
Minimally Invasive Spine Surgery

Burak Ozgur · Edward Benzel ·
Steven Garfin
Editors

Minimally Invasive Spine Surgery

A Practical Guide to Anatomy and
Techniques

 Springer

Editors

Burak Ozgur
Director of Minimally Invasive
Spine Surgery
Assistant Professor of Neurosurgery
Department of Neurosurgery
Cedars-Sinai Medical Center
Los Angeles, CA, USA

Edward Benzel
Chairman
Department of Neurosurgery
Cleveland Clinic Spine Institute
Cleveland, OH, USA

Steven Garfin
Professor and Chair
Department of Orthopaedic Surgery
University of California-San Diego
USCD Medical Center
San Diego, CA USA

Figures 1.1, 1.2, 1.8–1.10, 3.1(a) and (b), 3.2, 3.3, 3.4, 9.1, 10.1, 11.1–11.5, and 16.2 were created by Caspar Henselmann.

Figure 3.1(c) was created by Alice Y. Chen.

ISBN 978-0-387-89830-8 e-ISBN 978-0-387-89831-5
DOI 10.1007/978-0-387-89831-5
Springer Dordrecht Heidelberg London New York

Library of Congress Control Number: 2009930940

© Springer Science+Business Media, LLC 2009

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of going to press, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

I dedicate this book to the support and guidance of my parents, the patience and trust of my professors, teachers, and patients, and certainly to the boundless love, compassion, and encouragement of my wife, Iman, and kids, Omar, Ali, and Hala.

Burak M. Ozgur

I dedicate this book to my wife, Mary. She perpetually provides advice, guidance and friendship. Her unending support is the source of my strength.

Edward C. Benzel

I dedicate this book to my mentors, colleagues, and trainees, who helped me (taught, inspired, and tolerated me) treat patients and teach others.

Steven R. Garfin

Foreword

Unlike any other surgical specialty, spine surgery has evolved rapidly over the past three decades. I have been fortunate to observe this evolution over the past 40 years from the time I started my internship. At that time spine surgery was not a favorite rotation for the house staff and used to take the back seat to all other, more interesting orthopedic procedures. Diagnostic knee arthroscopy was just being introduced, and that was all we knew of the concept of less invasive surgery. During my training as a resident and, later, as a fellow in spine surgery, the focus was on fusion techniques, especially for spinal fractures and deformities. Although many principles of spine care have remained the same over the years, methods and surgical techniques have changed dramatically, as evident in minimally invasive spine surgery (MISS). Most of these techniques have withstood the test of time, though some did not, but all have contributed to our understanding and knowledge of spine surgery.

MISS has been among the latest advances in spine care, leaving a great impact on how we will treat future patients with spinal disorders. Although other specialties have enjoyed applying these methods of treatment for some time, progress in MISS slowly evolved. It started with the treatment of disc disease and now includes fusions, motion preservation techniques, and even spinal reconstruction. Considering the progress made over the past 40 years, I believe that these techniques will continue to evolve and improve over time.

Education plays a great role for progress in any field, in particular in a field as new and demanding as MISS. Today, increased knowledge and understanding about principles and treatment outcomes along with advanced technology allow us to manage more effectively the many conditions of the spine. Indeed, we could not have even dreamed of this a decade ago. However, the education in MISS should emphasize principles first. We should not forget that patient selection should occur on the basis of surgical indication rather than on the available techniques, even if they are less invasive.

The editors of this publication have successfully assembled the current state of knowledge in MISS by many leaders in this field, covering a wide variety of conditions in spine surgery and including both principles and techniques. Indications are clearly outlined and techniques discussed in a cogent and concise manner. As spine surgery becomes one specialized field, there is no doubt that this important book will serve as a valuable resource to both neurological and orthopedic spine surgeons and their trainees. Certainly, as advances continue to be made in our field, this text will serve as a basis for further innovations.

La Jolla, California

Behrooz A. Akbarnia

Foreword

In the last 20 years, spinal surgery has changed tremendously. Progress has included advanced instrumentation, the application of imaging techniques both in and out of the operating room, and improved understanding of biomechanics. Minimally invasive spine surgery, which is becoming a subspecialty in the field of spine surgery, has grown explosively in the last decade.

Minimally invasive spine surgery offers the benefits of decreased postoperative pain and disruption of normal anatomy, and the latter leads to shorter hospital stays. Theoretically, all of these will also decrease the expense of care, but this point has yet to be documented. As with most new techniques, a learning curve is associated with mastering minimally invasive spine surgery. In fact, for procedures such as thoracoscopic approaches to the spine, the learning curve is quite steep. Proficiency requires intensive courses, if not fellowships, to acquire the necessary surgical expertise to perform these elegant yet at times complex procedures. The editors of this book have assembled experts in the field of minimally invasive spine surgery and produced a text that should be a standard for that subspecialty.

The book addresses minimally invasive surgery for the entire spine, starting in the cervical area and proceeding to the thoracolumbar spine. The text includes an excellent introductory chapter and describes the multiple fusion techniques performed via minimally invasive procedures. Classically, the two chapters on “facet rhizotomy” and “facet and epidural steroid injection” would not be included under minimally invasive spine surgery. Nevertheless, they are reasonable editions to the book.

Although many of the procedures described in this book can be performed through traditional open techniques, the authors nicely describe their minimally invasive counterparts and often highlight the advantages of the minimal approach compared to the traditional open approach. Surgeons should first become experts in open approaches to the spine. Once they have mastered this fundamental armamentarium and know the anatomy well, they can apply the minimally invasive approaches to the spine that are so well described in this text. This book, which is very well done and timely, will become a standard text for any surgeon who performs minimally invasive spine surgery as well as for any surgeon who is developing his or her skills in this growing subspecialty.

Tucson; Phoenix, Arizona

Volker K. H. Sonntag, MD

Preface

The use of minimally invasive spine surgical principles and techniques is rapidly escalating. It is finding its way, to one degree or another, into the practice of many spine surgeons. The enthusiasm for its use, on the part of both the spine surgeon and the patient, is impressive and dominates medical websites and Internet discussion as well as many surgical society meetings.

The reasons for this popularity are myriad. They include safety, blood loss, pain, and popularity among patients. With this enthusiasm, however, some self-reflection and careful consideration are necessary. As physicians, we must always consider the best available evidence that supports the use of any new technology. In this text, our aim is to consider the available evidence to support minimally invasive spine surgery. However, we must also consider safety, learning curve issues, and the high cost of these technologies. The latter two concerns may be more relevant for some conditions than for others. In varying degrees, there are also important considerations to be made for surgeon-specific issues.

We have attempted to assemble, in the pages that follow, a collection of works that provide the foundation for a minimalist approach to surgery of the spine. This should provide insight into pathology-specific and technique-related concerns. With this comes an understanding of the limitations of minimally invasive surgery, as well as its advantages, on a case-by-case basis. One must remember that “through small openings can lurk large complications.” With this in mind, please read, enjoy, and learn from this collection of treatises from experienced authors/practitioners on the subject. We hope that you, as do we, find them to provide an objective, honest, and balanced approach to minimally invasive surgery and also to offer a useful reference for years to come.

Los Angeles, California
Cleveland, Ohio
La Jolla, California

Burak M. Ozgur
Edward C. Benzel
Steven R. Garfin

Contents

1	General Introduction and Principles of Minimally Invasive Spine Surgery	1
	Burak M. Ozgur	
2	Image-Guided Spinal Navigation: Principles and Clinical Applications	7
	Iain H. Kalfas	
3	Anterior Cervical Foraminotomy	23
	David H. Jho and Hae-Dong Jho	
4	Posterior Cervical Foraminotomy and Laminectomy	33
	John E. O’Toole, Kurt M. Eichholz, and Richard G. Fessler	
5	Posterior Cervical Instrumentation and Fusion	43
	Farbod Asgarzadie, Barón Zárate Kalfópulos, Vartan S. Tashjian, and Larry T. Khoo	
6	Thoracoscopic Discectomy	59
	Rohit B. Verma, Pablo Pazmino, and John J. Regan	
7	Thoracic and Lumbar Kyphoplasty	67
	Christopher M. Bono and Steven R. Garfin	
8	Thoracoscopic Deformity Correction	77
	Peter O. Newton and Andrew Perry	
9	Paracoccygeal Transsacral Access to the Lumbosacral Junction for Interbody Fusion and Stabilization	87
	Isador H. Lieberman and Andrew Cragg	
10	Facet Joint Anatomy and Approach for Denervation	93
	Ralph F. Rashbaum and Donna D. Ohnmeiss	
11	Facet Joint and Epidural Injections	99
	Mark S. Wallace and Tobias Moeller-Bertram	
12	Discography and Endoscopic Lumbar Discectomy	105
	Michael A. Chang, Christopher A. Yeung, Anthony T. Yeung, and Choll W. Kim	
13	Discectomy and Laminectomy	115
	Burak M. Ozgur, Scott C. Berta, and Andrew D. Nguyen	
14	Combining Minimally Invasive Techniques for Treating Multilevel Disease as Well as Adult Degenerative Scoliosis	121
	Burak M. Ozgur and Lissa C. Baird	

15	Transforaminal Lumbar Interbody Fusion (TLIF)	129
	Burak M. Ozgur, Scott C. Berta, and Samuel A. Hughes	
16	Lateral Approach for Anterior Lumbar Interbody Fusion (XLIF and DLIF) . . .	135
	Burak M. Ozgur and Lissa C. Baird	
17	Anterior Lumbar Interbody Fusion (ALIF)	143
	Henry E. Aryan, Sigurd H. Berven, and Christopher P. Ames	
18	Percutaneous Pedicle Screw Placement for Spinal Instrumentation	149
	Hormoz Sheikh, Ramiro A. Perez de la Torre, Oksana Didyuk, Vickram Tejwani, and Mick J. Perez-Cruet	
19	Iliac Crest Bone Graft Harvest and Fusion Techniques	159
	Jeff S. Silber and Alexander R. Vaccaro	
20	Technologies for Use in Indirect Distraction Procedures	167
	Hansen A. Yuan, Adam K. MacMillan, and Edward S. Ahn	
	Index	179

Contributors

Edward S. Ahn, PhD Chief Technology Officer, Angstrom Medica, Inc., Woburn, MA, USA

Christopher P. Ames, MD Associate Professor, Department of Neurosurgery, University of California-San Francisco, San Francisco, CA, USA

Henry E. Aryan, MD Clinical Instructor of Neurosurgery, Complex Spinal Reconstruction & Neurospinal Oncology, Department of Neurological Surgery, University of California-San Francisco, CA; Sierra Pacific Orthopaedic & Spine Center, Fresno, CA, USA

Farbod Asgarzadie, MD Assistant Professor, Department of Neurosurgery, Loma Linda University Medical Center, Loma Linda, CA, USA

Lissa C. Baird, MD Neurosurgery Resident, Division of Neurosurgery, University of California-San Diego, UCSD Medical Center, San Diego, CA, USA

Scott C. Berta, MD Neurosurgery Resident, Division of Neurosurgery, University of California-San Diego, UCSD Medical Center, San Diego, CA, USA

Sigurd H. Berven, MD Associate Professor in Residence, Department of Orthopaedic Surgery, University of California-San Francisco, UCSF Medical Center, San Francisco, CA, USA

Christopher M. Bono, MD Assistant Professor, Director of Spine Surgery, Department of Orthopaedic Surgery, Boston Medical Center, Boston University School of Medicine, Boston, MA, USA

Michael A. Chang, MD, PhD Department of Orthopedic Surgery, Wichita Clinic, Wichita, KS, USA

Andrew Cragg, MD Clinical Professor of Radiology, University of Minnesota, Edina, MN, USA

Oksana Didyuk, BS Research Assistant, Department of Neurosurgery, Providence Medical Center, Michigan Head and Spine Institute, Southfield, MI, USA

Kurt M. Eichholz, MD Assistant Professor of Neurological Surgery, Department of Neurological Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

Richard G. Fessler, MD, PhD Professor, Department of Neurosurgery, Northwestern University; University of Chicago, Chicago, IL, USA

Steven R. Garfin, MD Professor and Chair, Department of Orthopaedic Surgery, University of California-San Diego, UCSD Medical Center, San Diego, CA, USA

Samuel A. Hughes, MD, PhD Neurosurgery Resident, Department of Neurological Surgery, Oregon Health & Science University, Portland, OR, USA

David H. Jho, MD, PhD Neurosurgery Resident, Department of Neurosurgery, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

Hae-Dong Jho, MD, PhD Professor & Chairman, Department of Neuroendoscopy, Allegheny General Hospital, Drexel University College of Medicine, Pittsburgh, PA, USA

Iain H. Kalfas, MD, FACS Chairman, Department of Neurosurgery, Cleveland Clinic, Cleveland, OH, USA

Larry T. Khoo, MD Chief of Neurosurgery, UCLA Santa Monica Hospital, Assistant Professor of Neurological & Orthopedic Surgery, University of California-Los Angeles Comprehensive Spine Center, Los Angeles, CA, USA

Choll W. Kim, MD, PhD Assistant Professor, Department of Orthopaedic Surgery, University of California-San Diego, San Diego, CA, USA

Isador H. Lieberman, MD, MBA, FRCSC Professor of Surgery, Chairman, Medical Interventional and Surgical Spine Center, Cleveland Clinic Florida, Ft. Lauderdale, FL, USA

Adam K. MacMillan, BS Project Manager, Angstrom Medica, Inc., Woburn, MA, USA

Tobias Moeller-Bertram, MD Assistant Clinical Professor of Anesthesiology, Department of Anesthesiology, Center for Pain Medicine, University of California-San Diego, VA San Diego Healthcare Systems, San Diego, CA, USA

Peter O. Newton, MD Director of Scoliosis Service and Orthopaedic Research, Department of Orthopaedics, University of California-San Diego, Rady Children's Hospital, San Diego, CA, USA

Andrew D. Nguyen, MD, PhD Neurosurgery Resident Physician, Division of Neurosurgery and Senior Clinical Fellow, Division of Neuro-Interventional Radiology, University of California-San Diego Medical Center, San Diego, CA, USA

Donna D. Ohnmeiss, PhD President, Texas Back Institute Research Foundation, Plano, TX, USA

John E. O'Toole, MD Assistant Professor, Department of Neurosurgery, Rush Medical College of Rush University Medical Center, Chicago, IL, USA

Burak M. Ozgur, MD Director of Minimally Invasive Spine Surgery, Assistant Professor of Neurosurgery, Department of Neurosurgery, Cedars-Sinai Medical Center, Los Angeles, CA, USA

Pablo Pazmino, MD Department of Orthopaedic Surgery, Olympia Medical Center, Beverly Hills, CA, USA

Ramiro A. Perez de la Torre, MD Spine Fellow, Department of Neurosurgery, Providence Hospital, Southfield, MI, USA

Mick J. Perez-Cruet, MD, MS Director, Minimally Invasive Spine Surgery and Spine Program, Department of Neurosurgery, Providence Medical Center, Southfield, MI 48075; Adjunct Associate Professor, Oakland University, Rochester, MI, USA

Andrew Perry, MD Resident, Department of Orthopaedic Surgery, University of California-San Diego, San Diego, CA, USA

Ralph F. Rashbaum, MD Co-founder, Texas Back Institute Research Foundation, Plano, TX, USA

John J. Regan, MD Medical Director, Beverly Hills Spine Group, Cedar-Sinai Institute for Spinal Disorders, Beverly Hills, CA, USA

Hormoz Sheikh, MD Spine Research Fellow, Department of Neurosurgery, Providence Medical Center, Michigan Head and Spine Institute, Southfield, MI, USA

Jeff S. Silber, MD, DC Associate Professor, Department of Orthopaedic Surgery, Long Island Jewish Medical Center, New Hyde Park, NY; Albert Einstein School of Medicine, Bronx, NY, USA

Vartan S. Tashjian, MD, MS Department of Neurosurgery, University of California-Los Angeles, Santa Monica Orthopedic and Neurosurgical Spine Center, Los Angeles, CA, USA

Vickram Tejwani China Medical University, Shenyang, Liaoning, China; West Bloomfield, MI, USA

Alexander R. Vaccaro, MD, PhD Professor, Departments of Neurosurgery and Orthopaedic Surgery, Thomas Jefferson University and Rothman Institute, Philadelphia, PA, USA

Rohit B. Verma, MD Orthopaedic Spine Surgeon, Department of Orthopaedic Surgery, The Spine Institute; Department of Neurosurgery, The Chiari Institute, North Shore Manhasset Hospital, Great Neck, NY, USA

Mark S. Wallace, MD Professor of Clinical Anesthesiology, Program Director, Department of Anesthesiology, Center for Pain Medicine, University of California-San Diego Medical Center, La Jolla, CA, USA

Anthony T. Yeung, MD DISC – Desert Institute for Spine Care, Phoenix, AZ; Volunteer Clinical Associate Professor, Department of Orthopaedic Surgery, University of California-San Diego School of Medicine, San Diego, CA, USA

Christopher A. Yeung, MD DISC – Desert Institute for Spine Care, Phoenix AZ; Department of Orthopaedic Surgery, Volunteer Clinical Faculty, University of California-San Diego School of Medicine, San Diego, CA, USA

Hansen A. Yuan, MD Professor, Department of Orthopaedic and Neurological Surgery, State University of New York-Syracuse Medical Center, Syracuse, NY, USA

Barón Zárate Kalfópulos, MD Orthopaedic Surgeon, Department of Spinal Surgery, National Rehabilitation Center, Universidad Nacional Autónoma de México, México Distrito Federal, Mexico