Primary Bone Tumors
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Sundaram M, McLeod RA. MR imaging of tumor and tumorlike lesions of bone and soft tissue. *AJR* 1990; 155(4):817-824.	Review/Other-Dx	N/A	A review to examine the role of MRI in the diagnosis and staging of tumors and tumor like lesions of bone and soft tissue.	For tumors of bone, the plain radiograph is not only the least expensive diagnostic test but is the most reliable predictor of the histologic nature of a given lesion. MRI is the examination of choice for staging bone tumors. CT is preferred to MRI only when the characteristics of the lesion are inadequately defined on plain radiographs, as may occur in flat bones. Although MRI is of limited value in predicting the histology of bone tumors, it is a useful tool for distinguishing round-cell tumors and metastases from stress fractures and medullary infarcts in symptomatic patients with normal radiographs. For depiction of soft-tissue masses, MRI is unrivaled. Biopsy of bone and soft-tissue tumors should follow and not precede MRI. MRI reliably shows change in tumor volume after radiation or chemotherapy and is less reliable in predicting the amount of tumor necrosis.	4
2. Assoun J, Richardi G, Railhac JJ, et al. Osteoid osteoma: MR imaging versus CT. *Radiology* 1994; 191(1):217-223.	Observational-Dx	19 patients	To compare the performance of CT and MRI in diagnosis of osteoid osteoma.	CT was more accurate than MRI in detection of the osteoid osteoma nidus in 63% of cases. MRI was better than CT in showing intramedullary and soft-tissue changes in all cases. This may produce a misleading aggressive appearance on MRIs. There was a statistically significant correlation between presence or absence of marrow or soft-tissue changes and treatment with anti-inflammatory medications ($P<.05$).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
3. Zimmer WD, Berquist TH, McLeod RA, et al. Bone tumors: magnetic resonance imaging versus computed tomography. *Radiology* 1985; 155(3):709-718.	Observational-Dx	52 patients	To investigate the utility of MRI in the evaluation of bone tumors, identify criteria useful in distinguishing various types of tumors, and to compare MRI with CT.	MRI was superior to CT in 33% of bone tumor cases, about equal to CT in 64%, and inferior to CT in 2%. For delineating the extent of tumor in soft tissue, MRI was superior to CT in 38% of cases and about equal to CT in 62%. CT was superior in all cases for demonstrating calcific deposits and pathologic fractures. In 4 patients with metal prostheses or surgical clips, MRI was superior to CT in documenting recurrent tumor because of artifactual degradation of the CT image. Direct sagittal and coronal images from MRI permit accurate assessment of the relationship of tumor to adjacent normal structures, including the physis, joints, and neurovascular structures. MRI is useful in the evaluation of bone tumors: it is of greatest value in evaluations of the peripheral skeleton, the medullary canal, soft tissues, and postoperative tumor recurrence. With a 0.15-T magnet, MRI is less useful in the evaluation of the axial skeleton and cortical bone.	3
4. Frank JA, Ling A, Patronas NJ, et al. Detection of malignant bone tumors: MR imaging vs scintigraphy. *AJR* 1990; 155(5):1043-1048.	Observational-Dx	106 patients	To determine the relative sensitivities of MRI and scintigraphy for detecting primary malignant bone tumors and bone metastases.	A retrospective analysis showed that in 30 (28%) of 106 patients, MRI performed over a limited region of interest revealed a focal abnormality consistent with tumor that was not observed on scintigraphy. Only one patient had an abnormality on scintigraphy, caused by a metastasis that was not found on MRI. In 73 (69%) of the 106 patients, the results of MRI and scintigraphy were equivalent; in 41 cases results of both techniques were normal. A McNemar analysis of the discordant cases showed MRI to be more sensitive than scintigraphy was ($P<.001$).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
5. Bloem JL, Taminiau AH, Eulderink F, Hermans J, Pauwels EK. Radiologic staging of primary bone sarcoma: MR imaging, scintigraphy, angiography, and CT correlated with pathologic examination. *Radiology* 1988; 169(3):805-810.	Observational-Dx	56 patients	A prospective study to determine the appropriate application of diagnostic procedures in local staging of primary bone sarcoma by comparing results of CT, MRI, Tc-99m-methylene diphosphonate scintigraphy, and angiography with resected specimens.	MRI was significantly superior to CT and scintigraphy in defining intraosseous tumor length and was as accurate as CT in demonstrating cortical bone and joint involvement. It was also superior to CT in demonstrating involvement of muscle compartments. MRI was also the best modality in exhibiting the relationship between tumor and major neurovascular bundles; however, these differences were not significant.	3
6. Hogeboom WR, Hoekstra HJ, Mooyaart EL, et al. MRI or CT in the preoperative diagnosis of bone tumours. *Eur J Surg Oncol* 1992; 18(1):67-72.	Observational-Dx	25 patients	To determine the value of MRI and CT in the diagnosis of bone tumors.	MRI is superior to CT as it permits multidirectional exposures. Moreover, the tumor can be readily distinguished from the neurovascular structures without injection of contrast medium. MRI gives better contrast than CT, making it possible to study the relationship to the soft tissues, bone marrow and joints more accurately. On the other hand, CT gives a better picture of the destruction of cortical bone. The exact tumor length cannot be measured with MRI or CT and neither permits an exact, reliable diagnosis. Owing to the relatively slow exposure technique in combination with respiratory movements, depiction of the thoracic wall is less satisfactory with MRI than with CT. If both techniques are available, MRI is preferred.	3
7. Panicek DM, Gatsonis C, Rosenthal DI, et al. CT and MR imaging in the local staging of primary malignant musculoskeletal neoplasms: Report of the Radiology Diagnostic Oncology Group. *Radiology* 1997; 202(1):237-246.	Observational-Dx	316 patients	To assess the relative accuracies of CT and MRI in the local staging of primary malignant bone and soft-tissue tumors.	There was no statistically significant difference between CT and MRI in determining tumor involvement of muscle, bone, joints, or neurovascular structures. The combined interpretation of CT and MRI did not statistically significantly improve accuracy. Inter-reader variability was similar for both modalities.	2
8. Griffiths HJ, Galloway HR, Thompson RC, Jr., et al. The use of MRI in the diagnosis of benign and malignant bone and soft tissue tumours. *Australas Radiol* 1993; 37(1):35-39.	Review/Other-Dx	234 primary bone and soft tissue tumors	To investigate suspected primary bone and soft tissue tumors using plain films and MRI.	The workup of a suspected soft tissue tumor should be initially by MRI and that the workup of a suspected malignant bone tumor should be plain films followed by an MRI scan.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
9. Seeger LL, Widoff BE, Bassett LW, Rosen G, Eckardt JJ. Preoperative evaluation of osteosarcoma: value of gadopentetate dimeglumine-enhanced MR imaging. *AJR* 1991; 157(2):347-351.	Review/Other-Dx	21 patients	To determine if gadopentetate dimeglumine-enhanced MRIs could assist in the preoperative evaluation of osteosarcoma.	In some instances, use of gadopentetate dimeglumine obscured differentiation of tumor from normal marrow or tumor infiltration into perineurovascular fat, and tumor extension through pseudocapsule could not be differentiated from peritumoral edema after contrast administration. Contrast enhancement did assist in differentiation of intra-articular tumor from effusion; however, synovial invasion could be identified on unenhanced T1-weighted images by loss of synovial fat and cortical disruption. These results indicate that gadopentetate dimeglumine does not assist in defining tumor margins of osteosarcoma.	4
10. Lang P, Grampp S, Vahlensieck M, et al. Primary bone tumors: value of MR angiography for preoperative planning and monitoring response to chemotherapy. *AJR* 1995; 165(1):135-142.	Review/Other-Dx	13 patients	To investigate the use of MR angiography 2D and 3D displays in evaluating vascular morphology of musculoskeletal neoplasms for preoperative planning of limb-salvage surgery and to assess the use of MR angiography for monitoring changes in neovascularity and evaluating response to chemotherapy.	2D maximum intensity projections were useful for evaluating small vessel neovascularity; 3D displays demonstrated spatial relationships of tumor, feeder vessels, and normal vascular structures. Tumor encroachment onto or encasement of normal vascular structures was shown in 4 patients on 2D maximum intensity projections and on 3D displays. The 8 patients with osteogenic sarcoma who had follow-up imaging showed marked neovascularity prior to chemotherapy. 5 patients responded to chemotherapy (≥90% tumor necrosis at histology); MR angiography showed marked reduction in tumor neovascularity in these patients. 3 patients did not respond to chemotherapy; MR angiography showed unchanged neovascularity in one and increased neovascularity in two of these patients.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
11. Swan JS, Grist TM, Sproat IA, Heiner JP, Wiersma SR, Heisey DM. Musculoskeletal neoplasms: preoperative evaluation with MR angiography. *Radiology* 1995; 194(2):519-524.	Observational-Dx	23 patients	To assess the ability of MR angiography to depict vascularity of musculoskeletal neoplasms.	Of named vessels, 92% in proximity to tumor were noted by blinded readers. The PC technique provided supplemental data in 47% of cases, usually related to better delineation of in-plane feeder vessels and areas with pulsatile blood flow. Of the 28 branch feeder vessels, 23 were noted on both conventional arteriograms and MR angiograms in a nonblinded review, but 16 were difficult to distinguish as feeders because of lack of associated tumor blush.	2
12. Verstraete KL, De Deene Y, Roels H, Dierick A, Uyttendaele D, Kunnen M. Benign and malignant musculoskeletal lesions: dynamic contrast-enhanced MR imaging--parametric "first-pass" images depict tissue vascularization and perfusion. *Radiology* 1994; 192(3):835-843.	Observational-Dx	100 patients	To assess the diagnostic value of parametric MRIs that display the first pass of gadopentetate dimeglumine.	A significant difference ($P<.001$) was found between the first pass slope values of benign (mean, 36.2% per second) and malignant (mean, 67.4% per second) lesions. First pass images depicted tissue vascularization and perfusion rather than benignity or malignancy, because there is an overlap in the slope values of highly vascular benign lesions and malignant lesions.	3
13. Feydy A, Anract P, Tomeno B, Chevrot A, Drape JL. Assessment of vascular invasion by musculoskeletal tumors of the limbs: use of contrast-enhanced MR angiography. *Radiology* 2006; 238(2):611-621.	Observational-Dx	30 patients	To prospectively evaluate the accuracy of contrast material-enhanced MR angiography in the evaluation of vascular invasion by bone and soft-tissue tumors, with surgery serving as the reference standard.	Among the 31 cases, 20 were classified as negative and 11 were classified as positive at surgery. All but 3 cases with a gap between the tumor and the vessels on MRI were classified as free and without adhesions at surgery. All cases with arterial stenoses at MR angiography had tumoral adhesion or tumoral encasement at surgery. MRI had a sensitivity of 64%, a specificity of 95%, a PPV of 88% a NPV of 83%, and an accuracy of 84% in the detection of vascular invasion on the basis of findings of partial or total encasement. MR angiography had a sensitivity of 82%, a specificity of 85%, a PPV of 75%, a NPV of 90%, and an accuracy of 84% in the detection of vascular invasion on the basis of the findings of a stenosis.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
14. Fayad LM, Wang X, Salibi N, et al. A feasibility study of quantitative molecular characterization of musculoskeletal lesions by proton MR spectroscopy at 3 T. *AJR* 2010; 195(1):W69-75.	Observational-Dx	33 patients	To establish the feasibility and potential value of measuring the concentration of choline-containing compounds by proton MRS in musculoskeletal lesions at 3T.	Spectral quality was excellent in 26 cases, adequate in 4 cases, and nondiagnostic in 4 cases. For malignant lesions (3 sarcomas), the choline concentrations were 1.5, 2.9, and 3.8 mmol/kg, respectively. For 5 benign lesions (two neurofibromas, two schwannomas, and one enchondroma), the choline concentrations were 0.11, 0.28, 0.13, 0.8, and 1.2 mmol/kg, respectively. For 7 benign lesions (two hematomas, two bone cysts, one lipoma, one giant cell tumor, and one pigmented villonodular synovitis), the spectra showed negligible choline content. For 3 post-treatment fibrosis cases, the choline concentration range was 0.2-0.4 mmol/kg. For the remaining 12 post-treatment fibrosis cases, the spectra showed negligible choline content. Average choline concentrations were different for malignant and benign lesions (2.7 vs 0.5 mmol/kg; P=0.01).	3
15. Wang CK, Li CW, Hsieh TJ, Chien SH, Liu GC, Tsai KB. Characterization of bone and soft-tissue tumors with in vivo 1H MR spectroscopy: initial results. *Radiology* 2004; 232(2):599-605.	Observational-Dx	36 consecutive patients	To determine if in vivo detection of choline by using hydrogen 1 MRS with dynamic contrast material-enhanced MRI can help differentiate between benign and malignant musculoskeletal tumors.	Choline was detected in 18/19 patients with malignant tumors and in 3/17 patients with benign lesions. The 3 benign lesions included one perineurioma, one giant cell tumor, and one abscess. Choline was not detected in 14 patients with benign lesions nor in one patient with a densely ossifying low-grade parosteal osteosarcoma. In vivo hydrogen 1MRS characterized bone and soft-tissue tumors, resulting in a sensitivity of 95%, specificity of 82%, and accuracy of 89% (P<.001).	2
16. Collins MS, Koyama T, Swee RG, Inwards CY. Clear cell chondrosarcoma: radiographic, computed tomographic, and magnetic resonance findings in 34 patients with pathologic correlation. *Skeletal Radiol* 2003; 32(12):687-694.	Review/Other-Dx	72 patients	To describe the radiographic features of clear cell chondrosarcoma, including the CT and MRI findings, and to correlate them with the histopathologic findings.	Clear cell chondrosarcoma typically presents radiographically as a geographic lytic lesion located in the epimetaphyseal region of long bones. Most commonly lesions are found in the proximal femur, followed by the proximal humerus. Lesions within the proximal humerus may exhibit more aggressive features. Lesions in the axial skeleton are typically expansile and destructive, often with soft tissue extension and lack of mineralization. MRI may show the presence or absence of bone marrow edema.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
17. Niitsu M, Takeda T. Solitary hot spots in the ribs on bone scan: value of thin-section reformatted computed tomography to exclude radiography-negative fractures. *J Comput Assist Tomogr* 2003; 27(4):469-474.	Review/Other-Dx	47 patients	To classify solitary, scintigraphy-positive and radiography-negative rib lesions and to clarify the features of rib fractures by using thin-section reformatted helical CT.	The final diagnosis included 17 cases of fractures where CT findings were fracture line, focal sclerosis, and callus formation. Fourteen ribs demonstrated intramedullary, focal osteosclerosis, and 8 ribs did not demonstrate any abnormalities. Four metastatic lesions appeared as intramedullary mixture of osteolysis and osteosclerosis, or bone destruction. Four intramedullary lesions with cystic appearance remained unchanged.	4
18. Davies M, Cassar-Pullicino VN, Davies AM, McCall IW, Tyrrell PN. The diagnostic accuracy of MR imaging in osteoid osteoma. *Skeletal Radiol* 2002; 31(10):559-569.	Review/Other-Dx	43 patients	To analyze the MRI appearances of a large series of osteoid osteomas, to assess the ability of MRI to detect the tumor, and to identify potential reasons for misdiagnosis.	The potential for a missed diagnosis was 35% based solely on the MR investigations. This included 6 tumors which were not seen and 9 which were poorly visualized. The major determinants of the diagnostic accuracy of MRI were the MR technique, skeletal location, and preliminary radiographic appearances. There was a wide spectrum of MR signal appearances of the lesion. The tumor was identified in 65% of sequences performed in the axial plane. The nidus was present in only one slice of the optimal sequence in 27 patients. Reactive bone changes were present in 33 and soft tissue changes in 37 patients.	4
19. Klein MH, Shankman S. Osteoid osteoma: radiologic and pathologic correlation. *Skeletal Radiol* 1992; 21(1):23-31.	Review/Other-Dx	67 cases	To review the radiologic and pathologic features of osteoid osteoma.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
20. Aoki J, Watanabe H, Shinozaki T, et al. FDG PET of primary benign and malignant bone tumors: standardized uptake value in 52 lesions. *Radiology* 2001; 219(3):774-777.	Observational-Dx	52 primary bone lesions	To evaluate the SUV of FDG-PET in the differentiation of benign from malignant bone lesions.	There was a statistically significant difference in SUV between benign (2.18 +/- 1.52 [SD]) and malignant (4.34 +/- 3.19) lesions in total (P=.002). However, giant cell tumors (n = 5; SUV, 4.64 +/- 1.05) showed significantly higher SUV than chondrosarcomas (n = 7; SUV, 2.23 +/- 0.74) (P=.036, adjusted for multiple comparisons) and had no statistically significant difference in SUV compared with osteosarcomas (n = 6; SUV, 3.07 +/- 0.96) (P=.171). There was no statistically significant difference in SUV between fibrous dysplasias (n = 6; SUV, 2.05 +/- 0.98) and osteosarcoma (P=.127) or chondrosarcomas (P=.667). Although the number of cases was small, three chondroblastomas, one sarcoidosis, and one Langerhans cell histiocytosis showed levels of FDG accumulation as high as that of osteosarcomas.	3
21. Bredella MA, Essary B, Torriani M, Ouellette HA, Palmer WE. Use of FDG-PET in differentiating benign from malignant compression fractures. *Skeletal Radiol* 2008; 37(5):405-413.	Observational-Dx	33 patients with 43 compression fractures	To evaluate the use of FDG-PET in differentiating benign from malignant compression fractures.	There were 14 malignant and 29 benign compression fractures, including 5 acute benign fractures. On FDG-PET, 5 benign fractures were falsely classified as malignant (false-positive). Three of these patients underwent prior treatment with bone marrow-stimulating agents. There were two false-negative results. Sensitivity, specificity, PPV, NPV, and accuracy of FDG-PET in differentiating benign from malignant compression fractures were 86%, 83%, 84%, 71%, and 92% respectively. The difference between SUV values of benign and malignant fractures was statistically significant (1.9 +/- 0.97 for benign and 3.9 +/- 1.52 for malignant fractures, P<0.001). SUV of benign acute and chronic fractures were not statistically significant.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
22. Dehdashti F, Siegel BA, Griffeth LK, et al. Benign versus malignant intraosseous lesions: discrimination by means of PET with 2-[F-18]fluoro-2-deoxy-D-glucose. *Radiology* 1996; 200(1):243-247.	Observational-Dx	20 patients	To assess the ability of FDG-PET to allow differentiation of benign from malignant intraosseous lesions.	SUV assessment of FDG accumulation within osseous lesions was superior to subjective visual analysis for discriminating benign from malignant lesions. With use of a 2.0 cutoff value for SUV, 14 of 15 malignant lesions were categorized correctly vs 12 of 15 correctly categorized by means of subjective image evaluation; four of five benign lesions were categorized correctly with both techniques.	2
23. Lee FY, Yu J, Chang SS, Fawwaz R, Parisien MV. Diagnostic value and limitations of fluorine-18 fluorodeoxyglucose positron emission tomography for cartilaginous tumors of bone. *J Bone Joint Surg Am* 2004; 86-A(12):2677-2685.	Observational-Dx	35 biopsy-proven cartilaginous tumors in 27 patients	To investigate the glucose metabolism of cartilage tumors measured by PET and its correlation with histopathologic grades.	There were 13 benign bone tumors, 12 grade-I chondrosarcomas, and 10 high-grade (grade-II or III) chondrosarcomas. The mean maximal SUV were 1.147 +/- 0.751 in the benign tumors, 0.898 +/- 0.908 in the grade-I chondrosarcomas, and 6.903 +/- 5.581 in the high-grade chondrosarcomas. There was no significant difference in these values between the benign cartilage tumors and the grade-I chondrosarcomas (P>0.05). However, there was a significant difference between the low-grade (benign and grade-I) and high-grade chondrosarcomas (P=0.009). Metastasis, but not tumor size or recurrence, was associated with a higher SUV (P=0.031). Two large pelvic grade-I chondrosarcomas demonstrated no radioisotope uptake on bone-scanning or on PET. PET demonstrated grade-II and III metastatic lesions in the lung and other anatomic locations. When the cutoff for the SUV was set at 2.3 for grade-II or III chondrosarcomas, the PPV was 0.82 (95% confidence interval, 0.48 to 0.97) and the NPV was 0.96 (95% confidence interval, 0.77 to 1.00).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
24. Shin DS, Shon OJ, Byun SJ, Choi JH, Chun KA, Cho IH. Differentiation between malignant and benign pathologic fractures with F-18-fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography. *Skeletal Radiol* 2008; 37(5):415-421.	Observational-Dx	34 patients	To evaluate the efficacy of FDG-PET/CT in differentiating malignant from benign pathologic fractures.	There were 19 malignant and 15 benign fractures. In the malignant fractures, PET/CT demonstrated high (mean SUVmax 12.0, range 4.3 to 45.7). FDG uptake in bone marrow in most cases (17/19). In benign fractures, there was low FDG uptake (mean SUVmax 2.9, range 0.6 to 5.5) within cortical bone or adjacent soft tissue around the fracture, rarely in the marrow. There were significant differences in the pattern of intramedullary FDG uptake (P<0.001) and in the mean SUVmax (P<0.01) between malignant and benign fractures. The sensitivity, specificity and diagnostic accuracy of FDG-PET/CT were 89.5%, 86.7% and 88.2%, respectively, with a cut-off SUVmax set at 4.7. The time interval between fracture and PET/CT did not significantly influence FDG uptake at the fracture site.	3
25. Shin DS, Shon OJ, Han DS, Choi JH, Chun KA, Cho IH. The clinical efficacy of (18)F-FDG-PET/CT in benign and malignant musculoskeletal tumors. *Ann Nucl Med* 2008; 22(7):603-609.	Observational-Dx	91 patients	To analyze the clinical efficacy of FDG-PET/CT in a relatively large group of patients with musculoskeletal tumors.	Final diagnosis revealed 19 benign soft tissue tumors (mean SUV(max) 4.7), 27 benign bone tumors (5.1), 25 malignant soft tissue tumors (8.8), and 20 malignant bone tumors (10.8). There was a significant difference in SUV(max) between benign and malignant musculoskeletal tumors in total (P<0.002), soft tissue tumors (P<0.05), and bone tumors (P<0.02). Sensitivity, specificity, and diagnostic accuracy were 80%, 65.2%, and 73% in total with cutoff SUV(max) 3.8, 80%, 68.4%, and 75% in the soft tissue tumors with cutoff SUV(max) 3.8, and 80%, 63%, and 70% in the bone tumors with cutoff SUV(max) 3.7.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
26. Levy JC, Temple HT, Mollabashy A, Sanders J, Kransdorf M. The causes of pain in benign solitary enchondromas of the proximal humerus. *Clin Orthop Relat Res* 2005; (431):181-186.	Review/Other-Dx	57 patients	To identify the cause of the pain in benign solitary enchondromas of the proximal humerus.	57 patients (mean age, 53.6 years) met the criteria of the study and were included for evaluation. Of patients presenting with pain, 82% (47/57 patients) had findings seen on MRI that correlated with the initial clinical diagnostic impression, suggesting that other disease was present that could explain the pain. Solitary enchondromas of the proximal humerus often are found incidentally during the initial evaluation of patients with shoulder pain.	4
27. Murphey MD, Flemming DJ, Boyea SR, Bojescul JA, Sweet DE, Temple HT. Enchondroma versus chondrosarcoma in the appendicular skeleton: differentiating features. *Radiographics* 1998; 18(5):1213-1237; quiz 1244-1215.	Observational-Dx	92 patients with enchondromas; 95 with chondrosarcomas	To identify clinical and imaging features of enchondroma and chondrosarcoma in a large population of pathologically proven lesions based on a retrospective review of patient charts and imaging studies.	Multiple clinical and imaging parameters demonstrated statistically significant differences between enchondroma and chondrosarcoma, particularly pain related to the lesion, deep endosteal scalloping (greater than two-thirds of cortical thickness), cortical destruction and soft-tissue mass (at CT or MRI), periosteal reaction (at radiography), and marked uptake of radionuclide (greater than the anterior iliac crest) at bone scintigraphy. All of these features strongly suggested the diagnosis of chondrosarcoma. These criteria allow distinction of appendicular enchondroma and chondrosarcoma in at least 90% of cases.	3
28. Bui KL, Ilaslan H, Bauer TW, Lietman SA, Joyce MJ, Sundaram M. Cortical scalloping and cortical penetration by small eccentric chondroid lesions in the long tubular bones: not a sign of malignancy? *Skeletal Radiol* 2009; 38(8):791-796.	Review/Other-Dx	122 patients	To evaluate by cross-sectional imaging the prevalence and degree of cortical scalloping by small eccentric chondromas correlated with histologic diagnosis and patient history.	The chondromas ranged in size from 1.6 to 3.8 cm (mean 2.3 cm). Two lesions were located in the proximal femoral diaphysis, two in the distal femoral diaphysis, six in the distal femoral metaphysis, and one in the proximal tibial epimetaphysis. The lesions were curetted due to diagnostic uncertainty, continued pain, marked radiologic cortical penetration, or due to patient insistence on biopsy. All 11 lesions were benign, nine histologically, and two by stability over 4 and 7 years. The prevalence of cortical scalloping among eccentric chondromas was 100%. Cortical scalloping or occupancy ranged from 50 to 100% (mean 75%).	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
29. Geirnaerdt MJ, Hogendoorn PC, Bloem JL, Taminiau AH, van der Woude HJ. Cartilaginous tumors: fast contrast-enhanced MR imaging. *Radiology* 2000; 214(2):539-546.	Observational-Dx	37 patients	To differentiate between benign and malignant cartilaginous tumors with fast contrast material-enhanced MRI.	Start of enhancement and the combination of start and progression of enhancement correlated significantly (P<.001) with benign and malignant tumors. Early enhancement was seen in chondrosarcoma, not seen in enchondroma, and seen in osteochondroma only when growth plates were unfused. The sensitivity was 89%, specificity 84%, PPV 84%, and NPV 89%. Differentiation of malignancy from benignity on the basis of early and exponential enhancement was possible with a sensitivity of 61%, specificity 95%, PPV 92%, and NPV 72%.	3
30. Geirnaerdt MJ, Hermans J, Bloem JL, et al. Usefulness of radiography in differentiating enchondroma from central grade 1 chondrosarcoma. *AJR* 1997; 169(4):1097-1104.	Observational-Dx	78 patients	To evaluate clinical symptoms and radiographic features that allow radiologists to differentiate between enchondroma and central grade 1 chondrosarcoma.	No statistically significant correlation was found between clinical symptoms and the benign or malignant nature of the neoplasms. Grade 1 chondrosarcomas were more likely to be found in the axial skeleton and in flat bones. Also, chondrosarcomas were significantly larger than enchondromas (P<.001). Ill-defined margins and lobulated contours were the only morphologic features seen on radiographs that allowed significant discrimination (P=.004 and .009, respectively). An optimal combination of four radiographic features still left 72 of the 78 lesions with a 10%-90% probability of malignancy, indicative of poor discriminating power. Kappa values generally showed poor to fair agreement.	3
31. Feldman F, Van Heertum R, Saxena C, Parisien M. 18FDG-PET applications for cartilage neoplasms. *Skeletal Radiol* 2005; 34(7):367-374.	Observational-Dx	29 patients	To assess the value of FDG-PET in defining aggressive cartilage neoplasms, particularly those with problematic or borderline histologic, imaging and clinical characteristics.	In 26 operated cases the overall sensitivity of whole-body FDG-PET in separating benign and malignant lesions was 90.9% (10/11), specificity 100% (18/18) and accuracy 96.6%.	3
32. Brien EW, Mirra JM, Kerr R. Benign and malignant cartilage tumors of bone and joint: their anatomic and theoretical basis with an emphasis on radiology, pathology and clinical biology. I. The intramedullary cartilage tumors. *Skeletal Radiol* 1997; 26(6):325-353.	Review/Other-Dx	3,067 primary bone tumors	To review important clinical, radiologic and histologic features of intramedullary cartilaginous lesions in an attempt to support theories related to anatomic considerations and pathogenesis.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
33. Liu PT, Chivers FS, Roberts CC, Schultz CJ, Beauchamp CP. Imaging of osteoid osteoma with dynamic gadolinium-enhanced MR imaging. *Radiology* 2003; 227(3):691-700.	Observational-Dx	11 patients	To compare dynamic gadolinium-enhanced T1-weighted MRI with nonenhanced T1-weighted and T2-weighted MRI and thin-section CT for the demonstration of osteoid osteomas.	Compared with CT, dynamic gadolinium-enhanced MRI demonstrated the osteoid osteoma equally well in 8/11 patients and with better conspicuity in 3/11 patients, although this difference was not statistically significant (P=.69). The dynamic gadolinium-enhanced MRIs demonstrated the osteoid osteomas significantly better than the nonenhanced T1-weighted (P<.001) and T2-weighted (P<.001) MRIs. On the dynamic gadolinium-enhanced MRIs, 9 (82%) of 11 patients had peak enhancement of the osteoid osteoma in the arterial phase with early partial washout, compared with slower, progressive enhancement of the adjacent marrow. This resulted in greatest lesion to marrow contrast material enhancement in the arterial phase. One osteoid osteoma had peak enhancement in the venous phase, and one showed progressive enhancement through all phases to 150 seconds.	2
34. Campbell RS, Grainger AJ, Mangham DC, Beggs I, Teh J, Davies AM. Intraosseous lipoma: report of 35 new cases and a review of the literature. *Skeletal Radiol* 2003; 32(4):209-222.	Review/Other-Dx	35 cases of intraosseous lipoma; 110 cases (meta-analysis)	To identify the common imaging features of intraosseous lipomas on radiographs, MRI and CT, and review their histological features.	The mean age at presentation is 43 years. Sex distribution is nearly equal. Lipomas occur most frequently in the lower limb (71% overall), particularly in the os calcis (32%). Other common sites include the metaphyses of long bones, where lesions are typically eccentric. Lipomas are usually well defined, but marginal sclerosis is commoner in lesions of the os calcis (61%) than at other sites (38%). Calcification is also more frequent in the os calcis (62%), and almost invariably centrally located. Calcification at other sites is less common (30%), and is more variable in appearance. Bone expansion is less common (30%), and usually minimal. Fat necrosis and cyst formation identified on MRI is common (67%), and more frequent in the os calcis.	4
35. Frick MA, Sundaram M, Unni KK, et al. Imaging findings in desmoplastic fibroma of bone: distinctive T2 characteristics. *AJR* 2005; 184(6):1762-1767.	Review/Other-Dx	95 patients	To evaluate the imaging features of desmoplastic fibroma of the bone, with an emphasis on MRI signal characteristics.	Significant T2 shortening of a nonsclerotic fibroosseous lesion should place desmoplastic fibroma high among the diagnostic considerations.	4

Primary Bone Tumors
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
36. Murphey MD, wan Jaovisidha S, Temple HT, Gannon FH, Jelinek JS, Malawer MM. Telangiectatic osteosarcoma: radiologic-pathologic comparison. *Radiology* 2003; 229(2):545-553.	Review/Other-Dx	40 patients	To describe the imaging characteristics of a large series of telangiectatic osteosarcomas with pathologic findings for comparison.	Lesions frequently affected the femur, tibia, and humerus. Radiographs showed geographic bone lysis, a wide zone of transition, and matrix mineralization. CT demonstrated low attenuation, MR demonstrated high signal intensity on T2-weighted images, and both demonstrated hemorrhage, which simulated the appearance of aneurysmal bone cyst. Viable sarcomatous tissue surrounding hemorrhagic and/or necrotic regions was best seen at contrast material-enhanced CT and MRI, with thick peripheral, septal, and nodular enhancement in all cases. Subtle matrix mineralization in this viable tissue was best seen at CT. An associated soft-tissue mass was also seen in 19/25 cases (76%) at CT and in 24/27 cases (89%) at MRI.	4
37. Weatherall PT, Maale GE, Mendelsohn DB, Sherry CS, Erdman WE, Pascoe HR. Chondroblastoma: classic and confusing appearance at MR imaging. *Radiology* 1994; 190(2):467-474.	Review/Other-Dx	22 patients	To define the characteristics of chondroblastoma at MRI and the combination of findings that are diagnostic for chondroblastoma.	Low to intermediate heterogeneous signal intensity, lobular internal architecture, and fine lobular margins were well defined with high-resolution T2-weighted (repetition time ≥1,500 msec, echo time ≥70 msec) MRI. Adjacent bone-marrow and soft-tissue edema and periosteal reactions were more dramatically demonstrated on MRIs than on radiographs. Bone marrow edema was prominent in all but 5 cases. Obvious periosteal reaction and adjacent soft-tissue edema were visible in 17 cases.	4

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:

  a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  c) the study is an expert opinion or consensus document.

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

CT = Computed tomography

FDG-PET = Fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography

MRI = Magnetic resonance imaging

MRS = Magnetic resonance spectroscopy

NPV = Negative predictive value

PPV = Positive predictive value

SUV = Standardized uptake value