OBJECTIVES

- Basic Approach to Interpretation
- Basic Technical Parameters
- Developmental Bone Diseases
- Aggressive vs. Non-aggressive Bone Diseases

Approach to Interpretation

- How to read an orthopedic film
  - Check film imprint label
  - Evaluate position and exposure
  - Evaluate soft tissues
  - Evaluate periosteal margins for new bone formation
  - Evaluate all cortices and subchondral bone
  - Evaluate the medullary cavity for changes in opacity
  - Evaluate joint capsular attachments
  - Evaluate joint spaces
  - Evaluate the periarticular margins
  - Check the physeal closures in relation to the age of the animal
  - Stand back to evaluate overall alignment and relationship of bones

Roentgen Signs

- Opacity
- Size
- Shape
- Number
- Location or Position
- Margination or Contour

Radiographic Technique

- Bone
  - High density
  - High Z due to Ca & Ph
  - No motion
- Low kVp technique (<60-80) improves contrast
- Positioning: At Least 2 Orthogonal Projections
  - Oblique projections: carpus/tarsus
  - Stressed projections: instability

Developmental Bone Diseases
Osteochondrosis (OC/OCD)

• Failure of endochondral ossification
  • Leads to increased thickness of articular cartilage
  • Appears as subchondral defect
• Osteochondrosis = OC
• Osteochondritis dissecans = OCD
  • When a flap is formed and separates from subchondral bone
  • Only seen radiographically when... mineralized or... with arthrography

• Occurrence
  • Young, rapidly growing, large to giant breed dogs
  • Usually develop signs between 6-9 months of age
  • Occurs in specific anatomic locations
    • Caudal aspect of humeral head
    • Medial aspect of the humeral condyle
    • Lateral femoral condyle
    • Traction ridges of the talus (medial most commonly)
    • Can occur in other locations
    • Frequently bilateral

Shoulder Osteochondrosis

• Roentgen signs
  • Subchondral defect and sclerosis of the caudal or caudolateral aspect of the humeral head

Elbow Osteochondrosis

• Roentgen signs
  • Subchondral defect and sclerosis of the medial aspect of the humeral condyle, best seen on DLP/OMO view
  • Secondary osteoarthritis

Stifle Osteochondrosis

• Roentgen signs
  • Subchondral defect and sclerosis of the distal aspect of the lateral femoral condyle
  • May also affect medial condyle but less common
  • Joint effusion and osteoarthritis

Tarsal Osteochondrosis

• Roentgen signs
  • Flattening of the medial trochlear ridge of the talus
  • Widening of the joint space
  • On the lateral view, the plantar aspect of the tibiotarsal joint will appear wide
  • Associated with intracapsular ST swelling and DJD
Elbow Dysplasia

- Fragmented medial coronoid process (FCP)
- Ununited anconeal process (UAP)
- Osteochondrosis of the medial humeral condyle (OC)
- Asynchronous growth of the radius and ulna (?)
- Proximal ulnar dysplasia (?)
- Flexor Enthesopathy (?)

Fragmented Medial Coronoid Process

- Occurrence
  - Most common developmental abnormality of the elbow
  - Medium and large breed dogs
  - Retrievers, GSD, Bernese Mountain Dog
  - Clinical signs develop usually at 5-12 months of age
  - Higher incidence in males

- Roentgen signs
  - Earliest signs are sclerosis of the trochlear notch of the ulna and osteophytes on the anconeal process and radial head
  - Osteophytes on the medial coronoid seen on the craniocaudal view

Ununited Anconeal Process

- Occurrence
  - Anconeal process forms from separate center of ossification
  - Normally fuses to proximal ulna at 5 months of age
  - Failure to fuse (likely due to joint incongruity) → UAP
  - GSD predisposed; also seen in other large breeds and Bassett hounds

- Roentgen signs
  - Irregular, lucent line crossing the anconeal process with adjacent sclerosis
  - Best seen on flexed lateral view
  - Secondary osteoarthritis

Panosteitis

- Occurrence
  - 5-18 months of age; reports in mature animals (out to 7 years)
  - Large to giant breed dogs
  - GSD, Dobermans, Retrievers, Bassett hounds
  - Self limiting disease with unknown etiology
  - Shifting leg lameness with pain on palpation of long bones
  - Histologically no evidence of inflammation
Panosteitis

• Roentgen signs
  • Early
    • Increased medullary opacity
    • Usually in diaphysis near nutrient foramen
    • Blurring of trabecular pattern

Panosteitis

• Roentgen signs
  • Late
    • Medullary opacities become better delineated → patchy appearance of medullary cavity
    • Adjacent opacities may coalesce
    • Rough endosteal surface
    • Solid periosteal reaction may be noted

Hypertrophic Osteodystrophy (aka HOD & Metaphyseal Osteopathy)

• Occurrence
  • 2-7 months of age
  • Large to giant breeds of dog
  • Unknown etiology
  • Usually systemically ill
    • Swollen, painful distal radius/ulna and distal tibia
    • Pyrexia

Hypertrophic Osteodystrophy (HOD)

• Roentgen signs
  • Early
    • Thin, radiolucent band in the metaphysis just proximal to the physis → "double physis sign"
    • Sclerosis adjacent to the radiolucent line in the metaphysis

Hypertrophic Osteodystrophy (HOD)

• Roentgen signs
  • Late
    • Formation of a cuff or sleeve of periosteal new bone adjacent to the metaphysis, which is separated from cortex by thin, lucent zone
    • Represents subperiosteal hemorrhage

Hypertrophic Osteodystrophy (HOD)

• Roentgen signs
  • Late
    • Periosteal reaction becomes more solid and confluent with the cortex later on
    • Results in marked bony enlargement of the metaphysis
Retained Cartilaginous Core

- **Occurrence**
  - Unknown etiology
  - Form of OC of the distal ulnar metaphysis/physis
  - Failure of endochondral ossification resulting in formation of core of cartilage in the metaphysis

- **Large to giant breeds**
  - Saint Bernard
  - Usually develop clinical signs around 6-12 months of age
  - Often bilateral

- **Roentgen signs**
  - Conical, radiolucent zone extending from the distal ulnar physis proximally into the distal ulnar metaphysis
  - Smoothly margined or irregular

---

Hip Dysplasia

- **Normal hip joint**
  - At least ½ of the femoral head should be covered by the dorsal acetabular rim
  - The femoral neck should be narrower than the head and have a smooth margin

- **Roentgen signs**
  - Morgan line
  - Caudolateral Curvilinear Osteophyte formation along caudal femoral neck usually secondary to joint laxity
  - These osteophytes are actually enthesisophytes at the attachment of the joint capsule

---

Hip Dysplasia

- **Roentgen signs**
  - Periarticular osteophytes form along the acetabular rim, resulting in an irregular edge
  - Shallow, flattened acetabulum
  - Inadequate femoral head coverage or even subluxation

---

Aseptic Necrosis of the Femoral Head (Legg-Calve-Perthes)

- **Occurrence and Pathogenesis**
  - Adolescent toy and small breed dogs
  - Poodles, miniature pomeranians, terriers
  - Bilateral <15% of the time
  - Compromised blood supply to proximal femoral epiphysis
  - Necrosis of subchondral bone
  - Normal blood supply to femoral head in adult dogs
  - Synovial membrane (sole supply in puppies)
  - Arteries in round ligament of the head of the femur
  - Nutrient vessels through metaphysis (after physeal closure)
Aseptic Necrosis of the Femoral Head (Legg-Calve-Perthes)

- **Roentgen signs**
  - Increased width of joint space
  - Articular cartilage thickens as ischemia causes necrosis of subchondral bone

Aseptic Necrosis of the Femoral Head (Legg-Calve-Perthes)

- **Roentgen signs**
  - Irregular opacities in the femoral head
  - Fragmentation of trabeculae
  - Patchy regions of osteolysis in femoral head
  - Invasion of vascular granulation tissue absorbing and replacing dead bone

Patellar Luxation (PL)

- **Occurrence**
  - Young, small breed dogs; also seen in large breeds
  - Lateral luxation in small breeds
  - Lateral in large breeds
  - Most commonly congenital/developmental
  - Can be traumatic
  - Associated with malalignment of the quadriceps due to rotation and/or deformity of the femur and/or tibia

Medial Patellar Luxation (MPL)

- **Roentgen signs**
  - Patella medial to trochlear groove
  - Coxa vara
    - Lateral bowing of distal femur
    - Medial bowing of the proximal tibia
    - Medially located tibial tuberosity and quadriceps
  - Shallow trochlear groove
    - Requires oblique view to evaluate
  - Secondary osteoarthrosis usually mild
Pattern of Bone Lysis

- **Geographic lysis**
  - Large area of lysis
  - Lesion may appear expansile
  - Well-defined with short zone of transition
  - Nonaggressive or aggressive; however, usually considered least aggressive form of lysis
  - Bone cysts, multiple myeloma

- **Moth-eaten lysis**
  - Multiple smaller areas of lysis
  - These areas may become confluent to form a larger area of lysis
  - Usually has indistinct margins (long zone of transition)
  - Usually aggressive
  - *Osteomyelitis or neoplasia*

- **Permeative lysis**
  - Numerous small or pinpoint areas of lysis
  - Margins are indistinct (long zone of transition)
  - Most aggressive pattern
  - Usually associated with neoplasia

Summary of Lytic Patterns

- **Normal**
- **Geographic**
- **Moth-eaten**
- **Permeative**

***Classify based on most aggressive feature!!!***
Zone of Transition

Demarcation between the lesion and normal adjacent bone

- **Long zone of transition**
  - Demarcation between lesion and normal bone is less distinct
  - More aggressive lesions such as osteomyelitis and neoplasia

- **Short zone of transition**
  - Abrupt demarcation between normal bone and lesion
  - Nonaggressive lesions like a bone cyst

Type of Periosteal Reaction

- **Periosteal reactions**
  - Periosteum composed of two layers;
  - Inner cambium layer (bone producing)
  - Outer fibrous layer
  - Periosteum is attached to the cortex by Sharpey's fibers

- Periosteal reaction classified in terms of:
  - Aggressiveness
  - Activity
  - Duration

Type of Periosteal Reaction

- **Aggressiveness**
  - Classification based on organization of new bone
  - The more disorganized the new bone formation $\rightarrow$ the more aggressive the lesion

Primary Bone Tumors

- **Occurrence**
  - Mostly large and giant breed dogs; no breed predilection
  - Mean age = 7 years
  - Bimodal distribution seen in animals as young as 6 months
  - Slightly more common in male dogs
  - May be associated with a previous fracture or metallic implant

Cortical Disruption

- Processes that destroy cortices are more aggressive than lesions that allow the cortex to remodel or conform to the enlarging mass

- Intact Cortex
- Disrupted Cortex
Primary Bone Tumors

- Roentgen signs
  - Radiographic appearance is variable
  - Primarily osteoblastic
  - Primarily osteolytic
  - Combination of both
  - Lytic and/or productive changes are aggressive in nature
  - Typically monostotic
  - Located often in metaphyseal region of a long bone
  - Does not typically cross the joint

- Osteosarcoma
  - Most common primary bone tumor (>85%)
  - "Away from the elbow, toward the knee"...aaaand distal tibia

- Chondrosarcoma
- Fibrosarcoma
- Hemangiosarcoma

- Differential diagnoses
  - Osteomyelitis
  - Metastatic neoplasia

Hypertrophic Osteopathy (HO)

- Occurrence
  - Middle aged to older dogs
  - Usually due to concurrent thoracic or abdominal disease
    - Often pulmonary neoplasia; also reported with pulmonary abscesses, bronchopneumonia, bacterial endocarditis, heartworm disease, esophageal pathology, as well as hepatic and bladder neoplasia
  - Gradual or occasional acute onset in lameness
  - Animal reluctant to move
  - Symmetric, non-edematous, firm swelling of the distal limbs

- Roentgen signs
  - Begins on the abaxial surface of the distal metacarpal/metatarsal bones and progresses proximally along the diaphysis
  - Radiographs of the thorax and abdomen should be obtained to investigate for underlying disease

Conclusions

- All the previously described skeletal changes fall along a continuum
  - Some lesions will be clearly non-aggressive or aggressive
  - A lesion may have features of both
  - Should be characterized based on the MOST AGGRESSIVE FEATURE
  - Generalized or Focal bone lesions
  - If focal, apply following criteria;
    - Location of lesion
    - Zone of transition
    - Pattern of lysis
    - Periosteal reaction
    - Cortical disruption
    - Rate of change
  - If diagnosis is still unclear...
    - Repeat radiographs in 10-14 days
    - Metastasis check
    - Bone biopsy or fine needle aspirate
Fungal Osteomyelitis

- **Occurrence**
  - Typically seen in young to middle-aged dogs
  - May be seen in any breed; however, more common in large breeds such as working or sporting breeds
  - Usually hematogenous in origin
- **Systemic signs**
  - Fever
  - Lethargy
  - Anorexia
  - Lymphadenopathy, etc...

Fungal Osteomyelitis

- **Roentgen signs**
  - Variable radiographic appearance
  - Both lytic and productive changes
  - Periosteal reaction usually semi-aggressive
  - Osteolysis may extend through the cortex
  - Often sclerosis in adjacent medullary region
  - Usually in the metaphyseal region of long bones
  - May be joint involvement with extensive bone destruction
  - Often polyostotic but can be monostotic
- **Differential Diagnoses**
  - Primary bone tumors
  - Metastatic bone tumors

Bacterial Osteomyelitis

- **Occurrence**
  - Usually secondary to...
    - Direct inoculation (bite wound, open fracture, or surgery)
    - Extension from soft tissue injury
  - May be hematogenous in young or immunocompromised animals
  - Hematogenous route is much less common in small animals

Bacterial Osteomyelitis

- **Roentgen signs**
  - Earliest stage
    - No bony abnormalities, just soft tissue swelling
    - May take 7-14 days before periosteal reaction visible
    - Periosteal reaction typically solid and extends along shaft of diaphysis; however, can be lamellar to palisading/columnar

Bacterial Osteomyelitis

- **Nonhematogenous origin**
  - Lesion location depends on affected area
  - May affect multiple bones in the same limb
  - Lucencies around surgical implants
  - May see draining tract from surgical implant or foreign body
- **Hematogenous origin**
  - Metaphyseal due to extensive capillary network
  - Often multiple limbs affected (polyostotic)
- **Differential Diagnoses**
  - Healing fracture
  - Primary or metastatic bone tumor
  - Fungal osteomyelitis

QUESTIONS?