ABSTRACT

Two cats, both over 10 yr old, were presented for evaluation of non-painful bony proliferations on the appendicular skeleton. These proliferations were identifiable via palpation. Radiographs showed a smooth, proliferative bony lesion of the distal femur (case 1) and tarsus (case 2) with mild soft tissue swelling. Surgical debulking with incomplete resection was performed in each cat. Subsequent histopathology resulted in a diagnosis of periosteal chondrosarcoma (PC). Although both cats have experienced local recurrence, both are still alive more than 2.5 yr after mass debulking. Periosteal chondrosarcoma is a differential diagnosis in proliferative cortical bony lesions near an articular surface in older cats. Partial resection of these masses can lead to an excellent quality of life, and proper diagnosis can avoid amputation or even euthanasia. (J Am Anim Hosp Assoc 2016; 52:312–318. DOI 10.5326/JAAHA-MS-6349)

Introduction

Tumors of bone and cartilage are relatively uncommon in the dog and cat population as a whole, representing less than 5% of all tumors. Bone tumors are usually malignant, with benign masses being rare in both species. Osteosarcoma is the most common primary bone tumor in cats, accounting for 70–80% of all primary bone tumors, with fibrosarcoma being the second most common. Malignant bone tumors commonly exhibit osteolysis and destruction of cortical and medullary bone, with irregular sclerotic new bone formation. Based on the biologic behavior of these tumors, limb amputation is most often recommended when the disease is first identified.

Benign or low-grade tumors affecting bone or cartilage, such as periosteal chondrosarcoma and osteochondroma, are rare, but they could have an excellent outcome without radical surgical excision. Periosteal chondrosarcoma is a low-grade malignant cartilaginous tumor arising from the external surface of bone. These tumors occur in older dogs and mature cats, usually on bones with flat surfaces, and produce slow-growing nodular masses that are slow to invade either the overlying soft tissue or the bone from which they arise.

This report describes the clinical, radiological, and histopathological findings of two cats with periosteal chondrosarcoma. These cases highlight the typical signalment, location in the skeleton, and unique histologic appearance of this tumor in two cats. To the authors’ knowledge, the long-term outcome following surgical debulking of periosteal chondrosarcoma has not been reported in cats.

Case Report

Case 1

A 13 yr old male castrated domestic shorthair cat weighing 4.3 kg was referred to the Purdue University Veterinary Teaching Hospital for evaluation of a non-painful bony proliferation at the level of the right lateral stifle noted 1 wk prior. The owner did not report any lameness or difficulty jumping after noting this mass. Referral radiographs demonstrated an osteoproducive lesion arising from the lateral aspect of the right distal femur. Radiographically the
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lesion lacked any evidence of osteolysis. Complete blood count, serum biochemistry, and three-view thoracic radiographs were unremarkable. Physical exam at the time of presentation was within normal limits aside from the palpable bony mass. Right lateral and caudocranial stifle radiographs demonstrated a 3 cm irregularly shaped, sharply marginated ossified mass caudolateral to the lateral epicondyle of the femur with superimposition of the mass on the femoral cortex and mild soft tissue swelling. There was a smooth, radiodense contour of the outer margin of the tumor that had a bosselated appearance on the medial side and smooth continuous radiodense border on its caudal side (Figure 1A). This was interpreted to most likely be a non-aggressive bony lesion with considerations of an osteoma or an osteochondroma, but malignant neoplasia could not be ruled out. An excisional biopsy was recommended as a diagnostic option. Based upon histopathologic results, potential future options that were discussed with the owner included amputation, chemotherapy, radiation, or no further treatment with continued monitoring. A preoperative computed tomography was performed prior to surgical biopsy. Results of the advanced imaging described a smoothly marginated, lobulated, bone-attenuating mass measuring 3 cm × 2.1 cm × 2 cm arising from the lateral cortex of the metaphysis at the level of the lateral epicondyle and lateral trochlear ridge of the distal femur without invasion of the cortex or medullary cavity.

For surgical resection of the exostotic mass, the cat was sedated with 0.01 mg/kg acepromazine and 0.1 mg/kg hydromorphone subcutaneously and induced with 6 mg/kg propofol IV. Anesthesia was maintained via inhalant isoflurane. Meloxicam 0.1 mg/kg was given subcutaneously intraoperatively. A lateral approach to the stifle was made, and the biceps fascia was incised. The mass was isolated by elevating the soft tissue and muscular attachments on the caudolateral aspect of the distal femur, taking care to avoid damage to the origin of the lateral collateral ligaments, sciatic nerve, and vascular supply. The joint capsule was incised for more complete access to the mass. The tumor was debulked using rongeurs on the lateral and caudal aspect of the lateral femoral epicondyle. Four mcg/kg dexmedetomidine with 0.05 mg/kg hydromorphone were administered postoperatively once, and 0.02 mg/kg buprenorphine was given transmuosally every 8–12 hr for 5 days. On gross observation at surgery the mass was described as a multilobulated, smoothly margined heterogenous firm mass arising from the lateral epicondyle of the femur. The mass appeared mostly bony and hard, but parts were also friable and crumbled when removed by a rongeur. The mass did not appear to invade surrounding structures and seemed to arise from the surface of the lateral epicondyle of the femur. Postoperative radiographs were taken and verified that 70–80% of the mass had been resected (Figure 1B).

Histopathology was performed at the Department of Veterinary Pathobiology at Texas A&M. Microscopic evaluation revealed the periosteal cartilaginous nodule undergoing orderly endochondral ossification along its base in which cancellous bone was being formed and separated by inter trabecular marrow spaces containing capillaries and adipose tissue. No cartilage cap was present at the surface of the specimen; however, the more common pattern of a cartilaginous neoplasm was present in the superficial tissue of the mass. Superficial tumor tissue consisted of proliferative nodular masses of cartilage in which the chondrocytes, while being small, were hyperchromatic and proliferating along the borders of the mass. Sections of the surgical specimen from deeper central areas of the mass were formed of cancellous bone sometimes separated by small random masses of ischemic hyaline cartilage that contained mostly necrotic chondrocytes. The morphologic diagnosis for both the dense and friable bony proliferations was a low-grade chondrosarcoma of the periosteum.

Recheck examinations with follow-up radiographs were performed at 2 mo, 6 mo, and 12 mo postoperatively and demonstrated that the remnant periosteal chondrosarcoma remained fairly static with only mild, smooth bony remodeling occurring. Approximately 2.5 yr after surgical resection, the owner reported that the cat had developed a slight limp when walking and began stretching the right hind limb out when lying down as opposed to keeping it in the normal flexed position. A smooth bulge was palpated on the right lateral distal femur, and radiographs showed a discoid osseous structure on the lateral femoral epicondyle described as having an irregular to spiculated pattern (Figure 1C). Small mineralized bodies were also noted in the soft tissue just lateral to the bony proliferation. Repeat surgical debulking was discussed, but the owner declined given the cat’s good quality of life and advanced age.

Case 2

An 11.5 yr old spayed female domestic long hair cat weighing 5.3 kg was presented to the Purdue University Veterinary Teaching Hospital for evaluation and surgical biopsy of a firm mass palpated on the left caudoproximal metatarsal region that had been present for 5 mo. No lameness or discomfort was noted by the owner. A previous punch biopsy revealed granulation tissue and following biopsy, a draining tract developed that reoccurred whenever the cat was discontinued from antibiotics. Aside from the mass and an enlarged left popliteal lymph node, all other physical exam parameters were within normal limits. Lateral and dorsoplantar radiographs of the left tarsus revealed an irregularly shaped bony
FIGURE 1 Radiographic appearance of lateral femoral epicondylar periosteal chondrosarcoma pre-operative (A), immediately following surgical debulkment (B), and 2.5 yr following surgical debulkment (C).
proliferation on the plantarolateral aspect of the tarsus and proximal fifth metatarsal bone (Figure 2). A large mass of radiodense coalescing nodules arose from the plantar cortical surface of the foot, extending from the second row of tarsal bones in a distal direction along the proximal one third of the shafts of the metatarsal bones. A smooth periosteal response adjacent to the bony proliferation was present on the lateral surface of the fifth metatarsal bone. Soft tissue swelling with minimal amorphous calcification was noted around the pes, especially the plantar aspect of the tarsus and metatarsus. An enlarged left popliteal lymph node was also present. Radiographic impression indicated that this lesion, consisting of coalescing radiodense nodules, extended from its origin on the surface of the distal tarsus to the proximal one-third of the metatarsus. Differentials included several benign neoplasms, such as osteochondroma, osteoma, or a synovial osteochondroma, with possible enthesiopathy of the lateral collateral ligament of the antebrachiocarpal joint. A malignant bone neoplasm could not be ruled out, and biopsy was recommended. The soft tissue swelling and enlarged popliteal lymph node was thought to be a secondary response to a soft tissue infection or cellulitis, although no cytology was performed on the lymph node for confirmation.

Surgical biopsy was planned, and the cat was premedicated with 0.02 mg/kg acepromazine and 0.2 mg/kg butorphanol subcutaneously. Following induction with 6 mg/kg propofol IV, anesthesia was maintained using inhalant isofluorane. Atropine 0.02 mg/kg was administered intravenously intraoperatively. A 5 cm elliptical incision was made, centered over the previously performed biopsy site. The mass was identified and debulked by approximately 60% using freer periosteal elevators and rongeurs, and the mass was removed until flexor tendons were identified. Grossly the periosteal mass was mostly firm with sections that crumbled when manipulated. Meloxicam 0.2 mg/kg was administered subcutaneously postoperatively once, and buprenorphine at 0.02 mg/kg was administered transmucosally every 8 hr for 5 days.

The biopsy sample was submitted to the Department of Veterinary Pathobiology at Texas A&M. Microscopically, the biopsy specimens displayed a superficial layer of compacted chronic, reactive fibrovascular tissue that, on its deeper surface, underwent cartilaginous metaplasia as it fused with deeper underlying osteocartilaginous components. There was no definitive fibrous or chondrogenic layer of perichondrium overlying the outer layer of disorganized hyaline cartilage that formed the surface of the osteocartilaginous component. Also noted was a nodular mass of disorganized hyaline cartilage that, in its superficial region, merged with compacted fibrous tissue (Figure 3A). The hyalinized cartilage had histologic features similar to that of fibrocartilage due to the amount of fibrous tissue matrix that also hosted chondroid matrix. The chondroid matrix contained polygonal chondrocytes rather than the ovoid hyperchromatic chondrocytes exhibiting variability in cell size that were present in deeper layers of the nodule near the cortical surface (Figure 3B, C). The presence of bony trabecular systems at least partially composed of lamellar (mature) bone tissue and adipose type bone marrow in intertrabecular spaces indicated the chronicity of the lesion. The pathology report indicated that the age of the cat at onset of clinical signs, location in the skeleton, mass effect spanning the two different bones, and histological features were incompatible with a
diagnosis of developmental osteochondroma and a diagnosis of periosteal chondrosarcoma was made.

Approximately 3 yr later the cat had intermittent reluctance to jump, but the mass had not appreciably increased in size. The cat continues to maintain normal ambulation.

Discussion
When evaluating a geriatric cat with an appendicular bone tumor it is important to consider the differential diagnoses and to confirm the tumor type prior to definitive treatment and radical surgical resection. While the type of bone tumor is often inferred based on radiographic appearance and location, given the different biological behavior of primary bone tumors in cats when compared to dogs, diagnosis should rely on histopathologic confirmation of tumor type.

Primary bone tumors of the appendicular skeleton are more common than those of the axial skeleton and most frequently occur in the pelvic limbs, with a predilection for the metaphyseal region of long bones. Primary bone tumors of cats tend to affect older cats and there is no sex or breed predilection. Periosteal chondrosarcomas are primary bone tumors that can share several radiographic and histologic features with other benign and malignant bone tumors. Osteochondromas are benign tumors formed by endochondral ossification from the surface of bone and are capped with hyaline cartilage. In contrast to a periosteal chondrosarcoma, an osteochondroma produces an orderly cartilage-capped exostosis that results from developmental disturbances in the growing animal and ceases growth at time of skeletal maturity. Osteosarcomas are generally a tumor of older cats with a mean age of diagnosis being 10.7 yr. In a retrospective study of 145 cases of feline osteosarcoma, 34% were appendicular, 28% were axial, and 38% were extraskeletal including subcutaneous, orbital, oral, intestinal, and mammary. Cats affected with osteosarcomas usually present with progressive lameness, but they may present with acute signs if the bone tumors have induced a pathologic fracture. Similarly, pain has been found to be the presenting complaint in 95% of chondrosarcomas with 3–17% presenting with pathologic fractures. In contrast, pain was not the presenting complaint in either of the two cases described, and neither patient suffered from pathologic fractures or known metastasis.

As previously mentioned, radiographic appearance of periosteal chondrosarcomas can prove to be difficult to distinguish from other primary bone tumors. Formation of endosteal and periosteal new bone is an expected response to a variety of inflammatory, traumatic, and neoplastic bone lesions. In the initial stages of clinical disease, osteosarcomas, chondrosarcomas, and fibrosarcomas can all display cortical destruction and periosteal response. Both cats in this case report initially had proliferative bony lesions that, although only affecting the periosteum, could have been mistaken for an early stage of a more malignant neoplasm. It is important to understand that periosteal osteosarcomas also grow outward from the periosteal surface and may initially cause...

**FIGURE 3**  Histologic appearance of the dermal surface of one of several coalescing nodules of a low-grade periosteal chondrosarcoma. A dense layer of mature compacted fibrous tissue (A) overlies a peripheral nodule of disorganized hyaline cartilage whose deep surface has been partially replaced by cancellous bone and an incomplete subchondral bony plate (B). Mature adipose tissue fills the intertrabecular marrow spaces (C).
minimal cortical lysis, making them difficult to distinguish from a periosteal chondrosarcoma.\textsuperscript{1} High-grade periosteal osteosarcomas have been reported that arise on the surface of bone but later have the invasive and malignant characteristics of intraosseous osteosarcomas.\textsuperscript{1}

Another differential for consideration is a periosteal chondroma. This benign cartilage tumor of the periosteal surface produces an expansile radiographic bone lesion that may compress and attenuate the cortical surface while maintaining a smooth but discrete border. Evidence of osteolysis, production of reactive bone, soft tissue response, and change in radiographic appearance in a 2 wk interval may indicate malignant transformation of chondromas.\textsuperscript{9} In a retrospective study of 22 cases in man with periosteal cartilage tumors, it was reported that the size of the tumor was the most reliable predictor to differentiate between periosteal chondromas and periosteal chondrosarcomas, with chondromas having a mean size of 2.2 cm and chondrosarcomas having a mean size of 5.3 cm.\textsuperscript{11} However, permeation into soft tissue is an important characteristic of chondrosarcomas that can also be used to distinguish it from chondromas.\textsuperscript{11} Due to the potential for any of the above-mentioned neoplasms to display similar radiographic characteristics, the utilization of a biopsy in conjunction with radiography, computed tomography, and dimensional analysis is of principal importance.

Histologic evaluation is one of the most important diagnostic tests for differentiating periosteal chondrosarcomas from similar bone-derived tumors. Two dissimilar histologic patterns may exist for periosteal chondrosarcomas. In the first pattern, the tumor tissue is identical with that of a low-grade central chondrosarcoma, except that the tumor arises on the surface of the bone. The pattern consists of multiple lobules of neoplastic hyaline cartilage with cytologic features of intermediate or low grade malignancy. In the second pattern, the tumor tissue lacks a lobular structure, and the chondrocytes have less anaplastic features throughout. Hyalinization of much of the cartilage matrix gives the appearance of bone tissue and may create the false impression that this is a mixed tumor of bone and cartilage.\textsuperscript{4} To aid in differentiating periosteal chondrosarcoma from other bone tumors, it is important to recognize some of the more characteristic histopathologic features of the differentials. By definition, if malignant mesenchymal cells produce osteoid, the tumor is an osteosarcoma, even if cartilage matrix is present in some areas.\textsuperscript{4} In a retrospective study of 62 cats, feline osteosarcoma was characterized by moderate to abundant cellular pleomorphism, low mitotic index, small to moderate amounts of matrix, high cellularity, and moderate amounts of necrosis.\textsuperscript{6} In this study, 82.3% of cats with osteosarcoma had signs of tumor cell invasion within blood vessels.\textsuperscript{6} Histopathology can be helpful in ruling out osteosarcoma; however, in cases of low-grade fibrosarcoma, chondrosarcoma, and chondroma, histologic analysis can be difficult with bone needle biopsies and small excisional biopsies, stressing the importance of larger representative biopsies, perhaps from more than one site. With adequate-sized surgical biopsy specimens of viable tumor tissue, low-grade periosteal chondrosarcomas may be histologically differentiated from chondromas by greater variation in cell numbers, cell size, hyperchromaticity, and the presence of more than two cells per chondrocyte lacunae in chondrosarcoma even when mitotic figures are absent.\textsuperscript{3} Mitotic figures are seldom present in well-differentiated chondrosarcomas, and even the presence of a single mitotic figure strongly supports the diagnosis of malignancy.\textsuperscript{5} Since areas of ischemic and necrotic tumor tissue may be major components in biopsy specimens from either tumor type, difference in biological behavior over time may be better assessed in the individual patient by sequential radiographs of the tumor.\textsuperscript{2}

The most important clinical aspect for these cases is the documentation of prolonged survival with preservation of quality of life seen after incomplete surgical resection. In humans, prognosis for periosteal chondrosarcoma is good compared to those with central chondrosarcoma of the same histologic grade. Metastases are exceptional and occur very late. Wide surgical resection is considered the most effective treatment of choice.\textsuperscript{3} As seen in periosteal chondrosarcomas, intraosseous chondrosarcomas in the dog, cat, and sheep tend to grow more slowly and pursue a longer clinical course; however, they can develop hematogenous metastasis, albeit later in the course of disease and with much less frequency than osteosarcoma.\textsuperscript{4} While histologic diagnosis of primary bone sarcoma is based on the level of cytological differentiation attained by tumor cells in the neoplastic matrix, prognosis should be judged by the following criteria: (1) the state of immaturity of the tumor cell population; (2) the rate of tumor growth as indicated by mitotic index or by the change measured in sequential radiographs; (3) the ability of the host to contain the lesion as shown on radiographic studies; and (4) the category of bone sarcoma which indicates the rapidity of clinical course and the anticipated fate of the patient.\textsuperscript{4} In general, cats have been shown to have a longer survival with primary bone tumors than dogs, and, in one study, median survival time in 12 cats with appendicular osteosarcoma treated with amputation was 49.2 mo.\textsuperscript{12} To the authors’ knowledge, this is the first case report that highlights the excellent long-term prognosis and the characteristic radiographic and histologic features of periosteal chondrosarcoma in cats.
Conclusion

It is important to consider that the diagnosis will often determine the clinical management of the patient, and in the case of bone tumor masses, the management will frequently result in amputation of the affected limb or even euthanasia of the animal. It is therefore essential to base the diagnosis of the tumor not only on the histopathologic features of a representative sample of adequate size but also by evaluating the clinical, serial radiographic, and gross findings. In regards to the cases of periosteal chondrosarcoma, it has been shown that some large, proliferative bone masses in the feline can have an excellent prognosis, even with partial resection.

FOOTNOTES

a Acepromazine maleate; Vedco, Inc., St. Joseph, MO
b Hydromorphone hydrochloride injection; West-Ward Pharmaceutical Corp., Eatontown, NJ
c Propofol; Hospira, Inc., Lake Forest, IL
d Fluriso; Vet-One, Boise, ID
e Loxicom; Norbrook Laboratories, Lenexa, KS
f Dexdor; Orion Corporation, Espoo, Finland
g Torbugesic; Fort Dodge Animal Health, Fort Dodge, IA
h Atropine Sulfate; Med-Pharmex Inc., Pomona, CA
i Buprenorphine; Reckitt Benckiser Healthcare Ltd., Hull, England

REFERENCES