

Musculoskeletal Radiology Curriculum for Radiology Residents

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The Accreditation Council for Graduate Medical Education (ACGME), the body that accredits medical residency programs in the United States, has established Residency Review Committees (RRC) for each specialty. Representatives of these committees evaluate training programs throughout the country to determine whether they meet established standards for resident education. In an effort to ensure that resident education is sufficient and that quality health care remains available in the United States, the ACGME has established six General Competencies that residents in all specialties must achieve, and has determined that each residency must be able to assess their residents' progress in achieving these competencies through Practice Performance Measurements. The Competencies include patient care (PC), medical knowledge (MK), practice-based learning and improvement (PBL), interpersonal and communication skills (ICS), professionalism (P), and systems-based practice (SBP). The RRC for Diagnostic Radiology has defined the Competencies as they apply to radiology and has provided a list of required and suggested Practice Performance Measurements for each Competency. This information is available at the ACGME website, listed in the References section of this document.¹ As of July 1, 2006, all radiology residency programs are expected to meet these standards during their periodic accreditation evaluations,.

For diagnostic radiology residency programs, certain standards must be met for the residency program as a whole. These include semi-annual face-to-face evaluation for each resident, written evaluations for each rotation, training in medical physics and radiation safety, a program of didactic lectures, and specific requirements for mammography training.² For each of the nine subspecialty areas, there are additional requirements. Each subspecialty must have a written curriculum that specifies goals for each resident rotation on that subspecialty, and specific knowledge based and technical objectives that meet requirements for the General Competencies.

In an effort to aid residency programs in meeting these requirements for musculoskeletal (MSK) radiology, the current authors, who comprise the Residency and Fellowship Education Committee of the Society of Skeletal Radiology (SSR) 2005-2007, developed this document. It is intended to provide a robust framework for a musculoskeletal radiology curriculum at any residency in the United States, with the hope that it will be inclusive but flexible enough to satisfy the ACGME's requirements and suit any particular residency with a minimum of alteration. This document draws heavily on the rigorous efforts of the Education Committee of the Society of Thoracic Radiology (STR)

and their published curriculum for cardiothoracic radiology.³ The current authors acknowledge that significant organizational elements and language have been directly adopted and adapted from the STR document.

Several comments need to be made about the elements and structure of this curriculum. Hopefully, these comments will help to ensure this document is flexible enough to fit the needs of any residency program. There are several important requirements for MSK radiology education that are not listed in this curriculum. For instance, didactic lectures on musculoskeletal anatomy, physiology, pathology, and imaging should be part of any diagnostic radiology residency program. Likewise, radiology residents must have access to teaching files that have adequate examples of imaging of musculoskeletal pathology, and periodic case conferences or reviews of teaching cases during the MSK rotation are strongly encouraged. The ACGME guidelines also strongly suggest that residents attend relevant interdepartmental conferences, such as correlation conferences with Rheumatology, Orthopedics, and Sports Medicine, although this is not a strict requirement. Also, this curriculum also does not specify specific resources that residents on a musculoskeletal radiology rotation should read; each program will have their own suggestions for these resources and should add those to this document.

Each technical objective in this curriculum is followed by one or more abbreviations. These abbreviations denote the General Competencies that each objective addresses.

The rotations in this curriculum are expected to be 4-week or 1-month rotations. This curriculum is broken down into three rotations because that is the minimum number of months a resident should spend rotating in MSK. Certainly, many programs have more than 3 MSK rotations; in that case, they may expand this curriculum to meet that need and shuffle the knowledge and technical objectives among 4 or 5 rotations.

There are certain goals and objectives that are included in this curriculum that some residencies may cover on other services. For example, bone biopsies may occur in the vascular and interventional rotation, or spine imaging may lie completely within the neuroradiology rotation. Thus, although programs are required to provide training in these areas, they are free to delete these and other goals and objectives from the MSK curriculum if those requirements are met on other rotations. Likewise, decisions about which goals and objectives should fall in which rotation will vary widely from one institution to another. As an example, joint aspirations may be an important resident call duty at some facilities, in which case the program would prefer to teach residents joint aspirations and injections in the first rotation instead of the second. Alternatively, some residency programs may not expose their residents to sports medicine imaging until later in the residency, so residents might not learn joint injections for MR arthrography until the third rotation.

This document contains an appendix. That appendix is an MSK radiology curriculum guide previously developed and published in 1999 by the SSR Residency and Fellowship Education Committee and the Education Committee of the American Society of MSK Radiology and then revised, though not published, by the 2003-05 SSR Education

Committee. That document serves as a larger list of knowledge based objectives for radiology residents learning MSK radiology, and is the primary source of the knowledge objectives in the current document. Certainly, residents should be able to master the vast majority of topics covered in the appendix, but the curriculum below includes the knowledge objectives deemed to be most important to the practice of musculoskeletal radiology and those expected to be discussed extensively during MSK rotations.

This curriculum will be posted on the SSR website at www.skeletalrad.org in both pdf and doc formats. The latter will allow easy editing for residency programs. Also, as the SSR Residency and Fellowship Education Committee becomes aware of revisions that are needed, they will be made to the online documents. Along those lines, the reader should feel welcome to comment on the documents. Those comments should be directed to the chair of the SSR Residency and Fellowship Education Committee.

Rotation 1

Goals

After completing the first four-week rotation in musculoskeletal radiology, the resident will be able to:

- Demonstrate learning of knowledge based objectives and mastery of technical objectives for the first rotation
- Generate accurate and concise radiographic reports
- Communicate effectively with patients, referring clinicians, technologists and supervisory staff
- Understand standard radiographic positioning and anatomy
- Obtain essential patient information pertinent to the radiologic examination
- Demonstrate knowledge of clinical indications for radiography and indications for urgent computed tomography (CT) and magnetic resonance (MR) examinations
- Demonstrate a responsible work ethic
- Participate in quality improvement/ quality assurance activities
- Participate in the education of students and interns

Objectives

- **Knowledge based**
 - Demonstrate learning of normal radiographic and CT anatomy of the axial and appendicular skeleton
 - Demonstrate learning of normal MRI anatomy of the knee and shoulder
 - Demonstrate learning of normal MRI anatomy of the cervical, thoracic, and lumbar spine

- Recognize and accurately describe common fractures and dislocations of the appendicular skeleton
- Recognize and describe fractures and dislocations of the cervical, thoracic and lumbar spine. Understand basic mechanisms of injury and distinguish stable from unstable injuries
- Demonstrate learning of pathophysiology and radiology of fracture healing and complications of healing such as delayed union, malunion and nonunion
- Demonstrate learning of radiographic presentation and evaluation of osteomyelitis and septic arthritis
- Recognize and describe complications of orthopedic devices including fracture fixation and spine and arthroplasty hardware

- **Technical**

- Dictate clear, detailed, and accurate reports that include all pertinent information as established in the American College of Radiology (ACR) Guidelines for Communication⁴ (PBL, ICS)
- Use appropriate nomenclature when reporting radiographic, CT, MR or ultrasound (US) findings of musculoskeletal disease (ICS)
- Communicate all unexpected or significant findings to the ordering provider and document whom was called and the date and time of the discussion in the report (ICS, PC, P)
- Obtain relevant patient history from electronic records, dictated reports, the patient, or by communication with referring provider (PC)
- Recognize and describe positioning and anatomy of standard radiographic examinations of the musculoskeletal system (MK)
- Effectively provide feedback to radiology technologists regarding quality of exposure and patient positioning (ICS, SBP)
- Recognize when it is appropriate to obtain help from senior residents or faculty when assisting referring clinicians (PC, P)
- Demonstrate responsible, ethical behavior; positive work habits; and professional appearance; and adhere to principles of patient confidentiality (P)
- Participate in discussions with faculty and staff regarding operational challenges and potential system solutions regarding all aspects of radiologic services and patient care (SBP)

Rotation 2

Goals

After completing the second four-week rotation in musculoskeletal radiology, the resident will be able to:

- Demonstrate learning of knowledge based objectives and mastery of technical objectives for the second rotation
- Continue to build and improve on skills developed during the first rotation
- Develop skills in protocoling and monitoring CT and MR examinations
- Demonstrate an understanding of the ACR Appropriateness Criteria⁵ and ACR Practice Guidelines and Technical Standards for musculoskeletal imaging⁶
- Participate in the education of junior residents, interns, and medical students
- Perform image guided procedures

Objectives

- **Knowledge Based**
 - Recognize and describe the radiographic presentation of Paget disease
 - Demonstrate learning of a systematic approach to arthritis. Be able to describe and differentiate salient radiologic (radiographic, CT and MR) features of common arthropathies including osteoarthritis, inflammatory arthropathy (rheumatoid, psoriatic, reactive, juvenile chronic, and septic), crystal deposition diseases (calcium pyrophosphate deposition, gout, hydroxyapatite deposition), neuropathic arthropathy, connective tissue disease (systemic lupus erythematosus, scleroderma, dermatomyositis), pigmented villonodular synovitis, and synovial chondromatosis
 - Demonstrate a systematic assessment of a solitary lesion of bone and be able to categorize the lesion as aggressive or nonaggressive. Develop an appropriate differential diagnosis based on patient age, lesion location, and lesion characteristics (margin, matrix, periosteal reaction, soft tissue extension). Demonstrate knowledge of systematic, safe and cost effective radiologic work-up of bone lesions including biopsy approach and compartmental anatomy.
 - Recognize and describe common locations of and radiologic manifestations of osteonecrosis.
 - Demonstrate knowledge of MRI safety issues including contraindication to scanning and use of contrast.
 - Demonstrate learning of the use of various pulse sequences and planes of imaging used in MRI of musculoskeletal disorders
 - Demonstrate learning of common knee and shoulder pathology on MRI (meniscal tear, tendon and ligament injury, fracture, chondral disease, rotator cuff tear, and labral pathology)

- Demonstrate learning of common pathology of the cervical, thoracic, and lumbar spine on MRI
- Demonstrate learning of the normal MRI anatomy of the hip and ankle
- **Technical**
 - Build and improve on skills acquired during first rotation
 - Demonstrate the ability to gather essential and accurate patient information (electronic, personal communication) to appropriately prescribe MRI protocols (PC, ICS)
 - Provide effective and timely feedback and education to CT and MRI technologists regarding quality of examinations (ICS, SBP)
 - Demonstrate ability to monitor CT and MRI examinations to ensure the patient is adequately evaluated (MK, PC)
 - Demonstrate an understanding of indications, contraindications, needle path, risks and post procedural management of CT and US guided procedures including management of complications (MK, PC)
 - Provide technical and educational guidance to junior residents and students (ICS)
 - Safely perform fluroscopically guided joint injections and aspirations with faculty supervision (PC)
 - Demonstrate an understanding of indications, contraindications, radiation risks, and post procedural management of fluroscopically guided procedures including management of complications (MK, PC)
 - Demonstrate an ability to counsel a patient and obtain informed consent before performing a procedure, including a description of the procedure, risks, benefits, and alternatives; and solicit and respond to patient questions without discrimination based on religious, ethnic, sexual, economic, or educational differences (ICS, PC, P)
 - Maintain a log of all procedures performed including complications (PBL)

Rotation 3

Goals

After completing the third four-week rotation in musculoskeletal radiology, the resident will be able to:

- Demonstrate learning of knowledge based objectives and mastery of technical objectives for the third rotation
- Continue to refine skills developed during the first two rotations
- Effectively use information technology to address clinical problems
- Participate in the education of junior residents and medical students
- Become a more independent provider of musculoskeletal radiologic interpretive services
- Manage clinical and technical questions from technical and support staff

Objectives

- **Knowledge based**
 - Recognize radiologic findings and describe pathophysiology of endocrine disease including hyperparathyroidism, renal osteodystrophy, osteomalacia/rickets, hypophosphatasia, hypophosphatemia
 - Recognize radiologic findings of hematopoietic and storage diseases including sickle cell anemia, thalassemia, mastocytosis, and Gaucher's disease.
 - Demonstrate systematic approach to relatively common dysplasias and congenital conditions such as achondroplasia, osteogenesis imperfecta, osteopetrosis
 - Demonstrate learning of common pathology of the hip and ankle on MRI
 - Demonstrate learning of anatomy and common injuries/pathology of the elbow and wrist on MRI

- **Technical**
 - Improve and build on skills acquired during the first two rotations
 - Demonstrate the ability to locate, appraise and assimilate evidence from scientific studies related to the performance and interpretation of musculoskeletal imaging (PBL)
 - Demonstrate the ability to teach a junior colleague how to protocol examinations and plan procedures (PC, ICS)
 - Demonstrate the ability to assess and prioritize requests for add-on procedures (PC)
 - Demonstrate the ability to answer common procedural and policy questions from technologists and support staff (PC, ICS)

References

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5. American College of Radiology. ACR Appropriateness Criteria: Expert Panel on Musculoskeletal Imaging. Available online at http://www.acr.org/s_acr/sec.asp?CID=1206&DID=15047. Accessed 9/06/06.

6. American College of Radiology. ACR Practice Guidelines and Technical Standards. Available online at http://www.acr.org/s_acr/bin.asp?CID=1848&DID=14800&DOC=FILE.PDF. Accessed 9/06/06.

Appendix

MUSCULOSKELETAL RADIOLOGY CURRICULUM GUIDE

Revised by the Residency and Fellowship Education Committee of the Society of Skeletal Radiology, 2003-2005

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INTRODUCTION

The following curriculum guide is a revision of the original document, published in 1999¹, comprising a list of subjects that are important to a thorough understanding of disorders that affect the musculoskeletal system. It does not include every musculoskeletal condition, nor is it intended to replace any textbooks, yet it is comprehensive enough to fulfill three basic requirements: 1.) to provide practicing radiologists with a guide to the fundamentals needed to be valuable consultants to orthopedic surgeons, rheumatologists, and other referring physicians, 2.) to provide radiology residency program directors with a guide to subjects that should be covered in a four year teaching curriculum, and 3.) to serve as a “study guide” for diagnostic radiology residents preparing for examination by the American Board of Radiology.

Some sections in this revision have been expanded, and some of the material overlaps with that of other radiology subspecialties, particularly neuroradiology and pediatric radiology. The division into “basic” and “advanced” categories has been maintained, with advanced concepts indicated by an asterisk (*). Basic material includes fundamental information that radiology residents should know, while advanced material includes information that subspecialized musculoskeletal radiologists might expect to master. It is acknowledged again that this division is somewhat arbitrary. It is the authors’ hope that these guidelines will serve as a self-sufficient resource or as a template for a useful curriculum based on local teaching practices.

¹Academic Radiology 1999; 6:360-367

- I. Aspects of Basic Science Related to the Musculoskeletal System
 - A. Histogenesis of developing bone

1. Intramembranous ossification
 2. Endochondral ossification
 3. Remodeling
 - B. Bone anatomy
 1. Cellular constituents
 - a. Osteoblasts
 - b. Osteoclasts
 2. Non cellular constituents
 - a. Organic matrix
 - b. Inorganic matrix
- II. Techniques Relevant to Musculoskeletal Radiology
- A. Radiography
 1. Routine views
 2. Specialized views - Indications for obtaining specialized views
 - B. Computed tomography
 - C. Magnetic resonance imaging
 - D. Fluoroscopy
 - E. Ultrasonography
 - F. Densitometry
 - G. Nuclear scintigraphy
 1. Indications
 2. Choice of scintigraphic agent
 - H. Measurement and Evaluation Techniques
 1. Scoliosis
 2. Leg length
 3. Lower extremity mechanical axis determination
 4. Anteversion
 5. Bone age determination
 - L. Interventional procedures
 1. General considerations
 - a. Consent
 - b. Pre-procedure planning
 2. Arthrography
 - a. Shoulder
 - b. Hip (including prosthesis evaluation)
 - c. Wrist *
 - d. Knee
 - e. Elbow*
 - f. Ankle*
 3. Aspiration and injections
 4. Percutaneous biopsy
- III. Normal Features and Variants
- A. Sequence of ossification
 1. Elbow

- 2. Other*
 - B. Physiologic radiolucencies
 - 1. Pseudotumor humerus
 - 2. Pseudocyst calcaneus
 - C. Vascular channels
 - 1. Nutrient canal in phalanx or long bone cortex
 - 2. Vertebral body
 - 3. Scapula
 - 4. Iliac bone
 - D. Normal sulci
 - 1. Preauricular sulcus (paraglenoid fossa)
 - 2. Rhomboid fossa
 - E. Supracondylar process
 - F. Dorsal defect of patella
 - G. Epiphyseal ossification from multiple centers - Bipartite patella
 - H. Irregular epiphyseal ossification
 - 1. Femoral condyle
 - 2. Femoral head*
 - 3. Other*
 - I. Periosteal reaction of infancy
 - J. Physiologic bowing
 - K. Transverse (growth) line
 - L. Vacuum joint
 - M. Sesamoids and accessory ossicles
 - N. Accessory muscles*
 - O. Tug lesions
 - 1. Cortical desmoid
 - 2. Other*
- IV. Congenital and Developmental Abnormalities of the Spine
- A. Os odontoideum
 - B. Klippel-Feil
 - C. VACTERL association
 - D. Vertebral anomaly
 - 1. Fusion
 - 2. Segmentation
 - E. Spinal dysraphism
 - F. Diastatomyelia
 - G. Caudal regression syndrome
 - H. Schmorl node
 - I. Scheuermann disease
 - J. Limbus vertebra
 - K. Scoliosis
- V. Congenital Anomalies and Dysplasias
- A. Lower Extremity:

1. Developmental dysplasia of the hip
2. Blount disease
3. Discoid meniscus
4. Foot deformities
 - a. Tarsal coalition
 - b. Talipes equinovarus (clubfoot)
 - c. Pes planus
 - d. Pes cavus
 - e. Metatarsus adductus varus
 - f. Vertical talus
 - g. Rocker-bottom foot
5. Syndactyly
6. Polydactyly
7. Congenital pseudoarthrosis*
8. Fibular hemimelia*
9. Proximal femoral focal deficiency*
- B. Upper Extremity
 1. Madelung deformity
 2. Congenital dislocation of the radial head
 3. Carpal coalition
 4. Syndactyly
 5. Polydactyly
 6. Sprengel deformity
 7. Radial clubhand*
 8. Thrombocytopenia absent radius syndrome (TAR)*
- C. Trunk
 1. Pectus excavatum
 2. Pectus carinatum
 3. Poland syndrome*
- D. Diffuse or Multifocal Anomalies and Dysplasias
 1. Achondroplasia
 2. Osteogenesis imperfecta
 3. Sclerosing osseous dysplasias
 - a. Osteopoikilosis
 - b. Melorheostosis
 - c. Osteopathia striata
 - d. Mixed sclerosing bone dystrophy
 4. Osteopetrosis
 5. Cleidocranial dysplasia (dysostosis)
 6. Amniotic band syndrome
 7. Pyknodysostosis
 8. Syndromic connective tissue disorders
 - a. Ehlers-Danlos syndrome
 - b. Marfan syndrome
 9. Neurofibromatosis
 10. Cerebral palsy

11. Muscular dystrophies
12. Congenital insensitivity to pain
13. Mucopolysaccharidosis (general findings)
14. Tuberosus sclerosis
15. Trisomy 21 (Down syndrome)
16. Turner syndrome
17. Advanced dysplasias*
 - a. Chondrodysplasia punctata (stippled epiphyses)
 - b. Diaphyseal dysplasia
 - c. Dysplasia epiphysealis hemimelica
 - d. Metaphyseal dysplasia
 - e. Multiple epiphyseal dysplasia
 - f. Spondyloepiphyseal dysplasia
18. Advanced diffuse disease, other*
 - a. Arthrogyrosis multiplex congenita
 - b. Endosteal hyperostosis
 - c. Fibrodysplasia (myositis) ossificans progressiva
 - d. Idiopathic osteolysis
 - e. Macrodystrophia lipomatosa
 - f. Pachydermoperiostosis
 - g. Thanatophoric dwarfism
 - h. Nail-patella syndrome
 - i. Chondroectodermal dysplasia

Note: the advanced items in these lists are only a representative sample of the entities one may wish to investigate following the basic list. Decisions to include or exclude specific maladies were made based on the authors' experience, but the reader may need to be familiar with other disease processes based on one's patient population and practice.

VI. Infection

- A. Basic concepts
 1. Routes of spread
 - a. Hematogenous
 - b. Spread from a contiguous source
 - c. Direct implantation
 2. Pre-disposing factors
- B. Osteomyelitis
 1. Sites of localization
 - a. Infants
 - b. Children
 - c. Adults
 - d. Intravenous drug users
 2. Terminology
 - a. Sequestrum
 - b. Involucrum
 - c. Cloaca

- d. Brodie abscess
 - e. Sclerosing osteomyelitis
 - f. Multifocal
- C. Septic arthritis
 - 1. Bacterial
 - 2. Tuberculous
 - 3. Lyme disease
- D. Soft Tissue
 - 1. Abscess
 - 2. Cellulitis
 - 3. Myositis
 - 4. Gas gangrene
 - 5. Necrotizing fasciitis
- E. Organisms
 - 1. Bacterial
 - 2. Tuberculous
 - 3. Fungal
 - 4. Syphilis
 - 5. Rubella
 - 6. Leprosy
 - 7. Lyme disease
 - 8. Bacillary angiomatosis
 - 9. Parasitic infection
 - 10. Hydatid disease
 - 11. Cysticercosis

VII. Neoplasm/Tumor-like Conditions

- A. General principles
 - 1. Patient age
 - 2. Description
 - a. Size
 - b. Location
 - c. Aggressiveness/growth pattern
 - d. Internal characteristics
 - e. Involvement of adjacent structures
 - f. Specific to bone lesions
 - (i) Margin (zone of transition)
 - (ii) Pattern of osteolysis
 - (iii) Periosteal reaction
 - (iv) Soft tissue mass
 - (v) Matrix/calcification
 - 3. Biopsy planning/techniques
 - a. Compartment anatomy
 - b. Limb salvage approach
 - c. Specific site to biopsy
- B. Osseous lesions (within bone)

1. Benign
 - a. Cartilaginous
 - (i) Enchondroma
 - (a) Multiple (Ollier disease)
 - (b) Maffucci syndrome
 - (ii) Osteochondroma - Multiple hereditary exostoses
 - (iii) Chondromyxoid Fibroma
 - (iv) Chondroblastoma
 - (v) Chondroma - Periosteal (surface, juxtacortical)
 - b. Fibrous
 - (i) Fibroxanthoma (non-ossifying fibroma)
 - (a) Fibrous cortical defect
 - (b) Benign fibrous histiocytoma
 - (ii) Fibrous dysplasia - McCune-Albright
 - (iii) Chondromyxoid fibroma
 - (iv) Desmoplastic fibroma
 - (v) Osteofibrous dysplasia (ossifying fibroma)*
 - c. Osteogenic
 - (i) Enostosis (bone island) - Multiple
 - (ii) Osteoma - Multiple
 - (iii) Osteoid osteoma
 - (iv) Osteoblastoma
 - d. Lipoid
 - (i) Lipoma
 - (ii) Liposclerosing myxofibrous tumor (LSMFT)*
 - e. Vascular
 - (i) Hemangioma - Multiple (Osler-Weber-Rendu)
 - (ii) Hemophilic pseudotumor
 - (iii) Lymphangioma
 - (iv) Glomus tumor
 - (v) Hemangiopericytoma*
 - (vi) Gorham disease*
 - f. Other
 - (i) Unicameral bone cyst (simple bone cyst)
 - (ii) Aneurysmal bone cyst
 - (a) Primary
 - (b) Secondary
 - (ii) Giant cell tumor of bone
 - (iii) Langerhans cell histiocytosis (eosinophilic granuloma)
 - (iv) Chordoma
 - (v) Intraosseous ganglion

- (vi) Reactive lesions
 - (a) Giant cell reparative granuloma
 - (b) Bizarre parosteal osseous proliferation (BPOP)*
 - (c) Epidermoid inclusion cyst
- 2. Malignant
 - a. Primary
 - (i) Cartilaginous - Chondrosarcoma
 - (a) Central
 - (b) Peripheral
 - (c) Dedifferentiated
 - (d) Mesenchymal
 - (e) Clear cell
 - (ii) Fibrous
 - (a) Fibrosarcoma
 - (b) Malignant fibrous histiocytoma
 - (iii) Osteogenic - Osteosarcoma
 - (a) Conventional
 - (b) Surface
 - Periosteal
 - Parosteal
 - High grade surface
 - (c) Telangiectatic
 - (d) Low grade central
 - (iv) Vascular
 - (a) Angiosarcoma
 - (b) Hemangioendothelioma
 - (v) Other
 - (a) Chordoma
 - (b) Multiple myeloma (plasmacytoma)
 - (c) Ewing sarcoma
 - (d) Primitive neuroectodermal tumor (PNET)
 - (e) Adamantinoma
 - (f) Lymphoma
 - (g) Leukemia
 - (1) chloroma
 - b. Secondary
 - (i) Radiation
 - (ii) Paget disease
 - (iii) Metastatic
 - (a) Common primary tumors
 - (1) Blastic
 - (2) Lytic
 - (3) Aneurysmal/expansile

C. Extra-osseous/soft tissue lesions

1. Benign

- a. Fibrous
 - (i) Fibroma
 - (ii) Fibromatosis
 - (iii) Desmoid
 - (iv) Elastofibroma
- b. Neural
 - (i) Neurofibroma
 - (ii) Schwannoma
 - (iii) Neurofibromatosis
 - (iv) Neuroma
 - (v) Lipomatosis of nerve (fibrolipomatous hamartoma)
 - (vi) Post-resection neuroma
 - (vii) Morton neuroma
- c. Cartilaginous - soft tissue chondroma
- d. Vascular
 - (i) Hemangioma
 - (ii) Hemangioendothelioma
 - (iii) Glomus tumor
 - (iv) Vascular malformations
 - (v) Lymphangioma
- e. Lipoid
 - (i) Lipoma
 - (ii) Angiolipoma
 - (iii) Hibernoma
 - (iv) Lipoblastoma
- f. Muscle
 - (i) Rhabdomyoma
 - (ii) Leiomyoma
- g. Dermal/subcutaneous
 - (i) Sebaceous cyst
 - (ii) Dermatofibroma
 - (iii) Granuloma annulare
 - (iv) Granular cell tumor*
- h. Other
 - (i) Myxoma
 - (ii) Giant cell tumor of tendon sheath
 - (iii) Pigmented villonodular synovitis
 - (iv) Ganglion

2. Malignant

- a. Primary
 - (i) Fibrosarcoma
 - (ii) Malignant fibrous histiocytoma (high-grade undifferentiated pleomorphic sarcoma)

- (iii) Synovial sarcoma
- (iv) Rhabdomyosarcoma
- (v) Malignant peripheral nerve sheath tumor
- (vi) Epithelioid sarcoma*
- (vii) Liposarcoma
 - (a) Myxoid
 - (b) Well-differentiated
 - (c) Dedifferentiated
- (viii) Dermatofibrosarcoma protuberans*
- (ix) Alveolar soft part sarcoma*
- (x) Myxofibrosarcoma*
- (xi) Soft tissue osteosarcoma*
- (xii) Kaposi sarcoma*
- (xiii) Melanoma
- b. Secondary
 - (i) Metastasis
 - (ii) Leukemia
 - (iii) Lymphoma
 - (iv) Soft tissue extension of bone lesions

VIII. Trauma (Including Sports Injuries)

A. General principles

1. Biomechanics of fractures
 - a. Relationship of force and deformation
 - b. Mechanisms of direct and indirect loading
 - c. Relevant anatomy and terminology
 - d. Fracture / injury patterns and associated injuries
 - e. Avulsion fracture locations
2. Fracture description
3. Stress injuries (bone and soft tissue)
 - a. Mechanisms
 - b. Pathophysiology
 - c. Epidemiology
 - d. Imaging diagnosis
 - e. Implications for treatment
4. Repetitive trauma
 - a. Tendinosis
 - b. Enthesophytes
 - c. Other
5. Soft tissue injuries
 - a. Grades of muscle tear
 - b. Grades of ligament tear
 - c. Myositis ossificans
6. Thermal trauma
 - a. Burns
 - b. Cold injury

7. Open fractures
8. Treatment
 - a. Indications
 - b. Principles of treatment
 - c. Casting
 - d. Hardware - General types and uses
 - e. Complications- - Hardware failure
 - f. Bone grafting
9. Fracture healing
 - a. Pathophysiology
 - b. Biomechanics
 - c. Time course
10. Complications
 - a. Malunion
 - b. Nonunion
 - c. Premature physal closure
 - d. Osteonecrosis
 - (i) Femoral head
 - (ii) Scaphoid proximal pole
 - (iii) Talar dome
 - e. Infection
 - f. Compartment syndrome
 - g. Arthritis
11. Foreign bodies
12. Gunshot wounds
13. Traumatic myonecrosis
- B. Trauma in adults
 1. Hand
 - a. Phalanx fracture / dislocation
 - (i) Intra vs. extra articular
 - (ii) Volar plate fracture
 - (iii) Tuft fracture
 - b. Metacarpal fracture
 - (i) Bennett vs. Rolando fracture
 - (ii) Boxer fracture
 - c. Carpometacarpal dislocation
 - d. Tendon injuries
 - e. Pulley injuries
 - f. Capsular and collateral ligament injuries
 - (i) Gamekeeper (skier) thumb
 - (ii) Metacarpophalangeal joint
 2. Wrist
 - a. Colles fracture
 - b. Smith fracture
 - c. Radial styloid fracture
 - d. Isolated carpal bone fracture

- (i) Scaphoid fracture
 - (a) Significance of blood supply
 - (b) Osteonecrosis
 - (c) Non-union
 - (ii) Triquetral fracture
 - (iii) Hamate fracture
 - (iv) Other
 - e. Complex carpal bone injuries
 - (i) Perilunate dislocation
 - (ii) Lunate dislocation
 - f. Ligament tears
 - (i) Interosseous ligaments
 - (ii) Triangular fibrocartilage complex
 - (iii) Extrinsic ligaments
 - g. Chronic carpal instability
 - (i) Dorsal intercalated segment instability
 - (ii) Volar intercalated segment instability
 - (iii) Scapholunate advanced collapse
 - h. Distal radioulnar joint injury
 - i. Carpal tunnel syndrome
 - j. Ulnar impaction syndrome
- 3. Forearm
 - a. Galeazzi fracture/dislocation
 - b. Monteggia fracture/dislocation
 - c. Isolated ulna (nightstick) fracture
- 4. Elbow
 - a. Radial head fracture
 - b. Fracture/dislocation
 - c. Humeral condyle fractures
 - d. Extensor tendinosis (tennis elbow/lateral epicondylitis)
 - e. Flexor tendinosis (pitcher's elbow/medial epicondylitis)
 - f. Ulnar collateral ligament tear
 - g. Radial collateral ligament tear
 - h. Biceps avulsion
 - i. Triceps avulsion
- 5. Shoulder and scapula
 - a. Anatomic vs. surgical neck humerus fracture
 - b. Greater tuberosity humerus fracture
 - c. Scapular fracture
 - (i) Body
 - (ii) Glenoid
 - d. Dislocation
 - (i) Anterior
 - (a) Hill Sachs fracture
 - (b) Bankart fracture
 - (c) Recurrence

- (ii) Posterior
 - (a) Reverse Bankart
 - (b) Neurovascular injuries
 - (iii) Other - scapulothoracic dissociation*
 - e. Rotator cuff tear
 - f. Labral injury
 - (i) Patterns of instability
 - (ii) SLAP tear
 - g. Proximal biceps tear or dislocation
 - h. Impingement syndrome
 - (i) Anterior
 - (ii) Posterior
 - (iii) Coracoid
 - i. Adhesive capsulitis
- 6. Clavicle and acromioclavicular joint
 - a. Grades of acromioclavicular joint separation
 - b. Clavicle fracture
 - c. Sternoclavicular fracture / dislocation
 - d. Post-traumatic osteolysis
- 7. Skull/face
 - a. Skull fracture
 - (i) Base of skull
 - (ii) Temporal bone
 - (iii) Sinus fracture
 - b. Facial bone fracture
 - (i) Orbit fracture
 - (a) Blow-out fracture
 - (b) Blow-in fracture
 - (c) Rim fracture
 - (d) Floor fracture
 - (e) Medial wall fracture
 - (ii) Zygomaticomaxillary fracture
 - (iii) Complex (LeFort classification)
 - (iv) Mandible fracture
 - (v) Nasal bone fracture
- 8. Thoracic cage
- 9. Spine
 - a. Mechanism of injury
 - (i) Flexion
 - (ii) Extension
 - (iii) Axial load/burst
 - (iv) Distraction
 - (v) Translation
 - b. Fracture/ligament injury patterns
 - c. Column concept/stability
 - (i) Cervical

- (ii) Thoracic
 - (iii) Lumbar
 - (iv) Sacrum/coccyx
 - d. Associated neurologic injury
 - e. Acute disc herniation
- 10. Pelvis and hip
 - a. Pelvic fracture patterns
 - (i) Lateral compression
 - (ii) Anterior-posterior compression
 - (iii) Vertical shear
 - (iv) Complex
 - b. Acetabular fracture - fracture patterns
 - c. Hip dislocation - risk of osteonecrosis
 - d. Femoral neck fracture
 - e. Intertrochanteric fracture
 - f. Femoral head fracture
 - g. Labral injury
- 11. Femur fracture
- 12. Knee
 - a. Femoral condyle fracture
 - b. Tibial plateau fracture
 - c. Patella fracture
 - d. Knee dislocation
 - e. Patella dislocation
 - f. Meniscal injury
 - (i) Bucket handle tear
 - (ii) Parrot-beak tear
 - (iii) Horizontal oblique tear
 - (iv) Horizontal cleavage tear
 - (v) Vertical longitudinal tear
 - (vi) Radial tear
 - (vii) Complex tear
 - (viii) Root tear
 - (ix) Meniscocapsular separation
 - (x) Fraying and degeneration
 - (xi) Displaced fragments
 - (xii) Meniscal cyst
 - g. Ligament injury
 - (i) Anterior cruciate
 - (ii) Posterior cruciate
 - (iii) Medial collateral
 - (iv) Lateral collateral
 - h. Extensor mechanism injury
 - (i) Quadriceps tear
 - (ii) Patellar tendon (ligament) tear
 - (iii) Retinaculum injury

- i. Posterolateral corner injury
 - (i) Popliteus muscle/tendon
 - (ii) Arcuate ligament*
 - (iii) Popliteofibular ligament*
 - (iv) Fabellofibular ligament*
 - j. Articular cartilage injury
 - k. Overuse injuries
 - (i) Plica syndrome
 - (ii) Iliotibial band friction syndrome
 - (iii) Pes anserine bursitis
- 13. Ankle
 - a. Mechanisms of injury
 - b. Pilon fracture
 - c. Tilleaux fracture
 - d. Maisonneuve fracture
 - e. Ligament injury
 - (i) Anterior talofibular ligament
 - (ii) Deltoid ligament
 - (iii) Syndesmotic/anterior tibiofibular ligament
 - f. Talar fracture
 - (i) Dome fracture
 - (ii) Neck fracture
 - (iii) Lateral process fracture
- 14. Foot
 - a. Calcaneal fracture - anterior process fracture
 - b. Fifth metatarsal base fracture
 - c. Metatarsal fracture
 - d. Lisfranc fracture/dislocation
 - e. Phalanx fracture
 - f. Cuboid fracture
 - g. Navicular fracture
- C. Trauma in children (unique features)
 - 1. Biomechanics of the immature skeleton
 - 2. Growth plate injuries
 - 3. Hand, wrist, and forearm
 - a. Torus fracture
 - b. Greenstick fracture
 - c. Plastic bowing
 - 4. Elbow
 - a. Radial head subluxation/dislocation
 - b. Supracondylar fracture
 - c. Entrapped epicondyle
 - d. Little leaguer elbow
 - 5. Shoulder - little leaguer shoulder
 - 6. Spine - spondylolysis
 - 7. Hip - slipped capital femoral epiphysis

8. Knee - osteochondritis dissecans
9. Tibia, ankle, and foot
 - a. Toddler fracture
 - b. Triplane fracture
 - c. Juvenile Tilleaux fracture
10. Battered child
 - a. Reporting statutes
 - b. Metaphyseal corner fracture
 - c. Fracture location and patterns

IX. Metabolic, Systemic, and Hematologic Disorders

- A. Bone physiology
 1. Mineralization of bone
 2. Calcium homeostasis
 3. Bone resorption
 4. Bone formation
 5. Humoral regulation
 - a. Parathyroid hormone
 - b. Calcitonin
 - c. Vitamin D
- B. Osteoporosis
 1. Disuse
 2. Related to aging (postmenopausal, senile)
 3. Bone marrow edema (transient, migratory)
 4. Complex regional pain syndrome/reflex sympathetic dystrophy
 5. Drug induced
 - a. Steroid
 - b. Other
 6. Idiopathic juvenile osteoporosis *
- C. Hyperparathyroidism
 1. Subperiosteal resorption, acroosteolysis
 2. Brown tumor (primary)
- D. Rickets and osteomalacia
 1. Vitamin D dependent
 2. Vitamin D resistant
 3. Dietary
 4. Gastrointestinal malabsorption
 - a. Liver disease
 - b. Anticonvulsant therapy
 5. Tumor induced
- E. Renal osteodystrophy
 1. Secondary hyperparathyroidism
 2. Osteomalacia
 3. Osteosclerosis
 4. Tumoral calcinosis
- F. Systemic and congenital muscular disorders

1. Muscular dystrophy
 2. Cerebral palsy
 3. Other*
- G. Pituitary disorder
1. Gigantism
 2. Acromegaly
- H. Thyroid disorder
1. Hypothyroidism (cretinism) *
 2. Hyperthyroidism *
 3. Thyroid acropachy *
- I. Intoxication, poisoning
1. Heavy metal (lead)
 2. Fluorine
 3. Hypervitaminosis A
 4. Hypervitaminosis D
- J. Bone infarction
1. Causes
 2. Osteonecrosis (AVN: end of bones) vs. medullary infarction (shaft)
 3. Spontaneous at specific sites:
 - a. Legg-Calve-Perthes disease
 - b. Other *
- K. Hematologic disorders
1. Anemia
 - a. Sickle cell
 - b. Thalassemia
 - c. Other *
 2. Hemophilia
 3. Idiopathic myelofibrosis
 4. Marrow reconversion
 5. Extramedullary hematopoiesis *
- L. Multifocal soft tissue calcification
1. Calcification/ossification/periosteal reaction secondary to venous stasis
 2. Calcification/ossification secondary to paraplegia
 3. Milk-alkali syndrome
- M. Multifocal periosteal reaction
1. Hypertrophic osteoarthropathy
 - a. Primary (pachydermoperiostosis)
 - b. Secondary (pulmonary, non-pulmonary)
 2. Infantile cortical hyperostosis (Caffey disease)
 3. Prostaglandin
- N. Miscellaneous
1. Paget disease
 2. Amyloidosis
 3. Effect of pregnancy

4. Sarcoidosis
 5. Radiation induced marrow changes
 6. Scurvy *
 7. Hypophosphatasia *
 8. Mastocytosis *
 9. Lipid storage diseases
 - a. Gaucher
 - b. Xanthoma
- X. Joint Disorders
- A. Normal anatomy
 1. Types of joints
 - a. Fibrous
 - b. Cartilaginous
 - c. Synovial
 2. Intervertebral discs
 3. Enteses
 - B. General features
 1. Distribution of involvement
 2. Soft tissue changes
 3. Joint space width
 4. Bone density
 5. Osteophytes
 6. Subchondral cysts
 7. Osseous erosions
 8. Proliferative new bone
 9. Joint deformity
 10. Calcification
 - C. Specific diseases
 1. Osteoarthritis
 - a. Primary
 - b. Secondary
 - c. Erosive (inflammatory)
 2. Inflammatory joint diseases
 - a. Rheumatoid arthritis
 - b. Psoriatic arthritis
 - c. Reactive arthritis (Reiter syndrome)
 - d. Ankylosing spondylitis
 - e. Enteropathic spondyloarthropathy
 - f. Juvenile chronic arthritis
 - g. SAPHO*
 3. Connective tissue diseases
 - a. Systemic lupus erythematosus
 - b. Scleroderma
 - c. Dermatomyositis and polymyositis
 4. Crystal-associated arthropathies
 - a. Gout

- b. Calcium pyrophosphate dihydrate crystal deposition disease
- c. Calcium hydroxyapatite deposition disease
- 5. Neuropathic osteoarthropathy
 - a. Diabetes mellitus
 - b. Syringomyelia
 - c. Other*
- 6. Miscellaneous
 - a. Hemochromatosis
 - b. Alkaptonuria (ochronosis)
 - c. Hemophilic arthropathy
 - d. Pigmented villonodular synovitis
 - e. Synovial chondromatosis
 - f. Osteitis condensans ilii
 - g. Degenerative disc disease
 - h. Diffuse idiopathic skeletal hyperostosis
 - i. Jaccoud arthropathy*
 - j. Arthropathy associated with acquired immune deficiency syndrome*
 - k. Lipoma arborescens
 - l. Tumoral calcinosis