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## **Radiography and Biopsy of Bony Neoplasia** ( 1-Jan-1985 )

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### **General Considerations**

The diagnosis of primary bone tumors, particularly in the early stages of their development, is exceedingly difficult. Although the final diagnosis rests with the pathologist, close cooperation between clinician, radiologist, and pathologist, as demonstrated by Ling, Morgan, and Pool,(2) will enable a diagnosis to be made in many early cases that would otherwise remain undiagnosed.

- The process by which the clinical diagnosis is made can be improved by considering the following factors:
- The age, breed, and sex of the dog or cat
- The skeletal site and number of bones involved
- The duration of the disease
- The general condition of the dog or cat
- Any history of systemic disease or surgery for soft tissue tumors in the previous year
- Radiographic appearance of bone tumors

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### **Radiographic Appearance of Bone Tumors**

Most neoplastic bone lesions can be characterized radiographically as having an aggressive appearance. Radiographic criteria for an aggressive bone lesion are (1) cortical bone destruction, (2) active periosteal proliferation, and (3) an indistinct margin between normal and abnormal bone (Fig. 73-1). A bone lesion should be considered aggressive if any of the above criteria are detected radiographically. It is important to realize that the degree of osteolysis versus the degree of osteosclerosis in a bone lesion has nothing to do with categorizing the lesion as aggressive or nonaggressive.



FIG. 73-1 Lateral radiograph of a humerus in which an aggressive lesion is present. There is cortical destruction (large arrow), an active periosteal reaction (arrowhead), and an indistinct margin between normal and abnormal bone.

The differential diagnosis for aggressive lesions of bone includes the following:

I. Neoplasia

- A. Primary
- B. Secondary

II. Infection

- A. Bacterial
- B. Mycotic

III. Trauma

IV. Ischemia

V. Miscellaneous (hypertrophic osteodystrophy [HOD])

Neoplasia, infection, and trauma are the most common causes of aggressive bone lesions in animals.

It is impossible to make a definitive diagnosis of an aggressive bone lesion by radiographic means alone. The radiographic features of the lesion must be considered in conjunction with the signalment, anamnesis, and physical and laboratory findings before a list of differential diagnoses is formulated. Histologic evaluation of the lesion is usually necessary before a definitive diagnosis can be made. Once a bone lesion is identified, the following questions should be answered: (1) is the lesion solitary or multiple? (2) is the lesion primarily epiphyseal, metaphyseal, diaphyseal, or some combination thereof? (3) is the lesion aggressive or nonaggressive? The answers should then be considered with the other previously mentioned factors and a list of differential diagnoses formulated.

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## PRIMARY BONE TUMORS OF THE APPENDICULAR SKELETON

The most common primary bone tumor of the appendicular skeleton is osteosarcoma. Primary appendicular osteosarcomas are generally solitary aggressive lesions originating in the metaphyseal region of long tubular bones. In the pectoral limb, the proximal humerus and distal radius are sites frequently affected by osteosarcoma. In the pelvic limb, the most common sites are the distal femur, proximal tibia, and distal tibia.

Osteosarcomas can be predominantly osteolytic (Fig. 73-2), a mixture of osteolytic and osteoblastic (Fig. 73-3), or predominantly osteoblastic (Fig. 73-4).



FIG. 73-2 Craniocaudal radiograph of the distal femur in which a predominantly osteolytic osteosarcoma can be seen. The distal medial cortex is expanded and contains focal areas of destruction.

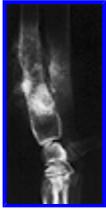


FIG. 73-3 Lateral radiograph of the distal antebrachium in which a radial osteosarcoma characterized by a mixture of osteolysis and osteosclerosis can be seen.



FIG. 73-4 Lateral radiograph of the distal femur in which a predominantly osteosclerotic osteosarcoma can be seen.

The appearance of the periosteal reaction associated with an osteosarcoma may be quite irregular (Fig. 73-5) or very smooth (Fig. 73-6). The irregular type of periosteal reaction has been referred to as having a "sunburst" appearance. Some have suggested that a sunburst type of periosteal reaction is seen only with osteosarcoma. This is not true; it has been observed with other types of tumors (Fig. 73-7) and with inflammatory diseases of bone. Thus, a sunburst is only one criterion of an aggressive bone lesion and is not pathognomonic for osteosarcoma.

It has been suggested that the periosteal spicules associated with malignant processes are long and thin (see Fig. 73-5) whereas those associated with benign processes are short and squat (Fig. 73-8). (1) There are instances, however, in which the periosteal spicules found with osteosarcomas are not long and thin, but short and squat (Fig. 73-9). Thus, in the dog, the type of periosteal spicules that are present cannot be used to differentiate between neoplasia and inflammation.



FIG. 73-5 Lateral radiograph of the tibia in which an extensive osteosarcoma is present. The periosteal spicules are bizarre.



FIG. 73-6 Cranio-caudal radiograph of the distal femur in which an osteosarcoma with a smooth periosteal reaction (arrows) can be seen.

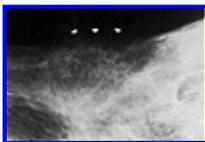


FIG. 73-7 Lateral radiograph of the maxilla of a dog with a nasal carcinoma in which a "sunburst" type of periosteal reaction can be seen (arrows).



FIG. 73-8 Lateral radiograph of the tibia of a dog with bacterial osteomyelitis. The periosteal reaction has a "short and squat" appearance distally.

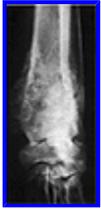


FIG. 73-9 Craniocaudal radiograph of the distal antebrachium of a dog with a radial osteosarcoma. The periosteal spicules are not long and thin but short and squat.

The diaphyseal margin of the periosteal reaction associated with osteosarcoma is sometimes triangular. Such a shape has been referred to as Codman's triangle (Fig. 73-10) and has been interpreted by some as being seen only in osteosarcoma. Codman's triangle, however, can be seen with any lesion resulting in periosteal elevation and is not specific to osteosarcoma.

Although osteosarcomas begin, in most instances, as monostotic lesions, they may not remain monostotic for the duration of their existence. As the disease progresses, the tumor may metastasize to other bones or may induce periosteal proliferation on adjacent bones either by direct infiltration or mechanical irritation of the periosteum (Figs. 73-10 and 73-11). In instances in which the primary tumor induces changes in an adjacent bone, the magnitude of the disease in the adjacent bone will generally be much less than that of the primary tumor (Figs. 73-10 and 73-11).

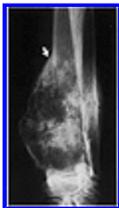


FIG. 73-10 Craniocaudal radiograph of the distal antebrachium of a dog with radial osteosarcoma. A Codman's triangle is present at the proximal medial aspect of the tumor (arrow). Periosteal reaction is also present on the distal ulna.

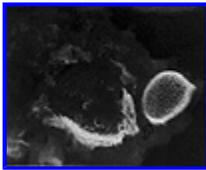


FIG. 73-11 Radiograph of a cross-sectional slice of the distal antebrachium of a dog with a radial osteosarcoma. The radius is nearly totally destroyed. There is a focal area of periosteal proliferation on the ulna (arrow) resulting from tumor extension into this bone or mechanical irritation of the periosteum by the enlarging radial tumor.

In young animals, the physal cartilage generally acts as a barrier preventing the metaphyseal tumor from spreading to the epiphysis. After the physis closes, metaphyseal tumors progress to involve the epiphyses. In mature animals, articular cartilage may act as a barrier to prevent tumors from invading opposing articular surfaces. However, in advanced tumors, opposing articular surfaces may become affected.

Two situations in which the development of osteosarcoma is associated with another osseous abnormality deserve consideration. The first is the association of osteosarcoma with polyostotic bone infarction. (A detailed discussion of polyostotic bone infarction can be found elsewhere in this text.) Polyostotic bone infarction is observed most frequently in terrier-type dogs. It appears radiographically as multifocal punctate areas of increased opacity within the medullary cavity of affected bones (Fig. 73-12). Dogs with bone infarction have a tendency to develop osteosarcomas in one or more bones (Fig. 73-13). These tumors are somewhat atypical in that they are nearly always osteolytic and frequently arise in locations other than common sites for osteosarcoma described above.



FIG. 73-12 Craniocaudal radiograph of the tibia in which multiple small radiopacities, representing bone infarction, can be seen.

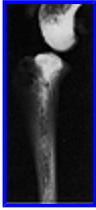


FIG. 73-13 Lateral radiograph of the proximal tibia in which an osteolytic osteosarcoma can be seen in the region of the tibial crest. Bone infarcts are present also.

The second situation in which osteosarcoma is associated with another osseous abnormality is in the presence of an internal fixation device. Multiple case reports have been published describing the development of malignant tumors adjacent to long-standing internal fixation devices. Although a direct cause and effect relationship between the device and tumor formation has not been established, the long latent period between placement of the device and detection of the tumor supports the hypothesis. Not all tumors occurring under such circumstances are osteosarcomas (Fig. 73-14). Nevertheless, the radiographic appearance is similar. The hallmark features are extensive, progressive soft tissue swelling, cortical destruction, and an aggressive/bizarre periosteal reaction (Fig. 73-14).

Primary bone tumors of the appendicular skeleton other than osteosarcoma are not common. Those that are seen occasionally include fibrosarcoma, chondrosarcoma, and hemangiosarcoma. These neoplasms generally appear similar or identical to osteosarcoma (Fig. 73-15). In such instances, a biopsy is necessary for definitive diagnosis.



FIG. 73-14 Cranio-caudal radiograph of the distal tibia of a dog in whom a tibial fracture was repaired 8 1/2 years previously with a Jonaspin and a Parham band. Distal to the old fracture site are soft tissue swelling, cortical destruction, and bizarre periosteal spicules. The histologic diagnosis was fibrosarcoma.



FIG. 73-15 Lateral view of the proximal humerus in which an aggressive lesion can be seen. The radiographic appearance is consistent with osteosarcoma. The histologic diagnosis was hemangiosarcoma.

Conditions that are most often mistaken radiographically for primary bone neoplasia are HOD, osteomyelitis, and trauma.

HOD should not be confused with primary bone neoplasia. HOD is a disease of dogs less than one year of age, and the distribution of lesions is polyostotic. What appears as periosteal spiculation is actually juxtacortical mineralization (Fig. 73-16). The cortex may be slightly irregular. In the early stages of HOD, a transverse band of metaphyseal lucency can be seen. The medullary cavity of affected bones is generally normal.



FIG. 73-16 Lateral radiograph of the antebrachium of a 5-month-old Great Dane with HOD. Radiographic findings inconsistent with primary bone neoplasia include polyostotic lesions, juxtacortical mineralization rather than periosteal spiculation, and lack of cortical destruction.

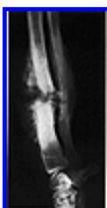


FIG. 73-17 Lateral radiograph of the distal antebrachium of a 2-year-old dog who was attacked by another dog 2 months previously. There are aggressive lesions of the distal radius and ulna and an apparent radial fracture. The radiographic findings are consistent with neoplasia, but the history is suggestive of trauma with subsequent infection. The diagnosis was bacterial osteomyelitis of the radius and ulna. Prognosis and therapy for lesions such as this must not be based solely on radiographic appearance.

Bacterial osteomyelitis is most often the result of direct contamination of the bone (e.g., surgery or bite wound) rather than being of hematogenous origin. Therefore, the radiographic appearance may be one of a solitary aggressive bone lesion. Thus, even though the radiographic appearance of the lesion may be consistent with primary bone neoplasia, there is usually an event in the history, such as surgical intervention, or physical evidence, such as draining fistulas, that suggest infection rather than tumor (Fig. 73-17).

Mycotic osteomyelitis usually of hematogenous origin and therefore is characterized by polyostotic lesions. The radiographic appearance of an individual fungal lesion in bone may be identical to that of primary bone neoplasia (Fig. 73-18). Thus, if only one lesion has been discovered, or multiple lesions are not present, the tentative diagnosis, based on radiographs, is likely to be neoplasia rather than osteomyelitis. However, the prognosis and therapy of aggressive bone lesions must not be based solely on radiographic appearance (Fig. 73-19).



FIG. 73-18 Lateral radiograph of the proximal humerus of a dog in whom an aggressive lesion can be seen. There were no other bone lesions. The appearance is consistent with primary bone neoplasia and infection. The diagnosis was actinomycosis osteomyelitis. Prognosis and therapy for lesions such as this must not be based solely on radiographic appearance.



FIG. 73-19 Lateral radiograph of the proximal humerus of the dog in Figure 73-18 after appropriate antibiotic therapy for actinomycosis. The biopsy site is evident (arrows). The bone is healing nicely. Amputation of this limb based on the initial radiographic appearance would have been negligent.

Traumatic bone lesions can have a very aggressive radiographic appearance, and in some instances neoplasia will be considered in the differential diagnosis (Fig. 73-20). In other instances, a history of previous trauma will influence radiographic evaluation, and neoplasia may not be given serious consideration (Fig. 73-21). However, in either situation, the definitive diagnosis cannot be substantiated with radiographs alone, and if the diagnosis is in doubt, more invasive techniques should be considered.



FIG. 73-20 Lateral radiograph of the distal humerus of a 9-month-old Irish setter with a 30-day history of lameness and progressive swelling. There is an area of soft tissue swelling containing foci of mineralization. In addition, there is a smooth periosteal reaction on the cranial diaphysis (arrows). Some cortical irregularity is present beneath the soft tissue mineralization. The lesion is aggressive, and neoplasia should be considered in the differential diagnosis. The final diagnosis was calcifying hematoma associated with avulsion of the head of the extensor carpi radialis.



FIG. 73-21 Radiograph of the distal aspect of the antebrachium of a dog in whom corrective surgery for valgus deformity was performed 6 weeks previously. The healing bone is heterogeneous in appearance. If the previous surgery were unknown to the interpreter of this radiograph and if internal fixation were not present, consideration of diseases more aggressive than trauma, such as tumor or infection, would be proper. The lesions in the radius and ulna healed satisfactorily without additional treatment.

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## PRIMARY BONE TUMORS OF THE AXIAL SKELETON

Osteosarcomas and chondrosarcomas are the two most frequently encountered primary neoplasms of the axial skeleton. These tumors appear similar radiographically and result in the production of aggressive bone lesions characterized by the same criteria listed above. Primary tumors of the axial skeleton may be purely osteolytic, osteolytic and osteoblastic, or purely osteoblastic. The skull (Fig. 73-22), ribs (Fig. 73-23) and pelvis (Fig. 73-24) are affected more

frequently than the vertebrae. The primary diagnostic considerations for aggressive lesions of the axial skeleton are neoplasia, infection, and trauma. Aggressive lesions of the axial skeleton require histopathologic examination for definitive diagnosis.



FIG. 73-22 Lateral skull radiograph in which an osteoblastic osteosarcoma involving the frontal region can be seen. In tumors as opaque as this, it is difficult to evaluate the underlying cortex. Cranial osteosarcomas may involve any bone.

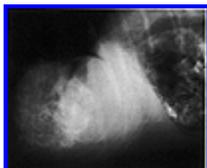


FIG. 73-23 Close-up view of a portion of a lateral thoracic radiograph in which an osteolytic and osteoblastic chondrosarcoma involves the distal aspect of the left sixth through ninth ribs. Clinically, these tumors are sometimes characterized by an "iceberg" effect in that only a small percentage of the total tumor mass is palpable externally.



FIG. 73-24 Ventrodorsal radiograph of the pelvis in which a chondrosarcoma can be seen. The pubic portion of the tumor is osteoblastic and the ischial portion is osteolytic.

There are two primary tumors that have a polyostotic distribution in the axial and appendicular skeletons; malignant lymphoma (Fig. 73-25) and multiple myeloma (Fig. 73-26). Both tumors generally appear as multifocal osteolytic lesions with little evidence of periosteal proliferation. A biopsy is necessary for distinction between the two. Generalized osteomyelitis or widespread metastasis of a solid tumor must also be considered in the differential diagnosis.



FIG. 73-25 Lateral radiograph of the antebrachium of a dog with osseous lymphosarcoma. Multiple osteolytic lesions can be seen. Most bones in this dog had a similar radiographic appearance.



FIG. 73-26 Ventrodorsal pelvic radiograph of a dog with multiple myeloma. Multiple osteolytic defects can be seen. The large defect just distal to the left femoral neck is a biopsy site. Many bones in this dog had a similar radiographic appearance.

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## SECONDARY BONE TUMORS OF THE AXIAL AND APPENDICULAR SKELETON

Any malignant tumor has the potential to metastasize to the skeleton. Metastatic sites in the skeleton, since they arise hematogenously, have a polyostotic distribution in most patients (Fig. 73-27). Secondary bone tumors have an aggressive radiographic appearance. They may be predominantly osteolytic, mixed osteolytic and osteoblastic, or predominantly osteoblastic. The distribution of metastatic tumors in the skeleton is variable, with all parts of the axial and appendicular skeleton being at risk. There is one metastatic site in the axial skeleton that deserves special consideration; the caudal lumbar spine. Metastasis of solid tumors to the caudal lumbar spine occurs primarily with intrapelvic malignancies, particularly those of the prostate and urinary bladder. The route of metastasis is most likely a

hematogenous via paravertebral veins. The radiographic appearance of this type of metastasis is aggressive, with osteoblastic reactions encountered more frequently than osteolytic ones. The lesions usually begin on the ventral margin of caudal lumbar vertebral bodies (Fig. 73-28) but may progress dorsally to involve the pedicles and lamina. The major radiographic differential diagnosis is spinal osteomyelitis. Diskospondylitis should not be considered in the radiographic differential diagnosis, since its appearance is quite different (Fig. 73-29). In diskospondylitis, the infectious process produces end-plate lysis that subsequently progresses to sclerosis of the body beneath the end-plate, periosteal spicules on the vertebral bodies, and, possibly, spinal subluxation. The radiographic lesions of diskospondylitis are aggressive but must not be confused with metastasis from an intrapelvic tumor. Primary or secondary neoplasia of the axial skeleton that produces the radiographic signs of diskospondylitis has not been reported.



FIG. 73-27 Lateral radiographs of the left shoulder (A), right shoulder (B.), and cervical spine (C) of a dog with metastatic adenocarcinoma. Predominantly osteolytic aggressive lesions are visible in multiple bones. The primary tumor site was not found. Many other bones in this dog had a similar radiographic appearance.



FIG. 73-28 Lateral radiograph of the caudal lumbar spine in which an aggressive osteoblastic reaction can be seen on the ventral margin of the vertebral bodies of L5 and L6. The diagnosis was metastasis of a squamous cell carcinoma of the urinary bladder. Note the lack of end-plate destruction.

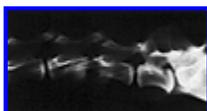


FIG. 73-29 Lateral radiograph of the lumbar spine of a dog with diskospondylitis. Note the end-plate destruction and associated vertebral sclerosis. These aggressive radiographic findings are consistent with neoplasia and inflammation, although neoplasia is an extremely uncommon cause.

## INVASIVE SOFT TISSUE TUMORS OF THE AXIAL AND APPENDICULAR SKELETON

Soft tissue tumors anywhere on the body may infiltrate into underlying bone. The three instances in which such infiltration is likely to present an orthopaedic problem are intrapelvic malignancies, subungual malignancies, and periarticular malignancies.



FIG. 73-30 Ventrodorsal radiograph of the pelvis in which an aggressive lesion of the right ischium is apparent. The diagnosis was pelvic infiltration by a prostatic adenocarcinoma. The radiographic changes are consistent with primary and metastatic neoplasia and an inflammatory lesion.



FIG. 73-31 Dorsopalmar radiograph of a canine manus in which osteolysis of the distal phalanx, active periosteal proliferation of the middle phalanx, and an adjacent soft tissue mass of one digit are visible. Diagnosis: squamous cell carcinoma.

Intrapelvic malignancies may result in metastatic neoplasia of the lumbar spine by metastasis through paravertebral veins (see Fig. 73-28). Intrapelvic malignancies may also infiltrate adjacent bones and produce lameness, pain, or both. The radiographic changes associated with pelvic infiltration of a soft tissue tumor are those of an aggressive lesion (Fig. 73-30) and are not specific.

Squamous cell carcinoma and malignant melanoma are the two most common subungual tumors in the dog. These tumors result in osseous changes in the adjacent distal phalanx. The changes are aggressive and predominantly osteolytic (Fig. 73-

31), although occasionally some evidence of periosteal spicules can be seen. These tumors cannot be distinguished from phalangeal osteomyelitis on a radiographic basis.

The most common periarticular malignancy resulting in underlying osseous infiltration is malignant synovioma. The radiographic changes associated with malignant synovioma may be limited solely to soft tissue swelling. When the underlying bone does become involved, the resulting changes are aggressive (Fig. 73-32). In classic cases of malignant synovioma, aggressive changes can be identified in multiple bones of an articulation. However, there may be instances in which only one bone is involved. The major differential diagnoses to be considered with malignant synovioma are degenerative joint disease, erosive arthritis, and septic arthritis. Biopsy is recommended to make a more definitive diagnosis.

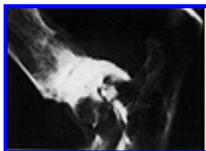


FIG. 73-32 Lateral radiograph of a canine tarsus in which poorly demarcated areas of osteolysis are present in the distal tibia and tarsal bones and are characteristic of an aggressive lesion. Diagnosis: malignant synovioma.

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## Pathologic Examination and Biopsy Procedure

To make a definitive diagnosis of a bone tumor, especially when clinical and radiographic examinations are inconclusive, it is important to take biopsy material from a lesion that is suspected of being a bone tumor. In addition, a correct diagnosis can be made by the pathologist only when an adequate, representative sample (or samples) of the tumor is taken.

In selecting the biopsy site, a recent radiograph should be used as a guide. The biopsy should be carried out under general anesthesia, maintaining aseptic conditions. The tissue taken at biopsy may be a punch biopsy specimen or a slice of tissue 2 mm to 3 mm thick. Special care should be taken to ensure that the biopsy extends to the site of tumor involvement of bone; this can be confirmed by postbiopsy radiographs. Too frequently the pathologist is presented with material from the soft tissue swelling that may surround the bone tumor or from areas of the proliferating osteogenic layer of the periosteum that is forming a periosteal collar of reactive new bone. Similar areas of endosteal new bone may be formed and should be avoided when taking the biopsy.

In animals with osteosarcoma, in which the tumor tissue in the early stages of development is confined to the medullary cavity, the biopsy instrument must completely penetrate the cortex and enter the medulla to reach the neoplastic tissue required by the pathologist to make the correct diagnosis.

The biopsy specimen may be cultured for fungi and bacteria by gently rolling a sterile swab over the surface. Touch impression smears may also be made from the biopsy specimens, which may be suitably stained and examined for the presence of an etiologic agent, such as fungi, or the presence of inflammatory or neoplastic cells. Immediately following culturing and the making of impression smears, the specimen should be fixed in 10% neutral buffered formalin. Postfixation, the specimen will require decalcification prior to sectioning, staining, and histologic examination.

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2. Ling GV, Morgan JP, Pool RR: Primary bone tumors in the dog: A combined clinical, radiographic, and histologic approach to early diagnosis. J Am Vet Med Assoc 165:55, 1974

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