

#### Chief Editor

#### S Rajasekaran PhD

Chairman and Head
Department of Orthopaedics, Trauma and Spine Surgery
Ganga Hospital
Coimbatore, Tamil Nadu, India
Adjunct Professor of Orthopaedic Surgery
The Tamil Nadu Dr MGR Medical University

Associate Editors

Anil K Jain Ajoy P Shetty Rishi M Kanna

**Foreword** 

**Alexander R Vaccaro** 



**JAYPEE BROTHERS MEDICAL PUBLISHERS (P) LTD** 

#### Published by

#### Jaypee Brothers Medical Publishers (P) Ltd

#### Corporate Office

4838/24 Ansari Road, Daryaganj, **New Delhi** - 110002, India Phone: +91-11-43574357, Fax: +91-11-43574314

#### Offices in India

- Ahmedabad, e-mail: ahmedabad@jaypeebrothers.com
- Bengaluru, e-mail: bangalore@jaypeebrothers.com
- Chennai, e-mail: chennai@jaypeebrothers.com
- Delhi, e-mail: jaypee@jaypeebrothers.com
- Hyderabad, e-mail: hyderabad@jaypeebrothers.com
- Kochi, e-mail: kochi@jaypeebrothers.com
- Kolkata, e-mail: kolkata@jaypeebrothers.com
- Lucknow, e-mail: lucknow@jaypeebrothers.com
- Mumbai, e-mail: mumbai@jaypeebrothers.com
- Nagpur, e-mail: nagpur@jaypeebrothers.com

#### **Overseas Offices**

- North America Office, USA, Ph: 001-636-6279734 e-mail: jaypee@jaypeebrothers.com, anjulav@jaypeebrothers.com
- Central America Office, Panama City, Panama, Ph: 001-507-317-0160
   e-mail: cservice@jphmedical.com, Website: www.jphmedical.com
- Europe Office, UK, Ph: +44 (0) 2031708910
   e-mail: info@jpmedpub.com

#### Spinal Infections and Trauma

© 2011, Jaypee Brothers Medical Publishers

All rights reserved. No part of this publication should be reproduced, stored in a retrieval system, or transmitted in any form or by any means: electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the editors and the publisher.

This book has been published in good faith that the material provided by the contributors is original. Every effort is made to ensure accuracy of material, but the publisher, printer and editors will not be held responsible for any inadvertent error (s). In case of any dispute, all legal matters are to be settled under Delhi jurisdiction only.

First Edition: 2011

ISBN 978-93-5025-075-4

Typeset at JPBMP typesetting unit

Printed at

# Dedicated to the pursuit of

# "Safe Spine Surgery"

the theme of

Association of Spine Surgeons of India

in the Silver Jubilee Year

# Contributors

#### **Abhay Nene**

Consultant Spine Surgeon PD Hinduja National Hospital and Medical Research Centre Mahim, Mumbai Maharashtra, India

#### **Abhishek Srivastava**

Senior Resident Department of Orthopaedics All India Institute of Medical Sciences Ansari Nagar, New Delhi

#### **Ajay Krishnan**

Spine Surgeon Stavya Spine Hospital and Research Institute Ellisbridge, Ahmedabad, Gujarat, India

#### **Ajoy P Shetty**

Consultant Spine Surgeon Ganga Hospital Coimbatore, Tamil Nadu, India

#### **Amol Rege**

Deenanath Mangeshkar Hospital and Research Centre Erandawane, Pune, Maharashtra, India

#### **Anand Agarwal**

Adjunct Prestigious University Professor University of Toledo, Ohio, USA Director of Neuro Spine Research Queen Mary University of London UK Consultant Orthopaedic and Spine Surgeon

#### **Anil K Jain**

Professor Department of Orthopaedics University College of Medical Sciences and Guru Teg Bahadur Hospital Delhi, India

#### **Ankur Nanda**

Consultant Spine Surgeon Indian Spinal Injuries Centre Vasant Kunj, Sector-C, New Delhi, India

#### Arvind G Kulkarni

Consultant Spine Surgeon Department of Orthopaedics Bombay Hospital and Medical Research Centre, Marine Lines, Mumbai Maharashtra, India

#### **Arvind Bhave**

Professor Departmen

Department of Orthopaedics
Bharati Vidyapeeth Medical College
Pune, Maharashtra, India
Hon. Spine Surgeon and Spinal
Endoscopist
Deenanath Mangeshkar Hospital,
Erandawana, Pune, Maharashtra, India
Bhave Hospital, Parvati Industrial Estate
Pune-Satara Road, Pune
Maharashtra, India

#### **Arvind Jayaswal**

Professor Department of Orthopaedics All India Institute of Medical Sciences Ansari Nagar, New Delhi, India

#### **Ashish D Diwan**

Chief of Spine Service
Department of Orthopaedic Surgery
St George Hospital
Director Bone Biology
Orthopaedic Research Institute
Senior Lecturer
St George Clinical School
University of New South Wales
Hon Associate Professor
Faculty of Engineering and

#### Ashok K Shyam

IT University of Sydney

Consultant Orthopaedic Surgeon and Chief Researcher Sancheti Institute for Orthopaedics and Rehabilitation Pune, Maharashtra, India

#### **Ashutosh Sabnis**

Spine Associate PD Hinduja National Hospital and Medical Research Centre Mahim, Mumbai, Maharashtra, India

#### **Bharat R Dave**

Spine Surgeon Stavya Spine Hospital and Research Institute Ellisbridge, Ahmedabad, Gujarat, India Honorary Spine Surgeon, VS Hospital Ellisbridge, Ahmedabad Gujarat, India

#### Bibhudendu Mohapatra

Fellow Spine Service St George Hospital Campus University of New South Wales

#### Darshan Gautam

Spine Fellow Indian Spinal Injuries Centre Vasant Kunj, Sector-C, New Delhi, India

#### Devarati Khurjekar

Assistant Lecturer BJ Medical College Pune, Maharashtra, India

#### Dilip K Sengupta

Assistant Professor Department of Orthopedics Dartmouth-Hitchcock Medical Center Lebanon, NH

#### E Subbian

Assistant Professor Department of Physical Medicine and Rehabilitation Christian Medical College and Hospital Vellore, Tamil Nadu, India

#### Gabriel David Sundararaj

Professor and Head Spinal Disorder Surgery Unit Department of Orthopaedics Christian Medical College and Hospital Vellore, Tamil Nadu, India

#### **Gautam Prasad**

Associate Spine consultant The Spine Foundation Lilavati Hospital and Research Center and Breach Candy Hospital, Mumbai Maharashtra, India

#### **Gautam Zaveri**

Consultant Spine Surgeon
Jaslok and Fortis Hospitals
Mumbai, Maharashtra, India
Associate Professor of Orthopaedics
DY Patil Medical College
Ghatkopar (E)
Mumbai, Maharashtra, India

#### Gomatam R Vijay Kumar

Consultant Neurosurgeon Institute of Neurosciences, Kolkata AMRI Hospital Salt Lake, Kolkata West Bengal, India

#### Gopala Krishnaiah T

viii

Assistant Professor Narayana Medical College and Hospital Nellore, Andhra Pradesh, India

#### **Greg Etherington**

Director of Deformity, Spine Service St George Hospital Campus Conjoint Lecturer University of New South Wales

#### **Gururaj Sangondimath**

Spine Fellow Indian Spinal Injuries Centre Vasant Kunj, Sector-C, New Delhi, India

#### Harsh Priyadarshi

Fellow, Spine Service St George Hospital Campus University of New South Wales

#### **Harvinder Singh Chhabra**

Chief of Spine Service and Medical Director Indian Spinal Injuries Centre Vasant Kunj, Sector-C New Delhi, India

#### **Henry Prakash**

Associate Professor Department of Physical Medicine and Rehabilitation Christian Medical College and Hospital Vellore, Tamil Nadu, India

#### Hiroshi Kuroki

Associate Professor

Research Engineering Center for Orthopaedic Research Excellence (E-CORE) Departments of Bioengineering and Orthopaedic Surgery

Colleges of Engineering and Medicine University of Toledo, Toledo, OH

#### J Naresh Babu

Director
Mallika Spine Centre
Hyderabad, AP, India
Consultant Spine Surgeon
Sunshine Hospitals and Medicity
Hospital
Hyderabad, AP, India

#### John Yeh

Senior Lecturer and Honorary Consultant Neurosurgeon and Spinal Surgeon St. Bartholomew's and The Royal London Hospitals Queen Mary University of London

Department of Neurosurgery The Royal London Hospital Whitechapel London E1 1BB

#### Joy Sarojini Michael

Professor

Department of Microbiology Christian Medical College and Hospital Vellore, Tamil Nadu, India

#### Kamran Farooque

Associate Professor Department of Orthopaedics All India Institute of Medical Sciences Ansari Nagar, New Delhi, India

#### **Kapil Mohan**

Spine Fellow PD Hinduja National Hospital and Medical Research Centre Mahim, Mumbai, Maharashtra, India

#### **Ketan S Khurjekar**

Chief, Spine Surgery Service Sancheti Institute of Orthopaedics and Rehabilitation Pune, Maharashtra, India

#### **Kshitij Chaudhary**

Assistant Professor King Edward Memorial Hospital Mumbai, Maharashtra, India

#### Kshitij Kumar M Agrawal

Tutor

Department of Orthopedics KEM Hospital Mumbai, Maharashtra, India

#### K Sriram

Childs Trust Hospital, Chennai, Tamil Nadu, India Senior Orthopedic Surgeon, St Isabel's Hospital, Chennai, Tamil Nadu, India Consultant, Apollo Specialty Hospital Chennai, Tamil Nadu, India

Senior Consultant, Kanchi Kamakoti

#### **K Venkatesh**

Associate Professor Department of Spinal Disorders Surgery Christian Medical College Vellore, Tamil Nadu, India

#### **KV** Menon

Consultant Spine Surgeon Lakeshore Hospital Cochin, Kerala, India

#### Mallikarjun

Clinical Fellow (Spine) Whitechapel Royal London Hospital

#### **Mathew Varghese**

Head, Department of Orthopaedics St Stephen's Hospital, Tis Hazari Delhi, India

#### **Mihir Bapat**

Consultant Spine Surgeon Kokilaben Dhirubai Ambani Hospital Mumbai, Maharashtra, India

#### **Mohit Arora**

Clinical Physiotherapist and Clinical Research Associate Indian Spinal Injuries Centre, Vasant Kunj, Sector-C, New Delhi, India

#### **Nishit Patel**

Spine Fellow Indian Spinal Injuries Centre Vasant Kunj, Sector-C, New Delhi, India

#### **Pradip S Nemade**

Assistant Professor Department of Orthopedics KEM Hospital Mumbai, Maharashtra, India

#### **Pranay Bhushan**

Senior Resident Department of Orthopaedics St Stephen's Hospital, Tis Hazari Delhi, India

#### **Premik Nagad**

Spine Fellow PD Hinduja National Hospital and Medical Research Centre Mahim, Mumbai, Maharashtra, India

#### Raghava D Mulukutla

Consultant Orthopaedic and spine surgeon Udai Clinic Orthopaedic centre and Apollo Health city Hyderabad, AP, India

#### Rajagopalan

Professor

Department of Orthopaedics St Johns Medical College Bengaluru, Karnataka, India

#### Ram Chaddha

Professor

Department of Orthopaedics KJ Somaiya Medical College Consultant Spine Surgeon Lilavati, Fortis Guru Nanak Hospitals, Mumbai Maharashtra, India

#### Ramesh Dalwai

Specialist Registrar, Spine Surgery Lakeshore Hospital Cochin, Kerala, India

#### Rishi M Kanna

Senior Registrar Department of Spine Surgery Ganga Hospital Coimbatore, Tamil Nadu, India

#### **Robert Pflugmacher**

Consultant Orthopaedic Spine Surgeon Department of Orthopaedic and Trauma Surgery University Medical School and Hospital of Bonn Sigmund-Freud-Str. 25 Bonn Germany

#### **R** Amritanand

Associate Professor Spinal Disorder Surgery Unit Department of Orthopaedics Christian Medical College and Hospital Vellore, Tamil Nadu, India

#### **Rushama Tandon**

Orthopedic and Spine Surgeon Northern Railway Central Hospital New Delhi, India

#### Sajan K Hegde

Consultant Spine Surgeon and Head Department of Orthopaedics Apollo Hospitals, 21, Greams Road Chennai, Tamil Nadu, India

#### Sameer Kalkotwar

Assistant Professor NKP Salve Medical College and Lata Mangeshkar Hospital, Nagpur Maharashtra, India

#### **Samir Dalvie**

Consultant Spine Surgeon PD Hinduja National Hospital and Medical Research Center, Mumbai Maharashtra, India

#### Saumyajit Basu

Consultant Spine Surgeon Park Clinic, Kolkata West Bengal, India

#### Saurabh Jain

Senior Registrar University College of Medical Sciences and Guru Teg Bahadur Hospital Delhi, India

#### **S** Danaviah

Research Scientist Africa Centre University of Kwazulu-Natal Durban

#### **S** Govender

Professor and Head Department of Orthopaedics and Spinal Surgery King George V Hospital University of Kwazulu-Natal Durban

#### **Shankar Acharya**

Senior Consultant Orthopaedic and Spine Surgeon Sir Ganga Ram Hospital Sant Parmanand Hopital New Delhi, India Chairman, AO Spine India Vice-President, Delhi Spine Society

#### Shekhar Bhojraj

Consultant Spine surgeon, Lilavati Hospital and Research Center and Breach Candy Hospital, Mumbai, Maharashtra, India

#### **Shwetabh**

Senior Resident Department of Orthopaedics Safdarjung Hospital, New Delhi, India

#### **Siddharth M Shah**

Registrar Department of Orthopaedics Bombay Hospital and Medical Research Centre, Marine Lines Mumbai, Maharashtra, India

#### **SM Tuli**

Ex-Director Institute of Medical Sciences Banaras Hindu University, Varanasi UP, India

#### Sonia Sandhu

Assistant Attending Neurologist Department of Neurology Memorial Sloan-Kettering Cancer Center 1275 York Avenue, New York

#### **S** Rajasekaran

Chairman and Head Department of Orthopaedics, Trauma and Spine Surgery Ganga Hospital Coimbatore, Tamil Nadu, India

#### **SS Patil**

Spine Fellow PD Hinduja National Hospital and Medical Research Centre, Mumbai Maharashtra, India

#### Subbiah M

Spine Fellow Ganga Hospital Coimbatore Tamil Nadu, India

#### **Sudhir K Srivastava**

Professor and Unit Head, Chief of Spinal Services Department of Orthopedics KEM Hospital, Mumbai Maharashtra, India

#### **Sunil K Bhosale**

Assistant Professor Department of Orthopedics KEM Hospital, Mumbai, Maharashtra, India

#### Suyra Prakash Rao V

Consultant Spine surgeon Kamineni Hospitals, King Koti Abids, Hyderabad, Andhra Pradesh, India

#### **Swapnil Keny**

Consultant, Pediatric Orthopaedic Surgeon Bombay Hospital, Mumbai Maharashtra, India Assistant Professor of Orthopaedics Sir JJ Group of Hospitals and Grant Medical College, Mumbai Maharashtra, India

#### **Tarak Patel**

Senior Spine Fellow The Spine Foundation Lilavati Hospital and Research Center and Breach Candy Hospital, Mumbai Maharashtra, India

#### **Thomas J Kishen**

Fellow Spine Service St George Hospital Campus Research Fellow Orthopaedic Research Institute St George Hospital Conjoint Lecturer University of New South Wales

#### **Uday M Pawar**

Associate Spine Surgeon PD Hinduja National Hospital Veer Savarkar marg, Mumbai Maharashtra, India

#### **Upendra BN**

Senior Research Associate Department of Orthopaedics All India Institute of Medical Sciences Ansari Nagar, New Delhi, India

#### Vijay K Goel

Distinguished University Professor Endowed Chair and McMaster-Gardner Professor of Orthopaedic Bioengineering Co-Director, Engineering Center for Orthopaedic Research Excellence (E-CORE) Departments of Bioengineering and Orthopaedic Surgery

Colleges of Engineering and Medicine

#### Vijay Kamath

Senior Registrar Department of Spine Surgery Ganga Hospital Coimabtore, Tamil Nadu, India

University of Toledo, Toledo, OH

#### **Vikas Tandon**

Consultant Spine Surgeon Indian Spinal Injuries Centre Vasant Kunj, Sector-C New Delhi, India

#### Vilas P Kanikdaley

Professor Department of Radiology Navodaya Medical College Raichur, Karnataka, India

#### Vinod Laheri

Emeritus Professor King Edward Memorial Hospital Mumbai Maharashtra, India

#### **Vivek Mittal**

Spine Fellow Indian Spinal Injuries Centre Vasant Kunj, Sector-C New Delhi, India

#### VT Ingalhalikar

Ex-Professor of Orthopaedics LTM Medical College Mumbai, Maharashtra, India Head of Department-Spine Unit Jupiter Hospital Thane, Mumbai, Maharashtra, India

#### Yogesh K Pithwa

Consultant Spine Surgeon HOSMAT Institute for Spinal Problems HOSMAT Hospital, Bengaluru Karnataka, India

# Foreword

In the past twenty years, the field of spinal surgery has expanded greatly, and no where is this more easily seen than in the areas of infection and trauma. While there has been a recent surge in the literature being published in this arena, the abundance of information occasionally makes the treatment of these patients less clear. Additionally, the management of these difficult patients is often on an emergent or urgent basis, leaving very little time for extensive literature reviews. Therefore, there is a real need for a concise, complete, and up-to-date reference on this topic. No where in the world is the experience with the management of spinal infections more abundant than that witnessed by the authors of the textbook *Spinal Infections and Trauma*, by Chief Editor S. Rajasekaran. The chapter selections and contributors have among themselves treated a myriad of complex spinal infections and traumatic injuries not seen with any degree of regularity or severity in the vast majority of tertiary referral centers throughout the world.



S Rajasekaran and the team of authors in conjunction with the Association of Spine Surgeons of India have attempted to answer all of our questions on the evaluation and management of these complex problems in one concise textbook. They ought to be congratulated on their ability to produce such a book, and in doing so, they have provided us with a reference which is easily readable and should be a part of every spine surgeons' library!

Alexander R Vaccaro MD, PhD
Professor of Orthopaedics and Neurosurgery
Thomas Jefferson University Hospital
925 Chestnut St
Philadelphia, Pennsylvania 19107-4216
United States

# Preface

The global burdens of spinal problems requiring surgery is on the increase. While there is no such thing as a *simple spine surgery* operation, management of neglected trauma and complex infections is particularly challenging and prone to complications. These problems still present in huge numbers to the practicing spinal surgeons in many parts of the world. Much of the current spine literature come from the western world and do not elaborate on the management of these challenging issues. As a result, there is a knowledge gap on the current and best methods to treat and manage these difficult problems. The members of the Association of Spine Surgeons of India have a huge area of expertise in this field which has not been adequately documented. This book is a compilation of the experience of ASSI members and is being published in commemoration of the Silver Jubilee Year of the Association. It is a matter of pride for us that all lead authors of the book are members of ASSI.



The book will serve as a reference and much information is available in the 60 chapters which have been contributed by 88 authors. Apart from surgical techniques, adequate emphasis has been laid on clinical features, value of modern diagnostic facilities and appropriate drug therapy. The success of treatment depends on all the above and it is our sincere belief that this book will help achieve the goal of safe spine surgery.

I thank my associate editors Anil Jain, Ajoy P Shetty, Rishi M Kanna and all the authors for their very valuable contributions. I also thank Ms Chetna Malhotra and all the staff of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi for their total support. Without their tolerance and acceptance for many late submissions and numerous requests for revisions, publications of this book would not have been possible.

Lastly, I would like to thank the members of ASSI for giving me the privilege of editing and compiling this book. It is an honor which I fondly cherish.

S Rajasekaran

# Contents

# **Spinal Infections**

## **Section 1: Fundamental Concepts**

1.	Bacteriology of Spinal Infections  GD Sundararaj, K Venkatesh, Joy Sarojini Michael  Pathogenesis 5	. 5
	Microbial Agents 5	
	Types of Spinal Infections 7	
	Diagnosis of Infection 13	
	Histology 14	
2.	Biomechanical Aspects of Spinal Infections	. 16
	Vijay K Goel, Hiroshi Kuroki, S Rajasekaran  Anatomical Concepts 16	
	<ul> <li>Anatomical Concepts 16</li> <li>Effects of Infectious Diseases on the Anatomical Structures 17</li> </ul>	
	Biomechanical Features in Infectious Diseases of the Spine 18	
	<ul> <li>Effect of Biomechanical Forces on Vertebral Endplates (VEP)</li> <li>20</li> </ul>	
3.	Imaging in Spinal Infections	25
	<ul> <li>Ketan S Khurjekar, Devarati K Khurjekar, Vilas P Kanikdaley, Ashok K Shyam</li> <li>Various Modalities of Imaging 25</li> <li>Spinal Osteomyelitis 29</li> <li>Spondylodiscitis 29</li> <li>Intraspinal Infections 38</li> </ul>	
4.	Management Principles of Spinal Infections	43
	Dilip K Sengupta	
	■ Bacteriology 43	
	<ul><li>Management Plan 43</li></ul>	
	Section 2: Tuberculosis of Spine	
	A. General Principle	
5.	Tuberculosis of the Spine: A Historical Perspective and Evolution of Treatment	. 55
	SM Tuli	
	<ul> <li>Historical Perspective 55</li> </ul>	
	Evolution of Treatment of Spinal Tuberculosis 56	
	<ul> <li>Evolution of Surgical Treatment of Spinal Tuberculosis 57</li> <li>Drug Resistance, Relapse, or Recurrence 59</li> </ul>	
	<ul><li>Drug Resistance, Relapse, or Recurrence 59</li><li>New Imaging Modalities 60</li></ul>	
	Immunodeficiency and Tuberculosis 61	
	■ The Challenges for Future 61	

xvi	Spinal Infections and Trauma	
_	inal Tuberculosis—Microbiology and Pathology emik Nagad, Abhay Nene	64
•	Types of Mycobacterium Organisms 64	
	Microbiological Diagnostic Methods for MTB 65	

- Pathology of Spinal Tuberculosis 66
- Atypical Tuberculosis 69
- Histopathology 70
- Histopathology 70

7.	Clinical Features and Physical Assessment of Tuberculosis of Spine	73
	VT Ingalhalikar	

- Clinical Presentation 73
- Tuberculous Cold Abscess 74
- Tubercular Spinal Deformity 76
- Neurological Deficits 77
- Tuberculosis of Specific Regions 78
- Differential Diagnosis 81

8.	<b>Investigations for Spinal Tuberculosis</b>	83
	Yogesh K Pithwa	

- Blood Investigations 83
- Tuberculin Skin Test 83
- Serological Tests 84
- Tissue Diagnosis 84
- Other Investigations 87

## 

#### Anil K Jain, Saurabh Jain

- Pathology of Neurological Deficits 90
- Staging of Neural Deficit 92
- Clinical Presentations 93
- Treatment 93
- Indications of Surgery 95
- Surgical Decompression (Anterior or Posterior) 96
- Surgical Approaches to Tubercular Spine 98
- Instrumented Stabilization 99
- Neurological Complications in Healed Disease 100

# **10. Deformity in Spinal Tuberculosis**S Rajasekaran

- Natural History of Progress of Deformity 103
- Other Factors Influencing Deformity 105
- Patterns of Healing 108
- Buckling Collapse 109
- Surgery for Prevention of Deformity 110
- Surgery for Established Deformity 110

### 

#### Gomatam R Vijay Kumar

- Definition 114
- Incidence 114
- Etiology and Pathogenesis 114
- Clinical Presentation 115
- Imaging Studies 115
- Management 116
- Outcome 117

### **B.** Management

12.	<ul> <li>K Sriram</li> <li>Historical Review 120</li> <li>Chemotherapy 120</li> <li>Surgery 121</li> <li>Tuberculosis of Cervical Spine 126</li> <li>Tuberculosis of the Lumbar Spine 127</li> </ul>	120
13.	<ul> <li>Drug Therapy for Spinal Tuberculosis</li> <li>Mathew Varghese, Shwetabh, Pranay Bhushan</li> <li>Rationale of Chemotherapy 133</li> <li>Essential Drugs/First-Line Drugs 133</li> <li>Reserve Drugs/Second-Line Drugs 134</li> <li>Differential Action of Antitubercular Drugs in Bacterial Population 135</li> <li>Scientific Basis for Intermittent Therapy: The "Lag Period" Factor 136</li> <li>Case Definitions 136</li> <li>Multidrug Regimens for Chemotherapy 136</li> <li>Management of Common Adverse Effects of Chemotherapy 139</li> </ul>	133
14.	<ul> <li>Multidrug-resistant Tuberculosis of the Spine</li> <li>Uday Pawar, Abhay Nene</li> <li>Definitions 141</li> <li>Causes of Drug Resistance 141</li> <li>Laboratory Diagnosis of Resistance 141</li> <li>Management Principles 142</li> </ul>	141
15.	<ul> <li>Upper Cervical Tuberculosis</li> <li>S Govender</li> <li>Pathology 145</li> <li>Presentation 145</li> <li>Imaging 145</li> <li>Treatment 148</li> </ul>	145
16.	Tuberculosis of the Lower Cervical Spine  Ram Chaddha, Swapnil Keny  Cervical Spine Infections 151  Peculiarities of Cervical Spine Tuberculosis 151  Classification 151  Clinical Features 154  Management 157  The Role of Surgery 157	151
17.	Thoracic and Thoracolumbar Tuberculosis  Shekhar Bhojraj, Sameer Kalkotwar, Tarak Patel, Gautam Prasad  Anatomical Peculiarities 167  Clinical Presentation 167  Diagnosis 167  Differential Diagnosis 170  Treatment 170  Complications 172  Special Situations 173  Authors' Recommendations 174	167
18.	<ul> <li>Lumbosacral Tuberculosis</li> <li>Shankar Acharya, Abhishek Srivastava</li> <li>Clinical Presentation 179</li> <li>Investigations 179</li> <li>Management 181</li> <li>Special Considerations in Lumbosacral Tuberculosis 183</li> </ul>	177

## C. Surgical Techniques

19.	Tuberculosis of Spine: Biopsy Techniques  Bharat R Dave, Ajay Krishnan  Techniques 190 Approach and Technique 191 Types of Needles Used 191 Difficult Areas 192 Complications 192 Examination of Specimen 192 Authors' Preferred Technique (For Thoracic and Lumbar Spine) 192	190
	Cold Abscess in Spinal Tuberculosis  Surya Prakash Rao V, Gopala Krishnaiah T  Pathogenesis 195  Craniovertebral Junction 195  Midcervical Spine (C3-C6) 196  Cervico-Dorsal Junction and Upper Dorsal Spine (C7-D4) 196  Thoracic Spine 196  Lumbar and Lumbosacral Spine 197  Prognostic Signs in Plain Radiograph 198  Principles of Management 199  Types of Treatment 199	
	<ul> <li>Minimally Invasive Spine Surgery in Spinal Infections</li> <li>Upendra BN, Abhishek Srivastava, Kamran Farooque, Arvind Jayaswal</li> <li>History of Minimally Invasive Spine Surgery (MISS) 201</li> <li>Advantages of MISS 201</li> <li>Thoracic-Lumbar Spine 202</li> <li>Cervical Spine 207</li> </ul>	
22.	Anterior Approaches in Spinal Tuberculosis  Mallikarjun, Sajan K Hegde  Evolution of the Anterior Approach of the Spine 209  Subaxial Cervical Spine TB 210  Cervicodorsal TB 210  Thoracic TB 213  Thoracolumbar Junction 213  Lumbar Spine 213	209
23.	Anterior Procedures in the Management of Tuberculosis of Thoracic, Thoracolumbar and Lumbar Spine  Subbiah M, Ajoy P Shetty, S Rajasekaran  Evolution of Anterior Surgeries in TB Spine 217  Anterior Surgical Options 218	217
24.	Posterior Approaches for Management of Spinal Tuberculosis  Gautam Zaveri  Posterior Approaches to the Thoracic Spine 225  Posterior Approach to the Lumbar Spine 232  Posterior Approach to the Cervical Spine 234	225
25.	Surgeries in Healed Tuberculosis of Spine  Ajoy P Shetty, Rishi M Kanna, Subbiah M  ■ Natural Healing in Spinal Tuberculosis 237  ■ Posterior Approaches 241	237

## Section 3: Pyogenic Infections of the Spine

26.	Pyogenic Vertebral Osteomyelitis.  GD Sundararaj, R Amritanand  Epidemiology 251  Pathogenesis 251  Bacteriology 252  Clinical Presentation 252  Diagnosis 254  Management 255  Facet Joint Septic Arthritis 257	251
27.	Spinal Epidural Abscess  Rushama Tandon Incidence 260 Pathophysiology and Pathogenesis 261 Clinical Features 263 Diagnosis 263 Management of Sea 264 Outcome 264 Tubercular Spinal Epidural Abscess 264 Epidural Granuloma 265  Section 4: Miscellaneous Spinal Infections	260
28.	Fungal Infections.  S Govender  Pathoanatomy 271  Clinical Features 271  Radiological Features 272  Diagnostic Tests 272  Treatment 272  Prevention of Invasive Aspergillosis in the Immunocompromised Patient 273  Epidemiology 274  Diagnostic Tests 274  Surgical Treatment 275  Medical Treatment 275	271
29.	Unusual Bacterial Infections  S Govender  Salmonella Spondylitis 278 Epidemiology 278 Etiology 278 Clinical Features 278 Imaging 278 Diagnostic Studies 279 Treatment 279 Preventative Measures 279 Introduction 280 Epidemiology 280 Clinical Manifestations 280	278

хх	Spinal Infections and Trauma	
•	Imaging Studies 280 Diagnostic Studies 280 Treatment 281 Prognosis 281	
	rasitic Infestations  Govender  Epidemiology 284  Parasitology 285  Clinical Features 285  Laboratory Findings 285  Imaging Features 285  Differential Diagnosis 286  Natural History 286  Treatment 286  Introduction 289  Life Cycle 289  Presentation 289  Investigations 289  Treatment 290	284
_	inal Infections in the Immunocompromised Patients  Govender, S Danaviah  HIV and Host Interactions 295  Opportunistic Spinal Infections 299  Antiretroviral Therapy 301  Malignancy and HIV/Aids 302	293
	stoperative Spondylodiscitis ghava D Mulukutla Incidence 307 Etiopathology 307 The Source 308 Clinical Presentation and Diagnosis 308 Investigations 309 Radiology 310 MRI 311 Management 311 Prevention 311 Treatment 312 Surgery 313 Instrumentation 314 Prognosis 315	307
	ri-implant Spinal Infections  lay Pawar, Samir Dalvie Risk Factors for Wound Infection 318 Anterior Versus Posterior Instrumentation 318 Clinical Presentation 318 Investigations 318 Microbiology of Infection 319	318

# **Spinal Trauma**

# Section 5: Basic Concepts in Spinal Injury

34.	Epidemiology of Traumatic Spinal Cord Injuries  Harvinder Singh Chhabra, Mohit Arora  Incidence Rate 327  Prevalence of SCI 327  Survival Time 329  Age 329  Gender 329  Marital Status 329  Educational Level 329  Primary Occupational Status at the Time of Injury 329  Mode of Injury 331  Neurological Level and Category of Injury 332  Time and Place of Injury 334  Associated Injuries 334	327
35.	Prehospital Care in Spinal Injury Patients  Sudhir K Srivastava, Sunil K Bhosale, Kshitij Kumar M Agrawal, Pradip S Nemade  Principles of Prehospital Care 338  Prehospital Care System 339  Initial Evaluation 339  Protection of Spine 340  Cervical Collars 341  Transfer to Tertiary Units 342  Consideration in Special Circumstances 343  Pitfalls of Spinal Immobilization 344  Future Trends 344	338
36.	Initial Evaluation of Patients with Spinal Injuries  SS Patil, Samir Dalvie General Evaluation 347 Local Examination 347 Neurological Examination 347 Classification and Scoring of the Spinal Injuries 351	347
37.	Radiology of Spinal Trauma  Ashutosh Sabnis, Kapil Mohan, Abhay Nene  Plain Radiograph 355  Cervical Spine Radiograph 355  Thoracolumbar Spine Radiograph 363  Plain Radiographs for Sacrum 364  Spinal Cord Injuries without Radiographic Abnormalities (SCIWORA) 364  Computed Tomography in Spinal Trauma 366  Magnetic Resonance Imaging in Spinal Trauma 370  Conventional Angiography for Spinal Trauma 373  Radionuclide Bone Imaging for Spinal Trauma 374	355
38.	Surgical Decision Making in Spinal Cord Injuries  Harvinder Singh Chhabra, Ankur Nanda, Vikas Tandon  Surgical or Conservative Management 377  The Context of Developing Countries 380  SCI—When to Operate 380	377

## Section 6: Spinal Cord Injury

39.	Pathophysiology of Spinal Cord Injury  Uday M Pawar, Dilip K Sengupta  Epidemiology 389  Pathophysiology of Spinal Cord Injury 389	389
40.	Current Status of Pharmacological Agents in Acute Spinal Cord Injury  Amol Rege  Pathophysiology of SCI 395  Mechanism of Action of Pharmacological Agents 396	395
41.	Regenerative Strategies in Spinal Cord Injury  Vijay Kamath, S Rajasekaran  Pathophysiology of the SCI and Obstacles to Regeneration in the Injured Spinal Cord 403  Approaches to Treatment 403  Challenges in Developing Cellular Therapies to Treat Spinal Cord Injury 405  What are Stem Cells? 406  Olfactory Ensheathing Cells (OECS) 406  Schwann Cells 408  Macrophages 408  Bone Marrow Stromal Stem Cells 408  Neural Stem Cells and Glial Progenitors 409  Embryonic Stem Cell-Derived NSCS, NPCS and OPCS 410  Adult-Derived NSCS 410  Delivery Methods 411	402
40	Upper Cervical Spine Injuries	401
42.	Saumyajit Basu  Anatomical Considerations 421  Atlanto-occipital Injuries 422  Atlas Fractures 422  Atlantoaxial Dislocations 423  Axis Fractures 424	421
43.	Missed Spinal Injuries  Gautam Zaveri  Epidemiology 431  Consequences of Missed Spinal Injuries 433  Etiology of Missed Injuries 434  Prevention 435  Thoracolumbar Trauma 439	431
	Section 8: Thoracolumbar Spine Trauma	
44.	Biomechanics and Classification of Thoracolumbar Spinal Injuries  Uday M Pawar, Swapnil Keny, Ram Chaddha  Thoracolumbar Spine 449  Concept of Instability and Surgical Indication 452	449

Contents	xxiii

45.	Vertebral Compression Fractures.  Arvind G Kulkarni, Siddharth M Shah  Etiology 457  Epidemiology 457  Classification 457  Biomechanics 458  Clinical Features 458  Differential Diagnosis 458  Investigations 458  Treatment 459	457
46.	Burst Fractures of the Thoracolumbar Spine  KV Menon, Ramesh Dalwai  Definition 462  Epidemiology 462  Classification 463  Pathological Anatomy 464  Management 465  Management Algorithm According to the AO Classification 468	462
47.	<ul> <li>Flexion-distraction Injuries and Fracture Dislocations of the Thoracic and Lumbar Spine.</li> <li>Harsh Priyadarshi, Thomas J Kishen, Greg Etherington, Ashish D Diwan</li> <li>Incidence 471</li> <li>Anatomy and Biomechanical Considerations 471</li> <li>Assessment 472</li> <li>Mechanism of Injury: Flexion-Distraction Injury of the Thoracic and Lumbar Spine 472</li> <li>Mechanism of Injury: Fracture Dislocations of the Thoracic and Lumbar Spine 475</li> <li>Management of Flexion-Distraction Injuries and Fracture Dislocations of the Thoracic and Lumbar Spine 476</li> </ul>	471
48.	Fractures of the Sacrum  J Naresh Babu  Sacral Anatomy 481  Etiology and Incidence 482  Evaluation of Sacral Fractures 482  Classification 484  Treatment 486	481
49.	Pediatric Spinal Injuries  Saumyajit Basu  Epidemiology 493  Related Anatomy 493  Biomechanics 494  SCIWORA 494  Clinical Presentation 495  Imaging Studies 495  Management Strategies 497  Late Complications of Pediatric Spinal Injuries 498	492
50.	Gunshot Injuries to the Spine  S Govender  Ballistics of Gunshot Injuries 500  Assessment 500  Role of Steroids 501  Investigations 501	500

Antibiotic Treatment 501

XX	Spinal Infections and Trauma	
51.	Indicatons for Surgery 502 Lead Toxicity 502 Migrating Bullets 502 Case Review 502 Results of Treatment 503 Nonoperative Management of Spinal Injuries. Rajagopalan, Rishi M Kanna	506
	Medical Management of Acute Spinal Cord Injury 506 Conservative Management of Upper Cervical Spine Injuries 507 Conservative Management of Lower Cervical Spine Injuries 510 Conservative Management of Thoracic Spine Injuries 511 Conservative Management of Thoracolumbar Fractures 511 Nonoperative Management of Thoracolumbar Fractures with Normal Neurology 514	
52.	atrogenic Spinal Cord Injury—Incidence, Prevention and Management  Bibhudendu Mohapatra, Thomas J Kishen, Sonia Sandhu, Greg Etherington, Ashish D Diwan  I atrogenic Spinal Cord Injury 518  Incidence of Iatrogenic Spinal Cord Injury 518  Etiopathogenesis of ISCI 520  Management of Iatrogenic Spinal Cord Injury 524	518
53.	GCI Rehabilitation  Gabriel David Sundararaj, Henry Prakash, E Subbian  Acute Phase Rehabilitation 531  Post-Acute Management of Conservatively and Surgically Managed Patients 531  Mobility 532  Neurogenic Bladder Management after SCI 533  Neurogenic Bowel 535  Sexual Rehabilitation 535  Functional Outcomes in SCI Rehabilitation 538	531
	Complications of Spinal Cord Injury  Harvinder Singh Chhabra, Gururaj Sangondimath, Darshan Gautam, Nishit Patel  Respiratory Complications in Spinal Cord Injury 541  ARDS 543  Cardiovascular Complications after SCI 544  Deep Vein Thrombosis in Spinal Cord Injury 550  Gastrointestinal (GI) Complications in Spinal Cord Injury Patients 552  Hemorrhoids 556  Pressure Ulcer (PrU) 556  Heterotopic Ossification (HO) 559  Spasticity 561  Genitourinary Tract Complications 562  Osteoporosis in Spinal Cord Injured Patient 566  Post-traumatic Pain Syndromes 567  Syringomyelia 569  Mortality in Spinal Cord Injury 571  Section 9: Special Situations	
55.	Management of Subaxial Cervical Spine Injuries  Gautam Zaveri  Emergency In-Hospital Care 587  Definitive Treatment 590  Indications for Surgery 590	587

	<ul><li>Selection of Surgical Approach 592</li><li>Complications 600</li></ul>		
	Osteoporosis and Spinal Trauma Raghava Dutt Incidence 604 Clinical Features 604 Classification 604 Pathology 604 Risk Factors 605 Diagnosis 605 Fractures in Osteoporotic Spine 607 Management 608 Prevention and Medical Management 608 Management of Vertebral Compression Fractures Nonoperative Management 609 Surgical Management 610 Minimally Invasive Techniques 610 Open Surgical Procedures 610 Methods of Fixation 611	609	604
57.	<ul> <li>Special Considerations for Geriatric Spinal Injuries</li> <li>Harvinder Singh Chhabra, Vivek Mittal</li> <li>Predisposing Factor 614</li> <li>Etiology 614</li> <li>Level of Injury 615</li> <li>Type of Injury 615</li> <li>Symptoms 617</li> <li>Diagnosis 617</li> <li>Complications 618</li> <li>Mortality 618</li> <li>Outcomes 621</li> </ul>		614
58.	Vertebroplasty for Osteoporotic Vertebral Fractures Arvind Bhave Consequence of Vertebral Compression Fractures Indications for Vertebroplasty 623 Contraindications 623 Timing of Vertebroplasty 623 Preoperative Evaluation 623 Materials Used for Augmentation 624 Vertebroplasty—How Does It Work? 624 Devices for Performing Vertebroplasty 625 Surgical Technique 625 Postoperative Management 626 Complications 627 Current Opinion on Vertebroplasty 628 Future of Vertebroplasty 628		623
59.	<ul> <li>Kyphoplasty of Symptomatic Vertebral Body Compression</li> <li>Anand Agarwal, John Yeh, Robert Pflugmacher</li> <li>Surgical Management 630</li> <li>Indications 630</li> <li>Diagnosis and Imaging 631</li> <li>Kyphoplasty 631</li> </ul>	ession Fractures	630

xxvi	Spinal Infections and Trauma	
60. Spi	inal Injuries in Ankylosing Spinal Disorders	638
_	hitij Chaudhary, Mihir Bapat, Vinod Laheri	
•	Clinical Presentation 638	
•	Investigations 638	
•	General Principles 639	
•	Spinal Fractures in Ankylosing Spondylitis 639	
•	Diffuse Idiopathic Skeletal Hyperostosis 641	
•	Complications 642	
Index		645