

Small Animal Musculoskeletal Radiology

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CVM 6103

Fall Semester, 2011

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SA Neuroradiology	Pages 37-52

Suggested Reading from: Thrall DE, Textbook of Veterinary Diagnostic Radiology 5th ed, Saunders, 2007

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Developmental Bone Disorders

Osteochondrosis

Osteochondrosis (OC) results from a focal area of dysfunction of endochondral ossification (bone that forms from a cartilage matrix) and occurs in both the articular-epiphyseal cartilage complex and the growth plate. The articular cartilage becomes thickened because it does not mineralize, and appears radiographically as a defect in the articular surface. Areas of the thickened cartilage may undergo necrosis and progressive chondromalacia. Repeated concussion from daily stress and strain may result in fissure formation that will eventually form a cartilage flap. This flap may mineralize and then can be seen radiographically. When a flap or joint mouse (osteochondral fragment) is present, the condition is known as **osteochondritis dissecans (OCD)**.

Manifestations of OC in the dog:

Articular surface:

- Shoulder OC (humeral head)
- Elbow OC (humeral condyle) – also fragmented coronoid process
- Stifle OC (femoral condyle)
- Tarsal OC (talus)
- Vertebral articular facets

Physeal area:

- Retained cartilaginous core (distal ulnar physis)
- Ununited anconeal process
- Ununited medial epicondyle of the humerus

Shoulder Osteochondrosis

Signalment:

Sex: Male:Female ratio reported as 2.24:1 (reported ranges of 2:1 to 6:1)

Age: 4-8 months of age onset of lameness (17% present over 1 year of age)

Breed: large and giant breed dogs

Clinical features:

Most common OC lesion (approximately 75% of OC cases)

Patients present with weight-bearing lameness of varying severity

Lameness worsens following exercise

Shortened forelimb stride

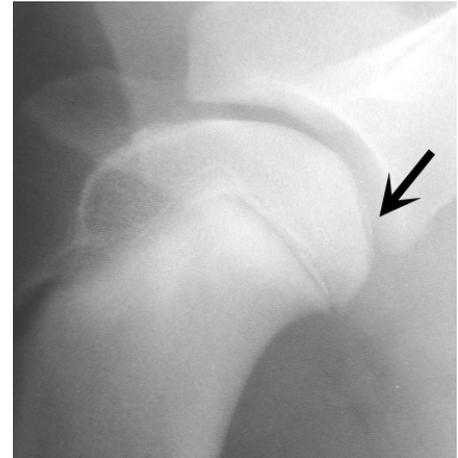
Pain on extension and flexion of shoulder

Often a bilateral disease (50% of dogs presenting with humeral head OC/OCD

have radiographically detectable bilateral lesions – however, only 21% of these dogs exhibit clinical signs in both front limbs)

Radiographic findings:

- Lateral view is most helpful
- A supinated view (caudomedial-cranio-lateral oblique) may demonstrate the lesion
- Defect, flattening, or irregularity of the caudal humeral head
- Sclerosis of the subchondral bone
- Mineralized flap present next to the defect or mineralized joint mouse in the caudal joint pouch or the bicipital tendon sheath (seen in approximately 26% of the dogs)
- Arthrography can be valuable to demonstrate flaps and joint mice, particularly in the bicipital tendon sheath
- Secondary osteoarthritis with osteophytes on the caudal rim of the glenoid cavity, caudal humeral head, and along bicipital tendon groove



Elbow Osteochondrosis

Signalment:

Sex: males typically affected more than females
Age: 5-10 months
Breed: large breeds, often retrievers

Clinical features:

Second most common OC lesion
Weight bearing lameness exacerbated by exercise
Pain on hyperextension or flexion of the elbow
Often bilateral

Radiographic findings:

- Demonstrated on the craniocaudal and craniolateral-caudomedial oblique views
- Subchondral defect on the articular surface of the medial humeral condyle
- Subchondral sclerosis
- Rarely see a mineralized flap or joint mouse (**NOTE:** do not confuse the normal sesamoid on the lateral aspect of the elbow with a joint mouse)
- Secondary osteoarthritis – medial epicondyle early in disease process



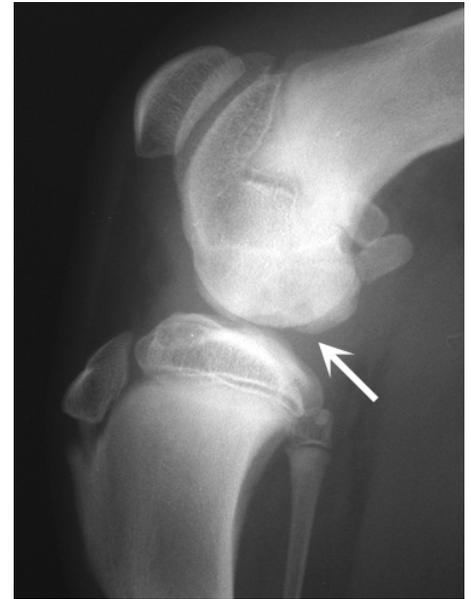
Stifle Osteochondrosis

Signalment:

Sex: males affected more than females
Age: 5-7 months of age at onset
Breed: large breed dogs, especially Great Dane,
Labrador and Golden Retriever, Newfoundland,
German shepherd

Clinical features:

Least common of the OC lesions
Insidious hind limb lameness exacerbated by exercise
Stifle joint pain, swelling, and reduced range of motion
Often bilateral



Radiographic findings:

- Best seen on the craniocaudal view, but also seen on the lateral view
- Generally the medial aspect of the lateral femoral condyle is affected; however, either or both condyles may be affected
- Radiolucent defect in the distal articular surface of the condyle, irregular margins (**NOTE:** Do not confuse the normal extensor fossa of the long digital extensor tendon with an OC lesion. The extensor fossa is on the lateral condyle but is proximal to the weight bearing surface on the lateral view, and is located more laterally on the craniocaudal view than the typical location of OC.)
- Subchondral sclerosis
- Intracapsular swelling commonly seen
- May see mineralized flap (rare) or joint mouse
- Secondary osteoarthritis with osteophyte formation on distal femur, patella, and proximal tibia

Tarsal Osteochondrosis

Signalment:

Sex: males and females almost equally affected
Age: 6-12 months of age at diagnosis
Breed: large breed dogs, Rottweilers and Labrador Retrievers (over 70% of reported cases)

Clinical features:

Third most common OC lesion
Progressive lameness of several months' duration
Intermittent or nonweight bearing lameness or persistent, weight bearing lameness exacerbated with exercise
Often hold affected tarsi in hyperextended position

Tarsal joint pain with flexion and extension, joint swelling
Bilateral in 40% of reported cases

Radiographic findings:

- Medial trochlear ridge is most commonly affected; however, lateral trochlear ridge may also be affected (OC of the lateral trochlear ridge is difficult to diagnose due to superimposition of the calcaneus on the DP view. A flexed DP view may be necessary in order to displace the calcaneus)
- Lesion best seen on DP view, a extreme flexed lateral view is also helpful
- Widening of the joint space medially, the space will appear wider than the lateral aspect
- Flattened or malshaped medial trochlear ridge on the DP view
- The caudal aspect of the joint will appear wide and irregular on the lateral view
- Subchondral sclerosis
- May see mineralized flap or joint mouse, this is generally in the caudal joint pouch (seen best on the extreme flexed lateral view)
- Intracapsular swelling of the tibiotarsal joint
- Secondary osteoarthritis with osteophytes on the caudal aspect of the distal tibia and the medial aspect of the talus



Retained Cartilaginous Core (OC of the distal ulnar physis)

Signalment:

Age: 6-12 months
Breed: large and giant breed dogs, especially Saint Bernard, Great Dane, Setters

Clinical features:

Often an incidental finding with no clinical lameness
Can result in asynchronous growth of radius and ulna, resulting in elbow subluxation and angular limb deformity

Radiographic findings:

- Inverted conical shaped radiolucent zone extending from the distal ulnar physis into the distal ulnar metaphysis, generally smoothly margined and symmetrical in asymptomatic patients
- Lesions that cause asynchronous growth are usually irregular in shape and may extend toward the cortex of the bone
- Usually bilaterally symmetrical



Canine Hip Dysplasia

Signalment:

Sex: no sex predilection

Age: dogs with severe dysplasia typically exhibit signs starting at 5-12 months of age, those with mild dysplasia may not present until old age

Breed: all breeds of dogs are affected with the highest incidence in large breeds, also affects purebred and domestic cats

Clinical features:

The underlying process is a joint laxity that leads to inappropriate development of the coxofemoral joint and subsequent development of secondary osteoarthritis

Clinical signs vary in severity. Patients may have abnormal gait, pain, reluctance to rise, climb stairs, and jump, and muscle atrophy

Generally a bilateral disease, but may be unilateral

Radiographic Evaluation of Hips:

Sedation is necessary for appropriate positioning of radiographs. In intact male dogs, consider the use of gonadal shielding.

1. Extended limb VD standard view (used by OFA):

This view assesses degree of laxity, degree of abnormal conformation, and degree of secondary osteoarthritis. OFA will not certify hips until the patient is 2 years of age.

- a. Limbs extended and parallel with patellas superimposed on midline of distal femurs
- b. Femurs should cross the ischiatic tuberosity equally
- c. Wings of the ilia and obturator foramina should be symmetric
- d. Include entire pelvis and both stifles



2. Distraction/Compression Projections (PennHIP):

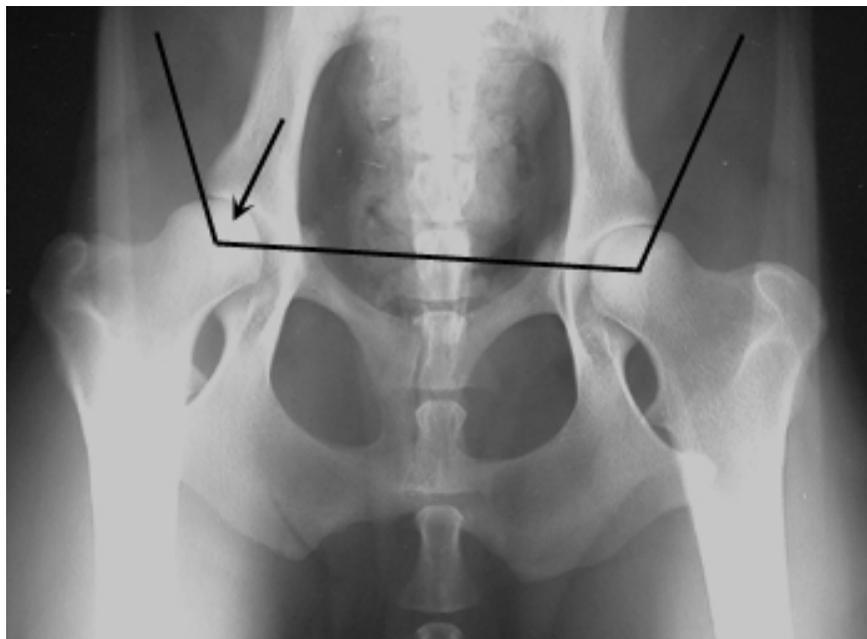
This is a specific, stress radiographic view that provides a quantitative measurement of passive hip laxity. The probability of developing hip dysplasia has been shown to relate directly to the amount of laxity. Evaluation in puppies can be done as early as 16 weeks. A veterinarian must receive certified training in the use of PennHIP.

- a. The patient is placed in dorsal recumbency and the limbs held in approximation of the neutral stance-phase of hip orientation
- b. Two views are made in this position – a compression view and a distraction view (a custom-designed distraction device is placed between the rear limbs). Additionally, an extended limb VD standard view is made.
- c. A distraction index (DI) is calculated that measures the amount of laxity between the compression and distraction views of the femoral heads – the greater the DI, the greater the probability of development of hip dysplasia. DI ranges from 0-1, a cut-off of 0.4 has been suggested as the index that identifies dogs having the highest probability of developing secondary osteoarthritis. An evaluation of secondary osteoarthritis is also made.

3. Nordberg angle:

This measurement is made from the extended limb VD standard view of the pelvis. The angle represents a numerical measurement of joint laxity.

- a. The Nordberg angle is defined by a line connecting the centers of the femoral heads and secondary lines from the centers of the femoral heads to the cranial acetabular rims. The angle between the lines is measured and is the Nordberg angle.
- b. Nordberg angle scores: normal is $\geq 105^\circ$, abnormal is $\leq 90^\circ$, borderline is 90° to 105°



Radiographic findings:

Normal:

- Deeply formed, cup-shaped acetabulum with a sharp cranial rim extending perpendicular to the long axis of the body
- Smooth circular articular margin of the femoral head (normal flattened region in the area of the fovea capitis)
- Greater than 2/3 of the femoral head under the dorsal acetabular margin
- Parallel articular margin between the acetabulum and the femoral head
- Narrow femoral neck with smooth margin

Abnormal:

- Shallow, flattened acetabular rim with flaring at the cranial margin
- Flattening of the femoral head
- Subluxation or luxation of the femoral head (less than 2/3 coverage)
- Lack of congruency of the joint seen as a wedge-shaped joint space
- Thickening of the femoral necks due to osteophyte production and remodeling
- Subchondral bony sclerosis
- Secondary osteoarthritis with osteophytes forming along the cranial and dorsal acetabulum, the femoral head, and the femoral necks
- An early sensitive sign of osteoarthritis is the “Morgan line”, solitary bony enthesophytes on the caudal aspect of the femoral head depicted as a sclerotic line directed distally rather than around the femoral head



OFA Evaluation of Hip Dysplasia:

OFA will certify dog hips after two years of age. Preliminary evaluation can be performed prior to two years of age. The extended VD standard view of the pelvis should be submitted. See the OFA website for more information and pricing: www.offa.org. There are seven categories reported by OFA. The first three are considered within normal limits for age and breed and are eligible for assignment of an OFA breed number. OFA classifications are based on comparisons among other dogs of the same breed and age. The grades are as follows:

- Excellent:** superior conformation present with a very tight joint space and almost complete coverage of the ball by the socket
- Good:** most of the socket covers the ball and there is a congruent joint space
- Fair:** slightly incongruent (subluxated) joint space with the persistence of good ball coverage by the socket or there is a congruent joint space but the socket's weight bearing surface is deviated inward
- Borderline:** there is no clear cut consensus between the radiologists to place the hip into a given category of normal or dysplastic, it is generally recommended to repeat the radiographs at a later date for comparison
- Mildly dysplastic:** the joint is obviously incongruent or subluxated, usually there is a shallow socket only partially covering the ball
- Moderately dysplastic:** there is significant subluxation present with the femoral head barely seated in the shallow acetabulum, secondary osteoarthritis is usually present
- Severely dysplastic:** the shallow acetabulum only partially covers the femoral head, there are pronounced osteoarthritic changes

Elbow Dysplasia

Elbow dysplasia is a general term used to identify an inherited polygenic disease in the elbow of dogs. Manifestations of elbow dysplasia can occur independently or in conjunction. These manifestations are:

- **Fragmented Medial Coronoid Process**
- **Ununited Anconeal Process**
- **Osteochondrosis of the medial humeral condyle**
- **Ununited medial epicondyle of the humerus**

Possible etiologies have been thought to be osteochondrosis leading to all manifestations, asynchronous growth of the radius and ulna, and proximal ulnar dysplasia resulting in an abnormally shaped trochlear notch of the ulna.

Fragmented Medial Coronoid Process (FCP)

Signalment:

Sex: males have a significantly higher incidence (up to 75% of cases)

Age: young dogs, signs may be apparent as early as 4-7 months of age, usually not radiographically apparent until 7-8 months of age

Breed: medium to large breed dogs, especially Rottweilers, Bernese Mountain dogs, retrievers, Newfoundlands, German shepherd dogs, Chow Chows

Clinical features:

FCP is the most common of the elbow dysplasia manifestations

Patients may present with a change in gait characterized by inward rotation of the elbow with outward rotation of the paw, stiffness in the front legs, and worsening signs with exercise

Elbow range of motion may be decreased

Often bilateral

Radiographic findings:

- It is rare to visualize the actual fragment which may be due to superimposition of the radius over the medial coronoid process, a non-ossified cartilage fragment, or a minimally displaced fragment
- Abnormally contoured or poorly defined medial coronoid process on the lateral view
- Blunted or rounded medial coronoid process on the cranio-caudal view
- Recognition of secondary osteoarthritis including bony proliferation on the proximal margin of the anconeal process (very sensitive indicator of elbow disease), the proximal radius, the medial humeral epicondyle, and the medial coronoid process
- Sclerosis of the trochlear notch of the elbow



- Elbow joint incongruity – widened humeroulnar joint space
- Rarely, a separate ossified fragment
- A special cranio(25°)lateral-caudomedial oblique view will highlight the medial coronoid region
- May cause a “kissing lesion” on medial humeral condyle, difficult to distinguish from OCD; OCD and FCP can be seen in conjunction

Ununited Anconeal Process (UAP)

Signalment:

Sex: Males are affected approximately twice as often

Age: 5-12 months of age, but clinical signs usually not apparent before 7-8 months of age

Breed: large breed dogs, German shepherd dogs are over-represented

Clinical features:

The normal anconeal process fuses to the olecranon by 20 weeks

Failure of fusion of the anconeal center of ossification to the olecranon after 20 weeks is diagnostic

Weight bearing lameness exacerbated by exercise

Often bilateral (20-35% of cases)

Radiographic findings:

- Radiolucent line separating the anconeal process from the olecranon after 20 weeks of age, anconeal process may be displaced
- The radiolucent line is generally irregular and of variable width, but may be sharply defined
- Fragment ends are often sclerotic
- Visualization of secondary osteoarthritis, often not until 7-8 months of age
- An extreme flexed lateral view will displace the physis of the medial humeral epicondyle (open until 9 months of age) away from the anconeus to facilitate diagnosis



Osteochondrosis of the humeral condyle:

See previous section on Osteochondrosis

OFA evaluation of elbow dysplasia:

OFA will certify dog elbows after two years of age. Preliminary evaluation can be performed prior to two years of age. Extreme flexed lateral views of both elbows should be submitted. See the OFA website for more information and pricing: www.offa.org. There is no grading system for normal non-dysplastic elbows. Elbow dysplasia is graded as follows:

- Grade I:** minimal bone changes (<3mm) along the proximal margin of the anconeal process
- Grade II:** additional bone proliferation (3-5mm) along the proximal margin of the anconeal process and sclerosis of the trochlear notch of the ulna
- Grade III:** well-developed degenerative joint disease with marked bone proliferation (>5mm) along the proximal margin of the anconeal process

Panosteitis

Signalment:

Sex: males affected four times more often than females

Age: 5-12 months, has been reported in dogs as old as 7 years

Breed: large and giant breed dogs, especially German shepherd, also Great Danes, Doberman pinschers, Retrievers, and Basset hounds

Clinical features:

Self-limiting disease affecting the long bones – proximal ulna, distal humerus, central radius, proximal and central femur, and proximal tibia

Patients often present with shifting leg lameness because lesions may be multifocal in multiple bones (or solitary or multifocal in a single bone)

Pain elicited on deep palpation of affected long bones

Severity and location of radiographic lesions do not always correlate with severity of clinical signs

Histologically there is not an inflammatory response, see increase in medullary, endosteal, and periosteal osteoblastic and fibroblastic activity

Unknown etiology (viral [most probable?], metabolic, genetic, endocrine dysfunction, autoimmune...)

Radiographic findings:

- Early lesions have blurring and accentuation of trabecular bone, irregularity of endosteal surface, diminished cortico-medullary definition
- Lesions often near nutrient foramina
- Older lesions have patchy, nodular opacities similar to cortical bone in the diaphyseal medullary cavity of long bones develop
- May coalesce to occupy most of the medullary cavity
- Chronic lesions often have smooth, continuous periosteal new bone
- Eventual remodeling to normal bone occurs



Hypertrophic Osteodystrophy (HOD)

Signalment:

Sex: no clear sex predilection

Age: 2-6 months of age

Breed: large and giant breed dogs, typically Great Dane, boxer, German shepherd, weimaraner

Clinical features:

Generally a self-limiting disease affecting the metaphyses of long bones

Metaphyseal regions of long bones may be swollen, warm, and painful

Severely affected patients may have systemic illness with fever, depression, anorexia, and are reluctant to stand or walk

Osteomalacia disease of unknown etiology; proposed etiologies include oversupplementation of minerals and vitamins, vitamin C deficiency, infection with link to respiratory disease (including distemper)

Histologically, lesions in the metaphyses consist of neutrophilic inflammatory response associated with necrosis, hemorrhage, and increased osteoclast numbers

Radiographic findings:

- Transverse radiolucent lines in the metaphyses, parallel and adjacent to physis. This represents a zone of necrotic bone.
- Metaphyseal flaring and sclerosis may occur
- Periosteal “cuffing” (paraperiosteal new bone formation) at the metaphysis develops as disease progresses
- Diffuse soft-tissue swelling centered on the metaphysis (extracapsular swelling)
- All long bone metaphyses can be affected, with changes bilaterally symmetrical
- Changes are most severe in the distal radius, ulna, tibia
- Occasionally, premature closure of the physes leading to asynchronous growth of the radius and ulna and angular limb deformities may occur



Aseptic Necrosis of the Femoral Head

(AKA: Legg-Calvé-Perthes Disease, avascular necrosis of the femoral head)

Signalment:

Sex: no sex predilection

Age: 4-10 months of age

Breed: toy and small breed dogs, especially Yorkshire terrier, Toy poodle, Pomeranian, Chihuahua, Jack Russell terrier, West Highland white terrier, Manchester terrier, Pug, Dachshund

Clinical features:

Weight bearing lameness that is usually unilateral (bilateral involvement <15%)

Pain on abduction of leg

Occurs as a result of primary necrosis of the capital femoral epiphysis

Inherited as an autosomal recessive trait in Toy poodle, Yorkshire terrier, West Highland white terrier

Radiographic findings:

- Early, see linear radiolucencies within the subchondral bone of femoral head
- Areas of decreased opacity may also be seen in femoral epiphysis and metaphysis
- Flattening and irregularity of femoral head and neck apparent when affected bone remodels and collapses upon itself
- Pathologic fractures of epiphysis may occur
- Remodeling of femoral head may cause coxofemoral joint space widening and subluxation with remodeling of the acetabulum
- Secondary osteoarthritis



Feline Capital Physeal Dysplasia Syndrome

Signalment:

Sex: 85% male

Age: 4.5-24 months of age

Breed: any breed, but Siamese is over-represented

Clinical features:

Most of the reported patients were overweight

Generally acute lameness because of secondary capital physeal fracture

Often bilateral, but may present at different times

Occurs as a result of disorganized growth of the physis resulting in persistence of open physis that cannot resist shear forces of normal activity

Radiographic features:

- May only see the capital physeal fracture
- May see resorption of the femoral neck



Patellar Luxation/Subluxation

Signalment:

Sex: either

Age: young and immature dogs; however, because of intermittent signs, the patient may not present until older

Breed: especially toy and miniature dog breeds; however, medium and large breed dogs can also be affected

Clinical features:

Clinical signs vary with degree of luxation/subluxation; animals with congenital luxation exhibit skipping or intermittent carrying of limb with flexed stifle

Congenital or developmental deformities of the rear limb predispose to patella luxation

- Abnormal femoral neck angles (coxo vara, coxo valga, femoral anteversion angle)
- Lateral bowing of femur
- Hypoplastic medial femoral condyle
- Displacement or rotation of the tibial tuberosity and crest, medial bowing
- Shallow trochlear groove and rotation of distal femur

Medial luxation most common and generally occurs in toy and small breed dogs

- Most affected dogs are bow-legged (genu varum)
- 50% of affected dogs have bilateral disease

Lateral luxation usually occurs in large breed dogs with knock-knees (genu valgum)

Patellar luxation/subluxation can be traumatic in origin

May have concurrent cruciate disease

Radiographic findings:

- The luxation is often intermittent and the patella is most often in a normal position on the radiographs (especially in subluxation cases)
- The craniocaudal view allows assessment of medial or lateral luxation. The hip, femur, and proximal tibia should be included to assess torsion or bowing (see descriptions in clinical features)
- May see luxated patella superimposed on femoral trochlea on the lateral view
- May see joint swelling and degenerative changes (consider concurrent cruciate disease when seen)
- Shallow trochlear groove of femur (requires skyline view for evaluation)



Growth Plate Injuries

Signalment:

Sex: no sex predilection

Age: skeletally immature (generally <10 months, but dependent upon the individual physal closure dates)

Breed: any breed

Clinical features:

Trauma is most common cause of injury; other causes of growth plate disturbances include HOD, retained cartilaginous core, chondrodysplasias

Growth plate injuries generally lead to premature closure

Can occur in any physis

Trauma and premature closure affecting the antebrachial physes are most clinically significant because of resultant asynchronous growth of the radius and ulna. Amount of growth deformity and resulting angular limb deformity depends upon the severity and amount of premature closure.

Typically more significant in young large and giant breed dogs.

Uncorrected deformities will generally lead to joint problems

Generally trauma leads to Salter Harris Type I, V, or VI as the cause of physal damage. Certainly a potential complication to any Salter Harris fracture, even with fixation, is premature closure of the physis.

Salter Harris fractures:

- » Type I: physal
- » Type II: physal-metaphyseal
- » Type III: physal-epiphyseal (articular)
- » Type IV: physal-epiphyseal-metaphyseal (articular)
- » Type V: compression physal
- » Type VI: eccentric physal impaction resulting in transphysal bridging

Radiographic findings:

- Depends upon the physis injured
- Affected physis may or may not appear radiographically closed
- Affected physis may be affected entirely or partially
- Both limbs can be affected to a varying degree of severity – recommend radiographs of both limbs
- Secondary angular limb deformities and joint incongruencies
- Premature closure of distal ulna
 - » Partial or complete closure of distal ulnar physis
 - » Shortened ulna
 - » Cranial and medial bowing of the radius with carpal valgus
 - » Humero-ulnar joint subluxation (wider joint space than humero-radial joint)
 - » Secondary osteoarthritis of elbow and carpus
 - » If occurs in the very young, may see ununited anconeal process due to new stress from the short ulna

- Premature closure of the distal radius
 - » Partial or complete closure of distal radial physis
 - » Shortened radius
 - » If partial closure, the radius will bow toward the unaffected side
 - » Humero-radial joint subluxation (wider joint space than humero-ulnar joint)
 - » May see fragmented medial coronoid process due to increased weight bearing on the ulna
 - » Secondary osteoarthritis of elbow and carpus
 - » May see carpal varus, but generally no angular limb deformity
- Premature closure of the proximal radius
 - » Similar findings as in premature closure of the distal radius



Non-developmental Bone Disorders

Neoplasia of Bone

Primary Bone Neoplasia

Signalment:

Sex: no definitive sex predilection

Age: commonly middle-aged to older dogs (median age: 7 years); there is a bimodal distribution with a small peak in age incidence from 18-24 months (youngest reported age: 6 months)

Breed: large and giant breeds

Tumor types:

Osteosarcoma: 85% of primary bone tumors

Chondrosarcoma: 5-10% of primary bone tumors

Hemangiosarcoma: <5% of primary bone tumors

Fibrosarcoma: <5% of primary bone tumors



Clinical features:

Osteosarcoma is the most common primary bone tumor

75% of osteosarcoma is in the appendicular skeleton; generally a *monostotic* aggressive lesion originating in the metaphysis of the long bones

Common sites: distal radius and proximal humerus (away from the elbow), distal femur and proximal tibia (toward the stifle), distal tibia, proximal femur (rare); front limbs are affected twice as often as rear limbs

Although only 10-15% of dogs have radiographically detectable lung or bone metastasis at presentation, 90% of dogs will die with metastasis within one year when treated with amputation alone

Radiographic findings:

- Variable findings from mainly lytic to almost entirely proliferative or most commonly a combination of both
- Lysis is generally aggressive (moth-eaten, permeative) and also generally involves the cortex
 - » Although OSA can be purely lytic, hemangiosarcoma is almost entirely lytic
- New bone formation is generally aggressive (palisading or spiculated sunburst pattern), Codman's triangle often present
- Soft tissue extension and swelling may be present
- Pathologic fracture may be present
- Generally monostotic, rarely crosses joint (articular cartilage may act as barrier) until late in the disease process, metaphyseal in location

Differential diagnosis:

Fungal osteomyelitis, multiple myeloma, lymphoma of bone, metastatic disease

Metastatic Bone Neoplasia

Signalment:

Sex: no predilection

Age: any age with neoplasia

Breed: no breed predilection

Clinical features:

Can occur with any tumor type (epithelial tumor types more common than mesenchymal tumor types); not uncommonly seen with common urogenital malignancies (prostate, bladder, urethral, and mammary)

Common sites: vertebrae, pelvis, femur, humerus, rib

Often a *polyostotic* aggressive lesion originating in the diaphysis of the bone (near the nutrient foramen), but metaphyseal location also common

Generally the primary solid tumor is known

Radiographic findings:

- Again, variable findings of aggressive lysis, proliferation or combination of both
- In long bones, either diaphyseal or metaphyseal location
- Generally polyostotic

Differential diagnosis:

Fungal osteomyelitis



Osteomyelitis

Mycotic (fungal) Osteomyelitis

Signalment:

Sex: no sex predilection

Age: tend to be young to middle age patients, generally younger than those with neoplasia

Breed: dogs are affected more often than cats, often occurs in large hunting breeds; however, any breed can be affected

Clinical features:

May be monostotic or polyostotic

Patients may present with a lameness, but infection may be occult and found on physical exam (swelling) or seen incidently on radiographs

Often the lesion will have a draining tract

Origin may be hematogenous following respiratory infection, but can be through direct puncture

Patients may have other systemic illness such as pneumonia, lymphadenopathy, fever

Geographic distribution:

1. *Blastomyces dermatitidis*: most common in Midwestern and Southwestern United States
2. *Histoplasma capsulatum*: most common in Midwestern United States
3. *Coccidioides immitis*: most common in Southwestern and Western United States

Radiographic findings:

- Often fungal lesions affect the metaphysis of long bones similar to primary bone neoplasia. Lesions can be seen in both the metaphysis and the diaphysis of the bone and can involve the joint.
- Lesions are more often polyostotic and cross joints, but may be monostotic
- Radiographic appearance is variable. Patterns of aggressive lysis (punctate, moth-eaten) with cortical lysis and semi-aggressive proliferation (pallisading) are often seen. Codman's triangle may also be present.
- A sclerotic margin may be seen around regions of lysis as a result of the body's attempt to wall-off the infection
- Diffuse adjacent soft tissue swelling is common
- May visualize regional lymphadenopathy on the radiograph (*i.e.*, popliteal lymphnode on the rear limb)



Differential diagnosis:

Primary bone tumor, metastatic bone tumor

Bacterial Osteomyelitis

Signalment:

Sex: no sex predilection

Age: young patients may have hematogenous origin, may be seen in any age secondary to penetrating wound or surgery

Breed: any

Clinical features:

Limb is typically warm, swollen, and painful on palpation

Routes of infection include direct inoculation (direct puncture, open fractures, long surgical procedures), extension from soft tissue infection (bite wound, gun shot wound), and hematogenous spread

A draining tract may be present in chronic infection

Radiographic findings:

- Acutely, the only finding will be soft tissue swelling
- By 7-14 days of infection there is often a periosteal reaction which is usually semi-aggressive (pallisading, undulating). This reaction is often very extensive along the diaphysis of the bone.
- At times it is difficult to distinguish between normal callus formation and infection. Osteomyelitis results in a reaction extending beyond the limits of the fracture. It is often seen circumferentially on all cortices.
- Often there will be lysis associated with surgical implants
- There is variable cortical lysis (generally semi-aggressive)
- A sequestrum may be a sequela (see large animal notes)

Differential diagnosis:

Healing fracture, primary bone tumor, metastatic bone tumor, fungal osteomyelitis



Hypertrophic Osteopathy (HO)

Signalment:

- Sex: no sex predilection
- Age: generally middle-aged to older patients
- Breed: any

Clinical features:

HO is a generalized osteoproliferative disorder of the periosteum that affects the long bones of the extremities, beginning in metacarpus/metatarsus

HO is usually secondary to thoracic disease – it may be seen with intrathoracic neoplasia (pleural based, pulmonary) and has been seen with fungal pneumonia, intrathoracic foreign bodies, *Dirofilaria immitis*, and spirocercosis. HO has also been reported in primary intra-abdominal neoplasia without thoracic involvement.

The pathogenesis is unknown. Increased blood flow to the extremities is a consistent pathologic finding. Other theories include a neurogenic or hormonal etiology.

The lesion may be found incidentally in a patient presenting for thoracic disease. Patients may have diffuse swelling of the affected limbs with pain and lameness

Radiographic findings:

- Semi-aggressive periosteal new bone and cortical thickening along the diaphyses of long bones. The pattern of periosteal reaction is usually solid, lacy and/or palisading and perpendicular to the cortex.
- Bony proliferation begins on abaxial surfaces of MT/MC V and MT/MC II. Proliferation will progressively extend proximally toward the axial skeleton.
- Bony destruction will not be seen
- Changes are generally bilaterally symmetric
- May see associated diffuse soft tissue swelling
- Bones of the joints are generally not involved



Miscellaneous Joint Disorders

Osteoarthritis

(AKA: degenerative joint disease, osteoarthrosis, arthritis)

Signalment:

Sex: either

Age: any, but common in older patients

Breed: any

Osteoarthritis can be classified as primary or secondary. Often the osteoarthritis is secondary, and therefore, the signalment depends entirely upon the underlying abnormality leading to the secondary osteoarthritis. Primary osteoarthritis is more common in middle aged to older patients.

Clinical features:

Most common type of arthropathy in dogs and cats

Occurs most frequently in the weight bearing joints of medium-sized to large dogs

Non-inflammatory degenerative disorder of the joints

May be classified as:

1. Primary (idiopathic): resulting from normal wear and tear with no known specific or predisposing cause
2. Secondary: resulting from a specific cause or predisposing condition (*i.e.*, hip dysplasia, OCD, Cranial cruciate ligament rupture)

Typically the patient will be stiff upon rising, but will “warm” out of the stiffness

Radiographic findings:

- Findings will vary according to the stage of the disease
- Intracapsular joint swelling: represents joint effusion **and/or** capsular thickening/periarticular tissue thickening (in chronic cases, most often both)
- Periarticular osteophyte formation: new bone at the margins of the articular surface due to abnormal stresses placed upon the joint
- Subchondral bone sclerosis
- With advanced disease, may see subchondral bone cystic changes
- Dystrophic mineralization of the periarticular and intraarticular soft tissues may occur
- Joint mice may be present. Causes of joint mice include: osteochondral fragment from OCD, avulsed fragments of bone, osteochondral components of disintegrating joint surface, small synovial osteochondromas
- May see narrowing or collapse of the joint space (difficult to appreciate on a non-weight bearing radiograph)

Septic Arthritis

Signalment:

Sex: either

Age: in young animals may occur from hematogenous spread with no penetrating injury, in older animals may occur from penetrating injury

Breed: any

Clinical features:

Rare

Routes of infection: hematogenous (young patients), direct puncture (trauma or iatrogenic), extension from regional soft tissues

Severe pain and swelling of affected joints – monoarticular if infection is from direct puncture or extension, polyarticular if infection is from hematogenous spread

Patient may exhibit signs of systemic illness

Radiographic findings:

- Early in the disease, may be normal or demonstrate intracapsular joint swelling
- Joint space may appear widened due to effusion (do not forget that young patients have normally appearing wide joint spaces due to incomplete mineralization of cartilage)
- May see intracapsular gas from puncture or gas-producing organism
- Later in the disease, may see subchondral bone destruction on all adjacent articular surfaces (more severe than that of osteoarthritis)
- In long standing cases, secondary osteoarthritis may be seen

Differential diagnosis:

Non-erosive arthropathy (early stages), erosive arthropathy (later stages)

Non-erosive Polyarthropathy

Etiologies:

- Idiopathic (uncomplicated, associated with infections remote from the joints, associated with gastrointestinal disease, associated with neoplasia remote from the joints)
- Systemic lupus erythematosus (SLE)
- Polyarthritis/polymyositis complex
- Polyarthritis/meningitis syndrome
- Sjogren syndrome
- Familial renal amyloidosis of Chinese Shar Pei dogs
- Heritable polyarthritis of the adolescent Akita
- Polyarteritis Nodosa

Signalment:

Will depend upon the type of polyarthritis

Clinical features:

- Diagnosis is based on history, clinical signs, laboratory tests, radiologic, and pathologic features
- Generally, a specific diagnosis is made by elimination of other causes
- Multiple joints are affected. Common joints include stifle, carpus, and tarsus.

Radiographic findings:

- Other than intracapsular swelling, radiographs are usually normal
- In chronic cases, secondary osteoarthritis may be seen
- No specific findings for any of the etiologies



Erosive Polyarthropathy

Etiologies:

- Rheumatoid arthritis (most common form of erosive polyarthropathy)
- Feline noninfectious polyarthrititis – erosive form
- Polyarthrititis of the Greyhound

Signalment: (Rheumatoid arthritis)

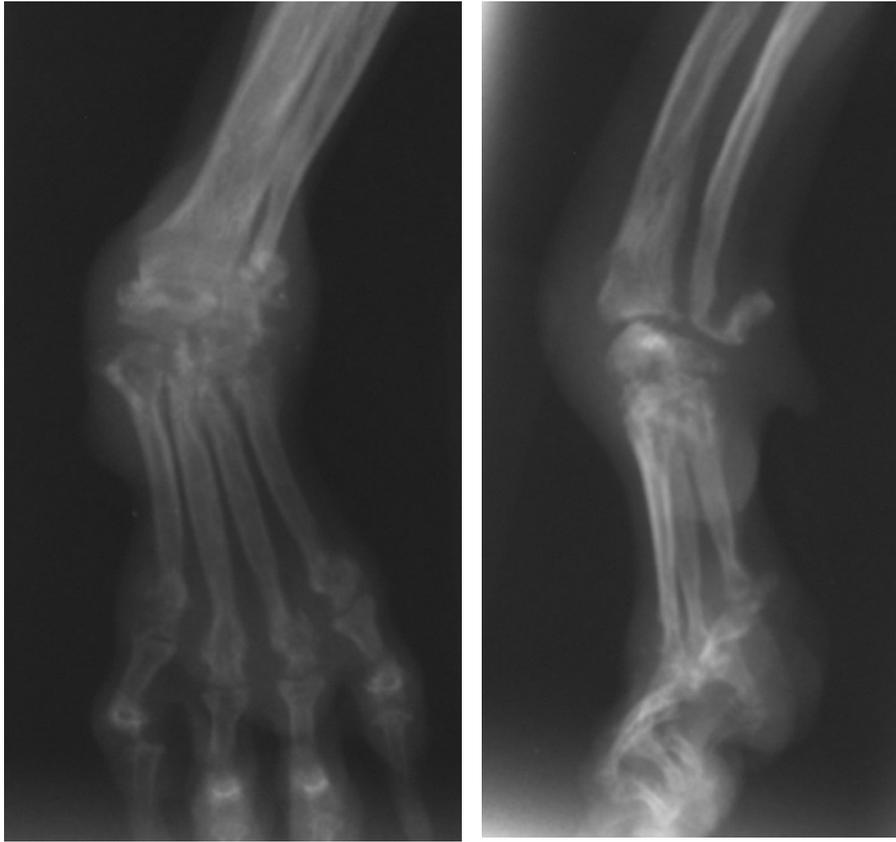
- Sex: no sex predilection
- Age: middle aged dogs
- Breed: small to medium-sized dogs, especially poodles and shelties

Clinical features:

- An immune-mediated disease with circulating auto-antibodies against IgG
- Variable degree of lameness and joint stiffness which generally affects the limbs symmetrically
- Patients may have systemic signs including fever, anorexia, lymphadenopathy
- This disease is accompanied by degeneration of the joint capsule and ligaments leading to joint laxity, luxations, and angular deformities
- Joints most affected include carpus, metacarpus, tarsus and metatarsus

Radiographic findings:

- Intracapsular and periarticular joint swelling
- Early bony changes may include coarse trabeculation of periarticular bone
- Narrowed joint spaces due to articular cartilage destruction
- Later bony changes include lucent and cyst-like subchondral bone changes, especially at the joint capsule attachments
- Progressive, marked destruction of articular bone
- Mushrooming at ends of metacarpi and metatarsi – represents collapse of subchondral bone in advanced cases
- Subluxation and luxation of joints due to ligament destruction, angular deformities
- Periarticular bone proliferation due to periostitis and/or secondary osteoarthritis
- Mineralized periarticular tissues



Cranial Cruciate Ligament Tear/Rupture

Signalment:

Sex: historically females were affected more often than males; however, the disease population has changed and there appears to be no sex predilection

Age: any age; however, the disease appears to be affecting younger patients

Breed: any breed, but common in large breed dogs

Clinical features:

Can occur from an acute or a chronic injury and may have partial or complete tears

Most common cause of stifle osteoarthritis

May palpate a cranial “drawer” that is diagnostic; however, a partial tear or chronic fibrosis may prevent palpation of this sign

May be concurrent with other stifle diseases (OCD, patellar luxation, meniscal tear)

Associated causes can include conformational abnormalities, excessive activity, immune mediated processes, Cushing’s disease



Radiographic findings:

- Intracapsular soft tissue swelling – cranial displacement or partial obliteration of the infrapatellar fat pad, loss of the caudal fascial plane
- Thickening of the medial joint capsule – medial buttress
- Enthesopathy at the insertion of the cranial cruciate ligament on the cranial aspect of the tibial plateau
- May see an avulsion fragment (more likely in younger patients) or joint mouse from dystrophic mineralization of the damaged ligament
- The tibia may be cranially displaced relative to the femur (more commonly seen when the radiograph is made in tibial thrust – TPLO view)
- Secondary osteoarthritis typified by osteophytes on the distal patella, the trochlear ridges and epicondyles of the femur, the fabellae, and the medial and lateral edges of the proximal tibia and possibly a subchondral cyst in the intercondylar region of the femur

Synovial Cell Sarcoma

Signalment:

Sex: no sex predilection

Age: more common in middle age (6-8 years) but at any age possible

Breed: medium-sized to large dogs

Clinical features:

Malignant neoplasm thought to arise from tenosynovial tissue in joints, bursa or tendon sheaths. This tumor is uncommon in dogs and rare in cats.

Joints affected: stifle (most common), elbow

Patients present with a slowly growing nonpainful mass

Unpredictable capacity to metastasize. May have metastasis (lung, regional node) at time of presentation

Radiographic findings:

- Initially, radiographs demonstrate a soft tissue mass at the joint (intracapsular swelling)
- As the disease progresses, lytic lesions of multiple bones of the joint are present. Ragged lysis of cortical bone at attachments of synovium is seen.
- An aggressive periosteal reaction may also be seen

Differential diagnosis:

Fibrosarcoma, rhabdomyosarcoma, fibromyxosarcoma, malignant fibrous histiocytoma, liposarcoma, undifferentiated sarcoma



Biceps Tendinopathy (Bicipital Tenosynovitis)

Signalment:

Sex: no sex predilection

Age: any age, but typically middle aged (average age 4.6 years in 23 dogs reported)

Breed: large breed dogs, especially Labrador Retrievers and Rottweilers

Clinical features:

Patients generally present for chronic, intermittent weight-bearing front limb lameness

Pain on manipulation of scapulohumeral joint and palpation of biceps tendon

May be secondary to tendon trauma, strain, rupture, or entrapment of joint mice

Calcification of the tendon may occur; additionally, calcification of the supraspinatus and infraspinatus tendons may occur

Arthrography can be useful in diagnosis as the scapulohumeral joint communicates with the bicipital tendon sheath in dogs

Radiographic findings:

- Initially, no abnormalities seen unless avulsion of supraglenoid tubercle occurs
- In more chronic cases, may see increased mineralization (osteophytes) in the intertubercular groove
- May see focal mineralized bodies adjacent to the greater tubercle (calcifying tendinopathy of biceps)
- May see remodeling of the supraglenoid tubercle
- May see secondary osteoarthritis
- Arthrography may demonstrate incomplete filling of sheath and irregularity of tendon border from fibrosis and/or synovial hyperplasia
- Skyline view of the scapulohumeral joint is useful to differentiate mineralization of the biceps tendon from mineralization of the supraspinatus tendon

Differential diagnosis:

Calcifying tendinopathy of the supraspinatus or infraspinatus tendons



Fractures

A disruption in the continuity of bone that is generally seen as a radiolucent line on radiographs

Radiographic Evaluation of Fractures

Radiography of a suspected fracture should include two orthogonal views of the region, along with the joints above and below the affected bone.

Radiographic evaluation should include:

- » Bones involved and location in bone
- » Type of fracture
- » Involvement of joint, if present
- » Displacement and angulation
- » Soft tissue changes

Fracture location:

- » epiphyseal, physeal, metaphyseal, diaphyseal
- » proximal or distal

Fracture type:

1. Incomplete or complete
 - a. Incomplete – fracture through only one cortex
 - b. Complete
 - » Transverse
 - » Oblique
 - » Spiral
2. Comminuted – multiple fracture lines that communicate to single point or plane
3. Segmental – multiple fractures that do not meet at a single point
4. Closed or open – open fractures have a skin defect, emphysema, or foreign debris deep within the surrounding tissues
5. Compression – often appears as increased bony opacity with no distinct radiolucent line
6. Pathologic – a fracture of bone that has been weakened by an underlying process that may be developmental (incomplete ossification of humeral condyle in Spaniels) or acquired (neoplasia, hyperparathyroidism)
7. Stress – a fracture that occurs when repetitive stress causes bone fatigue
8. Avulsion – a fracture at bony insertion of ligament or tendon
9. Physeal – fractures that occur in immature patients, Salter Harris classification

Fracture displacement:

The displacement is described by how the distal, unfixed segment is located relative to the proximal, fixed segment

Descriptors may include medially, laterally, cranially or caudally displaced; distracted; proximally overriding; cranially or caudally angulated

Radiographic Evaluation of Fracture Healing

Fractures heal by periosteal and endosteal bony proliferation

Bony callus production produced varies greatly with location, type of fracture, type of fracture stabilization, and age of the patient

- » Callus is generally radiographically visible 10-14 days after initial fracture, but may be seen much earlier in young animals
- » Minimal callus is seen during healing of fractures of intramembranous bones and with primary bone healing
- » Callus remodeling involves the restoration of normal bone contour and function

Many factors affect fracture healing, including local blood supply, location of fracture (metaphyseal heal faster than diaphyseal), type of fracture (spiral and oblique heal faster than transverse), type of fracture stabilization (especially if motion is present at fracture site), age of patient (younger patients heal faster), presence of concurrent infection or other systemic illness/disease

Radiographic signs of primary bone healing:

- Lack of callus
- Gradual loss in opacity of fracture ends
- Progressive disappearance of fracture line

Radiographic signs of secondary bone healing:

- 1 week post-reduction: fracture fragments lose sharp margins, bony resorption at fragment ends which results in widening of fracture line
- 2-3 weeks post-reduction: periosteal and endosteal callus formation, decreasing width of fracture line
- after 4-5 weeks post-reduction: callus increases in opacity, bridges, remodels
- after 12 weeks post-reduction: continued callus remodeling, cortical shadow seen through callus, continuity of medullary cavity gradually reestablished, cortical remodeling

Radiographically healed fracture:

- Complete ossified bridging callus
- Bony continuity of cortex
- No remaining visible fracture line

Radiographic Evaluation of fracture stabilization:

- Immediate post-operative radiographs: evaluate for alignment and reduction of fracture, position of the fixation device including screws and pins
- Post-operative reevaluation radiographs: evaluate for any change in alignment and reduction of fracture, change in position of fixation device, evidence of fixation failure, evidence of infection, presence and progression of healing callus
 - » Generally made at 2-4 weeks, 6-8 weeks, and then at 4 week intervals as needed until complete fracture healing apparent

Rate of Union in Terms of Clinical Union

Age of Animal	External, Skeletal, and Intramedullary Pin Fixation	Fixation with bone plates
Under 3 months	2-3 weeks	4 weeks
3-6 months	4-6 weeks	2-3 months
6-12 months	5-8 weeks	3-5 months
Over 1 year	7-12 weeks	5 months – 1 year

From Brinker WO, Piermattei, DL, Flo GL, Handbook of Small Animal Orthopedics & Fracture Treatment, 2nd edition, Saunders, 1990

Fracture Complications**Delayed Union:**

Bones do not heal within the expected time frame (see Table in Thrall, p 173)

Healing is gradual, and will eventually occur

Causes: motion at fracture site, infection, older patient, pathologic condition in bone

Radiographic findings:

- Persistent presence of radiolucent fracture line
- Minimal periosteal production with incomplete callus

Nonunion:

Bone healing stops prior to complete fracture healing

Causes: motion at fracture site, poor or no vascularity at fracture, presence of infection, interposed muscle or fat at fracture site

Radiographic findings:

- Lack of bridging callus
- Fracture ends become flared, smooth, and rounded
- Medullary canal seals over with sclerotic bone

Malunion:

Healing of fracture occurs with an angulation or rotation at fracture site

Causes: poor initial surgical reduction, healing complications with loosening of stabilization device or rotation, angulation or collapse of fracture segments

Radiographic findings:

- Fracture is healed but bone is shortened, angulated, rotated, or otherwise malformed
- May see secondary changes to regional joints

Premature Closure of Physis:

See previous notes

Infection:

See previous notes

Causes: contamination from open fractures, long surgical procedures, excessive tissue damage, contact with foreign objects

Radiographic findings specific to fractures:

- Soft tissue swelling, may be diffuse or focal
- Irregular periosteal proliferation extending well beyond the fracture, generally circumferential involving all cortices
- May see bony lysis
- May result in delayed union or nonunion
- May see sequestrum formation of one of the bony fragments
- Ill-defined lucencies associated with implants

Failure of Implant:

Causes: inappropriate initial stabilization, improper patient management during healing process (client noncompliance), motion at fracture site, infection

Radiographic findings:

- Bent or broken implants
- Movement of implants – retraction of screws, retraction of pins
- Bony resorption around implants
- Distraction or displacement at fracture

Selected Disorders of the Axial Skeleton

Spine

Spina Bifida

Signalment:

Sex: no sex predilection

Age: if clinical signs occur, noticed most frequently when patient begins to walk

Breed: "screw tail" dog breeds (Bulldog, Boston Terrier, Pug) and Manx cat

Clinical features:

Incomplete development of dorsal aspect of vertebra due to developmental failure of the lateral arches to fuse dorsally

Most commonly occurs in thoracic and lumbar regions, but may occur anywhere

Often no clinical signs, but signs may include ataxia, paresis, fecal and urinary incontinence, perineal analgesia, and poor anal tone

Spina Bifida Occulta: no clinical signs

Spina Bifida Manifesta: sac containing neural tissue protrudes through bone defect

1. Meningocele – sac contains meninges
2. Myelocele – sac contains spinal cord
3. Meningomyelocele – sac contains meninges and spinal cord or nerve roots

Radiographic findings:

- May see a radiolucent line on midline between two unfused sides of dorsal spinous process
- May see a cleft spinous process
- May see lack of dorsal lamina and dorsal spinous process
- Myelography, CT, or MRI necessary to evaluate for protrusion of meninges or spinal cord



Block Vertebra

Clinical features:

Developmental failure of somite segmentation; may involve vertebral arch, dorsal spinous process, or entire vertebral body

Rarely causes signs

Potential increased risk of intervertebral disk protrusion at ends of block vertebra

Radiographic findings:

- Will see partial or complete fusion of two adjacent vertebral bodies
- Partial or absent intervertebral disk space
- May see abnormal angulation of spine or stenosis of canal



Hemivertebra

Clinical features:

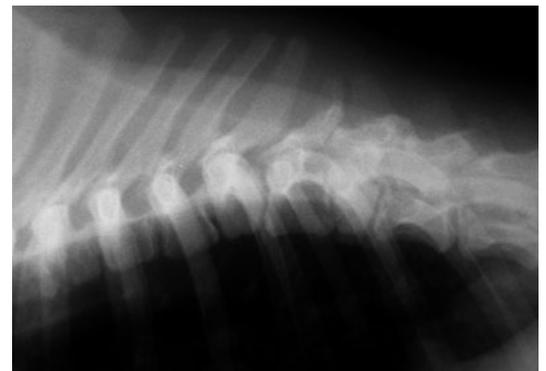
Developmental displacement of vertebral somites

Rarely produces clinical signs

Most common in “screw tail” dog breeds (Bulldog, Boston Terrier, Pug) and Manx cat

Radiographic findings:

- Wedged shape – base may be oriented dorsally, medially, ventrally
- Butterfly – the central portion of vertebra does not form but see left and right segments (butterfly shaped on VD view)
- Intervertebral disk spaces generally conform to shape of vertebra
- May see angular deformity of spine
 - » Lordosis – ventral deviation
 - » Kyphosis – dorsal arching
 - » Scoliosis – lateral bowing



Transitional Vertebrae

Clinical features:

Developmental anomaly where the vertebra has some anatomic characteristics of an adjacent region

Generally occurs at junctions of spinal regions

Although generally no clinical signs, may

- » Predispose the ipsilateral coxofemoral joint to osteoarthritis
- » Have an association in the lumbosacral region with instability, disk prolapse, and cauda equine syndrome

Radiographic findings:

- Cervicothoracic transitional vertebrae: thoracoization of C7 with unilateral or bilateral rib development or cervicoization of T1 with unilateral or bilateral rib agenesis
- Thoracolumbar transitional vertebrae: lumbarization of T13 with unilateral or bilateral rib agenesis or thoracoization of L1 with unilateral or bilateral rib development
- Lumbosacral transitional vertebrae: lumbarization of S1 (lack of fusion of S1 with remainder of sacrum) with unilateral or bilateral transverse process on sacrum, sacralization of L7 (partial or complete fusion of L7 with the sacrum) with unilateral or bilateral absence of transverse process and articulation with sacrum and ilium

Atlantoaxial Subluxation

Signalment:

Sex: no sex predilection

Age: generally recognized in dogs less than 1 year of age

Breed: miniature and toy breeds, especially Yorkshire Terrier, Chihuahua, Toy Poodle, Pekinese

Clinical features:

Developmental anomaly with hypoplasia or aplasia of the odontoid process of C2

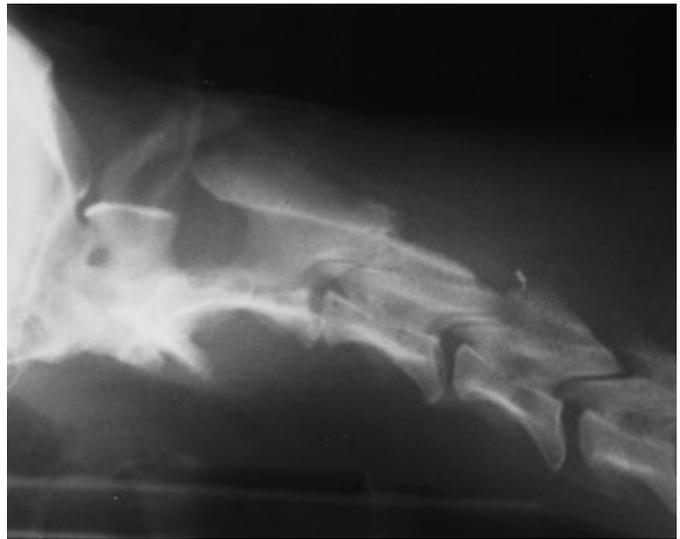
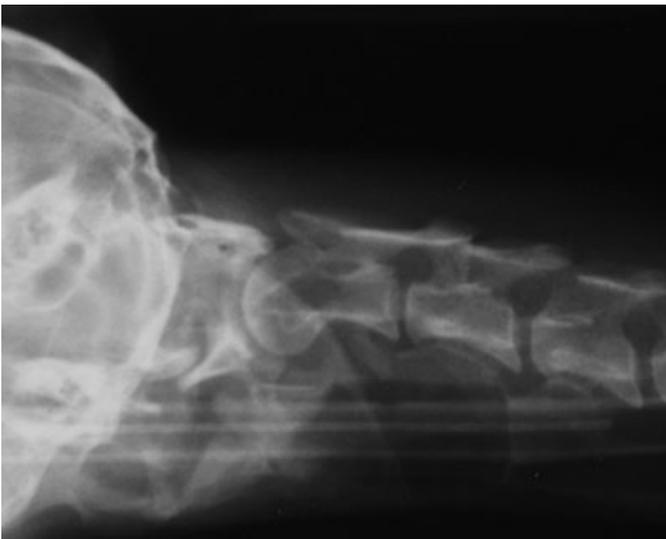
Clinical signs usually occur before 1 year of age

Signs are a result of cord compression by abnormal rotation of C2 into spinal canal; signs vary with degree of luxation and include cervical pain, cervical rigidity, spastic paraparesis, tetraplegia

Cervical manipulation for radiographs may cause worsening of signs; be very cautious when manipulating the sedated or anesthetized patient

Radiographic findings:

- Hypoplastic or absent odontoid process of C2 – best viewed on VD and lateral oblique radiographs
- Widened space between the arch of C1 and the spinous process of C2
- May see abnormal angulation of C2 relative to C1



Intervertebral Disk Disease (Herniation, Prolapse, Rupture)

Signalment:

Sex: no sex predilection

Age: neural signs generally manifest after 3 years of age

Breed: chondrodystrophic breeds are overrepresented

Types:

1. Hansen Type I herniation:
 - Associated with degeneration and rupture of dorsal annulus – the nucleus pulposus extrudes through ruptured annulus into canal
 - Commonly associated with chondroid metaplasia and disk degeneration
 - Common in chondrodystrophoid breeds – Dachshund, Beagle, Cocker Spaniel, Pekinese, Toy Poodle
 - Frequently more acute and more severe signs
2. Hansen Type II herniation:
 - Disk protrusion characterized by bulging of intervertebral disk without complete rupture of annulus
 - Commonly associated with fibroid metaplasia and disk degeneration
 - Common in nonchondrodystrophoid breeds
 - Often a more gradual process

Clinical features:

Common sites of intervertebral disk prolapse are in the cervical spine, the thoracolumbar junction, and the lumbar spine

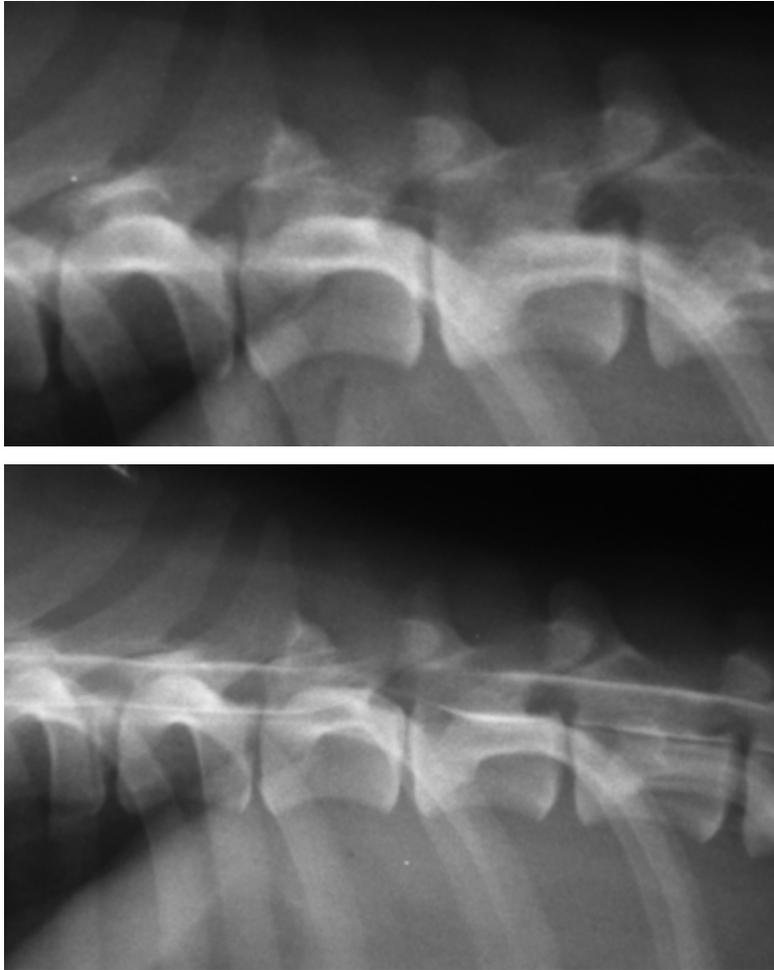
Intervertebral disk prolapse does not generally occur in the cranial and mid thoracic spine due to additional support from intercapital ligaments between the rib heads

Clinical signs vary with degree of cord compression from the disk protrusion and range from pain to complete paralysis and lack of deep pain

Intervertebral disk degeneration may appear as a mineralized disk *in situ*

Radiographic findings:

- Narrowed or wedged intervertebral disc space (compared to adjacent spaces)
- Decreased size of intervertebral foramen
- Increased opacity of intervertebral foramen – may see mineralized disc in spinal canal
- Narrowed articular facet joint space
- May see sclerosis of endplates and spondylosis with chronic prolapse
- Myelography shows an extradural lesion
- Mineralization of intervertebral disks *in situ* indicates intervertebral disk degeneration, and NOT disk protrusion, although a portion may have broken off.



Myelography:

The technique of myelography involves the injection of radiographic contrast (non-ionic iodinated contrast) into the subarachnoid space. The contrast may be introduced at the lower lumbar region (generally L5-6) or at the cisterna magna. Myelography allows evaluation of the spinal cord. Interpretation involves assessing for different types of spinal cord compressions/abnormalities. An extradural compression causes displacement of the subarachnoid space away from the lesion on one view and may cause widening of the cord on the opposite view due to compression. Extradural lesions include intervertebral disk prolapse, tumors of the vertebral bodies, and lymphomas. An intradural-extramedullary lesion results in splitting of the contrast around a subarachnoid lesion (a “golf tee” sign). These lesions include meningiomas and tumors of the nerve roots. An intramedullary lesion results in circumferential widening of the cord. An intramedullary lesion is generally a tumor of the cord.

Cervical Spondylomyelopathy

(Wobbler syndrome, cervical vertebral instability, cervical vertebral malformation-malarticulation syndrome)

Signalment:

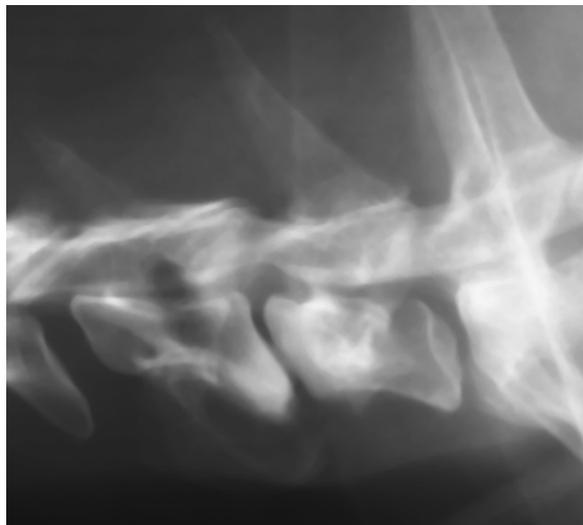
Age and Breed: may be seen in any breed at any age, but commonly seen in young (<2 years) Great Danes and middle aged to older Doberman Pinschers

Clinical features:

Clinical signs include ataxia, weakness, tetraparesis, and tetraparalysis
The syndrome is characterized by deformity of vertebral bodies, vertebral canal stenosis, vertebral instability, vertebral malarticulation, ligamentous hypertrophy
May have associated intervertebral disk prolapse
C4-5, C5-6, C6-7 most common sites, multiple lesions may be present

Radiographic findings:

- Potential abnormalities on survey radiographs
 - » Abnormally shaped vertebrae
 - » Coning or stenosis of the cranial aspect of the spinal canal of a vertebra
 - » Dorsal tipping (subluxation) of one or more vertebrae
 - » Proliferative changes associated with articular facets
 - » Spondylosis and endplate sclerosis may be present
 - » Findings of intervertebral disk prolapse
- Findings on contrast radiography (myelography)
 - » Extradural lesion at the site, often the most affected survey site is not the most affected site on contrast radiography
 - » Lesion is generally dynamic – compression worsens with hyperextension and improves or resolves with ventroflexion or traction (ligamentous hypertrophy) – but lesion can be static with herniated disks, canal stenosis, or articular facet proliferation



Degenerative Lumbosacral Stenosis (cauda equina syndrome, lumbosacral instability, lumbosacral malarticulation)

Clinical features:

Multifactorial disease that may result from:

1. Stenotic lumbar or sacral spinal canal
2. Osteochondrosis-like lesion involving the craniodorsal aspect of sacrum
3. Lumbosacral malalignment
4. Lumbosacral instability
5. Herniated discs and presence of fibrous connective tissue
6. Spondylosis with or without vertebral facet osteophytes impinging on nerve roots at the intervertebral foramina

Usually seen in large breed dogs, especially German Shepherds

May have associated intervertebral disk prolapse, lumbosacral subluxation, ligamentous hypertrophy

Clinical signs include pain on palpation of the lumbosacral region, difficulty rising, pelvic limb lameness or weakness, urinary or fecal incontinence

Radiographic findings:

- Best evaluated with CT or MRI
- May see spondylosis and endplate sclerosis at the lumbosacral junction
- Narrowing and wedging of the LS disk space
- May see ventral displacement of the sacrum relative to L7
- May see stenosis of the canal from proliferative changes on the facets or from congenital stenosis
- Generally, a myelogram will not demonstrate this disease because the subarachnoid space does not extend far enough caudally in most patients; if subarachnoid space does indeed extend far enough caudally, flexion and extension lateral views are helpful



Discospondylitis

Clinical features:

Discospondylitis is an infection of the intervertebral disk with extension to the regional vertebral bodies

Often seen at more than one disk space, generally not adjacent spaces

Clinical signs vary depending upon location and severity – may include fever, anorexia, pain, stiffness, spinal hyperesthesia, secondary cord compression may result in neurologic abnormalities

Routes of infection:

1. Hematogenous (most common): infection associated with urogenital infections, dental disease, endocarditis
2. Migrating foreign bodies (plant awn)
3. Post-operative complication after spinal cord or vertebrae surgery

Organisms: *Staphylococcus spp.* (most common), *Brucella canis*, mycoses, mycobacterium

Radiographic findings:

- Acutely, radiographs will be normal; radiographic changes lag behind onset of clinical signs
- Irregular lysis of one or both endplates adjacent to the affected disk
- Widening or collapse of the affected intervertebral disk space
- Proliferative new bone at the endplates of the affected vertebral bodies
- Spondylosis formation at the margins of the vertebral bodies
- With healing, should see diminished lysis with progressive new bone and then progressive remodeling
- With healing, vertebral fusion may or may not occur; serial radiographs aid in determining inactivity of lesion (no change for two or more sets of radiographs)



Spondylitis

Clinical features:

An infection of the ventral vertebral bodies, generally a bacterial infection
Common causes include direct extension from infected adjacent soft tissues,
migrating foreign bodies (plant awns), external wound
Clinical signs include fever, pain, discomfort

Radiographic findings:

- Proliferative irregular or spiculated periosteal reaction involving one or more vertebral bodies
- Generally along the ventral margins
- May see associated retroperitoneal swelling

Differential diagnosis:

Metastatic carcinoma

Spondylosis deformans

Clinical features:

A degenerative change associated with the intervertebral joints; related to joint instability and degeneration
Common in dogs and cats
Rarely clinically significant

Radiographic findings:

- Smoothly marginated, solid bony proliferation arising from the ventral margins of the endplates
- Appearance will vary from small incompletely bridging spurs to completely bridging bone over several vertebral bodies
- Can form laterally and appear as increased opacity within the intervertebral foramen on the lateral view (superimposed)

Neoplasia

Clinical features:

Both primary bone and metastatic neoplasia may affect the spine – see appendicular notes on these types – these tumors may cause neurologic defects due to expansion of the bone and compression on the spinal cord, or due to pathologic fractures

As in the appendicular skeleton, primary bone tumors generally affect one vertebra, whereas, metastatic tumors generally affect many vertebrae

Tumors of the spinal cord and meninges also occur – these tumors are best demonstrated with myelography, CT or MRI

Radiographic findings:

- Findings will be variable and may include bony lysis and bony proliferation
- May see pathologic fractures
- Tumors of the cord and meninges may cause enlargement of the spinal canal or intervertebral foramen
- Multiple myeloma
 - » Punched-out lytic lesions of the bone
 - » Affects the spine (dorsal lamina and dorsal spinous processes), the pelvis, the long bones, and sometimes the calvarium

Trauma

Trauma to the spine includes fractures (including compression fractures), subluxations, luxations, traumatic herniated disk, or a combination of the above. Careful attention should be paid to spinal alignment and trauma to surrounding tissues (retroperitoneal and peritoneal spaces). If a spinal fracture is suspected, the lateral radiograph should be taken and evaluated prior to making the VD. A cross-table VD view can be made so that the patient does not need to be manipulated on his/her back with the possibility of causing further trauma. Myelography, CT or MRI is often needed for assessment of the spinal cord.

Radiographic findings will depend upon the type of trauma.

Skull

Cranio-mandibular Osteopathy (CMO)

Signalment:

Sex: no sex predilection

Age: clinical signs generally seen at 3-8 months of age

Breed: terrier breeds, especially West Highland White, Scottish and Cairn Terriers, also reported in other terrier breeds, Labradors, Doberman Pinschers, German Shepherd Dogs, and Boxers

Clinical features:

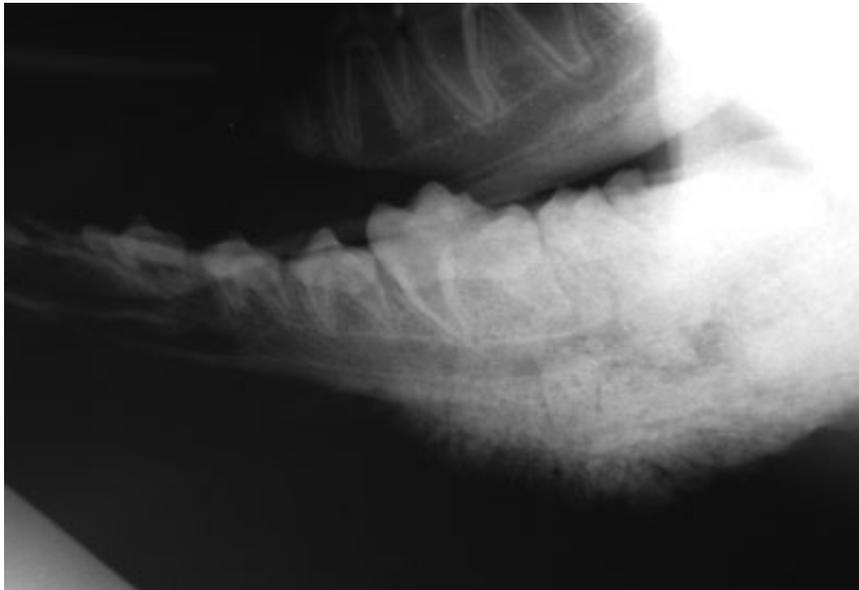
CMO is a proliferative, nonneoplastic disorder affecting bones of cranium and mandibles, occasionally produces a periosteal reaction on long bones

The disease is self-limiting and bony proliferation tends to slow at 7-8 months of age

Clinical signs include mandibular swelling, drooling, difficulty eating, fever, and pain upon opening the mouth

Radiographic findings:

- Irregular, opaque (may appear as pallasading) periosteal new bone involving the mandibles (often near angular process), temporal bone (petrous portion and tympanic bullae), and occasionally the frontal, parietal, or maxillary bones
- Findings are usually bilateral, but may be unilateral
- Ankylosis of the temporomandibular joint may occur
- Bony proliferation generally ceases with skeletal maturity and lesions may eventually regress



Otitis Externa and Media

Clinical features:

Otitis interna is a physical exam diagnosis (*i.e.*, appropriate neurologic findings)

Etiology:

1. Middle and internal ear infections are generally an extension of chronic otitis externa
2. Nasopharyngeal and auricular polyps may have associated otitis, but also often have associated nasal disease (polyps are more common in cats)
3. Trauma or neoplasia may be an underlying cause

Radiographic findings:

- Acute infections commonly have no radiographic abnormalities
- Narrowing, obliteration, or mineralization of the external ear canal
- Soft tissue/fluid opacity within the tympanic bullae
- Bony changes of the tympanic bullae, including lysis, sclerosis, thickening, or periosteal proliferation
- Nasopharyngeal polyps may be seen as a soft tissue mass in the nasopharynx
- Neoplasia will have a variable appearance depending upon if it is a bone tumor or a soft tissue tumor



Nondestructive Rhinitis

Clinical features:

Etiologies:

1. infection – adenovirus and influenza virus in dogs, herpes and caliciviruses in cats, secondary bacterial infections, parasites
2. foreign bodies
3. nasopharyngeal polyps
4. allergies
5. coagulopathies

Infections commonly affect the paranasal sinuses and the mucous membranes of the nasal cavity

Radiographic findings:

- may see increased opacity of the nasal passages or frontal sinuses
- fluid or inflammatory debris may silhouette with the nasal (maxillary) turbinates and cause blurring and loss of visualization
- fluid or inflammatory debris in the ethmoid turbinates should not cause lysis or lack of visualization of the bony turbinates
- findings may be unilateral or bilateral
- may see a radiopaque foreign body – plant awns and grasses are not usually radiographically apparent
- may see lysis with chronic long standing bacterial infection or foreign bodies
- open-mouth VD view is best for evaluation of nasal passages

Destructive Rhinitis

Clinical features:

Etiologies:

1. fungal infection: cryptococcus in cats, aspergillus or blastomycosis in dogs
2. neoplasia: adenocarcinoma (most common), squamous cell carcinoma (also common), chondrosarcoma, osteosarcoma (also lymphosarcoma in cats)
3. chronic long standing foreign bodies or secondary bacterial infections

Tumors are generally seen in middle aged to older patients with dolichocephalic dogs affected with a higher frequency

Fungal infections are generally seen in young to middle aged patients, especially large breed hunting dogs

Most common clinical sign is unilateral or bilateral nasal discharge, epistaxis is seen early with fungal infections and late with neoplasia (in general)

Radiographic findings:

- early findings may mimic nondestructive rhinitis – increased opacity within the nasal passages or frontal sinuses
- irregular opacities in nasal passages and/or frontal sinuses
- neoplasia may often be centered at the maxillary recess
- lysis of the ethmoid turbinates or the nasal septum
- lysis of cortical bone (nasal, frontal) and cribriform plate with tumor extension extranasally (external soft tissue swelling)
- fungal infection is often more diffuse with nodular opacities (fungal mats) seen in the frontal sinuses
- aspergillus infection often causes diffuse punctate lysis and a periosteal reaction on the frontal bones (osteomyelitis)
- open-mouth VD view is best for evaluation of nasal passages



Hyperparathyroidism

Clinical features:

Primary hyperparathyroidism – tumor of parathyroid gland that results in excessive production of parathyroid hormone, this leads to hypercalcemia and subsequent bone resorption

Secondary hyperparathyroidism – renal and nutritional causes, subsequent to nonendocrine alterations in calcium and phosphorus homeostasis that leads to increased levels of parathyroid hormone and subsequent bone resorption

Radiographic findings:

- early lesion is loss of the lamina dura
- demineralization of mandible and maxilla
- floating appearance to teeth
- fibrous osteodystrophy may lead to thickening of affected portion of skull



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