Juvenile musculoskeletal diseases

Central Canadian Veterinary Conference
Winnipeg, Manitoba
Feb 2, 2019

Shawn Mackenzie, DVM, DVSc, DipACVR

Radiographic assessment of the young growing animals can be challenging due to the many normal bone and joint features and their changes over time. The recognition of normal anatomy such as physis, cuboidal bones, apophysis, and separate centre of ossification is essential for diagnosing abnormalities. There are many excellent resources that can be used for recognition of normal anatomy and normal variations[1,2,3]. The closure times of some of the more clinically relevant physis and apophysis are listed in Table 1. These are approximate guidelines and in some giant breeds certain growth plates may remain open for up to 18 months. Developmental lesions may also be challenging because they may be focal, multifocal, or diffuse. Performing radiographs of the contralateral limb can be useful for comparing suspicious lesion but many juvenile musculoskeletal diseases are bilateral. Many of the radiographic findings associated with juvenile joint disease are due too degenerative changes which may take time to develop and to be recognized and these changes can mask underlying etiology.

Table 1: Approximate closure times of select growth plates in dogs

Thoracic limb	**Age at closure**		**Hindlimb**	**Age at closure**
Scapular tuberosity	5mo		Greater trochanter	11mo
Proximal humerus	12mo		Lesser trochanter	12mo
Anconeal process	5mo		Distal femur	11mo
Distal ulna	11mo		Proximal tibia	12mo
Distal radius	11mo		Tibial tuberosity	12mo
			Distal tibia	11mo
			Tuber calcaneus	8mo

Performing musculoskeletal radiographs

Performing orthopedic radiographs in young animals can be challenging and if inappropriately positioned or improper exposure used many of these diseases may be missed. The lesion should be localized as best as possible prior to examination. Evaluation should consist of at least 2 orthogonal radiographs but often when evaluating musculoskeletal

structures additional oblique radiographs or stressed radiographs are useful. Radiographs should be centered and collimated for the joint of interest or if the structure of interest is a long bone the joint above and below the bone should be. Ensuring the region of interest is isolated (i.e. not superimposed on the thorax, abdomen, other limb) is important. Radiographs of the entire limb often leads to poor positioning of many of the joints and bones should be avoided when possible. For proper orthopedic examination most dogs will require some degree of sedation and positioning can be done with sand bags, troughs, tape, and Velcro straps so that you and your staff can leave the room while the x-ray is being performed.

Interpretation of musculoskeletal radiographs

Approaching these radiographic studies using a systematic approach can help ensure all structures are identified and assessed. Different approaches to evaluating musculoskeletal radiographs may be used but using a commonly taught pneumonic, the ABCDs (alignment, bone, cartilage, devices when present, soft tissues), can be useful to direct the attention of the reader to different regions. The soft tissues are often very helpful as soft tissue swelling may provide a clue for the region of a lesion. For juvenile animals particular attention should be placed on the joints and physeal region. Once the overall assessment of the radiographs is performed one can start to focus on certain pathological conditions and the regions where this may occur.

Juvenile musculoskeletal disorders

Below are some of the more commonly encountered juvenile musculoskeletal disorders. This list is not extensive as there are many other rare metabolic or hereditary conditions.

Osteochondrosis and Osteochondritis Dissecans

- Young, rapidly growing, large-breed dogs
- Epiphyseal cartilage necrosis from failure of normal endochondral ossification
- Can be present without clinical signs if vascular bed of subchondral bone can bypass lesion and endochondral ossification can resume
- Osteochondritis *dissecans* refers to when a chondral or osteochondral fragment separate
    - Often impossible to differentiate on survey radiographs
- Most common locations; caudal aspect of the proximal humeral head, distomedial aspect of humeral trochlea, lateral and medial femoral condyles, femoral trochlea, medial and lateral trochlear ridges of talus
- Frequently bilateral
    - Perform orthogonal radiographs of contralateral limb
- Radiographic signs:
    - Flattening or concavity of subchondral bone surface surrounded by sclerosis
    - Separate osteochondral fragments (‘joint mice’)
    - Joint effusion

    - Subchondral lesions involving opposite articular surface ('kissing lesion')
- Oblique radiographs may be helpful
    - Especially lesions affecting lateral trochlea of the talus
        - Lesion can be superimposed with calcaneus on DP view, DLPMo and/or flexed FP view can be helpful

Elbow dysplasia

- Non-specific term referring to triad of developmental lesion
    - Ununited anconeal process
    - Medial coronoid disease
    - Osteochondrosis of distomedial aspect of humeral trochlea
- May all be associated with underlying osteochondrosis lesions and/or asynchronous growth of radius/ulna and abnormal shape of ulnar notch and elbow joint incongruity
- Radiographic study of the elbow includes standard lateral, flexed lateral, and craniocaudal radiographs
    - CT is more sensitive to radiographs in diagnosis the changes associated with elbow dysplasia

Ununited anconeal process

- Breeds at greatest risk include Bernese mountain dogs, mastiffs, Rottweilers and Saint Bernard
- Flexed lateral radiograph are most useful
- Radiographic findings:
    - Small and poorly defined incomplete and irregular separation from olecranon
    - Number of breeds including GSD, pit bulls, Retrievers all have separate centers of ossification of the anconeal process
        - Should fuse by 5mo

Medial coronoid disease

- Medium and large breed dogs
- Clinical signs usually apparent at 4-6mo
- Radiographic findings:
    - Fragmentation of medial coronoid not always apparent on radiographs due to superimposition
    - Often times cartilage fragments still partially attached and separated by fissures
        - CT very helpful in these cases
    - Margins of medial coronoid process may be blunted, poorly defined, irregular or rounded
    - Subchondral bone sclerosis along trochlear notch is an early sign

Hip dysplasia

- A heritable disease manifested as hip joint laxity
- Occurs secondary to abnormally developed hip joint
- May also occur secondary to cartilage damage from trauma
- Cartilage breakdowns over time and is associated with hip pain and degenerative joint changes
- No accurate way to predict the clinical significance of the hip changes
    - Multiple factors such as weight, exercise, muscle confirmation will play a role
- Radiographic signs include:
    - Shallow acetabulum
    - Decreased coverage of the femoral head by the dorsal acetabulum
    - Widened hip joints
    - Flattening of the femoral head
    - Periarticular new bone
- Screening
    - Orthopedic foundation of America (http://www.ofa.org)
        - Radiographs can be performed by any veterinarian and sent to OFA for grading and certification
        - VD radiograph of the pelvis with pelvic limbs extended and parallel and stifle joints rotated in. Obturator foramen should be equal in size and should include from ilium to stifle joints
        - Need to be 24 months old to certify
            - Will do preliminary evaluations as young as 4 months of age
        - A group of radiologists asses the images and provide a grade of excellent, good, fair, borderline, mild, moderate or severe.
            - Excellent, good and fair are all normal

    - PennHIP
        - Antech imaging services: https://info.antechimagingservices.com/pennhip
        - Need to do additional training
            - Now free and available online
        - Puppies as young as 16 weeks of age can be tested
        - Laxity is the most important risk factor for the development of hip osteoarthrosis
        - Assess passive hip laxity which has been shown to reflect functional hip laxity
            - Quantitative compression and distraction index
            - Provide distraction index for breeds
        - Gives estimate of risk for hip dysplasia

Asceptic necrosis of the femoral head (Legge-Calve-Perthes Disease)

- Toy and small-breed dogs
- Compromised blood supply to femoral capital epiphysis

- Results in necrosis of subchondral bone of femoral capital physis
- Revasculatization occurs in attempt to repair lesion and removal of necrotic bones lead to decreased opacity of femoral head
- Radiographic findings:
  - Misshapen femoral head with a nonuniform opacity
  - Small femoral head and increased hip joint space

Panosteitits

- Self-limiting disease
- Affects long bones of primarily young large- or giant-breed dogs
- Males more commonly affected than females
- May be solitary or multifocal in multiple bones
- Often originate near nutrient foramen
- May occur over several months with lesions resolving in some bones and developing in new ones
  - Radiographic lesions do not necessarily correlate with clinical signs
- Radiographic signs:
  - Early changes very mild and hard to diagnose
  - As lesion progresses increased medullary opacity with smooth, continuous periosteal reaction, cortical thickening, and mild endosteum irregularity

Hypertrophic osteodystrophy (metaphyseal osteopathy)

- Systemic illness typically affecting large and giant breed dogs
- Unknown cause
- Typically bilateral in metaphysis of long bones
- Often self-limiting but can lead to abnormal/premature physeal closure and angular limb deformities
- Radiographic signs:
  - Focal lucent zones within metaphysis
    - Usually transversely oriented and parallel to physis 'double physis sign'
  - Soft tissue swelling around physis
  - Irregular periosteal new bone along metaphysis

Metaphyseal osteodystrophy of radius and ulna in Newfoundland dogs [4, 5]

- Irregularities in bone remodeling in distal radius in ulna seen in ~50% of Newfoundland dogs
- All dogs with lesions had changes at 6mos of age
  - Residual changes visible at 18-24 months
- Incidental findings
- Radiographic findings:
  - Lesion in distal radius and ulna seen as islands of reduced opacity outlined by thickened, radiopaque osseous trabeculae
    - May represent sclerosing dysplasia

Retained cartilage core

- Primarily distal ulnar metaphysis of large breed dogs
- Disruption of normal progression of endochondral ossification with retention of hypertrophied cartilage cells in central metaphysis
    - May cause angular limb deformity but often incidental
- Radiographic signs
    - Cone-shaped radiolucent area in distal ulnar metaphysis

Multiple cartilage exostosis

- Benign proliferative disease of bone and cartilage
- Affects any bone that develops by endochondral ossification
- Chondrocytes pushed into metaphyses and don't differentiate into osteoblasts
    - Cartilage islands continue to grow and proliferate into a cartilaginous mass that ossify
- Growth of mass tends to cease when animal reaches maturity
- Clinical signs usually secondary to mass effect (e.g. tracheal compression)

Osteochondrosis or focal chondrodysplasia of the supraglenoid tubercles[6]

- Abnormal ossification of the supraglenoid tubercle and cranial glenoid cavity
- Reported in 8mo English Setter with bilateral shoulder lameness
    - I've seen it in pointer and setter breeds
- Bilateral irregular margination and separation of the supraglenoid tubercle from the scapula
    - Also involves cranial articular surface of glenoid cavity
- Bilateral symmetrical
- Treatment is cage rest

Osteochondral dysplasias

- Heterogenous group of diseases that have similar radiographic and clinical sings
- Includes a number of different conditions
    - Include chondrodysplasia, osteochondrodysplasia, enchondrodystropy, oculoskeletal dysplasia, and many others
- Can result in disproportionate dwarfism
- May be associated with other systemic lesions
        - E.g. ocular defects seen in Labs, GSD, Samoyeds – oculoskeletal dysplasia
- Many are inherited
- Specific cases:
    - Chondrodysplasia of Alaskan Malamutes
        - Autosomal recessive gene
        - Skeletal abnormalities and macrocytic hemolytic anemia
        - Limb shortening with cranial and lateral deviation of forelimbs
        - Enlarged carpi

        - Distal metaphysis of radius is flared and border irregular
        - Coarse trabecular bone and thin cortices
        - Angular limb deformities due to asynchronous growth of radius and ulna

    - Chondrodysplasia of Norwegian Elkhounds
        - Similar to changes seen in chondrodysplasia of Alaskan Malamutes but also affects axial skeleton

    - Osteochondrodysplasia of Scottish Fold cats
        - Simple autosomal dominant trait
        - Affected animals are shorter and difficulty supporting weight
        - Metaphyses are distorted and physis are widened
        - Shortening of MC, MT and phalanges
        - Secondary DJD and ankylosis are seen in severe cases
        -

Fractures

- Tibial tuberosity avulsion
- Salter-Harris fractures
    - type I=physis, type II = physis and metaphysis, type III = physis and epiphysis, type IV= metaphysis, physis and epiphysis, type V = crushing injury of growth plate (rare)
- Capital physeal fractures
    - Spontaneous fractures
        - Young cats
        - Large male cats that are neutered young are at greatest risk
- Incomplete ossification of humeral condyle
    - Heritable condition of pure-breed and cross-breed spaniels
    - Results in higher-than-normal incidence of humeral condylar fractures
    - Medial and lateral centres of humeral condyle should fuse by 84d

Hemimelia[7]

- Congenital bone disease that includes amelia, polydactyly, ectrodactyly, and syndactyly.
- Hemimelia indicates complete or partial agenesis of one or more bones of the limb
    - Radius, tibia and ulna are most common
- Terminal hemimelia = all or part of the middle and distal bones of a limb are absent
- Intercalary hemimelia= all or part of middle bones of a limb are absent
- Longitudinal hemimelia = absence of one or more bones along the pre-axial (medial) or postaxial (lateral) side of a limb
- Transverse hemimelia = complete absence of one or more bones across the limb's width
- Pre-axial longitudinal intercalary radial hemimelia of the radius is the most commonly seen in small animals
- May be inherited but more often result of in utero environmental factors

Conclusions

Juvenile musculoskeletal diseases can be difficult due to the complexity of the anatomy and the changes over time. Attempting to localize the lesion and ensuring properly performed radiographs will increase the likelihood of identifying lesions on radiographs. Reviewing these radiographs in two steps, a complete review of the radiographs in a systematic order followed by a more scrutinizing evaluation of the regions where specific diseases occur, will aid in the evaluation of these studies.

References:

1. Thrall DE. *Textbook of Veterinary Diagnostic Radiology*. 6th edition. St Louis, 2013, Elsevier.
2. Coulson A and Lewis N. *An Atlas of Interpretative Radiographic Anatomy of the Dog & Cat.* 2nd edition. 2011, Wiley-Blackwell
3. Thrall DE and Robertson ID. *Atlas of Normal Radiographic Anatomy and Anatomic Variants in the Dog and Cat.* 2nd edition. 2016. Saunders.
4. Trangerud C et al. *A New Type of Radiographic Bone Remodeling in the Distal Radial and Ulnar Metaphysis in 54 Newfoundland Dogs.* Veterinary Radiology and Ultrasound 46 (2), 2005
5. Trangerud C et al. *Bone Dysplasia in the Radial and Ulnar Metaphysis of a Newfoundland Dog.* Veterinary Pathology 45, 2008
6. De Simone A et al. *Imaging diagnosis – Bilateral Abnormal Ossification of the Supraglenoid Tubercle and Cranial Glenoid Cavity in an English Setter.* Veterinary Radiology and Ultrasound. 54 (2), 2013.
7. Pisoni et al. *Bilateral radial hemimelia and multiple malformations in a kitten.* Journal of Feline Medicine and Surgery 14(8), 2012.