our appreciation goes to Vidula H Bhoyroo, Jessada Mahatthananchai, Amber Parkinson, Roger Kistler, and Jecca Reichmuth for their support, never-ending patience, and most important their willingness to collaborate with the editors and authors to produce this book. Finally, we thank all the authors who did a tremendous job in producing up-to-date informative and well-documented chapters. Their support will make this book a true classic in the field of pelvic and acetabular fracture management.

David L Helfet, MD

To my wife, Molly, and children, Kelly and Arthur John (A.J.), for their continued love, support, and understanding.

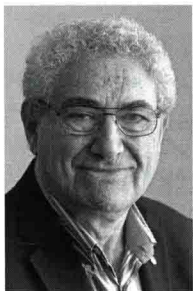
Also to all those colleagues, fellows, and residents who have contributed to my learning and maturation as a pelvic and acetabular fracture surgeon.

Mark Vrahas, MD

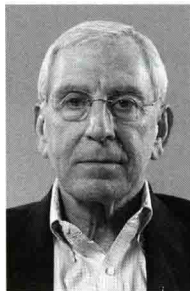
For my parents, Mark and Ruthann, who nurtured my dreams; my wife Cynthia who inspires me; and my sons Mark, Alexander, and Remy who fill my life with pride and joy.

Contributors

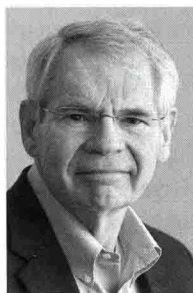
Editors



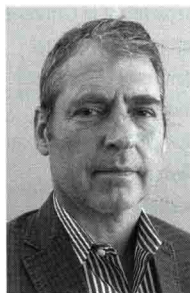
Marvin Tile, CM, MD, BSc(Med), FRCS(C)
Professor Emeritus, Surgery, University of Toronto
Orthopaedic Surgeon
Sunnybrook Health Sciences Centre
Room MG301
2075 Bayview Avenue
Toronto, ON M4N 3M5
Canada



David L Helfet, MD
Professor of Orthopaedic Surgery
Weill Medical College of Cornell University
Director, Orthopaedic Trauma Service
Hospital for Special Surgery/New York Presbyterian
Hospital
535 East 70th Street
New York, NY 10021
USA



James F Kellam, MD, FRCS(C), FACS, FRCS(I)
Professor
Department of Orthopaedic Surgery
University of Texas Health Science Center at Houston
6431 Fannin Street
Houston, TX 77030
USA



Mark Vrahas, MD
Robert W. Lovett Professor of Orthopaedic Surgery
Harvard Medical School
Chairman, Harvard Orthopaedic Trauma Initiative
55 Fruit Street, YAW 3C
Boston, MA 02114
USA

Authors

Timothy S Achor, MD

Department of Orthopaedic Surgery
Fellowship Director, Orthopaedic Trauma Fellowship
University of Texas Health Science Center at Houston
Memorial Hermann–Texas Medical Center
6400 Fannin Street
Suite 1700
Houston, TX 77030
USA

Jorge E Alonso, MD

Professor, Department of Orthopaedic Surgery
Director of Orthopaedic Trauma
University of South Alabama
3421 Medical Park Drive
Mobile, AL 36693-3330
USA

Mario Arduini, MD

University of Rome, "Tor Vergata"
Viale Oxford, 81
Rome 00133
Italy

David E Asprinio, MD

Professor and Chairman
Department of Orthopaedic Surgery
New York Medical College
Director of Orthopaedic Surgery
Westchester Medical Center
Macy Pavillion S106
95 Grassland Road
Valhalla, NY 10595
USA

Craig S Bartlett III, MD

Associate Professor of Orthopaedics
Medical Director of Orthopaedic Trauma
The University of Vermont
Orthopaedic Specialty Center
192 Tilley Drive
South Burlington, VT 05403
USA

Peter Bates, FRCS (Trauma and Orth)

Barts Health at Royal London Hospital
Orthopaedic Department
Second Floor
John Harrison House
Philpot Street
London E1 1BB
United Kingdom

Martin Beck, MD

Head, Clinic for Orthopaedic Surgery
Luzerner Kantonsspital
6004 Luzern
Switzerland

Martin D Bircher, FRCS

Pelvic Unit St George's Hospital and Medical School
Blackshaw Road
Tooting
London SW178OT
United Kingdom

Philip A Brady, MB, BCh, BAO, BMedSci, FRCS

(Tr & Orth)
Consultant Orthopaedic Surgeon
Blackrock Clinic
Rock Road, Blackrock
County Dublin
Ireland

Holly Brown Lenard, MD, PLLC

Orthopaedic Surgeon
11211 Prosperity Farms Road
Suite C-114
Palm Beach Gardens, FL 33410
USA

Eben A Carroll, MD

Assistant Professor
Department of Orthopaedic Surgery
Director of Orthopaedic Trauma
Wake Forest University School of Medicine
Medical Center Blvd
Winston-Salem, NC 27157-1070
USA

Musa Citak, Prof, Dr med

Endoklinik Hamburg
Holstenstraße 2
22767 Hamburg
Germany

Carol E Copeland, MD

Associate Professor
Department of Orthopaedics and Rehabilitation
Division of Orthopaedic Trauma
Penn State Hershey Medical Center
500 University Drive, H089
Hershey, PA 17033
USA

Colin V Crickard, MD

Department of Orthopaedic Surgery
Carolinas Medical Center
1025 Morehead Medical Drive
Suite 300
Charlotte, NC 28204
USA

Ulf Culemann, Prof, Dr med

Chefarzt der Klinik für Unfallchirurgie
AKH-Gruppe
Allgemeines Krankenhaus Celle
Siemensplatz 4
S 29223 Celle
Germany

David C Dewar, MBBS, B(Med)Sc, FRACS

Orthopaedic Surgeon
Department of Orthopaedics
John Hunter Hospital
University of Newcastle
Locked Bag 1
Hunter Region Mail Centre
Newcastle, 2310
Australia

Claudio Dora, Prof Dr med

Department of Orthopedics
University of Zurich
Balgrist Hospital
Forchstrasse 340
8008 Zürich
Switzerland

Thomas A Einhorn, MD

Professor and Chairman
Department of Orthopaedic Surgery
Boston University Medical Center
720 Harrison Avenue
Suite 808
Boston, MA 02118
USA

Wolfgang K Ertel, MD, FACS

Surgeon in Chief
Department of Special Orthopaedic and Trauma
Surgery
Charité
Campus Benjamin Franklin
Hindenburgdamm 30
12203 Berlin
Germany

Emily L Exten, MD

Department of Orthopaedic Surgery
Meriter Hospitals & Clinics
202 S Park Street
Madison, WI 53715
USA

Carl R Freeman, MD

Lieutenant Commander, USN
Assistant Professor of Surgery
F. Edward Herbert School of Medicine
Uniformed Services University of the Health Sciences
Department of Orthopaedic Surgery
Naval Hospital Jacksonville
2080 Child Street
Jacksonville, FL 32214
USA

Axel Gänsslen, Dr med

Consultant
Klinik für Unfallchirurgie, Orthopädie und
Handchirurgie
Klinikum der Stadt Wolfsburg
Sauerbruchstraße 7
38440 Wolfsburg
Germany

Reinhold Ganz, MD

Emeritus
University of Bern
Walchstrasse 10
3073 Gümligen
Switzerland

Sean E Garvin, MD

Assistant Attending Anesthesiologist
Hospital for Special Surgery
Clinical Assistant Professor, Anesthesiology
Weill Medical College of Cornell University
535 East 70th Street
New York, NY 10021
USA

Joshua L Gary, MD

Assistant Professor of Orthopaedic Surgery
University of Texas Health Science Center at Houston
Department of Orthopaedic Surgery
6400 Fannin Street
Suite 1700
Houston, TX 77030
USA

William H Geerts, MD

Thromboembolism Program
Room D674
Sunnybrook Health Sciences Centre
2075 Bayview Ave
Toronto, ON M4N 3M5
Canada

John T Gorczyca, MD

Professor of Orthopaedics
Chief, Division of Orthopaedic Trauma
University of Rochester Medical Center
601 Elmwood Avenue
Box 665
Rochester, NY 14642
USA

Douglas ST Green, MD

Hospital for Special Surgery
535 East 70th Street
New York, NY 10021
USA

Andrew Grose, MD

Department of Orthopedic Surgery
New York Medical College
Westchester Medical Center
19 Bradhurst Avenue
Hawthorne, NY 10532
USA

Karen Hand, MD

Memorial Hospital at Gulfport
1340 Broad Avenue
Suite 450
Gulfport, MS 39501
USA

John H Healey, MD, FACS

Professor of Orthopaedic Surgery
Weill Medical College
Cornell University
Memorial Sloan-Kettering Cancer Center
1275 York Avenue
New York, NY 10065
USA

Patrick DG Henry, MD, FRCSC

Assistant Professor
University of Toronto
Department of Surgery, Division of Orthopaedic
Surgery
Sunnybrook Health Sciences Centre
2075 Bayview Avenue
Toronto, ON M4N 3M5
Canada

Eero Hirvensalo, MD, PhD

Associate Professor
Helsinki University
Chairman, Musculoskeletal Division of Surgery
Helsinki University Hospital
Töölö Hospital
Topeliuksenkatu 5
00029 HUS, Helsinki
Finland

Alexander Hofmann, PD Dr med

Department of Orthopaedics and Trauma Surgery
University Medical Center
Johannes Gutenberg University
Langenbeckstr. 1
55131 Mainz
Germany

Jörg H Holstein, Priv-Doz, Dr med

Klinik für Unfall-, Hand- und
Wiederherstellungschirurgie
Universitätsklinikum des Saarlandes
66421 Homburg/Saar
Germany

Devon M Jeffcoat, MD

David Geffen School of Medicine at UCLA
10833 Le Conte Avenue
76-143 CHS
Los Angeles, CA 90095
USA

Richard J Jenkinson, MD, MSc, FRCS(C)

Assistant Professor, University of Toronto
Sunnybrook Health Sciences Centre
Room MG 321
2075 Bayview Avenue
Toronto, ON M4N 3M5
Canada

Matthew L Jimenez, MD

Clinical Professor of Orthopaedic Surgery
Illinois Bone and Joint Institute
Department of Orthopaedic Surgery
University of Illinois
8930 Waukegan Road
Morton Grove, IL 60053
USA

Eric E Johnson, MD

Mullikin Professor of Orthopaedic Surgery
David Geffen School of Medicine at UCLA
10833 Le Conte Avenue
Room 76-138
Los Angeles, CA 90095
USA

David M Kahler, MD

Professor, Department of Orthopaedic Surgery
University of Virginia Health System
Box 800159
Charlottesville, VA 22908-0159
USA

Ron Kodama, MD, FRCSC

Professor of Surgery, Division of Urology
University of Toronto
Sunnybrook Health Sciences Centre
Room MG 406
2075 Bayview Avenue
Toronto, ON M4N 3M5
Canada

Hans J Kreder, MD, MPH, FRCS(C)

Professor, University of Toronto
Orthopaedic Surgery and HPME
Chief, Holland Musculoskeletal Program
Marvin Tile Chair and Chief, Orthopaedic Surgery
Sunnybrook Health Sciences Centre
2075 Bayview Avenue
Toronto, ON M4N 3M5
Canada

Christian Krettek, Prof, Dr med

Medizinische Hochschule Hannover
Carl Neubergstrasse 1
30625 Hannover
Germany

William D Lack, MD

Department of Orthopaedic Surgery and Rehabilitation
Loyola University Medical Center
2160 S First Ave
Maywood, IL 60153
USA

Joseph M Lane, MD

Chief of Metabolic Bone Diseases Service
Department of Orthopaedic Surgery
Hospital for Special Surgery
523 East 72nd Street
New York, NY 10021
USA

Kelly Lefavre, BScH, MD, MSc (Epid), FRCS

Associate Professor, Department of Orthopaedics
Division of Orthopaedic Trauma
University of British Columbia
Vancouver General Hospital
3rd Floor Ortho Trauma
2775 Laurel Street
Vancouver, BC V5Z 1M9
Canada

Michael Leunig, PD, Dr med

Head of Orthopaedics
Schulthess Clinic
Lengghalde 2
8008 Zürich
Switzerland

Meir (Iri) Liebergall, MD

Professor
Chairman, Orthopedic Surgery Complex
The Hadassah-Hebrew University Medical Center
PO Box 12000
Jerusalem, il-91120
Israel

Jan Lindahl, MD

Head of Pelvis and Lower Extremity Trauma Unit
Helsinki University Hospital
Töölö Hospital
Topeliuksenkatu 5
00029 HUS, Helsinki
Finland

Ted Manson, MD

Associate Professor
R Adams Cowley Shock Trauma Center
Division of Orthopaedic Trauma
22 South Greene Street
Room T3R59
Baltimore, MD 21201-1544
USA

Jeffrey W Mast, MD

4790 Caughlin Parkway #140
Reno, NV 89519
USA

Keith A Mayo, MD

Professor of Orthopaedic Surgery
Director, Hansjörg Wyss Hip and Pelvis Center
University of Washington School of Medicine
1959 Northeast Pacific Street B307
Seattle, WA 98195
USA

Dana C Mears, MD, PhD

Clinical Professor of Orthopaedic Surgery
University of Pittsburgh Medical Center
Greater Pittsburgh Orthopaedic Associates
5820 Centre Avenue
Pittsburgh, PA 15206
USA

Berton R Moed, MD

The Hansjörg Wyss Endowed Chair in Orthopaedic Surgery
Professor and Chairman
Department of Orthopaedic Surgery
Saint Louis University School of Medicine
3635 Vista Avenue
7th Floor Desloge Towers
St Louis, MO 63110
USA

Rami Mosheiff, Prof, Dr med

Head of Orthopedic Trauma Unit
Department of Orthopedic Surgery
Hadassah University Hospital
Ein Kerem
PO Box 12000
Jerusalem, il-91120
Israel

Sean E Nork, MD

Professor
Harborview Medical Center
Department of Orthopaedic Surgery
University of Washington
325 Ninth Avenue
Box 359798
Seattle, WA 98104
USA

Markku T Nousiainen, BA(Hons), MS, MEd, MD, FRCS(C)

Assistant Professor, Department of Surgery
University of Toronto
Sunnybrook Health Sciences Centre
Suite 621
43 Wellesley Street East
Toronto, Ontario M4Y 1H1
Canada

Peter J O'Brien, MD, FRCS

Associate Professor
Head, Division of Orthopaedic Trauma
Department of Orthopaedics
University of British Columbia
2775 Laurel St
3rd Floor
Vancouver, BC V5Z 1M9
Canada

Steven A Olson, MD, FACS

Professor, Department of Orthopaedic Surgery
Vice Chair and Chief, Division of Orthopaedic Trauma
Chairman, Perioperative Executive Committee
Duke University Hospital
DUMC 3389
Durham, NC 27710
USA

Michel Oransky, MD

Aurelia Hospital
Via Aurelia 860
Rome 00165
Italy

Robert V O'Toole, MD

Associate Professor
R. Adams Cowley Shock Trauma Center
Department of Orthopaedics
University of Maryland School of Medicine
T3R62
22 South Greene Street
Baltimore, MD 21201-1544
USA

Joshua C Patt, MD, MPH

Carolinas Medical Center
Department of Orthopaedic Surgery
Residency Program Director
Musculoskeletal Oncology and
Spine Surgery
1025 Morehead Medical Drive
Suite 300
Charlotte, NC 28204
USA

Jason L Pittman, MD

Department of Orthopaedic Surgery
Boston University Medical Center
720 Harrison Avenue
Suite 808
Boston, MA 02118
USA

Tim Pohlemann, MD

Universitätsklinikum Saarland
Direktor Klinik für Unfall-, Hand- und Wiederherstel-
lungschirurgie
Gebäude 57
Kirrberger Straße 1
66421 Homburg/Saar
Germany

Jason W Roberts, MD

Orthopaedic Trauma Surgery
Bronson Healthcare Midwest
Clinical Assistant Professor
Western Michigan University School of Medicine
Kalamazoo, MI 49007
USA

Pol M Rommens, Prof Dr med, Dr.h.c

Director, Department of Orthopaedics and
Traumatology
University Medical Center
Johannes Gutenberg University
Langenbeckstrasse 1
55131 Mainz
Germany

Milton Lee (Chip) Routt Jr, MD

Professor
Andrew R. Burgess Endowed Chair
Department of Orthopedic Surgery
University of Texas
Memorial Hermann Medical Center
6400 Fannin Street
Suite 1700
Houston, TX 77030
USA

Joel Rubenstein, MD, FRCP(C)

Associate Professor
Department of Medical Imaging
Sunnybrook Health Sciences Centre
2075 Bayview Avenue
Toronto, ON M4N 3M5
Canada

Anas Saleh, MD

Department of Orthopedic Surgery
Cleveland Clinic Foundation
9500 Euclid Avenue
Cleveland, OH 44195
USA

Carlos Sancineto, MD

Hospital Italiano de Buenos Aires
Chief, Orthopaedic Trauma Section
Potosi 4247 Buenos Aires, 1181 Argentina

Raj Satkunasivam, MD

Sunnybrook Health Sciences Centre
2075 Bayview Avenue
Room MG406
North York, ON M4N 3M5
Canada

Gregory J Schmeling, MD

Medical College of Wisconsin
Milwaukee Medical Complex
Box 149
8700 W Wisconsin Avenue
Milwaukee, WI 53226
USA

Stephen H Sims, MD

Department of Orthopaedics
Carolinas Medical Center
1025 Morehead Medical Drive
Suite 300
Charlotte, NC 28204
USA

Theddy Slongo, MD

Senior Consultant, Paediatric Trauma and
Orthopaedics
University Children's Hospital
Department of Paediatric Surgery
3010 Bern
Switzerland

Adam J Starr, MD

Department of Orthopaedic Surgery
UT Southwestern Medical Center
5323 Harry Hines Blvd
Dallas, TX 75390-8883
USA

David JG Stephen, MD, FRCS(C)

Associate Professor
University of Toronto
Orthopedic Surgery
Sunnybrook Health Sciences Centre
Room MG365
2075 Bayview Avenue
North York, ON M4N 3M5
Canada

Michael D Stover, MD

Professor, Feinberg School of Medicine
Northwestern University
676 N St Clair
Suite 1350
Chicago, IL 60611
USA

Volker Stüber

Medizinische Hochschule Hannover
Klinik für Unfallchirurgie
Carl-Neuberg-Straße 1
30625 Hannover
Germany

Timo Stübiger, Dr med

Medizinische Hochschule Hannover
Klinik für Unfallchirurgie
Carl-Neuberg-Straße 1
30625 Hannover
Germany

Lisa M Tibor, MD

Department of Orthopaedics
Kaiser Permanente Medical Center
1200 El Camino Real
South San Francisco, CA 94030
USA

Aasis Unnanuntana, MD

Associate Professor
Department of Orthopaedic Surgery
Siriraj Hospital
Mahidol University
2 Wang Lang Road, Siriraj
Bangkoknoi district, Bangkok
Thailand

Manyi Wang, MD

Professor and Chief
Department of Orthopedic Trauma
Beijing Jishuitan Hospital
Beijing Xin Jie Kou Dong Jie No. 31
100035 Beijing
China

Michael J Weaver, MD

Clinical Instructor, Harvard Medical School
Department of Orthopaedic Surgery
Brigham and Women's Hospital
75 Francis Street
Boston, MA 02115
USA

David S Wellman, MD

Assistant Attending Orthopaedic Surgeon
Hospital for Special Surgery
Instructor in Orthopaedic Surgery
Weil Cornell Medical College
535 E 70th Street
New York, NY 10021
USA

Xinbao Wu, MD

Associate Professor
Department of Orthopedic Trauma
Beijing Jishuitan Hospital
Beijing Xin Jie Kou Dong Jie No. 31
100035 Beijing
China

Shiwen Zhu, MD

Associate Professor
Department of Orthopedic Trauma
Beijing Jishuitan Hospital
Beijing Xin Jie Kou Dong Jie No.31
100035 Beijing
China

Michael Zlowodzki, MD

Indiana University
IU Health Methodist Hospital
1801 N Senate Blvd
Suite 535
Indianapolis, IN 46202
USA

Volume 1

Section 1 1

Principles of the treatment of pelvic ring injuries

1.1	Anatomy of the pelvic ring	3
	Marvin Tile, James F Kellam	
1	Introduction	3
2	Structural stability	3
3	Interior of pelvis	8
4	References	16
1.2	Biomechanics and methods of internal fixation	17
	John T Gorczyca	
1	Introduction	17
2	Anatomical structures	17
3	Concept of pelvic stability	19
4	Injury force patterns	20
5	Biomechanics of pelvic fixation	22
6	Conclusion	35
7	References	36
1.3	Pathoanatomy, mechanisms of injury, and classification	39
	Kelly Lefavre, Peter J O'Brien, Marvin Tile	
1	Introduction	39
2	Pathoanatomy	39
3	Mechanisms of injury	41
4	Classification	47
5	Comprehensive classification	52
6	Type 61-A: stable	53
7	Type 61-B: partially stable	54
8	Type 61-C: completely unstable (Young-Burgess APC III, VS)	55
9	Pelvic ring disruption associated with acetabular fracture	56
10	Conclusion	57
11	References	60

1.4	General assessment and management of the polytrauma patient	61
	Wolfgang K Ertel, James F Kellam	
1	Introduction	61
2	General principles	62
3	Principles of damage control	69
4	Relationship of pelvic fractures to injuries in other systems	71
5	Specific treatment of pelvic disruption in a multiply injured patient	72
6	Control of pelvic hemorrhage	76
7	Definite fracture care in the multiply injured patient	80
8	Conclusion	80
9	References	81
1.5	Defining the injury: assessment and principles of management of pelvic ring fractures	83
	Richard J Jenkinson, Marvin Tile, Joel Rubenstein	
1	Introduction	83
2	Clinical assessment	83
3	Radiographic assessment	87
4	Principles of management of pelvic ring fractures	92
5	References	98

Section 2

Techniques

99

1.6	Surgical approaches to the pelvis	103
	Michael J Weaver, James F Kellam	
1	General considerations	103
2	Approaches to the anterior ring	103
3	Approaches to the posterior ring	108
4	Anterior (intrapelvic) approach to the sacroiliac joint	108
5	Posterior (extrapelvic) approach to the sacroiliac joint and lateral sacrum	110
6	Sacral approach	113
7	References	115
1.7	External fixation of the pelvic ring	117
	Pol M Rommens, Alexander Hofmann	
1	Introduction	117
2	Biomechanical aspects	117
3	Indications	119
4	Application methods	121
5	Pin placement in the iliac crest	123
6	Pin placement in the anterior inferior iliac spine	128
7	Frame design	128
8	Aftercare	129
9	Conclusion	129
10	References	131
1.8.1	Internal fixation of the injured pelvic ring: rationale	133
	Marvin Tile	
1	Introduction	133
2	Benefits of internal fixation	133
3	Risks	135
4	Individual types: rationale	137
5	Conclusion	137
6	References	138
1.8.2	Internal fixation of the injured pelvic ring: navigation	139
	Rami Mosheiff, Meir (Iri) Liebergall	
1	Patient selection and indications	139
2	Preoperative assessment	140
3	Surgical technique	143
4	Principles of navigation and guidance	144
5	Conclusion	151
6	References	152

1.8.3	The management of the injured pelvic ring: internal fixation of stable pelvic ring fractures (type A)	153
	Markku T Nousiainen, Philip A Brady	
1	Patient selection/indications	153
2	Nonoperative management	154
3	Preoperative planning	154
4	Surgical techniques	155
5	Postoperative care	157
6	Results	157
7	Complications	157
8	Conclusion	157
9	References	158
1.8.4	The management of the injured pelvic ring: internal fixation of the anterior pelvic injuries—open book type (B1)	159
	Sean E Nork	
1	Introduction	159
2	Nonoperative management	162
3	Preoperative planning	162
4	Surgical techniques	163
5	Postoperative care	170
6	Results	170
7	Complications	171
8	Conclusion	172
9	References	173
1.8.5	Internal fixation of lateral compression fractures (type B2)	175
	Stephen H Sims	
1	Patient selection and indications	175
2	Nonoperative treatment	176
3	Preoperative planning	177
4	Surgical technique	177
5	Special fracture considerations	181
6	Postoperative care	185
7	Results	185
8	Conclusion	185
9	References	185

1.8.6 Internal fixation of unstable fractures (types B3 and C)	187
Milton Lee (Chip) Routt Jr, Timothy S Achor	
1 Patient selection/indications	187
2 Nonoperative management	192
3 Preoperative planning	192
4 Surgical techniques	194
5 Postoperative care	230
6 Results	231
7 Complications	231
8 Conclusion	232
9 References	233
1.9 Sacral fractures	235
Tim Pohlemann, Jörg H Holstein, Ulf Culemann	
1 Introduction	235
2 Anatomy	235
3 Neurovascular anatomy	236
4 Clinical importance of the sacral anatomy	237
5 Classification	237
6 Incidence and injury mechanism	240
7 Patient selection and indications	241
8 Preoperative planning	244
9 Surgical techniques	244
10 Surgical approaches	248
11 Fracture stabilization and choice of implants	251
12 Completely unstable pelvic ring injury (type C) with major displacement and without neurological deficit	255
13 Postoperative care	258
14 Complications	260
15 Conclusion	260
16 References	261

Section 3 **263**

Special indications

1.10 Lumbosacral instability and stabilization	265
Colin V Crickard, Joshua C Patt	
1 Introduction	265
2 Preoperative planning	269
3 Surgical technique	269
4 Decompression technique	272
5 Closure technique	272
6 Postoperative care	273
7 Outcomes	273
8 Conclusion	274
9 References	274
1.11 Open pelvic fracture	275
Robert V O'Toole, Ted Manson	
1 Introduction	275
2 Classification	275
3 Initial management	276
4 Preoperative planning	277
5 Surgical techniques	278
6 Tips and tricks	282
7 Postoperative care	282
8 Results	283
9 Complications	283
10 Conclusion	283
11 References	284
1.12 Pelvic ring disruption in women: genitourinary and obstetrical implications	285
Carol E Copeland	
1 Introduction	285
2 The nonpregnant female patient	285
3 The pregnant trauma patient	295
4 Pelvic trauma as a consequence of pregnancy	297
5 Conclusion	301
6 References	302
1.13 Urological injuries in pelvic ring trauma: assessment and management in male patients	305
Ron Kodama, Raj Satkunasivam	
1 Anatomy and classification	305
2 Bladder injuries	307
3 Pelvic fracture urethral injuries	309
4 Conclusion	311
5 References	312

1.14	Injury to the pelvis in pediatric patients: the immature skeleton	313
	Theddy Slongo	
1	Anatomy and classification	313
2	Patient selection and indications	319
3	Preoperative planning	320
4	Surgical techniques	321
5	Postoperative care	331
6	Results and outcomes	332
7	Complications	334
8	Conclusion	334
9	References	335
1.15.1	Insufficiency fractures of the pelvis: metabolic and nonoperative workup	337
	Aasis Unnanuntana, Anas Saleh, Joseph M Lane	
1	Introduction	337
2	Etiology and pathogenesis	337
3	Assessment and medical evaluation	338
4	Nonoperative management	342
5	Conclusion	344
6	References	344
1.15.2	Insufficiency fractures of the pelvis: operative management	347
	Karen Hand, James F Kellam	
1	Patient selection and indications	347
2	Preoperative planning	347
3	Surgical techniques	347
4	Postoperative care	348
5	Conclusion	348
6	References	350

Section 4 **351**

Results and complications

1.16.1	Outcomes after pelvic ring injuries: general concept and conclusion	353
	Patrick DG Henry, Richard J Jenkinson, Hans J Kreder	
1	Introduction	353
2	Outcomes and complications following pelvic ring injuries	353
3	Injury and treatment factors related to outcome	357
4	Conclusion	358
5	References	359
1.16.2	Outcomes after pelvic ring injuries: critical review of the world experience	361
	Axel Gänsslen	
1	Introduction	361
2	Health outcomes and management	361
3	Level of evidence and evidence-based practice	363
4	Basis of outcomes evaluation of pelvic ring injuries	363
5	Outcomes after type A injuries	364
6	Outcomes after type B injuries	365
7	Outcomes after type C injuries	368
8	Conclusion	373
9	References	374
1.17	Venous thromboembolism in pelvic trauma	377
	William H Geerts	
1	Introduction	377
2	Epidemiology of venous thromboembolism in pelvic trauma	377
3	Diagnosis of clinically suspected venous thromboembolism	380
4	Treatment of venous thromboembolism in patients with pelvic trauma	382
5	Prevention of venous thromboembolism in pelvic trauma	383
6	Screening for asymptomatic deep vein thrombosis	388
7	Practical aspects of thrombosis prevention in patients with pelvic fracture	389
8	Conclusion	391
9	References	392

1.18	Complications of pelvic trauma	401
	Andrew Grose, David E Asprinio, Marvin Tile	
1	Introduction	401
2	Early complications	401
3	Late complications	408
4	Conclusion	411
5	References	412
1.19	Malunion and nonunion of the pelvis: posttraumatic deformity	415
	Michael D Stover, William D Lack	
1	Incidence	415
2	Etiology	415
3	Deformity	416
4	Definition	416
5	Symptomatology	416
6	Patient evaluation	419
7	Treatment	420
8	References	423

Volume 2

Section 5

425

Principles of the treatment of acetabular fractures

2.1	Anatomy of the acetabulum	427	2.5	Decision making: nonoperative and operative indications for treatment of acetabular fractures	481
	Carl R Freeman, Michael Leunig, Martin Beck, Reinhold Ganz			Steven A Olson, Michael Zlowodzki	
1	Introduction	427	1	Introduction	481
2	Hip development	427	2	Pelvic anatomy	481
3	Acetabular landmarks	427	3	Fracture classifications	482
4	Acetabular structure	429	4	Nonoperative treatment of acetabular fractures	482
5	Radiographic anatomy	430	5	Operative treatment of acetabular fractures	485
6	Hip stability	432	6	Choice of operative approach	485
7	Acetabular orientation	432	7	Special circumstances	492
8	Acetabular cartilage	432	8	Delayed fracture indications	494
9	Acetabular biomechanics	433	9	Acute total hip arthroplasty	494
10	Hip circulation	434	10	Conclusion	495
11	Summary	439	11	References	495
12	References	439			
2.2	Biomechanics of acetabular fractures	441	2.6	General assessment and perioperative management of acetabular fractures	497
	Steven A Olson			Andrew Grose, Douglas ST Green, Sean E Garvin	
1	Normal hip mechanics	441	1	Introduction	497
2	Acetabular fractures	442	2	Evaluation of the patient as a whole	497
3	Mechanics of acetabular fixation	444	3	Evaluation of the patient as a surgical candidate	498
4	Conclusion	445	4	Medical optimization and anesthetic management	498
5	References	445	5	General guidelines for anesthesia for pelvic fractures	499
2.3	Pathoanatomy and classification of acetabular fractures	447	6	Anesthetic plan: nuances for associated injuries	500
	Jorge E Alonso, James F Kellam, Marvin Tile		7	Blood/fluid resuscitation	500
1	Introduction	447	8	Conclusion	501
2	Mechanism of injury	447	9	References	501
3	Diagnosing the fracture	449			
4	Letournel-Judet classification (AO/OTA Fracture and Dislocation Classification)	453			
5	Conclusion	468			
6	References	470			
2.4	Defining the injury: assessment and principles of management of acetabular fractures	471			
	Markku T Nousiainen, Philip A Brady, Marvin Tile				
1	Introduction	471			
2	Clinical assessment	471			
3	Radiographic assessment	471			
4	Postoperative assessment	476			
5	Imaging of complications and associated injuries	478			
6	Conclusion	479			
7	References	480			