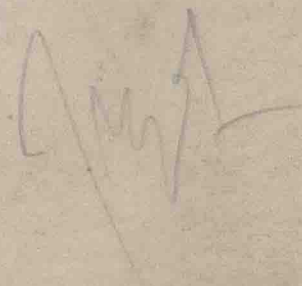


# Clinical Radiology of the Spine and the Spinal Cord

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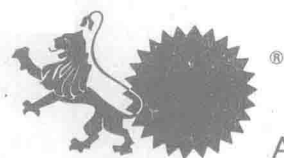
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# Preface

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It is 20 years since my training in neuroradiology commenced at Atkinson Morley's Hospital, London, England. After 8 years as Consultant and Clinical Lecturer at the Regional Neurological Centre, Newcastle-upon-Tyne, England, I joined the Department of Radiology at the Medical School of McMaster University. In these three institutions and in several other hospitals in different parts of the world where I worked for shorter periods, I learned a great deal from colleagues, residents, students, and foremost, from the patients I examined.

In writing this book, it is my intention to share these experiences with the reader, hoping thereby to enhance the knowledge and skills they themselves gain over the years. There is no substitute for the day-to-day practice of radiology. The obligation to commit in a written report one's own interpretation of a study; the questions of medical students, nurses, and radiographers; and the discussions of problem cases with the clinicians concerned—all are essential in the making of a competent radiologist. Because we live in an era of ongoing technical advances, as attested to by the introduction of computed tomography, nonionic contrast media, digital subtraction angiography and magnetic resonance, it is neither feasible nor practical to describe every possible image of one disease entity, let alone the spine and the spinal cord in health and disease. The radiological literature is voluminous; new findings, unusual cases and recent observations continue to be published and will not cease. In mentioning some old techniques of investigating disc disease, it is with the intention that they might be useful for those who have no access to modern technology.

I have borrowed a number of illustrations from

friends and colleagues whose names are appropriately mentioned, and I wish to thank them all for their help. I wish to thank my associates in the affiliated Radiology Departments of McMaster University, at McMaster Health Sciences Centre, Hamilton General Hospital, St. Joseph's Hospital, and Henderson General Hospital for allowing me access to their material. All photographic prints and many of the illustrations were made by the Audiovisual Department of McMaster University. Special thanks are due to all staff members of that department, and in particular to Mr. Geoffrey Brown for his efforts to obtain the best reproductions of the original radiographs. The secretarial assistance of Monika Ferrier and Monica Schmidt-Oak was indispensable, and to both ladies I wish to say thank you. Thanks are also due to the radiographers in our and in other institutions from which some of the illustrations were borrowed. The CT images from McMaster University Medical Centre were done on the Technicare Delta 2020 scanner. The Magnetic Resonance Images were obtained, unless otherwise stated, from Dr. A. Kuchnert, Diagnostic Imaging Clinic in Dietzenbach, West Germany, utilizing Siemens Magnetom.

To my wife Wilma and to my children, Dena and Karem, I wish to apologize for my frequent infringement upon family time while writing this book. To Berta Steiner, Director of Production at University Park Press, I express my appreciation for her cooperation and diligent attention to the production for the volume. Last but not least, I wish to thank Mrs. Ruby Richardson of University Park Press for her patience and endeavors in the formulation of this book.

M.B.

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# Notice

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The author and the publisher have exercised great care to ensure that the drug dosages, formulas, and other information presented in this book are accurate and in accord with the professional standards in effect at the time of publication. Readers are, however, advised to always check the manufacturer's product information sheet that is packaged with the respective products to be fully informed of changes in recommended dosages, contraindications, and the like before prescribing or administering any drugs or radiographic contrast media.

# Contents

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## Preface v

## 1 The Normal Spine 1

---

### Cervical Spine 1

Anteroposterior Radiograph	1
Lateral Radiograph	1
<i>Cervical Vertebrae</i>	1
<i>Intervertebral Discs</i>	1
<i>Spinal Canal</i>	4
<i>Craniocervical Area</i>	5
<i>Width of the Atlantoaxial Predental Space</i>	5
<i>Posterior Cervical Line</i>	5
<i>Prevertebral Space</i>	7
Oblique Projection	8
Pillar Projection	8
Open-Mouth View	8

### Thoracic and Lumbar Spine 11

Anteroposterior Radiograph	11
Lateral Radiograph	14
Oblique Projection	16

### Spinal Ligaments 17

Anterior Longitudinal Ligament	17
Complex of the Posterior Spinal Ligaments	17
Craniovertebral Ligaments	19

### Spinal Mobility 19

Flexion	19
Extension	19
Rotation	19
Lateral Tilting	22

### Normal Mobility of the Lumbar Spine 23

Pseudosubluxation	23
-------------------	----

### Normal Spine in Infants and Children 23

Development of Vertebral Column	23
Mesenchymal Stage	23
Stage of Chondrification	25
Stage of Primary Ossification	25
Stage of Secondary Ossification	26
Development of Atlas	29
Development of Axis	29

## 2 Developmental Anomalies of the Spine 31

---

### Anomalies of the Craniovertebral Region 31

Basilar Invagination	31
Hypoplasia of the Basisphenoid	32
Platybasia	32

**Anomalies of the Atlas 36**

- Occipitalization of the Atlas* 36
- Atlantoaxial Fusion* 38
- Arcuate Foramen (Ponticulus Posterior)* 38
- Defects in the Posterior Arch* 38
- Ossification Anomalies of the Anterior Arch* 40
- Asymmetry of the Lateral Masses* 40

**Anomalies of the Dens 41**

- Ossification Anomalies* 41
- Os Odontoideum* 41
- Ossiculum Terminale (Proatlas)* 41
- Hypoplasia of Dens* 41
- Large Odontoid* 45
- Aplasia of the Dens* 45
- Occipital Vertebra* 45

**Segmentation Failure 49**

- Block Vertebra* 49
- Klippel-Feil Syndrome* 49
- Hemivertebrae* 51
- Butterfly Vertebra* 55
- Coronal Cleft Vertebrae* 55

**Neural Arch Defects 55****Anomalies of Vertebral Appendages 57**

- Anomalies of the Transverse Processes* 57
- Congenital Absence of Pedicle* 58
- Anomalies of the Articular Facets* 61

**Phylogenetic and Transition Anomalies 61**

- Variation in the Number of Vertebrae* 61
- Transitional Vertebra* 61

**Lumbosacral Dysgenesis 61****Vertebral Anomalies as Part of Generalized Skeletal Dysplasia 65**

- Achondroplasia* 65
- Hurler's Syndrome* 65
- Morquio-Brailsford Syndrome (MPS-IV)* 69
- Osteogenesis Imperfecta* 70

**3 Introduction to Myelography and Computed Tomography 74****Evolution of Contrast Media for Myelography 74**

- Gas* 74
- Lipiodol* 74

- Thorotrast* 74
- Iophendylate* 74
- Emulsified Myodil* 75
- Hydrosoluble Ionic Contrast Media* 75
- Hydrosoluble Nonionic Contrast Media* 75

**Technique of Myelography with Nonionic Contrast Media 76**

- Hospitalization* 76
- Lumbar Myelography* 76
- Cervical Myelography* 76
- Dose and Concentration of Metrizamide* 76
- Postmyelography Instructions* 77

**Gross Anatomy of the Spinal Cord and Meninges 77**

- Spinal Cord Diameter* 77
- Length of the Spinal Cord* 78
- Relation Between the Cord and the Vertebral Segments* 79
- Spinal Meninges* 79
- Spinal Nerve Roots* 80
- Meningeal Sleeves Surrounding the Nerve Roots* 81
- Radiographic Factors for Water-Soluble Contrast Myelography* 81
- Radiographic Projections* 82

**Roentgenographic Anatomy 85**

- Spinal Cord* 85
- Nerve Roots* 86
- Blood Vessels* 86
- Subarachnoid Space* 88

**Computed Tomography 88**

- CT of the Lumbar Spine* 88
- CT of the Thoracic Spine* 91
- CT of the Cervical Spine* 91
- CT of the Sacrum* 91
- CT Myelography* 100

**Appendix 1 Phenothiazine Derivatives 101****Appendix 2 Compound Injection of Pethidine 101****4 Spinal Fractures and Dislocations 102****Injuries of the Cervical Spine 102**

- Atlantooccipital Dislocation* 102
- Occipital Condyle Fracture* 104

Unilateral Atlantooccipital Dislocation	104
Fractures of the Atlas	104
Fractures of the Axis	107
<i>Fractures of the Dens</i>	107
<i>Healing of Odontoid Fractures</i>	111
<i>Radiological Features of Odontoid Fractures</i>	112
<i>Fractures of the Dens in Young Children</i>	113
<i>Iatrogenic Distraction of a Fractured Odontoid</i>	115
Fracture of the Neural Arch of the Axis	115
Fracture of the Lateral Mass of the Axis	118
Fractures of the Body of the Axis	118

## Atlantoaxial Subluxation 119

Traumatic Atlantoaxial Subluxation	120
Atlantoaxial Subluxation in Rheumatoid Arthritis	120
Atlantoaxial Subluxation Due to Congenital Anomalies of the Dens	120
Atlantoaxial Subluxation in Down's Syndrome	123
Atlantoaxial Subluxation Due to Inflammatory Lesions of the Neck	123
Atlantoaxial Subluxation in Association with Skeletal Dysplasia	123

## Rotary Fixation of the Atlantoaxial Joint 123

## Injuries of the Lower Cervical Vertebrae 125

Acute Disc Herniation	125
Fractures of the Cervical Spine	126
Dislocation of the Cervical Spine	131
<i>Bilateral Interfacet Dislocation</i>	132
<i>Unilateral Interfacet Dislocation</i>	132
<i>Hyperextension Dislocation</i>	134

## Trauma in the Presence of Cervical Spondylosis 136

## Fractures of the Cervical Spine in Ankylosing Spondylitis (Marie-Strümpell Disease) 136

## Cervical Spine Injuries in Newborn Infants 137

## Injuries of the Thoracolumbar Spine 138

Classification	138
Fractures of the Vertebral Body	138
<i>Anterior Wedge Compression</i>	138

<i>Lateral Wedge Compression</i>	138
<i>Comminuted or "Burst" Fracture</i>	138
<i>Vertebral Edge Fracture</i>	141
Fractures of the Posterior Vertebral Elements	142
Fractures of the Transverse Processes	143
Distraction Fractures of the Lumbar Vertebrae	144
Fracture-Dislocations of the Thoracolumbar Vertebrae	146

## Injuries of the Sacrum and Coccyx 146

## Computed Tomography in Spinal Injuries 149

## Myelography in Spinal Injuries 149

Posttraumatic Syringomyelia	150
Posttraumatic Arachnoidal Adhesions	151
Traumatic Meningocele	152

## 5 Intervertebral Disc 159

### Anatomy 159

### Degenerative Disease of the Spine 160

Radiological Features of Primary Degenerative Disc Disease	161
Stenosis of the Lumbar Spinal Canal	164
<i>Causes</i>	164
<i>Plain Film Findings</i>	166
<i>CT Findings</i>	167
<i>Myelography in Lumbar Canal Stenosis</i>	170
Redundant Lumbar Nerve Root Syndrome	170
Cervical Spondylosis	173
<i>Myelography</i>	177
Ankylosing Hyperostosis	178
Calcification of the Intervertebral Disc	179
<i>Degenerative Disc Calcification</i>	179
<i>Disc Calcification in Children</i>	180
<i>Intervertebral Disc Calcification in a Fixed Spine</i>	181
<i>Ochronosis (Alkaptonuria)</i>	181
<i>Chondrocalcinosis and Pseudogout</i>	182
Idiopathic Ossification of the Posterior Spinal Ligament	182
Ossification of the Flaval Ligaments	184

## Lumbar Intervertebral Disc Herniation 185

Terminology	185
Types of Intervertebral Disc Herniation	185



Spine Radiographs in Acute Disc Herniation	187	<b>Infections of the Intervertebral Disc</b>	<b>216</b>
Myelography in Lumbar Disc Herniation	187	Tuberculous Spondylitis (Pott's Disease)	216
CT in Lumbar Disc Herniation	193	Age Incidence	216
<b>Discography</b>	<b>195</b>	Pathology	216
Normal Discogram	195	Distribution of Lesions	216
Abnormal Discogram	195	Radiological Features	217
<b>Lumbar Epidural Venography</b>	<b>200</b>	Atypical Forms of Spinal Tuberculosis	220
Anatomy	200	Computed Tomography of Spinal Tuberculosis	220
External Vertebral Veins	200	Healing of Spinal Tuberculosis	220
Internal Vertebral Veins	200	Pyogenic Infections of the Vertebral Column	220
Communicating Veins	201	Salmonella Osteomyelitis	224
Interpretation of the Lumbar Epidural Venogram	201	Brucella Osteomyelitis	224
<b>Epidurography</b>	<b>202</b>	Mycotic Infections	224
<b>Advantages and Limitations of Radiological Methods Used for the Diagnosis of Lumbar Disc Herniation</b>	<b>204</b>	Charcot's Spine	224
Myelography	204	<b>Nonpyogenic Discitis in Children</b>	<b>226</b>
Discography	204	Hydatid Disease of the Spine (Spinal Echinococcosis)	228
Epidural Venography	204	<b>Sarcoidosis of the Spine</b>	<b>229</b>
Epidurography	204	<b>6 Intraspinal Mass Lesions</b>	<b>232</b>
<b>Intradural Lumbar Disc Herniation</b>	<b>205</b>	<b>Histological Introduction</b>	<b>232</b>
<b>Thoracic Disc Herniation</b>	<b>205</b>	<b>Classification</b>	<b>234</b>
<b>Back Pain After Lumbar Disc Surgery</b>	<b>206</b>	<b>Value of Survey Radiography</b>	<b>234</b>
Radiological Investigations	206	Changes in the Pedicles	234
<b>Facet Joints as a Cause of Back Pain and Sciatica</b>	<b>208</b>	Sagittal Diameter of the Spinal Canal	236
Anatomy	208	Scoliosis	238
Nerve Block of the Facet Joints	208	Deformation of the Paravertebral Shadows	238
<b>Schmorl's Nodes and Scheuermann's Disease</b>	<b>210</b>	<b>Intramedullary Lesions of the Spinal Cord</b>	<b>239</b>
Schmorl's Nodes	210	Ependymoma	240
Scheuermann's Disease	211	Extraspinal Ependymoma	241
<b>Inflammatory Diseases</b>	<b>211</b>	Astrocytoma	241
Rheumatoid Spondylitis	211	Oligodendroglioma	243
Ankylosing Spondylitis (Marie-Strümpell Disease)	212	Myelographic Appearance	243
Psoriatic Spondylitis	214	<b>Syringomyelia</b>	<b>245</b>
Reiter's Spondylitis	214	Etiology	246
Colitic Spondylitis	215	Chiari Type 1 Malformation	247
		Pathophysiology of Syringomyelia	247
		Gardner's Theory	247
		Williams' Theory	247
		Aboulker's Theory	247
		Ball and Dayan Theory	247

Radiological Diagnosis	247	
Myelography	248	
Computed Tomography	249	
Direct Puncture of the Syrinx	250	
Metrizamide Ventriculography	253	
Syringomyelia with Clinical Manifestations		
Incriminating the Caudal End of the Spinal Cord	254	
<b>Hemangioblastoma</b>	<b>254</b>	
Von Hippel-Lindau Syndrome	254	
<b>Intradural Extramedullary Lesions</b>	<b>256</b>	
Neurilemmoma	256	
Pathological Considerations	256	
Myelographic Appearances	257	
Meningioma	261	
Differential Diagnosis	261	
Extradural Meningiomas	261	
Extraspinal Meningiomas	261	
Multiple Meningiomas	261	
<b>Seeding Metastases</b>	<b>263</b>	
Myelographic Appearance	263	
<b>Extradural Lesions</b>	<b>265</b>	
Pathological Considerations	265	
Myelographic Appearance	265	
Epidural Abscess	265	
Spontaneous Epidural Hematoma	266	
Neuroblastoma	267	
Age and Sex Incidence	267	
Sites	268	
Tumor Spread	268	
Spinal Cord Involvement	268	
Radiological Findings	268	
Survival Rate	268	
Epidural Sarcoma	268	
Lymphoma	271	
Neurilemmoma	271	
Ganglioneuroma	271	
Paraganglioma	271	
Leukemia	271	
Extramedullary Hematopoiesis	272	
Hemangiopericytoma of the Meninges	273	
<b>Lesions of the Arachnoid Mater</b>	<b>273</b>	
Perineural Cysts	273	
Meningeal Sacral Cysts	273	
Extradural and Intradural Spinal Arachnoid Cysts	276	
Arachnoiditis	277	
<b>Multiple Neurofibromatosis (Von Recklinghausen Disease)</b>	<b>278</b>	
Cutaneous Manifestations	278	
Spinal Manifestations	278	
Kyphoscoliosis	278	
Vertebral Scaloping	279	
Widening of Intervertebral Foramina	279	
Abnormal Findings at Myelography	279	
Intracranial Manifestations	279	
Cranial Manifestations	280	
Pelvic and Limb Changes	281	
Chest Manifestations	281	
Gastrointestinal Tract Manifestations	281	
Urinary System Changes	283	
Vascular Lesions	283	
<b>Intraspinal Vascular Malformations</b>	<b>283</b>	
Anatomy	283	
Anterior Spinal Artery	283	
Posterior Spinal Arteries	284	
Radiculomedullary Arteries	284	
Pathological Considerations	285	
Clinical Presentation	286	
Radiological Manifestations	286	
<b>Spinal Epidural Angioma</b>	<b>289</b>	
<b>Dilatation of Spinal Vessels in Lesions Other Than Vascular Malformations</b>	<b>289</b>	
<b>7 Spinal Dysraphism</b>	<b>296</b>	
<b>Embryology</b>	<b>297</b>	
Development of the Spinal Cord	298	
<b>Myelomeningocele</b>	<b>300</b>	
Incidence and Etiology	300	
Pathophysiology	301	
Hydrocephalus and Myelomeningocele	301	
Prenatal Diagnosis of Myelomeningocele	304	
Vertebral and Rib Malformations in Children with Myelomeningocele	305	
Calvarial Abnormalities Associated with Myelomeningocele	306	
Renal Complications in Patients with Myelomeningocele	307	
<b>Meningocele</b>	<b>307</b>	
Anterior Sacral Meningocele	308	
Intrathoracic Meningocele	311	

**Tethered Cord Syndrome 313**

**Intraspinal Lipoma 316**

- Intraspinal Lipoma in Association with Spina Bifida 317
- Intraspinal Lipoma Unassociated with Spina Bifida 318
- Epidural Lipoma Unassociated with Spina Bifida* 321

**Intraspinal Dermoid and Epidermoid Cysts 323**

**Diastematomyelia 323**

**Neurenteric Cyst 327**

**Split Notochordal Syndrome 328**

**Multiple Lesions 328**

**8 Tumors and Tumor-Like Lesions of the Vertebral Column 332**

**Spinal Metastases 332**

- Clinical Manifestations 333
- Radiological Features 333

**Benign Bone Tumors 337**

- Osteoid Osteoma 337
- Osteoblastoma 338
- Osteochondroma 339
- Chondromyxoid Fibroma 341
- Vertebral Hemangioma 341
- Symptomatic Vertebral Hemangioma* 343
- Skeletal Angiomatosis* 344

**Tumor-Like Lesions 346**

- Eosinophilic Granuloma 346
- Radiological Features* 346
- Prognosis* 347
- Aneurysmal Bone Cyst 347
- Unicameral Simple Bone Cyst 348
- Fibrous Dysplasia 348

**Spinal Involvement in Malignant Bone Marrow Disease 348**

- Myeloma 348
- Hodgkin's Lymphoma 351
- Burkitt's Lymphoma 352
- Leukemia 353

**Primary Malignant Bone Tumors 353**

- Chordoma 353
  - Age and Sex* 353
  - Symptoms* 353
  - Radiographic Features* 353
  - Pathology* 356
  - Course and Outcome* 356
- Osteosarcoma 357
- Ewing's Sarcoma 358
  - Epidural Ewing's Sarcoma* 359
- Chondrosarcoma 359
- Fibrosarcoma 359
- Angiosarcoma 359

**Tumors That May Be Benign or Malignant 359**

- Giant Cell Tumors 359
- Teratoma 361
  - Differential Diagnosis* 362
- Hemangiopericytoma 364

**CT-Guided Vertebral Biopsy 365**

- Safety and Reliability 365
- Anesthesia 365
- Type of Needle 365
- Technique 365

**9 Spinal Deformities 370**

**Spondylolisthesis 370**

- Etiology 370
- Types of Spondylolisthesis 373
  - Dysplastic Spondylolisthesis* 373
  - Spondylolytic Spondylolisthesis* 374
  - Degenerative Spondylolisthesis* 374
  - Spondylolisthesis After Multiple Bilateral Laminectomies and Facetectomies* 374
  - Spondylolisthesis Secondary to Bone or Disc Disease* 376
  - Traumatic Spondylolisthesis* 376
- Incidence 376
- Classification of Spondylolisthesis 376
- Malalignment of the Apophyseal Joints as a Sign of Spondylolisthesis 377
  - Bow Sign (Inverted Napoleon Hat Sign)* 377
- CT in Spondylolysis and Spondylolisthesis 377
- Myelography 379

**Scoliosis 381**

- Classification 381
  - Idiopathic Scoliosis* 382
  - Infantile Idiopathic Scoliosis 382

Juvenile Idiopathic Scoliosis	382
Adolescent Idiopathic Scoliosis	382
<i>Scoliosis Secondary to Congenital Vertebral Anomalies</i>	382
<i>Scoliosis in Association with Neuromuscular Diseases</i>	382
Primary and Secondary Curves of Spinal Scoliosis	383
Intrinsic Vertebral Changes	383
Radiography	383
Radiation Protection	384
Curve Measurement	385
Estimation of Vertebral Growth	385
Spinal Flexibility	386

## **Kyphosis 386**

## **Kyphoscoliosis 387**

## **Sway-Back Syndrome 387**

## **Straight-Back Syndrome 388**

## **Radiation-Induced Spinal Deformities 388**

## **Spinal Changes in Acromegaly 389**

## **Spine in Children with Neuromuscular Disorders 390**

## **Spine in Marfan's Syndrome 390**

## **10 Miscellaneous Conditions 392**

### **Osteoporosis 392**

Causes	392
Radiographic Features	392

### **Osteomalacia 394**

Etiology	395
Radiological Manifestations	395

### **Hypophosphatasia 397**

### **Paget's Disease 398**

Pathology	398
Etiology	398
Age and Sex	398
Incidence and Geographic Distribution	399
Clinical Manifestations	399

Radiological Manifestations	399
Sarcomatous Degeneration	401

## **Osteopetrosis 403**

Pathology	403
Clinical Manifestations	403
Radiological Appearance	403

## **Melorheostosis 404**

## **Osteopoikilosis 404**

## **Myelofibrosis (Myelosclerosis) 404**

Idiopathic Myelofibrosis	404
Secondary Myelofibrosis	405

## **Mastocytosis 408**

## **Skeletal Fluorosis 408**

Radiological Features	408
Industrial Fluorosis	409

## **11 Magnetic Resonance Imaging 411**

Armin Kühnert and Mohamed Banna

### **Magnetic Resonance 411**

Proton Density	411
Relaxation Times	412
Chemical Environment	413
Proton Diffusion	413
Pulse Sequences	418

### **Technique 415**

### **Normal Appearances 415**

### **Diseases of the Spinal Cord 416**

Lesions at the Craniocervical Junction	416
Multiple Sclerosis	418
Syringomyelia	418
Intraspinal Tumors	421
Vascular Malformation	421

### **Diseases of the Intervertebral Disc 424**

### **Diseases of the Vertebral Column 424**

## **Index 435**

# The Normal Spine

## Cervical Spine

Routine radiographs of the cervical spine usually comprise an anteroposterior, a lateral, an open-mouth and two oblique views with 45° rotation. These may be supplemented by two lateral radiographs with head flexion and extension (Merrill, 1967). To highlight the appearance of the various vertebral elements in the different projections, a number of disarticulated vertebrae were used. Each vertebral element was covered with lead paint, and standard radiographs were made (Fig. 1.1).

### Anteroposterior Radiograph

The prominent structures shown in the frontal projection are the body of the cervical vertebrae, the uncovertebral joints, the bifid spinous processes, and the transverse processes of the seventh cervical vertebra (Fig. 1.2). Note in this projection that the transverse processes are superimposed on the articular pillars, the laminae are superimposed on the vertebral bodies, and adjacent articular facets overlap one another. Note also that the pedicles are not seen end-on because they form an angle of approximately 45° with the vertebral body and are superimposed on the base of the laminae (Fig. 1.3). Particular attention should be given to the height of the interspinous spaces; widening of an interspinous distance such that it measures more than 1.5 times the interspinous distance at the contiguous levels above and

below indicates an anterior cruciate ligament rupture. A particular importance is the alignment along the midline; an abrupt deviation indicates a unilateral facet dislocation.

### Lateral Radiograph

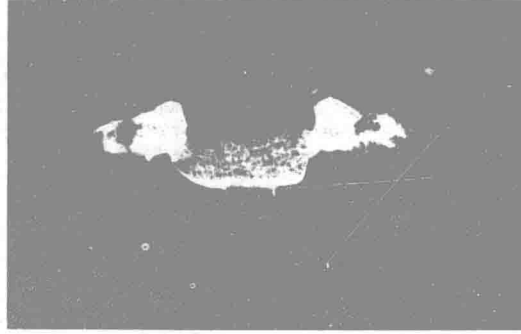
The lateral radiograph is the most important in the examination of the cervical spine. It provides information about the: (1) cervical vertebrae; (2) intervertebral discs; (3) spinal canal; (4) retropharyngeal space; (5) craniocervical area (Fig. 1.4). The craniocervical area is separately discussed.

### Cervical Vertebrae

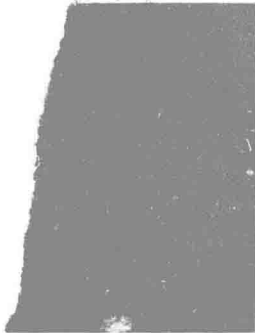
The various elements of a typical cervical vertebra (C3-7) are shown in Figure 1.5. Note that in the lateral projection the pedicles are foreshortened and the laminae are largely obscured by the articular pillars.

### Intervertebral Discs

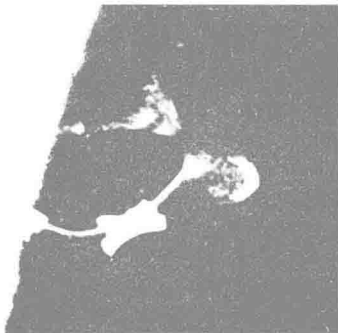
The width of the intervertebral disc spaces and the integrity of the vertebral end-plates should be thoroughly examined. Note that the C7-T1 disc is slightly narrower than the ones above, and there is no intervertebral disc at C1-2. The vertebral end-plate is a thin band of condensed cancellous bone at the upper and lower ends of the vertebral body. The word "end-plate" is a literal translation from the German *Schlussplatte*.



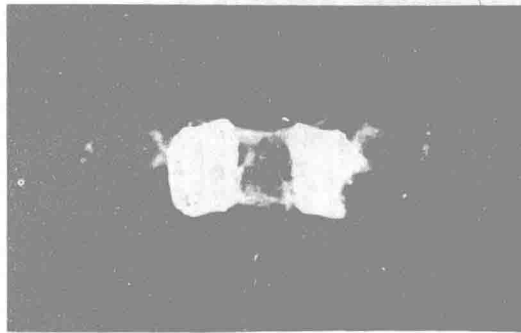
Antero-posterior projection



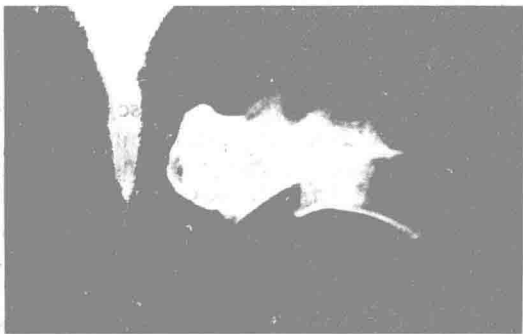
Oblique projection



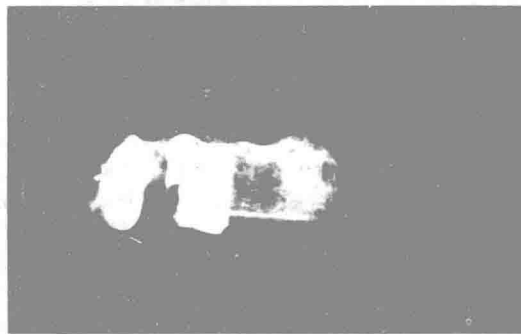
view



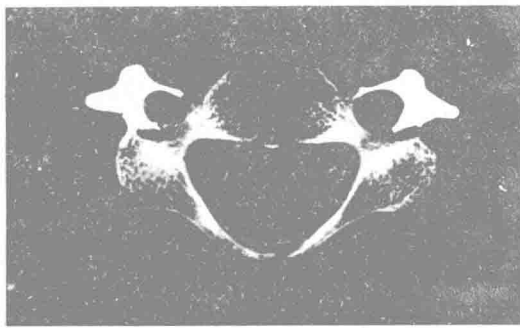
Antero-posterior projection



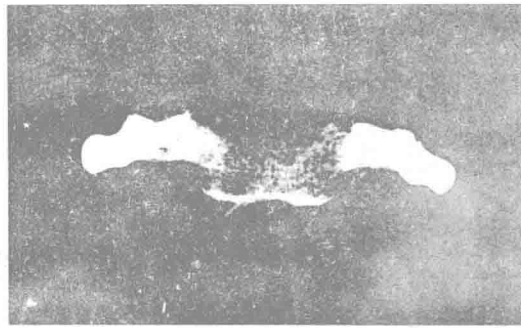
Lateral projection



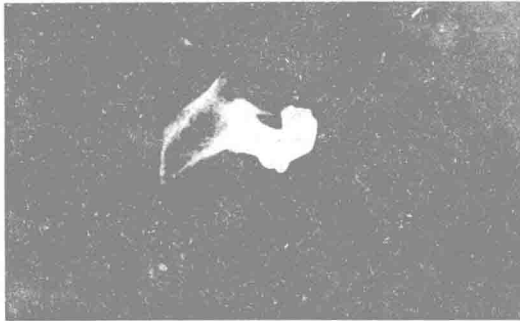
Oblique projection



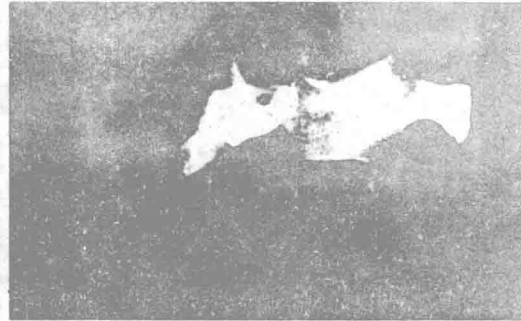
Superior-inferior view



Antero-posterior projection



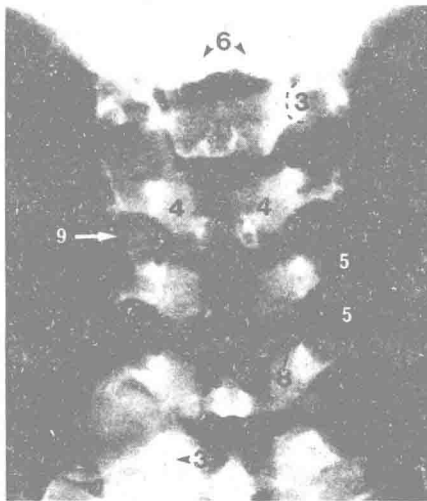
Lateral projection



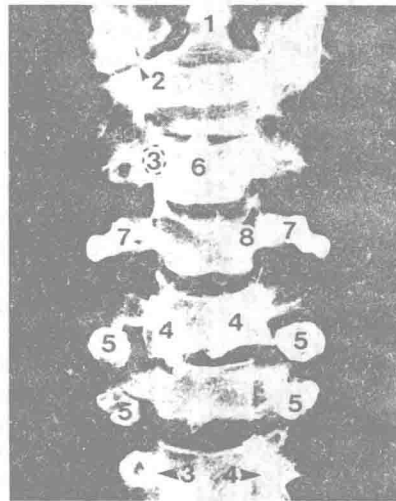
Oblique projection

C

**Figure 1.1** Cervical vertebrae in which the posterior elements were coated with lead paint to highlight their appearances in the standard radiographic projection.

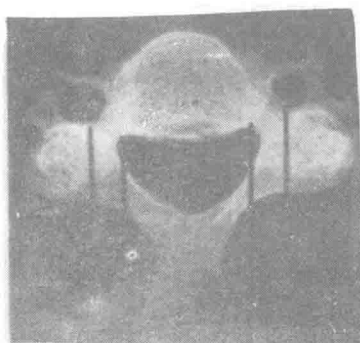


A

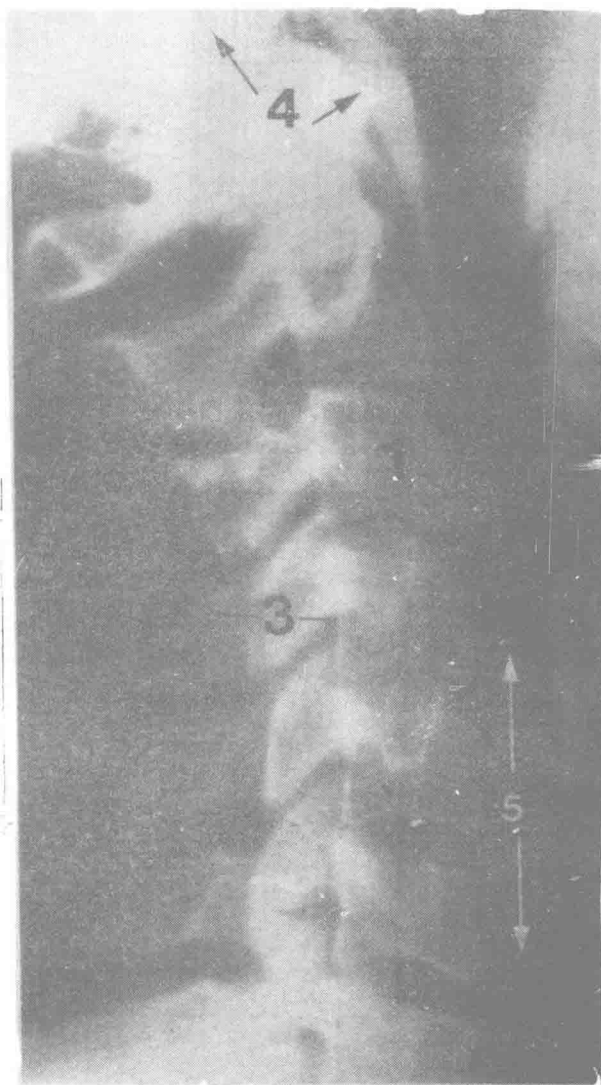


B

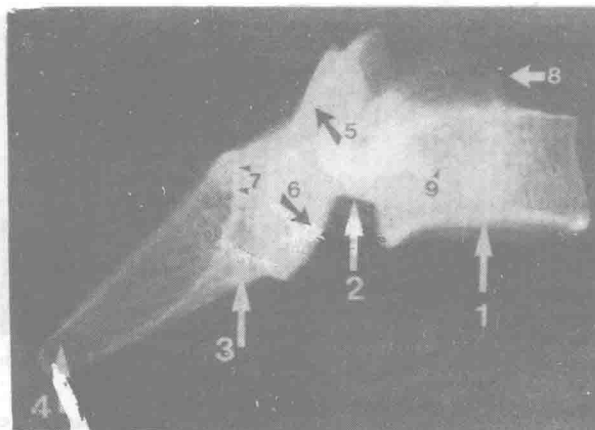
**Figure 1.2** Anteroposterior radiograph of the cervical spine (A) and the dry skeleton covered with lead paint (B). (1) odontoid process. (2) superior articular facets of the axis. (3) pedicle. (4) laminae. (5) superior and inferior articular facets. (6) bifid spinous process of cervical vertebra. (7) transverse processes. (8) uncinat process. (9) cornua of the thyroid cartilage. Note that on the seventh cervical vertebra of the dry skeleton a wire was put around the right pedicle (3) and the base of the left lamina (4).



**Figure 1.3** Superior inferior view of a lower cervical vertebra. Note that the pedicles and the base of the laminae are in the same sagittal plane.



**Figure 1.4** Lateral view of the cervical spine. This projection provides information related to: (1) the vertebrae, (2) the intervertebral discs, (3) the spinal canal, (4) the craniovertebral junction, and (5) the retropharyngeal space.



**Figure 1.5** Typical lower cervical vertebra in the lateral projection. (1) vertebral end-plate. (2) pedicles, (3) laminae. (4) spinous process. (5) superior and (6) inferior articular facets. (7) spinolaminar line. (8) uncinate processes. (9) transverse processes.

### Spinal Canal

Assessment of the cervical spine is not complete without reference to the sagittal diameter of the spinal canal (Fig. 1.6). This may be measured from the center of the posterior surface of the vertebral body to the nearest point on the spinolaminar line (the line formed by fusion of the laminae with the base of the spinous process). In cases of cervical spondylosis, measurements made at the level of the intervertebral discs are more significant. In adults, using a target film distance of 180 cm, the sagittal diameter of the spinal canal at C3–7 is approximately 17 mm (range 12–24 mm). The sagittal diameter of the spinal canal is wider at C1 (16–32 mm) and C2 (15–27 mm).

In children, the diameter of the spinal canal appears abnormally wide in relation to the size of the vertebrae. In the absence of bone erosion this is a normal finding and does not necessarily indicate an intraspinal expanding lesion (Wholey, Bruwer, and Baker, 1958).





**Figure 1.6 Spinal canal.** Measurements of the spinal canal are made from the center of the posterior surface of the vertebral bodies to the nearest point on the spinolaminar line. Note that the sagittal diameter of the spinal canal is widest at C1 and C2, and there is a uniform diameter of the spinal canal from C3 to C7.

### Craniocervical Area

Several lines and measurements have been devised to assess the craniocervical relation (Wackenheim, 1974). The majority of these lines are of limited value when correlated with the patient's symptomatology. Slight deviation from the set standards is not invariably symptomatic, and symptoms from hind-brain herniation may develop in the absence of bony abnormality (Burrows, 1981). The lines which are probably in use more than

others are Chamberlain's line, McRae's line, and the basilar line (Fig. 1.7).

### Palatooccipital Line (Chamberlain's Line)

The palatooccipital line is drawn from the posterior margin of the hard palate to the posterior rim of the foramen magnum. The tip of the odontoid process normally lies 1–7 mm above this line. In pointing out the limitations of this measurement, McRae showed that the position of the odontoid process is influenced by the length of the clivus and the size of the occipital condyles. If the clivus is short or the occipital condyles are small, the atlas and axis are high in position and may be thought to be abnormal.

### Sagittal Diameter of the Foramen Magnum

The normal sagittal diameter of the foramen magnum measures 27–40 mm. McRae (1960) estimated the size of the foramen magnum in cases of occipitalization of the atlas by measuring the shortest anteroposterior diameter of what he called the *effective foramen magnum*. In cases of basilar invagination the effective foramen magnum may lie between the posterior surface of the dens and the posterior rim of the foramen magnum or the fused posterior arch of the atlas if the latter is occipitalized. Patients showing an anteroposterior diameter of the effective foramen magnum of less than 19 mm had symptoms or signs of disease in the lower medulla or upper spinal cord.

**Basilar Line** The basilar line, also called the clivoaxial line, is a downward extension of a line drawn along the posterior surface of the clivus. It passes at an angle tangential to, or intersecting the tip of, the odontoid process.

### Width of the Atlantoaxial Predental Space

With the head in a flexed position, the distance between the posterior surface of the anterior arch of the atlas and the anterior surface of the dens should not exceed 3 mm in adults or 5 mm in children (Fig. 1.8).

### Posterior Cervical Line

On a true lateral projection, a line is drawn from the anterior cortex of the posterior arch of C1 to the spinolaminar line of C3. Normally, this line touches, lies just behind, or is up to 1.5 mm in front of the anterior cortex of the posterior arch of C2 (Fig. 1.9). Dislocation of C2 on C3 is almost certainly present if the posterior cervical line lies 2 mm or more in front of the anterior cortex of the posterior arch of C2 (Swischuk, 1977). This line is useful in children with questionable C2 dislocation or fracture of the neural arch of the axis. If a fracture is present the body of the axis, carrying the atlas and the cranium, moves forward but its laminae remain attached to C3. Thus the line connecting the spinolaminar junction of the displaced C1 to the spi-