Radiologic evaluation of knee tumors in adults

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INTRODUCTION — The knee is one of the largest and most complex joints in the body. It is lined by synovium and consists of two hinge-type joints between the femoral condyles and the medial and lateral tibial plateaus, and of a gliding-type joint between the patella and the trochlear groove of the anterior distal femur (picture 1) [1].

The radiographic evaluation of suspected or clinically apparent tumors of or near the knee is addressed here, including plain film, magnetic resonance imaging (MRI), and computed tomography (CT) features and the radiographic appearance of selected tumor-like intraarticular disorders.

The history and physical examination, which are necessary to develop a differential diagnosis prior to the selection of imaging tests, a general review of imaging tests that are used in the evaluation of bone and joint pain, and the use of imaging in the assessment of children and adolescents with knee pain are presented separately. (See "General evaluation of the adult with knee pain" and "Approach to the child or adolescent athlete with acute knee pain or injury" and "Approach to the child or adolescent athlete with chronic knee pain or injury").

IMAGING MODALITIES FOR MASS LESIONS OF THE KNEE — Plain film radiography, computed tomography (CT), and magnetic resonance imaging (MRI) are the mainstays of diagnostic imaging for patients with intraarticular or juxtaarticular bony or soft tissue mass lesions [2]. The following is a brief discussion of the role of each of these modalities in assessing knee tumors and tumor-like disorders.

Plain film radiography — Plain film is the initial modality of choice for detection and assessment of the general features of the tumor. Accuracy of plain film for detection of soft tissue tumors is limited. Plain film is the most valuable method to evaluate the margin between normal bone and a neoplasm that is characteristic of bone tumor (zone of transition). Radiographic features of the zone of transition are important in distinguishing between benign and malignant bone lesions. Plain film radiography also demonstrates the extent of cortical destruction, periosteal reaction, matrix calcifications, and pathological fractures. Certain radiographic patterns, combined with the age of the patient, can be very suggestive of specific tumors.

CT scanning — CT is the best method for detection of juxtaarticular bone lesions not optimally seen by plain film. CT provides better assessment of cortical invasion, pathological fracture, periosteal reaction, and matrix mineralization and detection of cystic or fatty nature of tumor. CT is used for biopsy guidance, preoperative evaluation, and detection of recurrence. For primary bone tumors, intravenous contrast is not usually indicated. For soft tissue masses, use of CT with intravenous contrast is recommended when MRI is not available or is contraindicated; in these cases, contrast administration helps to delineate the mass, distinguishing it from adjacent soft tissue, and shows cystic and necrotic areas, vascularity, and the relationship to vascular structures.

MR imaging — MRI is nonspecific for differentiation of most tumors. MRI is the modality of choice for local staging, for definition of medullary and extracortical spread, and for delineation of tumor in relation to critical neurovascular structures.
The zone of transition, an important feature in plain film imaging, as discussed earlier (see 'Plain film radiography' above), is not valid on MRI. Gadolinium contrast administration may be useful to differentiate solid from cystic or necrotic tumor, to evaluate response to nonsurgical therapy, and to detect tumor recurrence. Administration of gadolinium-containing MRI contrast agents should be avoided in patients with severely impaired renal function (e.g., estimated glomerular filtration rate <15 to 30 mL/min). If gadolinium-based imaging must be performed in a patient with moderately to severely impaired renal function, there may be a role for dialysis to reduce the risk of development of nephrogenic systemic fibrosis (NFS). Approaches to prevention of NFS are discussed separately. (See "Nephrogenic systemic fibrosis/nephrogenic fibrosing dermopathy in advanced renal failure", section on 'If gadolinium must be given'.)

Radionuclide scan — The use of radionuclide bone scan (bone scintigraphy) for tumor is limited to evaluation of metastatic skeletal involvement. (See "Imaging techniques for evaluation of the painful joint", section on 'Bone scan'.)

INTRAARTICULAR TUMORS AND TUMOR-LIKE LESIONS — Benign intraarticular lesions of the knee include pigmented villonodular synovitis (PVNS), synovial chondromatosis (synovial osteochondromatosis), synovial hemangioma, and lipoma arborescens. Primary malignant intraarticular knee lesions include synovial sarcoma and synovial chondrosarcoma.

Pigmented villonodular synovitis — PVNS is an idiopathic, benign disorder occurring primarily in young and middle-aged adults. The pathologic process can involve any joint, bursa, or tendon sheath. The disease is characterized by synovial hypertrophy with diffuse hemosiderin deposits within the joint. The knee is the most commonly involved joint in PVNS. PVNS typically involves one compartment of the knee, and the joint space is maintained until late in the disease.

● Plain film radiography – Plain film radiography often demonstrates a joint effusion, suprapatellar soft tissue density, and erosions in the femur and tibia, without signs of bone repair or osteophyte formation [1,3].

● Magnetic resonance imaging (MRI) – MRI confirms the diagnosis of PVNS. MRI findings of PVNS are joint effusion and nodular intraarticular masses with low signal intensity in all (T1, T2, short tau inversion recovery [STIR], etc) sequences from hemosiderin deposition (image 1) [1]. Bony erosions (when present) and extraarticular extension of the lesion are well-demonstrated on MRI. MRI is useful in the preoperative planning and the postoperative follow-up.

● Computed tomography (CT) – CT demonstrates hyperdense, hemosiderin-laden masses and delineates bone cysts and erosions. CT is also valuable for needle biopsy guidance when MRI is nondiagnostic or contraindicated and for preoperative planning.

Synovial (osteochondromatosis — Synovial chondromatosis is a benign disorder of the synovial lining, characterized by the presence of loose cartilaginous bodies. Ossification of these cartilaginous bodies may occur (osteochondromatosis). This monoarticular disorder is more common in men. The knee is the most commonly involved joint. Secondary osteoarthritis is present due to cartilage damage from the presence of loose bodies [4].

● Plain film radiography – Plain film radiography demonstrates joint effusion and is diagnostic when the chondroid loose bodies are ossified enough to be visualized by radiograph (image 2). Erosions are not a common feature in the knee because of the expansile nature of this joint as compared with the hip joint [4-6].
CT and MRI – CT or MRI is recommended when synovial chondromatosis is clinically suspected and when radiographs are normal or only demonstrate joint effusion. MRI and CT show the loose bodies when they are not visible on plain film. MRI and CT also show the extent of the lesions, required for preoperative assessment [4].

Synovial hemangioma — Synovial hemangioma is a rare benign vascular lesion that most commonly affects the knee joint. It occurs mostly in children and adolescents and presents with swelling, pain, and nontraumatic hemorrhaxis. (See "Hemarthrosis", section on 'Tumors'.) Plain film radiography is normal in half of the patients or shows joint effusion, soft tissue swelling, and erosions. The presence of phleboliths is suggestive of hemangioma, but MRI is the modality of choice for diagnosis [1].

Lipoma arborescens — Lipoma arborescens is an intraarticular disorder characterized by benign lipomatous proliferation of the synovium, manifested as slowly progressive and painless joint effusion. Etiology is unknown; however, it can be associated with osteoarthritis and rheumatoid arthritis. It occurs more commonly in men, in the fourth and fifth decade, and, most often, in the knee joint. MRI demonstrates characteristic villous synovial masses that have fat signal intensity on all imaging sequences (image 3) [7].

Synovial sarcoma — Synovial sarcoma is an uncommon mesenchymal tumor, most commonly involving the knee and the foot. It typically occurs before age 50 and presents with a progressively enlarging soft tissue mass and pain. (See "Clinical presentation, histopathology, diagnostic evaluation, and staging of soft tissue sarcoma", section on 'Histopathology'.) Plain film radiography demonstrates a soft tissue mass, occasional bone invasion, and soft tissue calcification. MRI with intravenous gadolinium is the procedure of choice for further evaluation.

Synovial chondrosarcoma — Synovial chondrosarcoma is a rare tumor arising from the synovium and most commonly involving the knee joint. It can occur as a primary malignancy or as secondary to malignant transformation of synovial (osteochondromatosis. Plain film radiography demonstrates soft tissue mass, chondroid calcifications, and bone destruction. MRI demonstrates soft tissue mass and bone destruction.

JUXTAARTICULAR BONE OR SOFT TISSUE TUMOR — Plain film radiography is usually the first imaging modality employed in patients who present with mass lesions in the region of the knee. Further evaluation of bony lesions is facilitated by computed tomography (CT) scanning, while magnetic resonance imaging (MRI) is used for soft tissue tumors. The most commonly encountered benign bone lesions that occur around the knee joint are enchondroma, nonossifying fibroma, osteochondroma, giant cell tumor, chondroblastoma, and aneurysmal bone cyst. Malignant bone tumors include osteosarcoma (conventional), osteosarcoma (parosteal), chondrosarcoma, metastases, and myeloma. The most common benign soft tissue tumors around the knee in adults are lipoma and hemangioma. The most common malignant soft tissue tumor around the knee is sarcoma, with undifferentiated/unclassified soft tissue sarcoma (previously termed malignant fibrous histiocytoma or undifferentiated pleomorphic sarcoma), liposarcoma, leiomyosarcoma, synovial sarcoma, and malignant peripheral nerve sheath tumor accounting for 75 percent of all soft tissue sarcomas. (See "Clinical presentation, histopathology, diagnostic evaluation, and staging of soft tissue sarcoma", section on 'Histopathology'.)

Enchondroma — Enchondroma is a common benign bone tumor arising from the hyaline cartilage, seen in young patients ages 15 to 35 years. It most commonly occurs around the wrist and hand; however, the femur is also affected in approximately 10 percent of cases. Enchondroma is usually asymptomatic, or it may present with painless swelling. The presence of pain is suspicious for malignant transformation to chondrosarcoma or for the presence of pathological fracture [8-10]. (See "Benign bone tumors in children and adolescents: An overview", section on 'Enchondroma'.)
Plain film radiography – Plain film radiography demonstrates a metaphyseal lesion, which may extend to the diaphyseal or subarticular region of the bone. Enchondroma is a medullary osteolytic lesion, more centrally located within the metaphysis, with a lobulated border. Stippled calcifications are seen in 50 percent of lesions (image 4) [8-10].

CT and MRI – Enchondroma is a common incidental finding on knee MRI, seen in up to 3 percent of cases. CT and MRI allow differentiation between an enchondroma and a chondrosarcoma [8-10].

Nonossifying fibroma (NOF) — Nonossifying fibroma (NOF) is a benign bone tumor composed of connective tissue, seen in young people of ages 10 to 20 years. NOF is most commonly seen in the tibia and the femur. It is usually clinically silent and is discovered incidentally or following pathological fracture [8-10]. (See "Benign bone tumors in children and adolescents: An overview", section on 'Nonossifying fibroma'.)

Plain film radiography – Plain film radiography demonstrates a well-circumscribed, eccentric, multiloculated osteolytic lesion, arising from the metaphyseal cortex. Lesions are often bilateral and symmetrical. Most NOFs gradually disappear over time, being replaced by normal bone [8-10].

CT and MRI – Cross-sectional imaging is not necessary for the diagnosis of NOF. These lesions may be seen as incidental findings, and their MRI appearance parallels their radiographic findings [8-10].

Plain film radiography – Osteochondroma is a metaphyseal lesion, occurring often at or near the attachment sites of tendons. It presents as a sessile or pedunculated osseous mass, typically growing away from the adjacent joint. This lesion is in continuity with the medullary cavity and cortex of the parent bone and is covered by a cap of hyaline cartilage (image 5). The cartilage cap frequently contains calcifications visible on radiographs [8-10].

MRI – MRI allows measurement of the thickness of the cartilaginous cap of the enchondroma, which assists in predicting the risk of malignant transformation [8-10].

Giant cell tumor — Giant cell tumor is a benign bone tumor affecting predominantly young people, 20 to 40 years of age. Ninety to 95 percent of giant cell tumors are benign, and 5 to 10 percent are locally aggressive or malignant. Giant cell tumors have a predilection for the subarticular region and metaphysis of the long bones, occurring mainly in the distal portion of the femur and in the proximal aspect of the tibia. Giant cell tumor occurs around the knee in 50 to 65 percent of cases. Clinical presentation includes pain, swelling, and limitation of motion. Pathologic fracture occurs in up to 10 percent of cases. Giant cell tumors may be accompanied by a secondary aneurysmal bone cyst [10,11]. (See "Giant cell tumor of bone".)

Plain film radiography – Plain film radiographs demonstrate a subarticular and metaphyseal lytic lesion. The lesion is typically eccentric and elongated, and it may appear multiloculated and expansile. Radiographs are inaccurate for distinguishing benign from aggressive giant cell tumors [10,11].
● CT – CT allows evaluation of the extraosseous and intraosseous extent of tumor. One or more fluid levels may be appreciated on CT, although this finding is not specific to giant cell tumor [10,11].

● MRI – The primary role of MRI is to define the intraosseous, intraarticular, and soft tissue extent of the lesion, and its relationship to major vessels and nerves [10,11].

Chondroblastoma — Chondroblastoma is a benign bone tumor of cartilage origin, occurring in young people, 10 to 25 years of age, more commonly in males. Clinically, chondroblastoma presents with joint pain and swelling. It has predilection for the epiphyses and apophyses, occurring frequently in the femur, tibia, and patella, which is considered an “epiphyseal equivalent” structure [10,11]. (See "Benign bone tumors in children and adolescents: An overview", section on 'Chondroblastoma'.)

● Plain film radiography — Plain film radiographs demonstrate a circular osteolytic lesion, 5 to 6 cm in diameter, arising from the epiphysis or apophysis of the long bones or in the patella. Metaphyseal extension is seen in 25 to 50 percent of cases. Calcification may be seen in the matrix in 30 to 50 percent of cases. Joint effusion is also a common finding [10,11].

● CT and MRI — CT is used in diagnosis of aggressive or recurrent chondroblastoma. A fluid level may be seen on CT or MRI; however, it is a nonspecific finding [10,11].

Aneurysmal bone cyst (ABC) — Aneurysmal bone cyst (ABC) is a benign lesion that contains blood-filled cavities and is seen in young people, 10 to 30 years of age. Although ABC is not a neoplastic lesion, it should be considered in the differential diagnosis of lytic neoplasms around the knee joint. ABC may develop after trauma or may accompany other benign processes, such as giant cell tumor or chondroblastoma. It occurs in the metaphysis of the long bones, including the tibia and the femur. Clinically, ABC presents with pain and swelling [10,11]. (See "Benign bone tumors in children and adolescents: An overview", section on 'Aneurysmal bone cyst'.)

● Plain film radiography — Plain film radiography of ABC demonstrates an eccentric, thin-walled, expansile osteolytic lesion of the metaphysis of long bones. ABCs usually have a septated, multiloculated appearance with a fluid-fluid level [10,11].

● CT and MRI — CT and MRI are useful in delineating the size and location of the intraosseous and extraosseous components of an ABC. Presence of a fluid level, although seen in other lesions such as chondroblastoma and giant cell tumor, is most suggestive of an ABC [10,11].

Osteosarcoma (conventional) — Conventional osteosarcoma is a malignant bone tumor seen in young patients, ages 10 to 25. It is a metaphyseal tumor most commonly seen in the distal femur and in the proximal tibia. Fifty to 75 percent of all cases develop around the knee. Clinically, it presents with pain, swelling, restriction of motion, warmth, and fever. Osteosarcoma may result from malignant transformation of benign neoplasms. It frequently metastasizes to other bones and to the lung [10,11]. (See "Osteosarcoma: Epidemiology, pathogenesis, clinical presentation, diagnosis, and histology".)

● Plain film radiography — Plain film radiography of osteosarcoma demonstrates a metaphyseal bone tumor with large soft tissue component. Osteolytic, osteosclerotic, or mixed patterns of medullary and cortical destruction are present. A prominent, aggressive periosteal reaction is commonly seen [10,11].
CT and MRI – CT and MRI are useful for delineating the extent of tumor and its relationship to surrounding neurovascular structures and in evaluating the response of tumor to therapy (image 6). MRI is superior to CT in defining the intraosseous and extraosseous extent of the tumor [10,11].

Radionuclide scan – Bone scan shows increased uptake in the primary tumor and is useful for detecting skeletal metastases, and it may also demonstrate uptake in extraskeletal metastases [10,11].

Osteosarcoma (parosteal) — Parosteal osteosarcoma is a malignant bone tumor seen in patients aged 20 to 45 years. It is a metaphyseal bone tumor, particularly common on the posterior surface of the distal femur and the proximal tibia. Parosteal osteosarcomas affect the bones about the knee in approximately 70 percent of cases. Clinically, parosteal osteosarcoma presents with insidious onset of pain, swelling, and palpable mass, often about the knee [10,11]. (See "Osteosarcoma: Epidemiology, pathogenesis, clinical presentation, diagnosis, and histology", section on 'Surface (juxtacortical) osteosarcomas'.)

Plain film radiography – Plain film radiography most commonly demonstrates a bone lesion on the posterior surface of the distal femoral metaphysis. Parosteal osteosarcoma presents as a large, oval, sclerotic and sessile lesion of the bone. Ossification begins centrally within the mass, and progresses peripherally [10,11].

CT and MRI – CT and MRI define the extent of the tumor and may show medullary involvement. MRI shows the soft tissue and intraosseous components and the relationship of the mass to neurovascular structures [10,11].

Chondrosarcoma — Chondrosarcoma is a malignant cartilage tumor seen in patients aged 30 to 60 years. It arises from the femur in 24 percent of cases and, less commonly, from the tibia. Clinically, chondrosarcoma presents with pain, soft tissue mass, pathologic fracture, warmth, and erythema. Chondrosarcoma is classified as central or peripheral, with the peripheral form arising from a preexisting osteochondroma [10,11]. (See “Chondrosarcoma”.)

Plain film radiography – Plain film radiography demonstrates an elongated, poorly defined metaphyseal lesion, with cortical destruction, periosteal reaction, and calcification. Calcification is seen in 60 percent of cases. The pattern and density of calcifications correlate with the degree of malignancy [10,11].

CT and MRI – CT and MRI provide information regarding the intraosseous and soft tissue extent of the tumor. Calcification is more readily detected by CT [10,11].

Skeletal metastasis — Skeletal metastasis is the most common malignant tumor of the bone, typically seen in patients over 40 years of age. Metastases are most commonly seen in the axial skeleton, with rare occurrence about the knee. Seventy percent of cases exhibit a permeative or moth-eaten appearance of osteolysis. When a joint is involved, both sides of the articulation may show destruction [10,11].

Multiple myeloma — Multiple myeloma is a malignant disease of plasma cells and is the most common primary malignancy of bone. The bones about the knee are an uncommon site of involvement for multiple myeloma. Early manifestation of multiple myeloma is diffuse osteopenia. In later stages, widespread, well-defined osteolytic lesions are seen [10,11]. (See "Clinical features, laboratory manifestations, and diagnosis of multiple myeloma".)
Lipoma — Lipoma is the most common soft tissue tumor, occurring commonly after the age of 20 years. Lipoma presents as an asymptomatic, slow-growing, round, well-defined mass with a soft consistency, usually superficial in location. Lipoma may also be intramuscular in location, presenting as a large and less well-defined mass. Plain film radiography reveals a radiolucent, round soft tissue mass, which may demonstrate calcification. CT and MRI show a homogeneously fatty mass. MRI helps in differentiating a lipoma from a liposarcoma [12]. (See "Overview of benign lesions of the skin", section on 'Lipoma'.)

Hemangioma — Soft tissue hemangioma is one of the most common soft tissue tumors, seen most frequently in infancy and childhood, but it is also encountered in adults, more commonly in women. It is usually intramuscular, although synovial hemangiomas also occur (see 'Intraarticular tumors and tumor-like lesions' above). Soft tissue hemangioma is a deep intramuscular mass which has cystic, dilated blood-filled spaces. Clinically, it presents as a mass or pain due to muscle hypoxia. Plain film radiographs demonstrate an area of increased density suggestive of a mass, or they may be normal. The presence of phleboliths associated with a soft tissue mass is a specific finding seen in hemangiomas. MRI is useful for characterization of the extent of the hemangioma and demonstrates a specific appearance [12].

Soft tissue sarcomas — Sarcoma is the most common malignant soft tissue tumor around the knee, with undifferentiated/unclassified soft tissue sarcomas (previously included within the terms “malignant fibrous histiocytoma [MFH]” and “undifferentiated pleomorphic sarcoma (UPS)”, and now reclassified as a separate category of soft tissue sarcoma with a pleomorphic variant [13]), the most common subtype. Undifferentiated/unclassified sarcoma is the most common malignant sarcoma of older adults, ages 50 to 70. (See "Clinical presentation, histopathology, diagnostic evaluation, and staging of soft tissue sarcoma", section on 'Histopathology'.) About 40 percent of soft tissue sarcomas occur in the lower extremities, usually around the knee. Soft tissue sarcomas usually present as a painless mass, often large at the time of diagnosis, and they metastasize hematogenously, mainly to the lung. Plain film radiographs demonstrate a soft tissue mass and may be used to evaluate the bone involvement and calcifications within the tumor. MRI is the imaging modality of choice, showing the extent of the tumor and adjacent neurovascular involvement. MRI is valuable for preoperative planning and for postoperative follow-up [14].

SUMMARY

● Plain film radiography, computed tomography (CT), and magnetic resonance imaging (MRI) are the mainstays of diagnostic imaging for patients with intraarticular, juxtaarticular bony, or periarticular soft tissue mass lesions. (See 'Imaging modalities for mass lesions of the knee' above.)

● Various types of benign and malignant tumors and tumor-like conditions found in or near the knee joint are discussed with an emphasis on the radiologic features of each that are helpful in diagnosis. (See 'Intraarticular tumors and tumor-like lesions' above and 'Juxtaarticular bone or soft tissue tumor' above.)

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REFERENCES


