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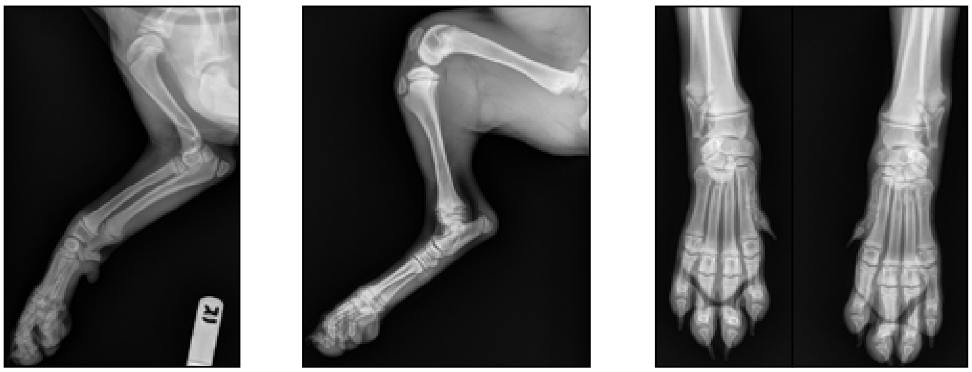
Imaging Services

ANTECH IMAGING NEWS

Pediatric Radiology in Dogs & Cats

Everyone loves to play with puppies and kittens, but when it comes time to evaluate their growth plates, it may not be as enjoyable! This issue aims to change the uncertainty of pediatric radiographs.

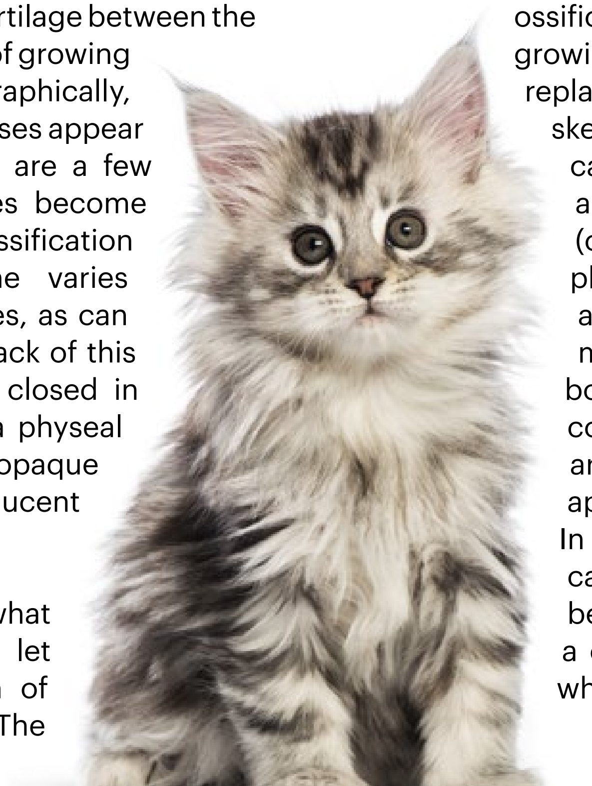


Figures 1-3. Normal 3 month old puppy.

Figures 4-5. Normal 3 month old cat.

The Basics of Growth Plates

Growth plate, physis, and epiphyseal plate are synonyms for the layer of cartilage between the metaphysis and epiphysis of growing long bones. Radiographically, cartilage is radiolucent. Physes appear very wide in puppies that are a few weeks old, and the physes become thinner as endochondral ossification occurs. The closure time varies between the different bones, as can be seen in Table 2 at the back of this issue. Once the physis is closed in mature animals, it leaves a physeal scar, seen as a thin radiopaque line, where the open lucent physis once was (Figure 6).



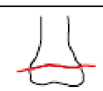
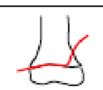
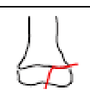
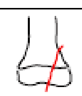
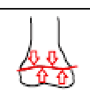
To better understand what is seen radiographically, let us review the mechanism of endochondral ossification. The long bones increase in length by endochondral ossification: a process by which growing cartilage is systematically replaced by bone to form the growing skeleton. Growth continues by cartilage cell multiplication arranged in longitudinal rows (columnar cartilage) at the growth plate. The cartilaginous columns are then eroded from within the medullary cavity and replaced by bony trabeculae. This process is continuous, and the two epiphyses are pushed further and further apart, increasing diaphyseal length. In the beginning, the epiphysis is cartilaginous (Figures 7-8). Then it becomes ossified and finally retains a cartilaginous shell on its surface, which is the articular cartilage.

Continued on next page

Interpretation of growth plate abnormalities

It can not be emphasized enough that orthogonal radiographs are essential when evaluating physes, and comparison with the opposite leg is extremely helpful and recommended.

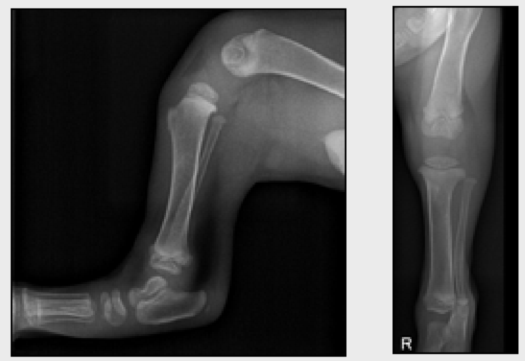
The Salter-Harris classification characterizes physeal injuries (Table 1). Physeal injuries can be subtle, particularly type 1. Reevaluation at about 2-4 weeks is important if changes are not seen at the initial presentation.

TYPE	FIGURE	DESCRIPTION
I		Fracture line through the physis only (zone of hypertrophy)
II		Fracture line through the physis and extending to include a portion of the metaphysis
III		Fracture line through the physis and exiting through the epiphysis into a joint
IV		Vertical fracture line through the epiphysis, physis, and metaphysis
V		Crush injury to the physis

Serious complications can occur following physeal trauma, including growth disturbances and joint abnormalities. Premature closure of a physis results in cessation of growth, which usually leads to bone shortening, and possibly adjacent joint incongruity. If only part of the physes is affected, angular limb deformity can also occur. This is of particular concern at the distal ulna in dogs, in which the cone-shaped physis-epiphysis often results in a crushing injury. This does not occur in cats, because their distal ulnar physis not cone-shaped. Abnormal weight bearing can eventually lead to osteoarthrosis. of the coxofemoral joint.

The femoral head is particular in terms of its blood supply. The vascular supply to the femoral head is derived solely from epiphyseal vessels entering the epiphysis at the joint capsule insertion line. The open physes of immature animals act as a barrier; since the metaphyseal

Figure 6. Normal radial physeal scar adult dog.



Figures 7-8. Normal 4.5 week-old dog. Notice the lack of mineralization of the patella and tibial tuberosity apophysis and impression of increased joint space due to incomplete mineralization.

Figure 9. Bilateral Salter Harris type IV fractures distal humeral condyles (oblique fractures coursing from the articular surface, through epiphysis, physis and extending to the metaphysis).

Figure 10. Unilateral right femoral capital physeal fracture with minimal displacement in a 5 month old cat.

Figure 11. Avascular necrosis of the femoral head – Legg-Calve-Perthes disease. Unilateral changes of femoral head irregularity, radiolucencies, and sclerosis with mild incongruity of coxofemoral joint.

Figure 12. Acute avulsion of the tibial tuberosity.

Figure 13. Ununited anconeal process.

vessels do not cross physes. Any compromise to the femoral epiphyseal blood vessels may cause an ischemic insult.

Avascular necrosis of the femoral head (Legg-Calve-Perthes Disease) is the result of such an insult (Figure 11). The compromised bone supply initially results in necrotic subchondral bone followed by revascularization and formation of granulation tissue hence the variable radiographic appearance at different stages. Decreased opacities of the femoral head are initially seen. Then flattening, remodeling (lucencies and sclerosis), and irregularities of the femoral head and neck follow, usually with incongruity of the coxofemoral joint.

Although non-articular, avulsions of apophyseal growth centers, such as at the tibial tuberosity, need mentioning (Figure 12). Even though an apophyseal growth center does not contribute to the length of the bone and is not articular, it is clinically significant, particularly at the tibial tuberosity due to the attachment of the patellar ligament as it influences the stifle joint.

Growth centers can also demonstrate either a lack or incomplete ossification, such as seen with ununited anconeal processes (Figure 13) and incomplete ossification of humeral condyles in Spaniels, respectively. An ununited anconeal process affects large breed dogs, most often German shepherds, and should be united by five months. Incomplete ossification of the distal humeral condyle has been reported in Spaniels, which predisposes affected patients to condylar fractures.

Retained cartilage cores can occur in the distal ulna of large breeds as a result of delayed endochondral ossification (Figures 14-15). They appear as triangular-

shaped radiolucencies that extend from the distal ulnar physis to the distal metaphysis, tapering proximally. Although they can be of no clinical significance in some dogs, in others they can result in slowed distal ulnar growth, asynchronous radioulnar growth, angular and rotational deformities.

Hypertrophic osteodystrophy (HOD) is a metaphyseal osteopathy (Figures 16a-b). However, an example is included since the radiographic changes can be confusing due to the initial "double-physeal sign" in which irregular radiolucent lines are seen in the metaphyses, adjacent and parallel to the physes.

Features Of Abdominal Radiographs Of Pediatric Patients

Immature dogs and cats normally lack sufficient abdominal fat to provide good contrast; therefore, the abdominal detail is poor (Figure 17). The immature patients usually also have somewhat of a normal pendulous abdominal appearance.
In neonates and young dogs, the liver is larger (nearly two times g/kg of bodyweight vs. the adult) therefore occupies a larger portion of the abdomen.
These features often combined wrongly lead one to think there is abdominal effusion while, in fact, it is a normal immature abdomen.

Figures 14-15. Distal ulnar retained cartilage cores. Two different patients with varying degrees of involvement. Notice the thickened caudal radial cortices and radial bowing from abnormal weight-bearing and growth, respectively. There is mild elbow incongruity.

Figure 16a. Bilateral HOD distal antebrachii.

Figure 16b. Bilateral HOD distal antebrachii.

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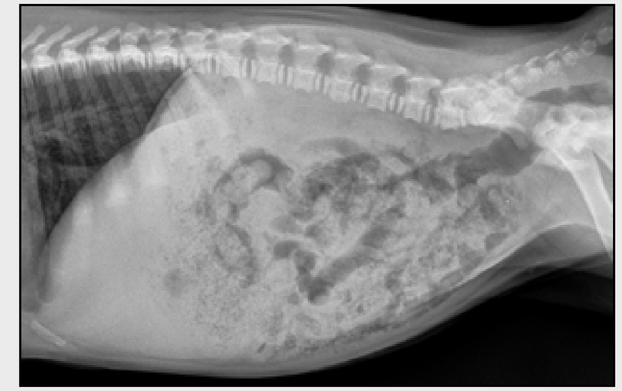


Figure 17. One-month-old dog with normal post-prandial abdomen. Notice the size of the liver and general poor abdominal detail.

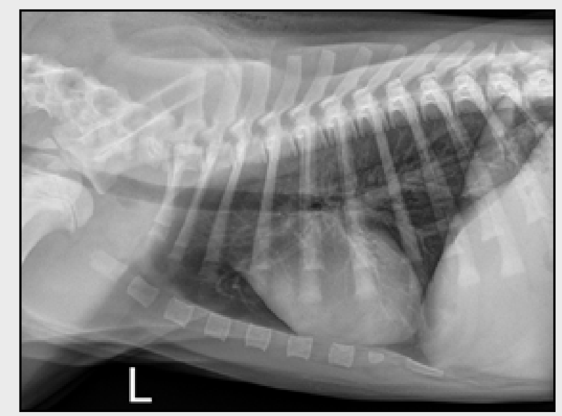


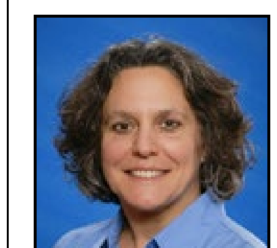
Figure 18. Notice lack of mineralization of costal arches in this 2 month old dog.

Figure 19. Notice the thymus as the triangular shaped opacity to the left of midline cranial to the cardiac silhouette.

Sail Sign in the Pediatric Thorax

The main characteristic in thoracic radiographs of immature dogs is the thymus, often referred to as the "sail sign." The thymus lies within the cranioventral mediastinal reflection and is often seen on VD or DV views of the thorax to the left of midline cranial to the cardiac silhouette (Figure 18). It is sometimes also seen on lateral views along and partially obscuring the cranial margin of the cardiac silhouette. It can grow in size up until sexual maturity then begins to involute and is gradually replaced by fat. A vestigial thymus is seen in some adults.
The costal arches are cartilaginous and non-mineralized in puppies, unlike mineralized arches that are often seen in mature patients (Figure 19).

Elisabeth Girard, DVM, DACVR



Dr. Girard obtained her Doctor of Veterinary Medicine degree at The University of Montreal, where she also completed a one-year internship in Small Animal Medicine and Surgery. She did her Radiology Residency at the University of Georgia. After her Residency, she worked as a radiologist in Portland, OR, then moved to the Chicago area and worked for a large referral specialty practice for nine years.

She joined ANTECH Imaging Services as a staff radiologist in 2012., and she is now back home living in Quebec, Canada, with her husband and two children.

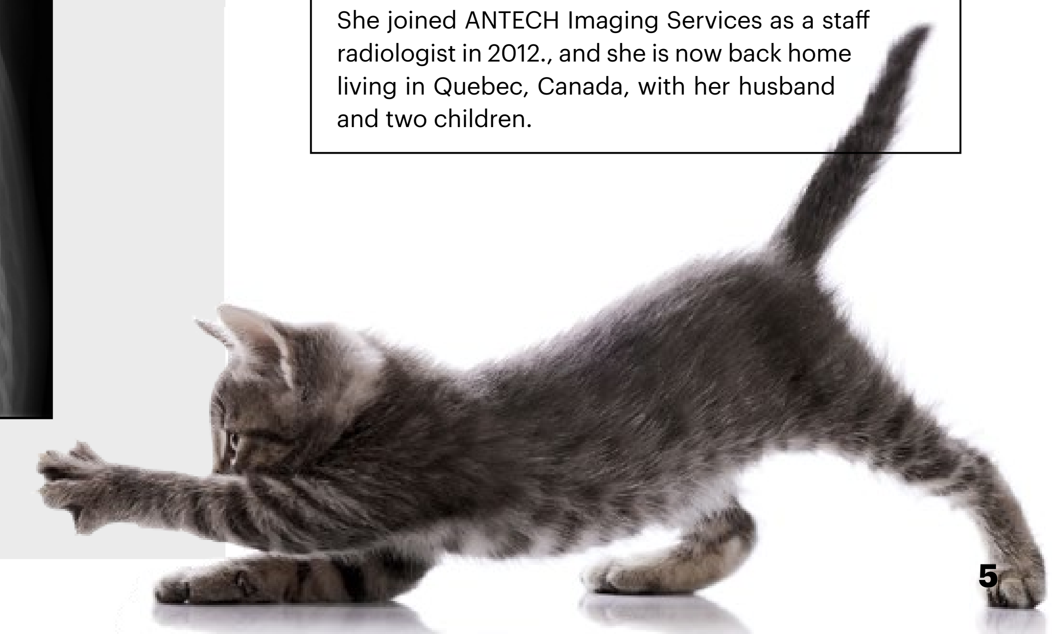


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Table 2. Approximate Age When Physeal Closure Occurs

Bone	Physis	Canine	Feline
Scapula	Supraglenoid tubercle	4-7 months	3.5-4 months
Humerus	Proximal	12-18 months	18-24 months
	Medial epicondyle	6-8 months	
	Condyle to shaft	6-8 months	3.5-4 months
	Condyle *(lateral & medial parts)*	*6-10 weeks*	3.5 months
Radius	Proximal	7-10 months	5-7 months
	Distal	*10-12 months*	14-22 months
Ulna	Anconeal process	*<5 months*	
	Olecranon tuberosity	7-10 months	9-13 months
	Distal	*9-12 months*	14-25 months
Metacarpus/metatarsus			
MC1	Proximal	6-7 months	4.5-5 months
MC2-5	Distal	6-7 months	4.5-5 months
Phalanges (fore & hind)			
P1 & P2	Proximal	6-7 months	
Pelvis	Acetabular	3-5 months	
	Ischiatic tuberosity	10-12 months	
	Ilial crest	24-36 months	
	Pubic symphysis	4-5 months	
Femur	Head, capital physis	*8-11 months*	7-11 months
	Greater trochanter	9-12 months	13-19 months
	Lesser trochanter	9-12 months	
	Distal physis	9-12 months	
Tibia	Tibial tuberosity	*10-12 months*	9-10 months
	Tibial plateau	9-10 months	12-19 months
	Distal physis	12-15 months	10-12 months
	Medial malleolus	3-5 months	
Fibula	Proximal	10-12 months	13-18 months
	Distal (lateral malleolus)	12-13 months	10-14 months
Tarsus			
Calcaneus	Tuberosity	6-7 months	
Spine ossification centers			
Axis	Arches fuse	3-4 months (106 days)	
	Intercentrum	3-4 months (115 days)	
Atlas	Centrum of proatlas + C1	100-110 days	
	Intercentrum 2, centrum 1 & 2	3.3-5 months	
	Neural arches (bilateral)	30 days	
	Caudal physis	7-12 months	
Cervical, thoracic, lumbar	Cranial physis	7-10 months	7-10 months
	Caudal physis	8-12 months	8-11 months
Sacrum	Cranial and caudal physes	7-12 months	
Caudal	Cranial and caudal physes	7-12 months	

- Physes most commonly associated with clinical disorders are shown in *italics*.

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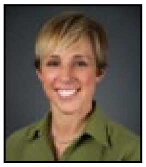

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