Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Lee K, Goodman SB. Current state and future of joint replacements in the hip and knee. *Expert Rev Med Devices*. 2008;5(3):383-393.	Review/Other-Dx	N/A	Review current state and future of joint replacement in the hip and knee.	Potential advancements in arthroplasty surgery include new, more wear-resistant bearing surfaces, porous metals to enhance osseointegration and replace lost bone stock, a clearer understanding of the biological processes associated with periprosthetic osteolysis, minimally invasive surgery and computer assisted surgery. Long-term studies are needed to establish the efficacy of these new technologies.	4
2. Mulcahy H, Chew FS. Current concepts of hip arthroplasty for radiologists: part 1, features and radiographic assessment. *AJR Am J Roentgenol*. 2012;199(3):559-569.	Review/Other-Dx	N/A	To systematically review radiographic assessment of hip arthroplasty including classifications based on different types and techniques of hip arthroplasty, terminology for prosthetic designs and materials, surgical techniques, and initial and follow-up radiographic assessments.	Assessment of postoperative hip arthroplasty radiographs is extremely important. It is well known that patients with complications may be asymptomatic, and for this reason, routine radiographic follow-up is recommended for all patients with hip arthroplasty. The foundation of radiologic interpretation of hip arthroplasty is knowledge of the normal appearance of the many different types of prostheses. A standard approach to radiologic reporting should be undertaken.	4
3. Bozic KJ, Kurtz SM, Lau E, Ong K, Vail TP, Berry DJ. The epidemiology of revision total hip arthroplasty in the United States. *J Bone Joint Surg Am*. 2009;91(1):128-133.	Review/Other-Dx	51,345 revision THA procedures	To evaluate the mechanisms of failure and the types of revision THA procedures performed in the United States with use of newly implemented ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification) diagnosis and procedure codes related specifically to revision THA in a large, nationally representative population.	The most common type of revision THA procedure performed was all-component revision (41.1%), and the most common causes of revision were instability/dislocation (22.5%), mechanical loosening (19.7%), and infection (14.8%). Revision THA procedures were most commonly performed in large, urban, nonteaching hospitals for Medicare patients 75-84 years of age. The average length of hospital stay for all types of revision arthroplasties was 6.2 days, and the average total charges were $54,553. However, the average length of stay, average charges, and procedure frequencies varied considerably according to census region, hospital type, and type of revision THA procedure performed.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
4. Ilchmann T, Lüem M, Pannhorst S, Clauss M. Acetabular polyethylene wear volume after hip replacement: Reliability of volume calculations from plain radiographs. *Wear.* 2012;282-283(0):69-75.	Review/Other-Dx	21 polyethylene acetabular components	To analyze the reliability of assessing linear wear and calculating volume through the use of clinical AP radiographs of the pelvis.	The mean measured linear wear was 1.02 mm (3D), the mean wear volume 777.2 mm3 fluid displacement method. The mean radiographic linear wear and calculated volume were 1.09–1.2 mm and 730.1–813.3 mm3, respectively, depending on method of measurement and calculation. All measurements and calculations agreed well with the 3D and the fluid displacement method. Not taking the direction of wear into account led to an overestimation of the wear volume. Errors of measurement and the used formula of calculation were more important than probable wear in the sagittal plane. Radiographic measurements of linear wear in the film-plane can provide a reliable estimation of the total wear volume.	4
5. Maruyama M, Tensho K, Wakabayashi S, Hisa K. Standing versus supine radiographs to evaluate femoral head penetration in the polyethylene liner after total hip arthroplasty. *J Arthroplasty*. 2014;29(12):2415-2419.	Observational-Dx	75 patients (83 hips) with conventional polyethylene (group-1) and 275 patients (300 hips) with highly cross-linked polyethylene (group-2)	To determine the effect of weight-bearing, ie, standing on the 2D radiographic penetration of the femoral head within the socket.	Follow-up periods were 14.5 years in group-1 and 8.6 years in group-2. The average penetration rates in group-1 were 0.17 mm/year in supine position and 0.18 mm/year in standing position ($P<0.05$). On the other hand, the rates in group-2 were 0.03 mm/year and 0.04 mm/year respectively ($P<0.05$). Although there were statistical differences between groups, 0.01 mm differences are probably not clinically relevant.	3
6. Barrack RL, Burnett SJ. Preoperative planning for revision total hip arthroplasty. *J Bone Joint Surg Am.* 2005;87(12):2800-2811.	Review/Other-Dx	N/A	Preoperative planning for revision THA lectures.	No results stated in abstract.	4
7. Fritz J, Lurie B, Miller TT. Imaging of hip arthroplasty. *Semin Musculoskelet Radiol.* 2013;17(3):316-327.	Review/Other-Dx	N/A	To discuss and illustrate the imaging appearances of conditions associated with painful or dysfunctional hip arthroplasty with a focus on the MRI evaluation.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
8. Pessis E, Campagna R, Sverzut JM, et al. Virtual monochromatic spectral imaging with fast kilovoltage switching: reduction of metal artifacts at CT. *Radiographics.* 2013;33:573-583.	Review/Other-Dx	N/A	To review virtual monochromatic spectral imaging with fast kilovoltage switching.	More recently, dual-energy CT has been proposed as a means of reducing beam-hardening artifacts. The use of dual-energy CT scanners allows the synthesis of virtual monochromatic spectral images. Monochromatic images depict how the imaged object would look if the x-ray source produced x-ray photons at only a single energy level. For this reason, VMS imaging is expected to provide improved image quality by reducing beam-hardening artifacts.	4
9. Puri L, Wixson RL, Stern SH, Kohli J, Hendrix RW, Stulberg SD. Use of helical computed tomography for the assessment of acetabular osteolysis after total hip arthroplasty. *J Bone Joint Surg Am.* 2002;84-A:609-614.	Observational-Dx	40 patients (50 hips)	To determine the efficacy and potential role of high-resolution helical (or spiral) CT with metal-artifact minimization in the early detection of osteolysis of the pelvis and to use the method to determine if there was a relationship between the extent of osteolysis and the amount of polyethylene wear.	Acetabular lysis was identified on the radiographs of 16 hips and on the CT scans of 26 hips. Radiographs underestimated the extent of the lysis in 13/16 hips. There was no correlation (r = 0.036) between linear wear and the measured volume of bone loss, with the numbers available. On the basis of the amount of lysis seen on the CT scans, 1 patient underwent a revision procedure.	3
10. Roth TD, Maertz NA, Parr JA, Buckwalter KA, Choplin RH. CT of the hip prosthesis: appearance of components, fixation, and complications. *Radiographics.* 2012;32:1089-1107.	Review/Other-Dx	N/A	Review appearance of components, fixation, and complications of CT of the hip prosthesis.	No results stated in abstract.	4
11. Goldvasser D, Noz ME, Maguire GQ, Jr., Olivecrona H, Bragdon CR, Malchau H. A new technique for measuring wear in total hip arthroplasty using computed tomography. *J Arthroplasty.* 2012;27(9):1636-1640 e1631.	Review/Other-Dx	16 CT series from hip phantom	To investigate the use of a high-resolution clinical CT scanner to estimate femoral head displacement relative to the cup as an indirect method of estimating polyethylene wear.	The mean difference between the true phantom displacement as positioned by micrometers and the calculated displacement based on the CT images was as follows: for the x-axis, 0 mm (SD, 0.213; SE, 0.058); y-axis, 0.039 mm (SD, 0.035; SE, 0.026); and z-axis, 0.039 mm (SD, 0.051; SE, 0.020).	4
12. Bamberg F, Dierks A, Nikolaou K, Reiser MF, Becker CR, Johnson TR. Metal artifact reduction by dual energy computed tomography using monoenergetic extrapolation. *Eur Radiol.* 2011;21(7):1424-1429.	Observational-Dx	31 patients	To assess the performance and diagnostic value of a dual energy CT approach to reduce metal artefacts in subjects with metallic implants.	Image quality was rated superior to the standard image in 29/31 high energy reconstructions; the diagnostic value was rated superior in 27 patients. Image quality and diagnostic value scores improved significantly from 3.5 to 2.1 and from 3.6 to 1.9, respectively. In several examinations decisive diagnostic features were only discernible in the high energy reconstructions. The density of the artefacts decreased from -882 to -341 HU.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
13. Kress AM, Schmidt R, Vogel T, Nowak TE, Forst R, Mueller LA. Quantitative computed tomography-assisted osteodensitometry of the pelvis after press-fit cup fixation: a prospective ten-year follow-up. *J Bone Joint Surg Am*. 2011;93:1152-1157.	Review/Other-Dx	24 hips	To analyze the periprosthetic acetabular cortical and cancellous bone density changes at 10 years after implantation of a press-fit cup.	All acetabular cups showed radiographic signs of stable ingrowth, and no acetabular component had to be revised. The loss of periacetabular cancellous bone density about the cup was as much as -37% cranially, -60% ventrally, and -71% dorsally; the decrease was progressive between the 1-year and 3-year examinations only. In contrast, cortical bone density above the dome of the acetabular cup remained constant throughout the 10-year follow-up. A moderate change in cortical bone density of -5% to -18% was seen at the level of the cup 10 years postoperatively.	4
14. Pitto RP, Mueller LA, Reilly K, Schmidt R, Munro J. Quantitative computer-assisted osteodensitometry in total hip arthroplasty. *Int Orthop.* 2007;31:431-438.	Review/Other-Dx	N/A	To review role of quantitative computer-assisted osteodensitometry in assessing the in vivo structural bone changes after THA.	Quantitative CT-assisted osteodensitometry has been shown to be useful in assessing the in vivo structural bone changes after THA. It has a high resolution, accuracy and reproducibility, thereby making it a useful tool for research purposes, and it is able to differentiate between cortical and cancellous bone structures and assess the bone/implant interface.	4
15. Chang SD, Lee MJ, Munk PL, Janzen DL, MacKay A, Xiang QS. MRI of spinal hardware: comparison of conventional T1-weighted sequence with a new metal artifact reduction sequence. *Skeletal Radiol.* 2001;30:213-218.	Review/Other-Dx	10 patients	To compare diagnostic quality of MRIs of patients with spinal hardware acquired using a conventional T1-weighted spin-echo sequence and a new MARS.	The new MARS sequence effectively reduces the degree of tissue-obscuring artifact produced by spinal fixation hardware and subjectively improves image quality compared with the conventional T1-weighted spin-echo sequence.	4
16. Eustace S, Goldberg R, Williamson D, et al. MR imaging of soft tissues adjacent to orthopaedic hardware: techniques to minimize susceptibility artefact. *Clin Radiol.* 1997;52:589-594.	Review/Other-Dx	N/A	To outline a practical approach to imaging patients following orthopaedic hardware fixation and discuss techniques that may be utilized to minimize induced image degradation.	Recommendations for improved imaging of orthopaedic hardware are as follows: (1) image with a low field strength system, (2) select imaging plane to minimize amount of metal in sections, (3) select frequency encoding gradient to orientate axis of susceptibility artifact, and (4) use fast spin-echo sequences.	4
17. Eustace S, Jara H, Goldberg R, et al. A comparison of conventional spin-echo and turbo spin-echo imaging of soft tissues adjacent to orthopedic hardware. *J Bone Joint Surg Am.* 1998;170:455-458.	Observational-Dx	28 patients	To compare conventional spin-echo and turbo spin-echo imaging of soft tissues adjacent to orthopedic hardware.	Turbo spin-echo imaging decreased susceptibility artifact and improved visualization of soft tissues adjacent to the orthopedic hardware component in 20/28 cases (k= .97, P<.00l).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
18. Kolind SH, MacKay AL, Munk PL, Xiang QS. Quantitative evaluation of metal artifact reduction techniques. *J Magn Reson Imaging.* 2004;20:487-495.	Review/Other-Dx	Nonmetallic replicas of 2 metal implants (stainless steel and titanium/chromium-cobalt femoral prostheses)	To develop a technique to quantify artifact, and to use it to compare the effectiveness of several approaches to MAR, including view angle tilting and increasing the slice select and image bandwidths, in terms of MAR, noise, and blur.	Increasing the image bandwidth from +/-16 kHz to +/-64 kHz was found to reduce the artifact by an average of 60%, while employing view angle tilting alone was found to reduce the artifact by an average of 63%. The MARS, which combines several susceptibility artifact reduction techniques, resulted in the least amount of image distortion, reducing the artifact by an average of 79%.	4
19. Lee MJ, Janzen DL, Munk PL, MacKay A, Xiang QS, McGowen A. Quantitative assessment of an MR technique for reducing metal artifact: application to spin-echo imaging in a phantom. *Skeletal Radiol.* 2001;30:398-401.	Review/Other-Dx	2 metal phantoms (titanium/chromium-cobalt and stainless steel femoral prostheses)	To quantify image artifact reduction using a new technique (MARS) in vitro.	Conventional T1-weighted images produced 87% more low signal artifact and 212% more high signal artifact compared with the MARS modified T1-weighted images of the stainless steel prosthesis. Conventional T1-weighted images of the titanium prosthesis produced 84% more low signal artifact and 211% more high signal artifact than the MARS modified sequence. The level of artifact reduction was essentially uniform for the various threshold levels tested and was greatest at +/- 20% the global signal intensity average for water.	4
20. Olsen RV, Munk PL, Lee MJ, et al. Metal artifact reduction sequence: early clinical applications. *Radiographics.* 2000;20:699-712.	Review/Other-Dx	N/A	To review clinical applications of MARS.	In patients with persistent pain after femoral neck fracture, the MARS technique allows visualization of marrow adjacent to hip screws, thus enabling diagnosis or exclusion of avascular necrosis. In the knee, the MARS technique allows visualization of structures adjacent to implanted metal staples, pins, or screws. The technique can significantly improve visualization of periprosthetic bone and soft-tissue structures even in patients who have undergone total knee arthroplasty. In patients with spinal fixation hardware, the MARS technique frequently allows visualization of the vertebral bodies and spinal canal contents. The technique can be helpful after wrist fusion or screw fixation of scaphoid fractures.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
21. Potter HG, Nestor BJ, Sofka CM, Ho ST, Peters LE, Salvati EA. Magnetic resonance imaging after total hip arthroplasty: evaluation of periprosthetic soft tissue. *J Bone Joint Surg Am*. 2004;86-A:1947-1954.	Review/Other-Dx	28 hips in 27 patients	To investigate the use of modified MRI techniques involving commercially available software to visualize periprosthetic soft tissues, to define the bone-implant interface, and to detect the location and extent of osteolysis.	MRI demonstrated the bone-implant interface and the surrounding soft-tissue envelope in all hips. Radiographs consistently underestimated the extent and location of acetabular osteolysis when compared with MRI. MRI also disclosed radiographically occult extraosseous soft-tissue deposits that were similar in signal intensity to areas of osteolysis, demonstrated the relationship of these deposits to adjacent neurovascular structures, and allowed further visualization of hypertrophic synovial deposits that accompanied the bone resorption in 25/28 hips.	4
22. Toms AP, Smith-Bateman C, Malcolm PN, Cahir J, Graves M. Optimization of metal artefact reduction (MAR) sequences for MRI of total hip prostheses. *Clin Radiol.* 2010;65:447-452.	Review/Other--Dx	Phantom	To describe the relative contribution of matrix size and bandwidth to artifact reduction in order to define optimal sequence parameters for MARS for MRI of total hip prostheses.	Over 90% of the achievable reduction in artifacts was obtained with matrixes of 256x256 or greater and a receiver bandwidth of approximately 400Hz/pixel or greater. Thereafter increasing the receiver bandwidth or matrix had little impact on reducing susceptibility artifacts. Increasing the bandwidth produced a relative fall in the signal-to-noise ratio of between 49% and 56% for a given matrix, but, in practice, the image quality was still satisfactory even with the highest bandwidth and largest matrix sizes. The acquisition time increased linearly with increasing matrix parameters.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
23. White LM, Kim JK, Mehta M, et al. Complications of total hip arthroplasty: MR imaging-initial experience. *Radiology.* 2000;215:254-262.	Review/Other-Dx	14 metal hip implants in 12 patients	To investigate the use of standard MRI with simple parameter modifications for the detection and characterization of THA complications.	Phantom study results showed improved periprosthetic tissue depiction with use of thin sections, increased frequency-encoding gradient strength, and fast spin-echo sequences. The clinical study results demonstrated periprosthetic abnormalities in 11 cases: mechanical loosening in 2 cases (including 1 case with an associated periprosthetic fracture); granulomatosis, 8; and infection, 1. In 100% of cases, tissue depiction around the femoral component was judged to be of "diagnostic quality." Tissue depiction around the acetabular component was of diagnostic quality in 5 (36%) cases. In all 7 surgically confirmed cases, a correct diagnosis was made preoperatively with MRI.	4
24. Lee MJ, Kim S, Lee SA, et al. Overcoming artifacts from metallic orthopedic implants at high-field-strength MR imaging and multi-detector CT. *Radiographics.* 2007;27(3):791-803.	Review/Other-Dx	N/A	To survey the factors that affect metal implant–related artifacts and review the theories and techniques of artifact reduction at 3.0-T MRI and multidetector CT.	No results stated in abstract.	4
25. Sutter R, Ulbrich EJ, Jellus V, Nittka M, Pfirrmann CW. Reduction of metal artifacts in patients with total hip arthroplasty with slice-encoding metal artifact correction and view-angle tilting MR imaging. *Radiology.* 2012;265(1):204-214.	Observational-Dx	40 patients between March and May 2011; 15 patients between January and February 2012	To compare the new “warp” sequence (slice-encoding metal artifact correction, view-angle tilting, and increased bandwidth) for the reduction of both through-plane and in-plane MRI artifacts with current optimized MR sequences in patients with THA.	Signal void around the acetabular component was smaller for STIR-warp than STIR-high bandwidth images (21.6 cm2 vs 42.4 cm2; *P*=.0001), and for T1-warp than T1-high bandwidth images (17.6 cm2 vs 20.2 cm2; *P*=.0001). Anatomic distinction was better on STIR-warp compared with STIR-high bandwidth images (1.9–2.8 vs 3.6–4.6; *P*=.0001), and on T1-warp compared with T1-high bandwidth images (1.3–2.8 vs 1.8–3.2; *P*<.002). Distortion, blurring, and noise were lower with warp sequences than with the standard sequences (*P*=.0001). Almost half of the abnormal imaging findings were missed on STIR-high bandwidth compared with STIR-warp images (55 vs 105 findings; *P*=.0001), while T1-high bandwidth was similar to T1-warp imaging (50 vs 55 findings; *P*=.06).	2

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26. Brodner W, Bitzan P, Lomoschitz F, et al. Changes in bone mineral density in the proximal femur after cementless total hip arthroplasty. A five-year longitudinal study. *J Bone Joint Surg Br.* 2004;86:20-26.	Review/Other-Dx	100 patients	To prospectively investigate the BMD of the proximal femur after implantation of a tapered rectangular cementless stem in patients with a mean age of 60 years (16 to 87).	The BMD increased significantly in Gruen zones 2, 4 and 5 by 11%, 3% and 11% respectively, and decreased significantly in Gruen zones 1, 6 and 7 by 3%, 6% and 14% respectively, over the 5-year period. The net mean BMD did not change over this time period. The changes in the BMD were not confined to the first 12 months after surgery. This investigation revealed no change in the overall periprosthetic BMD, but demonstrated a regional redistribution of bone mass from the proximal to distal zones.	4
27. Albanese CV, Santori FS, Pavan L, Learmonth ID, Passariello R. Periprosthetic DXA after total hip arthroplasty with short vs. ultra-short custom-made femoral stems: 37 patients followed for 3 years. *Acta Orthop.* 2009;80:291-297.	Review/Other-Dx	37 patients	To assess the value of dual X-ray absorptiometry after cementless primary THA by comparing the effect of progressive shortening of the stem of 2 femoral implants on periprosthetic bone remodeling using a specifically developed protocol of analysis with 5 periprosthetic regions of interest.	The authors found that progressive shortening of the femoral stem produces more proximal loading, which effectively preserves metaphyseal bone stock and increases periprosthetic BMD in the medial regions of interest over time. In the type 2 group, higher absolute BMD values were observed in medial regions of interest 4 and 5. No differences were found in regions of interest 1, 2, and 3.	4
28. Love C, Marwin SE, Palestro CJ. Nuclear medicine and the infected joint replacement. *Semin Nucl Med.* 2009;39:66-78.	Review/Other-Dx	N/A	Review hip and knee arthroplasties and differentiating aseptic loosening, the most common cause of prosthetic joint failure, from infection.	No results stated in abstract.	4
29. Palestro CJ, Love C, Tronco GG, Tomas MB, Rini JN. Combined labeled leukocyte and technetium 99m sulfur colloid bone marrow imaging for diagnosing musculoskeletal infection. *Radiographics.* 2006;26:859-870.	Review/Other-Dx	N/A	To review combined labeled leukocyte and Tc-99m sulfur colloid bone marrow imaging for diagnosing musculoskeletal infection.	Combined WBC-marrow imaging is a very accurate technique for diagnosing osteomyelitis.	4
30. Joseph TN, Mujtaba M, Chen AL, et al. Efficacy of combined technetium-99m sulfur colloid/indium-111 leukocyte scans to detect infected total hip and knee arthroplasties. *J Arthroplasty.* 2001;16:753-758.	Observational-Dx	58 patients	To investigate the reliability of combined In-111 leukocyte/Tc-99m sulfur colloid scans, with and without the addition of blood pooling and blood flow studies, in the diagnosis of infected total joint arthroplasty.	Results for imaging alone included 100% specificity, 46% sensitivity, 100% PPV, 84% NPV, and 88% accuracy. Inclusion of blood pooling and flow phase data improved results to 66% sensitivity, 89% NPV, and 90% accuracy, with reductions in specificity (98%) and PPV (91%). Routine use of these radionuclide scans is not supported by these data.	3

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
31. Delank KS, Schmidt M, Michael JW, Dietlein M, Schicha H, Eysel P. The implications of 18F-FDG PET for the diagnosis of endoprosthetic loosening and infection in hip and knee arthroplasty: results from a prospective, blinded study. *BMC Musculoskelet Disord.* 2006;7:20.	Observational-Dx	27 patients	To evaluate the clinical value of FDG PET as a diagnostic modality for inflammation and loosening in hip and knee joint prostheses.	Evidence of loosening was correctly determined in 76.4% of cases using FDG-PET, and in 75% of cases using bone scan. The detection of periprosthetic inflammation using FDG-PET had a sensitivity of 100% for septic cases and of 45.5% in cases of increased abrasion and aseptic foreign-body reactions. However, reliable differentiation between abrasion-induced and bacterial-caused inflammation was not possible using FDG-PET.	3
32. Reinartz P. FDG-PET in patients with painful hip and knee arthroplasty: technical breakthrough or just more of the same. *Q J Nucl Med. Mol Imaging.* 2009;53:41-50.	Review/Other-Dx	N/A	To evaluate the pooled data of the major publications in the English literature analyzing the accuracy of the TPBS, WBC imaging and PET.	The data indicate that PET is a highly effective imaging procedure for diagnosing complications of hip and knee arthroplasty. Its only limitations are the restricted availability and the costs. Whether the same holds true for PET/CT has yet to be proven. While the hybrid devices are highly beneficial in oncology, their use in the diagnosis of pathological processes of joint prostheses is questionable due to the CT artifacts induced by the metallic implants. WBC imaging on the other hand has to be considered as gold standard since it yields the highest accuracy of the 3 diagnostic approaches, especially when combined with bone marrow scintigraphy. In departments where neither the equipment nor the know-how for PET and WBC imaging is available, TPBS is a viable alternative. Compared to the other diagnostic approaches it yields a slightly lower accuracy, but excels in simplicity and cost-effectiveness. Especially in knee prostheses, it nearly reaches the accuracy of WBC imaging and PET (TPBS 81%, WBC imaging 84%, PET 83%).	4
33. Even-Sapir E, Mishani E, Flusser G, Metser U. 18F-Fluoride positron emission tomography and positron emission tomography/computed tomography. Semin Nucl Med. 2007;37(6):462-469.	Review/Other-Dx	N/A	To review the role of 18F-fluoride PET/CT in the assessment of metabolic bone diseases and other pathological bone conditions.	The results of a few recent publications suggest that18F-fluoride PET/CT is a valuable modality in the diagnosis of pathological osseous conditions in patients also referred for nononcologic indications. 18F-fluoride PET and PET/CT are, however, not widely used in clinical practice.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
34. Ullmark G, Nilsson O, Maripuu E, Sorensen J. Analysis of bone mineralization on uncemented femoral stems by [18F]-fluoride-PET: a randomized clinical study of 16 hips in 8 patients. *Acta Orthop.* 2013;84(2):138-144.	Experimental-Dx	16 hips in 8 patients; 12 controls	Randomized study using F-18 fluoride PET/CT analysis for detection of bone mineralization adjacent to 2 different brands of hip prosthesis (SL-PLUS and BetaCone stems).	The clinical results were good at 2 years. By radiography, all stems were stable. At PET analyses 1 week after surgery, the activity was higher for the SL-PLUS group than for the BetaCone group. The activity was statistically significantly higher for both stems than the reference values at 4 months, and was most pronounced in the upper femur. At 1 year, the activity had declined more for the BetaCone group than for the SL-PLUS group.	1
35. Ullmark G, Sundgren K, Milbrink J, Nilsson O, Sorensen J. Osteonecrosis following resurfacing arthroplasty. *Acta Orthop.* 2009;80(6):670-674.	Review/Other-Dx	14 patients	To analyze bone metabolism and viability during the first year after resurfacing arthroplasty using F-18 fluoride PET/CT scans.	1 patient had a minor region of osteonecrosis on PET scan at 1 week and at 4 months. After 1 year, the necrosis had increased to include most of the head. 2 other patients, normal at 4 months, had developed equally large osteonecrosis at 1 year. A fourth patient had a minor osteonecrosis at 1 year. None of the patients had clinical symptoms, and the necrotic areas were not visible on plain radiographs.	4
36. Ullmark G, Sorensen J, Nilsson O. Analysis of bone formation on porous and calcium phosphate-coated acetabular cups: a randomised clinical [18F]fluoride PET study. *Hip Int.* 2012;22(2):172-178.	Experimental-Dx	16 THAs (8 patients) 13 controls	To analyze bone formation on porous and calcium phosphate-coated acetabular cups using F-18 fluoride PET/CT.	Bone forming activity had a mean of 5.71, 4.69 and 3.47 SUV around the calcium phosphate coated and 5.04, 4.80 and 3.50 SUV around the porous-coated-cups at 1 week, 4 months and 12 months, respectively. Normal bone metabolism was 3.68 SUV. After 1 year activity had declined to normal levels for both groups. The clinical results were good in all cases. Calcium phosphate coating resulted in higher uptake indicating higher bone forming activity after 1 week. F-18 fluoride PET/CT is a valuable tool to analyze bone formation and secondary stabilization of an acetabular cup.	1
37. Kobayashi N, Inaba Y, Choe H, et al. Use of F-18 fluoride PET to differentiate septic from aseptic loosening in total hip arthroplasty patients. Clin Nucl Med. 2011;36:e156-161.	Observational-Dx	65 joints	FDG-PET was used to evaluate THA cases with stable, septic or septic loosened implants to assess the possibility of differentiating these clinical settings using a novel uptake-type classification approach.	There were significant differences found between the SUVmax values for the aseptic and septic loosening THA cases. In the diagnosis of infection with type 3 pattern, the sensitivity and specificity were measured at 0.95 and 0.98 for all cases, and 0.95 and 0.88 for surgically treated cases, respectively.	3

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38. Miller TT. Imaging of hip arthroplasty. *Semin Musculoskelet Radiol.* 2006;10(1):30-46.	Review/Other-Dx	N/A	To review the appearance of normal hip arthroplasty as well as the appearances of potential complications.	No results stated in abstract.	4
39. Douis H, Dunlop DJ, Pearson AM, O'Hara JN, James SL. The role of ultrasound in the assessment of post-operative complications following hip arthroplasty. *Skeletal Radiol.* 2012;41:1035-1046.	Review/Other-Dx	N/A	To describe the common surgical approaches used during hip arthroplasty as this can influence the nature and location of subsequent complications. A review of the literature is presented along with the imaging appearances frequently encountered when imaging this patient population.	No results stated in abstract.	4
40. Mulhall KJ, Masterson E, Burke TE. Routine recovery room radiographs after total hip arthroplasty: ineffective for screening and unsuitable as baseline for longitudinal follow-up evaluation. *J Arthroplasty.* 2004;19(3):313-317.	Observational-Dx	2,065 consecutive THA patients	To assess the usefulness of traditional recovery room check radiographs after THA.	The authors found a 0.1% rate of radiologic diagnosis of dislocation in the population screened. In 100 patients randomly selected for comparison, the image quality in the recovery room radiographs was significantly inferior to standardized departmental radiographs ($P<.001$), with further significant differences between cup version ($P<.001$), and stem alignment assessments ($P=.002$). There was good agreement between the authors in the assessments of these radiographs with a weighted kappa statistic of 0.8653 ($P<.0001$). 7 recovery room radiographs needed repetition for poor quality vs none of the departmental films ($P=.007$).	3
41. Ndu A, Jegede K, Bohl DD, Keggi K, Grauer JN. Recovery room radiographs after total hip arthroplasty: tradition vs utility? *J Arthroplasty.* 2012;27(6):1051-1056.	Observational-Dx	632 patients	First, to determine the rate of adequacy for images taken in the post anesthesia care unit. Second, to determine the rate at which post anesthesia care unit radiographs uncover technical issues that require immediate (before the patient leaves the post anesthesia care unit) correction.	In a review of 632 consecutive recovery room series, the authors found that 17% of series were inadequate to detect technical issues. The authors identified technical issues on 12 series (1.9%) and technical issues that impacted inpatient management on 2 series (0.3%). 1 of these 2 was a dislocation that was detected clinically before imaging. The other was a medial penetration of an acetabular screw that probably did not require the immediate revision that it received. Findings suggest that the single routine inpatient series should be taken in the radiology suite, rather than in the recovery room.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
42. Total hip replacement. NIH Consens Statement 1994;12:1-31.	Review/Other-Dx	N/A	To provide physicians with a current consensus on total hip replacement.	Total hip replacement is an option for nearly all patients with diseases of the hip that cause chronic discomfort and significant functional impairment. Most patients have an excellent prognosis for long-term improvement in symptoms and physical function. At this time, a cemented femoral component using modern cementing techniques, paired with a porous-coated acetabular component, can give excellent long-term results. Revision of a total hip replacement is indicated when mechanical failure occurs. Continued periodic follow-up is necessary to identify early evidence of impending failure so as to permit remedial action before a catastrophic event.	4
43. Roder C, Eggli S, Aebi M, Busato A. The validity of clinical examination in the diagnosis of loosening of components in total hip arthroplasty. *J Bone Joint Surg Br.* 2003;85:37-44.	Observational-Dx	18,486 primary THAs	Follow-up data from primary THAs performed between 1967 and 2001 was analyzed to assess the validity of clinical procedures in diagnosing loosening of prosthetic components.	The prevalence of acetabular loosening increased from 0.6% to 13.9% during the period of the study and that of femoral loosening from 0.9% to 12.1%. Sensitivities and PPVs were low, suggesting that clinical procedures could not replace radiological assessment in the identification of loose prostheses. Specificities and NPVs were constantly above 0.86. The possibility of there being a prosthesis which is not loose in asymptomatic patients was consequently very high, particularly during the first 5- to 6-years after operation.	3
44. Position Statement on the Follow-up of Hip and Knee Arthroplasty. Australian Orthopedic Association. 2012; Available at: http://www.aoa.org.au/docs/subspecialties/arthposfollow_200812.pdf?sfvrsn=2. Accessed September 30, 2015.	Review/Other-Dx	N/A	Position statement on the follow-up of hip and knee arthroplasty by the Australian Orthopaedic Association.	On the basis of the available evidence and on the advice of orthopaedic experts, the TGA(therapeutic goods administration) recommends that patients with metal-on-metal hips implants be followed up regularly (at least annually in some cases) and that, in addition to soft tissue imaging, such as ultrasound and/or MRI, the follow-ups should include blood tests for cobalt and chromium.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Hacking C, Weinrauch P, Whitehouse SL, Crawford RW, Donnelly WJ. Is there a need for routine follow-up after primary total hip arthroplasty? *ANZ J Surg*. 2010;80:737-740.	Review/Other-Dx	158 patients	To determine if there is the need for routine follow-up after primary THA.	110 THAs in 104 patients (average age 70.4 (SD 9.8 years)). There were 70 (63.6%) in total, 13 (11.8%) femoral and 27 (24.5%) acetabular revisions. The indications for revision were aseptic loosening (70%), dislocation (8.2%), peri-prosthetic fracture (7.3%), osteolysis (6.4%) and infection (4.5%). Only 4 (3.6%) were asymptomatic revisions. A mean of 5.3 (SD 5.2 and 1.9 (SD 5.3)) follow-up appointments were required before revision in patients with and without symptoms, respectively. The average time from the primary to revision surgery was 11.8 (SD 7.23) years.	4
46. Bolz KM, Crawford RW, Donnelly B, Whitehouse SL, Graves N. The cost-effectiveness of routine follow-up after primary total hip arthroplasty. *J Arthroplasty*. 2010;25:191-196.	Review/Other-Dx	30, 440 primary THA	A decision-analytic Markov model was used to compare the costs and health outcomes of 3 different follow-up strategies after primary THA.	If there is no routine follow-up of patients for 7 years after primary THA, there would be cost savings between AU$6.5 and $11.9 million and gains of between 1.8 and 8.8 quality-adjusted life years.	4
47. FDA Safety Communication: Metal-on-Metal Hip Implants. 2013; Available at: http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm335775.htm. Accessed September 30, 2015.	Review/Other-Dx	N/A	Updated safety information and recommendations to patients and health care providers by FDA on MoM hip implants.	N/A	4
48. Stulberg SD, Wixson RL, Adams AD, Hendrix RW, Bernfield JB. Monitoring pelvic osteolysis following total hip replacement surgery: an algorithm for surveillance. *J Bone Joint Surg Am*. 2002;84-A Suppl 2:116-122.	Review/Other-Dx	120 hips (108 patients)	To determine the prevalence of CT scan-identifiable osteolysis in young, active patients with a single cup design after a minimum duration of follow-up of 7 years.	42 (52.5%) of the 80 hips had no osteolysis (Group I) on the CT scan, 29 (36.3%) had cavitary osteolysis (Group II), and 9 (11.3%) had segmental osteolysis (Group III). The osteolysis was most prevalent in Gruen zone I. In Group I, no patient had osteolysis on either the CT scan or the radiographs. In Group II, the osteolysis was understated on 9 (31%) of the 29 AP radiographs and was not evident on17 (59%). In Group III, the osteolysis was understated on 6/9 AP radiographs and was not evident on 2.	4
49. Cooper HJ, Ranawat AS, Potter HG, Foo LF, Koob TW, Ranawat CS. Early reactive synovitis and osteolysis after total hip arthroplasty. *Clin Orthop Relat Res*. 2010;468:3278-3285.	Review/Other-Dx	31 patients (33 hips)	To determine the incidence of early reactive synovitis and osteolysis in asymptomatic patients after THA, and whether there is an association between these MRI findings and clinical outcomes or radiographic wear measurements at this early stage.	Reactive synovitis was observed in 13 of 33 patients (39%) and focal osteolysis in 1 of 33 (3%). The presence of synovitis did not correlate with pain, activity level, patient satisfaction or clinical outcome scales, nor did it correlate with radiographic wear measurements at early follow-up.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
50. Mistry A, Cahir J, Donell ST, Nolan J, Toms AP. MRI of asymptomatic patients with metal-on-metal and polyethylene-on-metal total hip arthroplasties. *Clin Radiol.* 2011;66:540-545.	Review/Other-Dx	22 total hip replacements in 20 asymptomatic patients	To define and compare MRI findings of asymptomatic patients with MoM and polyethylene-on-metal total hip replacements.	A range of MRI abnormalities are present in normal asymptomatic total hip replacements but the increased frequency of these associated with MoM total hip replacement suggest that some of these changes might represent subclinical disease.	4
51. Utz JA, Lull RJ, Galvin EG. Asymptomatic total hip prosthesis: natural history determined using Tc-99m MDP bone scans. *Radiology.* 1986;161:509-512.	Review/Other-Dx	97 patients	To determine the normal postoperative appearance of radionuclide scans of the hip following administration of Tc-99m MDP.	Results showed that 6 months after implantation activity around the lesser trochanter and prosthesis shaft became insignificant. Activity around the acetabulum, greater trochanter, and prosthesis tip stabilized approximately 2 years after surgery; approximately 10% of patients in the study had persistent activity in these areas. Familiarity with this normal progression is fundamental to interpretation of postoperative bone scans in patients with total hip prosthesis.	4
52. Oswald SG, Van Nostrand D, Savory CG, Callaghan JJ. Three-phase bone scan and indium white blood cell scintigraphy following porous coated hip arthroplasty: a prospective study of the prosthetic tip. *J Nucl Med.* 1989;30:1321-1331.	Review/Other-Dx	25 uncomplicated porous coated hip arthroplasties in 21 patients	Patients were prospectively studied using TPBS and In-111-labeled WBC scintigraphy to establish the natural history of scintigraphic changes following uncomplicated porous coated hip arthroplasty.	Only 1 of 136 flow studies were abnormal and only 2 of 136 blood-pool images demonstrated focally increased activity. All 25 prostheses (120/143 scans) demonstrated increased uptake on the bone phase images. The area about the tip was divided into 3 segments; increased uptake at 24 months was noted in the medial, distal, and lateral segments in 16%, 72%, and 56% of prostheses, respectively. 20/25 prostheses (82/142 scans) showed uptake on In-111-WBC scintigraphy, being noted in 48% of prostheses at 24 months.	4
53. Patel SR, Toms AP, Rehman JM, Wimhurst J. A reliability study of measurement tools available on standard picture archiving and communication system workstations for the evaluation of hip radiographs following arthroplasty. *J Bone Joint Surg Am.* 2011;93(18):1712-1719.	Observational-Dx	50 AP pelvic and lateral hip radiographs	To assess the reliability of commonly used measurements of the position of hip prostheses on postoperative radiographs with use of tools available on all standard picture archiving and communication system workstations.	The results demonstrated excellent reliability for acetabular angle (r = 0.95), lower-limb length (r = 0.91), and lateral offset (r = 0.95) measurements and good reliability for center of rotation (r = 0.73) and lateral femoral stem angle (r = 0.68) measurements.	2

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
54. Lee YK, Kim TY, Ha YC, Kang BJ, Koo KH. Radiological measurement of femoral stem version using a modified Budin method. *Bone Joint J.* 2013;95-B(7):877-880.	Observational-Dx	36 patients	To propose a radiological method to measure stem version and assess its reliability and validity.	The mean radiological measurement was 13.36 degrees (SD 6.46) and the mean CT measurement was 12.35 degrees (SD 6.39) (*P*=0.096). The intra- and interobserver reliabilities were excellent for both measurements. The radiological measurements correlated well with the CT measurements (*P*=0.001, r = 0.877). The modified Budin method appears reliable and valid for the measurement of femoral stem anteversion.	1
55. Lu M, Zhou YX, Du H, Zhang J, Liu J. Reliability and validity of measuring acetabular component orientation by plain anteroposterior radiographs. *Clin Orthop Relat Res.* 2013;471(9):2987-2994.	Observational-Dx	60 patients	To evaluate the reliability and validity of measuring the orientation of acetabular components on plain AP radiographs.	Inter- and intraobserver reliability for measuring component orientation on plain AP radiographs was nearly perfect with ICCs of 0.896 and 0.969 for anteversion and 0.984 and 0.993 for inclination. Measurement of cup inclination angles differed between plain radiographs and CT scans, but the difference was small, and the difference, although statistically significant, probably was not clinically important (2.3 degrees +/- 1.8 degrees, *P*<0.001). There was no significant difference between the anteversion as measured on CT scan vs that measured on plain radiographs (*P*=0.19).	3
56. Nho JH, Lee YK, Kim HJ, Ha YC, Suh YS, Koo KH. Reliability and validity of measuring version of the acetabular component. *J Bone Joint Surg Br.* 2012;94(1):32-36.	Observational-Dx	36 patients	To evaluate the reliability and validity of 6 methods (those of Lewinnek; Widmer; Hassan et al; Ackland, Bourne and Uhthoff; Liaw et al; and Woo and Morrey) that are currently in use.	All measurements on both radiographs and CT scans had excellent intra- and interobserver reliability and the results from each of the 6 methods correlated well with the CT measurements. However, measurements made using the methods of Widmer and of Ackland, Bourne and Uhthoff were significantly different from the CT measurements (both *P*<0.001), whereas measurements made using the remaining 4 methods were similar to the CT measurements.	2

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
57. McArthur B, Cross M, Geatrakas C, Mayman D, Ghelman B. Measuring acetabular component version after THA: CT or plain radiograph? *Clin Orthop Relat Res.* 2012;470(10):2810-2818.	Observational-Dx	27 Sawbones pelvis	To determine whether appropriately positioned cross-table lateral radiographs could provide accurate measurements of acetabular component version, and compared accuracy and reliability of measurements from modified cross-table lateral radiographs with those from standard cross-table lateral radiographs and CT.	Interobserver and intraobserver reliabilities were greater than 0.95 (95% CI, 0.904–0.999) for all measurements. Correlation with navigated values was 0.96 or greater (95% CI, 0.925–0.998) for all methods. Although CT had the highest correlation with navigated values, the correlations for the modified cross-table lateral and cross-table lateral radiographs were similar.	1
58. Marx A, von Knoch M, Pfortner J, Wiese M, Saxler G. Misinterpretation of cup anteversion in total hip arthroplasty using planar radiography. *Arch Orthop Trauma Surg.* 2006;126(7):487-492.	Observational-Dx	42 patients	To clarify whether planar radiography can be used for accurate evaluation of the THA position.	The comparison showed that all 5 formulas presented substantial variations for the anteversion angle. Of these, Widmer's algorithm presented the smallest difference compared to the CT. Misinterpretation of postoperative planar radiographs is a common problem in THA.	3
59. Murray DW. The definition and measurement of acetabular orientation. *J Bone Joint Surg Br.* 1993;75(2):228-232.	Review/Other-Dx	N/A	To analyze the differences between the definitions of acetabular orientation and provide nomograms to convert from 1 to another.	It is recommended that the operative definitions be used to describe the orientation of prostheses and that the anatomical definitions be used for dysplastic acetabula.	4
60. Ghelman B, Kepler CK, Lyman S, Della Valle AG. CT outperforms radiography for determination of acetabular cup version after THA. *Clin Orthop Relat Res.* 2009;467(9):2362-2370.	Observational-Dx	42 patients	To retrospectively study patients, who underwent THAs, with multiple cross-table lateral radiographs and CT scans to determine whether radiographic or CT measurement of acetabular component version is more accurate.	ICCs for anteversion measurements of 2 observers were 0.9990 and 0.9998, respectively, when comparing measurements of identical radiographs (intraobserver). Paired values for 2 observers measuring the same radiograph had an ICC of 0.9686 (interobserver) compared with 0.7412 for measurements from serial radiographs of the same component. The ICC comparing radiographic vs CT-based measurements was 0.6981. CT measurements had stronger correlations with navigated values than radiographic measurements. Accuracy of anteversion measurements on cross-table radiographs depends on radiographic technique and patient positioning whereas properly performed CT measurements are independent of patient position.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
61. Loftus M, Ma Y, Ghelman B. Acetabular Version Measurement in Total Hip Arthroplasty: the Impact of Inclination and the Value of Multi-Planar CT Reformation. HSS J. 2015;11(1):65-70.	Review/Other-Dx	60 total hip arthroplasties	To determine how traditional versus corrected measurements of acetabular version vary from one another based on the inclination of the cup and to determine the reliability of the corrected acetabular version measurements based on interobserver and intraobserver consistency.	The "traditional" axial CT and "corrected" acetabular version measurements differed from one another in every case, with the traditional method yielding a version measurement that was on average 9.5 degrees higher than the corrected technique. However, as the acetabular cup inclination angle decreased, the "traditional" measurement became more variable and increasingly discordant with the "corrected" version measurement.	4
62. Spangehl MJ, Younger AS, Masri BA, Duncan CP. Diagnosis of infection following total hip arthroplasty. *Instr Course Lect.* 1998;47:285-295.	Review/Other-Dx	N/A	To review diagnosis of infection following THA.	No results stated in abstract.	4
63. Ong KL, Kurtz SM, Lau E, Bozic KJ, Berry DJ, Parvizi J. Prosthetic joint infection risk after total hip arthroplasty in the Medicare population. *J Arthroplasty.* 2009;24:105-109.	Review/Other-Dx	887 THA infections identified from 39,929 THA patients	To evaluate the incidence of early-onset (<2 years) and late-onset (>2 years) periprosthetic joint infection after primary THA.	The incidence of infection was 1.63% within 2 years and 0.59% between 2 and 10 years. Comorbidities, sex, procedure duration, and socioeconomic status were found to be significant risk factors.	4
64. Tunney MM, Patrick S, Gorman SP, et al. Improved detection of infection in hip replacements. A currently underestimated problem. *J Bone Joint Surg Br.* 1998;80:568-572.	Review/Other-Dx	120 patients	To determine if the detection rate of infection of total hip replacements could be improved by examining the removed prostheses.	Tissue removed from 18 of the culture-positive implants was suitable for quantitative tissue pathology and inflammatory cells were present in all samples. Furthermore, inflammatory cells were present in 87% of tissue samples taken from patients whose implants were culture-negative. This suggests that these implants may have been infected by bacteria which were not isolated by the techniques of culture used. The increased detection of bacteria from prostheses by culture has improved postoperative antibiotic therapy and should reduce the need for further revision.	4
65. Zimmerli W, Trampuz A, Ochsner PE. Prosthetic-joint infections. *N Engl J Med.* 2004;351:1645-1654.	Review/Other-Dx	N/A	To offer guidance in establishing the diagnosis of prosthetic joint infections correctly and an algorithm to summarize the appropriate medical and surgical options.	No results stated in abstract.	4
66. Parvizi J, Gehrke T. Definition of periprosthetic joint infection. *J Arthroplasty.* 2014;29(7):1331.	Review/Other-Dx	N/A	Editorial on the definition of periprosthetic joint infection.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
67. Tigges S, Stiles RG, Roberson JR. Appearance of septic hip prostheses on plain radiographs. *J Bone Joint Surg Am.* 1994;163:377-380.	Review/Other-Dx	20 hip prostheses	To evaluate the spectrum of plain radiographic findings in patients with septic hip prostheses.	Findings were normal in 10 prostheses, but nonfocal lucencies mimicking mechanical loosening were seen in 4 cases. 2 cases showed focal bone loss, indistinguishable from aggressive granulomatosis. A variety of findings, including subsidence and periostitis, were seen in the remaining 4 prostheses.	4
68. Cyteval C, Hamm V, Sarrabere MP, Lopez FM, Maury P, Taourel P. Painful infection at the site of hip prosthesis: CT imaging. *Radiology.* 2002;224:477-483.	Observational-Dx	65 patients	To prospectively determine the accuracy of CT in the detection of painful infection at the site of hip prosthesis before surgery. No intravenous contrast was administered.	Infection was detected clinically in 25% of patients. Periprosthetic bone abnormalities did not allow differentiation of infection from complications not related to sepsis, except for periostitis, with 100% specificity but only 16% sensitivity. Soft-tissue findings were accurate for detection of infection, with 100% sensitivity and 87% specificity. Fluid collection in muscles and perimuscular fat had a 100% PPV, and absence of joint distention had a 96% NPV.	2
69. Tomas X, Bori G, Garcia S, et al. Accuracy of CT-guided joint aspiration in patients with suspected infection status post-total hip arthroplasty. *Skeletal Radiol.* 2011;40:57-64.	Observational-Dx	63 patients	To determine the accuracy of guided CT aspiration in the detection of septic hip prosthesis before surgery. No intravenous contrast was administered.	All patients underwent revision surgery and infection was finally diagnosed in 33 patients. Statistical comparative analysis was performed comparing CT aspiration and surgical findings (95% CI; level of significance at P=0.05 2-sided) with 70% sensitivity, 100% specificity, 84% accuracy, 100% PPV, and 75% NPV. Using Fisher's exact test, the presence of periprosthetic fluid collections (P=0.001), prosthetic acetabular malposition (P=0.025) and aspirated fluid volume (P=0.009) were significantly higher in infected than in non-infected prostheses, whereas HO was not (P=0.429).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
70. Aliprandi A, Sconfienza LM, Randelli F, Bandirali M, Di Leo G, Sardanelli F. Magnetic resonance imaging of painful total hip replacement: detection and characterisation of periprosthetic fluid collection and interobserver reproducibility. *Radiol Med.* 2012;117:85-95.	Observational-Dx	19 patients	To demonstrate the diagnostic value of MRI when measuring and characterizing periprosthetic fluid collections in patients with painful hip prosthesis and to provide an estimation of interobserver reproducibility.	A total of 26 MRI studies were carried out (3 patients underwent 2 and 2 patients underwent 3 MRI examinations). Both readers detected soft tissue oedema (13/26, 50%) or fluid collection (21/26, 81%) and characterized the fluid as serous (9/21, 43%), purulent (8/21, 38%) or haematic (4/21, 19%). The collection involved skin/subcutaneous tissues (16/21, 76%), deep soft tissues (19/21, 91%) or the implant (12/21, 57%). For all evaluations, interobserver agreement was complete (=1). No significant differences were found between the measurements of the collections (P>0.258).	3
71. Plodkowski AJ, Hayter CL, Miller TT, Nguyen JT, Potter HG. Lamellated hyperintense synovitis: potential MR imaging sign of an infected knee arthroplasty. *Radiology.* 2013;266(1):256-260.	Observational-Dx	28 patients with proved infected total knee arthroplasty and 28 patients with noninfected arthroplasty	To determine the sensitivity and specificity of lamellated hyperintense synovitis for infection following knee arthroplasty and to determine the inter- and intraobserver variability of this sign at MRI.	The sensitivity of lamellated hyperintense synovitis for infection was 0.86–0.92 (95% CI: 0.75, 0.97) and the specificity was 0.85–0.87 (95% CI: 0.74, 0.94). There was almost perfect interobserver agreement (kappa = 0.82; 95% CI: 0.72, 0.93; *P*<0.001) and intraobserver agreement (for reader 1, kappa = 0.89 [95% CI: 0.78, 1.00; *P*<0.001] and for reader 2, kappa = 0.89 [95% CI: 0.77, 1.00; *P*<0.001]) in the classification of the synovial pattern.	2
72. Love C, Marwin SE, Tomas MB, et al. Diagnosing infection in the failed joint replacement: a comparison of coincidence detection18F-FDG and 111In-labeled leukocyte/99mTc-sulfur colloid marrow imaging. *J Nucl Med.* 2004;45:1864-1871.	Observational-Dx	59 patients	To investigate FDG imaging, using a coincidence detection system, for diagnosing prosthetic joint infection and to compare it with combined In-111-labeled leukocyte/Tc-99m-sulfur colloid marrow imaging in patients with failed lower extremity joint replacements.	25 (42%) prostheses, 14 hip and 11 knee, were infected. The sensitivity, specificity, and accuracy of FDG, by criterion, were as follows: criterion 1: 100%, 9%, 47%; criterion 2: 96%, 35%, 61%; criterion 3: 52%, 44%, 47%; criterion 4: 36%, 97%, 71%. The sensitivity, specificity, and accuracy of labeled leukocyte/marrow imaging were 100%, 91%, and 95%, respectively. WBC/marrow imaging, which was more accurate than any of the FDG criteria for all prostheses, as well as for hips and knees separately, was significantly more sensitive than criterion 3 (*P*<0.001) and criterion 4 (*P*<0.001) and was significantly more specific than criterion 1 (*P*<0.001), criterion 2 (*P*<0.001), and criterion 3 (*P*<0.001).	3

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
73. Larikka MJ, Ahonen AK, Junila JA, Niemela O, Hamalainen MM, Syrjala HP. Extended combined 99mTc-white blood cell and bone imaging improves the diagnostic accuracy in the detection of hip replacement infections. Eur *J Nucl Med.* 2001;28:288-293.	Observational-Dx	64 symptomatic patients	To evaluate whether extending the time for Tc-99m labeled leucocyte imaging to 24 hours post injection improves the accuracy of diagnosis of hip replacement infections.	There were 6 confirmed infections. All the bone imaging methods had a sensitivity of 100% in detecting prosthesis infections whereas the specificity varied from only 2% to 82%. Routine leucocyte imaging was less sensitive (50% vs 83%) and less specific (90% vs 100%) than late leucocyte imaging. All tests had a high NPV for excluding infection (95%-100%). However, both bone (10%-38%) and routine leucocyte imaging (33%) showed a poor PPV, whereas late leucocyte imaging had a PPV of 100% and a diagnostic accuracy of 98%.	3
74. Tehranzadeh J, Gubernick I, Blaha D. Prospective study of sequential technetium-99m phosphate and gallium imaging in painful hip prostheses (comparison of diagnostic modalities). *Clin Nucl Med.* 1988;13:229-236.	Observational-Dx	22 hip prostheses in 21 patients	22 painful hip prostheses were studied prospectively with plain radiography, aspiration and arthrography, Tc-99m phosphate bone imaging, and gallium imaging to evaluate loosening, infection, or both and to compare the accuracy of these modalities.	15 prostheses were revised yielding 14 loose femoral and 8 loose acetabular components. 5 proved to have infected prostheses. Arthrograms, plain radiographs, and bone scans are highly sensitive in detecting loosening of the femoral component.	3
75. Aliabadi P, Tumeh SS, Weissman BN, McNeil BJ. Cemented total hip prosthesis: radiographic and scintigraphic evaluation. *Radiology.* 1989;173:203-206.	Observational-Dx	44 patients	To review conventional radiographs, Tc-99m bone scans, and gallium-67 scans in patients who had undergone cemented total hip joint replacement.	A complete radiolucent line of 2 mm or wider along the bone-cement interface or metal-cement lucency on conventional radiographs was used as the criterion for prosthetic loosening with or without infection and proved to be 54% sensitive and 96% specific. Scintigraphic criteria for prosthetic loosening were increased focal uptake of the radiopharmaceutical for the femoral component and increased focal or diffuse uptake for the acetabular component. For bone scintigraphy, sensitivity was 73% and specificity was 96%. Combining the results of conventional radiographs and bone scans increased sensitivity to 84% and decreased specificity to 92% for the diagnosis of loosening, infection, or both. The study also showed that Ga-67 scintigraphy has a low sensitivity for the detection of infection.	3

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
76. Nagoya S, Kaya M, Sasaki M, Tateda K, Yamashita T. Diagnosis of peri-prosthetic infection at the hip using triple-phase bone scintigraphy. *J Bone Joint Surg Br.* 2008;90:140-144.	Observational-Dx	46 patients	To evaluate TPBS in the differential diagnosis of peri-prosthetic infection in patients with a total hip replacement or bipolar hemiarthroplasty who were due for revision surgery.	The PPVs and NPVs for the presence of infection were 83% and 93%, respectively. The diagnostic sensitivity was 88% and the specificity was 90%. This study indicates that TPBS is a useful tool in the detection of peri-prosthetic infection and offers a cost-effective method of screening.	3
77. Reinartz P, Mumme T, Hermanns B, et al. Radionuclide imaging of the painful hip arthroplasty: positron-emission tomography versus triple-phase bone scanning. *J Bone Joint Surg Br.* 2005;87:465-470.	Observational-Dx	63 patients (92 prostheses)	To assess the diagnostic ability of TPBS and PET to detect and differentiate these complications in patients with a hip arthroplasty.	The sensitivity, specificity and accuracy of PET was 0.94, 0.95 and 0.95 respectively, compared with 0.68, 0.76 and 0.74 for TPBS. The authors found that an image interpretation based exclusively upon quantitative criteria was inappropriate because of its low selectivity. The histological examination indicated that increased periprosthetic uptake of FDG in patients with aseptic loosening was caused by wear-induced polyethylene particles and the subsequent growth of aggressive granulomatous tissue.	2
78. Stumpe KD, Notzli HP, Zanetti M, et al. FDG PET for differentiation of infection and aseptic loosening in total hip replacements: comparison with conventional radiography and three-phase bone scintigraphy. *Radiology.* 2004;231:333-341.	Observational-Dx	35 patients	To compare the diagnostic efficacy of FDG-PET with that of conventional radiography and three-phase bone scintigraphy in patients suspected of having infection in their total hip replacements.	9 patients had septic and 21 patients had aseptic loosening. In 5 patients, neither loosening nor infection was confirmed. For diagnosing infection with FDG-PET, conventional radiography, and bone scintigraphy, respectively, sensitivity values for reader 1 and reader 2 were 33% and 22%, 89% and 78%, and 56% and 44%, while specificity values were 81% and 85%, 50% and 65%, and 88% and 92% and accuracy values were 69% for both readers, 60% and 69%, and 80% for both readers. PET was significantly more specific (P=.035) but less sensitive (P=.016) than conventional radiography for the diagnosis of infection.	2
79. McKillop JH, McKay I, Cuthbert GF, Fogelman I, Gray HW, Sturrock RD. Scintigraphic evaluation of the painful prosthetic joint: a comparison of gallium-67 citrate and indium-111 labelled leucocyte imaging. *Clin Radiol.* 1984;35:239-241.	Observational-Dx	15 patients	Radiopharmaceuticals gallium-67 and In-111 labeled leucocytes were compared in patients with a painful joint prosthesis in an attempt to identify those patients with periprosthetic infection.	Gallium-67 images were abnormal in 5/6 patients with periprosthetic infection and normal in 7/9 without evidence of infection. In-111 leucocyte images were abnormal in 3/6 patients with infection and normal in all 9 patients without infection. In-111 labeled leucocyte imaging is technically more difficult to perform than gallium-67 imaging.	3

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
80. Rushton N, Coakley AJ, Tudor J, Wraight EP. The value of technetium and gallium scanning in assessing pain after total hip replacement. *J Bone Joint Surg Br.* 1982;64:313-318.	Review/Other-Dx	51 patients and 34 controls	To evaluate the diagnostic accuracy of technetium and gallium scans in differentiating mechanically loose prostheses from infected loose prostheses.	Technetium and gallium scans were found to be remarkably accurate in detecting infection or loosening of the prosthesis when compared with conventional techniques and often allowed the diagnosis to be made earlier.	4
81. Gomez-Luzuriaga MA, Galan V, Villar JM. Scintigraphy with Tc, Ga and In in painful total hip prostheses. *Int Orthop.* 1988;12:163-167.	Observational-Dx	40 patients	To study a series of patients who were operated upon for a painful total hip prosthesis, half of which were infected. In each case, preoperative scintigraphy was performed using Tc-99m, Ga67 and In-111.	In-111 had a predictive value of more than 90% and showed greater reliability in the diagnosis of an infection as the cause of a painful total hip prosthesis.	3
82. Johnson JA, Christie MJ, Sandler MP, Parks PF, Jr., Homra L, Kaye JJ. Detection of occult infection following total joint arthroplasty using sequential technetium-99m HDP bone scintigraphy and indium-111 WBC imaging. *J Nucl Med.* 1988;29:1347-1353.	Observational-Dx	28 patients with 29 joint arthroplasties	To examine the sensitivity and specificity of In-111 WBC imaging in the preoperative determination of periprosthetic infection in patients with painful loose total joint arthroplasties.	The sensitivity of preoperative aspiration cultures was 12%, with a specificity of 81% and an accuracy of 58%. The sensitivity of In-111 WBC imaging alone was 100%, with a specificity of 50% and an accuracy of 65%. When correlated with the bone scintigraphy and read as sequential Tc-99m HDP/In-111 WBC imaging, the sensitivity was 88%, specificity 95%, and accuracy 93%.	3
83. Palestro CJ, Kim CK, Swyer AJ, Capozzi JD, Solomon RW, Goldsmith SJ. Total-hip arthroplasty: periprosthetic indium-111-labeled leukocyte activity and complementary technetium-99m-sulfur colloid imaging in suspected infection. *J Nucl Med.* 1990;31:1950-1955.	Observational-Dx	72 patients with 92 (68 primary, 24 revision) cemented THAs	To report the patterns of periprosthetic labeled leukocyte activity in 92 cemented total-hip arthroplasties, as well as the results of combined In-111-labeled leukocyte and Tc-99m sulfur colloid imaging of 50 of these arthroplasties.	Though present in all 23 infected arthroplasties, periprosthetic activity was also present in 77% of uninfected arthroplasties, and was greater than the contralateral zone 51% of the time. When analyzed by zone, head zone activity was the best criterion for infection (87% sensitivity, 94% specificity, 92% accuracy). 50 of the arthroplasties were studied with combined labeled leukocyte/sulfur colloid imaging. Using incongruence of images as the criterion for infection, the sensitivity, specificity, and accuracy of the study were 100%, 97%, and 98%, respectively. While variable periprosthetic activity makes labeled leukocyte imaging alone unreliable for diagnosing hip arthroplasty infection, the addition of sulfur colloid imaging results in a highly accurate diagnostic procedure.	3

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
84. Pelosi E, Baiocco C, Pennone M, et al. 99mTc-HMPAO-leukocyte scintigraphy in patients with symptomatic total hip or knee arthroplasty: improved diagnostic accuracy by means of semiquantitative evaluation. *J Nucl Med.* 2004;45:438-444.	Observational-Dx	78 patients	To evaluate the diagnostic value, in suspected infectious prostheses, of Tc99m-HMPAO leukocyte scintigraphy interpreted with the addition of a semiquantitative analysis.	On qualitative analysis, sensitivity, specificity, and accuracy were 80.4%-87%, 65.3%-71.4%, and 75.8%-77.9%, respectively. On semiquantitative analysis, sensitivity, specificity, and accuracy were 95.6%, 95.8%, and 95.8%, respectively. The analysis of 95% confidence intervals showed statistically significant differences in specificity and accuracy between semiquantitative and qualitative analyses.	2
85. Mulamba L, Ferrant A, Leners N, de Nayer P, Rombouts JJ, Vincent A. Indium-111 leucocyte scanning in the evaluation of painful hip arthroplasty. *Acta Orthop Scand.* 1983;54:695-697.	Review/Other-Dx	30 patients	To determine the value of In-111 leucocyte scan in the differential diagnosis of pain after hip arthroplasty.	In 12 patients, the In-111 leucocyte scan was abnormal and in all of them, microorganisms were found at the culture of the material from their hips at the operation. Among the 18 patients with a normal scan no infection was found in 17. In 1 patient, a thick-walled abscess growing Escherichia coli was found. The authors conclude that In-111 scanning is sensitive, specific and therefore useful in the differential diagnosis of pain after hip arthroplasty.	4
86. The Diagnosis of Periprosthetic Joint Infections of the Hip and Knee Guidline and Evidence Report 2010. American Academy of Orthopaedic Surgeons. 2010; Available at: http://www.aaos.org/research/guidelines/PJIguideline.pdf. Accessed September 30, 2015.	Review/Other-Dx	N/A	The Diagnosis of Periprosthetic Joint Infections of the Hip and Knee Guideline and Evidence Report.	N/A	4
87. Chryssikos T, Parvizi J, Ghanem E, Newberg A, Zhuang H, Alavi A. FDG-PET imaging can diagnose periprosthetic infection of the hip. *Clin Orthop Relat Res.* 2008;466:1338-1342.	Observational-Dx	113 patients with 127 painful hip prostheses	Prospective study to determine the accuracy of FDG-PET imaging in diagnosing periprosthetic infection in a large multicenter setting.	Among the 35 positive PET scans, 28 hips were confirmed infected according to the criteria for diagnosing periprosthetic infection. Of the 92 hip prostheses with negative FDG-PET findings, 87 were considered aseptic. The sensitivity, specificity, PPV and NPV for FDG-PET were 0.85 (28/33), 0.93 (87/94), 0.80 (28/35), and 0.95 (87/92), respectively. The overall accuracy of this novel noninvasive imaging modality reached 0.91 (115/127).	2

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
88. Zhuang H, Duarte PS, Pourdehnad M, et al. The promising role of 18F-FDG PET in detecting infected lower limb prosthesis implants. *J Nucl Med.* 2001;42:44-48.	Observational-Dx	74 prostheses in 62 patients	To evaluate the feasibility of using FDG-PET for the detection of infection associated with lower limb arthroplasty.	The sensitivity, specificity, and accuracy of PET for detecting infection associated with knee prostheses were 90.9%, 72.0%, and 77.8%, respectively. The sensitivity, specificity, and accuracy of PET for detecting infection associated with hip prostheses were 90%, 89.3%, and 89.5%, respectively. Overall, the sensitivity was 90.5% and the specificity was 81.1% for detection of lower limb infections.	3
89. Mumme T, Reinartz P, Alfer J, Muller-Rath R, Buell U, Wirtz DC. Diagnostic values of positron emission tomography versus triple-phase bone scan in hip arthroplasty loosening. *Arch Orthop Trauma Surg.* 2005;125:322-329.	Observational-Dx	50 patients with 70 total hip replacements	To examine the diagnostic valency of FDG-PET in cases of septic or aseptic hip arthroplasty loosening compared with conventional TPBS.	Sensitivity/specificity of FDG-PET was 91%/92% (accuracy 91%) compared with 78%/70% (accuracy 74%) for TPBS. A high correlation could be proved between FDG-PET investigation and operative histopathological findings (r(Spear ≤0.9). No significant differences were found regarding cemented and uncemented implanted hip arthroplasties (P≥0.05). Calculation of the SUV turned out to be inappropriate as a sole criterion for image interpretation.	3
90. Pill SG, Parvizi J, Tang PH, et al. Comparison of fluorodeoxyglucose positron emission tomography and (111)indium-white blood cell imaging in the diagnosis of periprosthetic infection of the hip. *J Arthroplasty.* 2006;21:91-97.	Observational-Dx	89 patients with 92 painful hip prostheses	To compare the accuracy of FDG-PET with Tc-99m sulfur colloid In-111-labeled WBC scintigraphy in diagnosis of periprosthetic infection.	FDG-PET correctly diagnosed 20/21 infected cases (sensitivity, 95.2%) and ruled out infection in 66/71 aseptic hips (specificity, 93%) corresponding to a PPV of 80% (20/25) and a NPV of 98.5% (66/67). Tc-99m sulfur colloid In-111-labeled WBC scintigraphy correctly identified 5/10 infected cases (sensitivity, 50%) and 39/41 aseptic cases (specificity, 95.1%) corresponding to a PPV and NPV of 41.7% (5/12 cases) and 88.6% (39/44 cases), respectively.	2
91. Garcia-Barrecheguren E, Rodriguez Fraile M, Toledo Santana G, Valenti Nin JR, Richter Echevarria JA. [FDG-PET: a new diagnostic approach in hip prosthetic replacement]. *Rev Esp Med Nucl.* 2007;26(4):208-220.	Observational-Dx	24 hip joint replacements	To evaluate the utility of FDG-PET imaging for diagnosing infected joint replacements.	The sensitivity and specificity of PET for detecting infection associated with prostheses were 64.3% and 64.7%, respectively. FDG imaging is not useful in patients with suspected prosthetic infection as a screening test.	2

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
92. Chacko TK, Zhuang H, Stevenson K, Moussavian B, Alavi A. The importance of the location of fluorodeoxyglucose uptake in periprosthetic infection in painful hip prostheses. *Nucl Med Commun.* 2002;23(9):851-855.	Observational-Dx	41 THAs from 32 patients	To determine the optimal criteria for diagnosing periprosthetic infection, thereby avoiding false positive results in this setting.	12 patients were proven eventually to have periprosthetic infection. Images from 11 of these patients displayed increased tracer uptake along the interface between bone and prosthesis. The intensity of the increased tracer uptake varied from mild to moderate, with SUVs <2. In contrast, images from uninfected, loose hip prostheses revealed very intense uptake around the head or neck of the prosthesis with SUVs as high as 7.	3
93. Zoccali C, Teori G, Salducca N. The role of FDG-PET in distinguishing between septic and aseptic loosening in hip prosthesis: a review of literature. *Int Orthop.* 2009;33:1-5.	Review/Other-Dx	5 studies	To perform a review of literature evaluating PET capacity to distinguish between septic and aseptic loosening in hip prosthesis.	The FDG-PET sensitivity in individuating hip prosthesis infections was 82.8% and specificity was 87.3%. FDG-PET could be a valid option if research is able to find an uptake pattern specific for septic and aseptic loosening.	4
94. Choe H, Inaba Y, Kobayashi N, et al. Use of 18F-fluoride PET to determine the appropriate tissue sampling region for improved sensitivity of tissue examinations in cases of suspected periprosthetic infection after total hip arthroplasty. *Acta Orthop.* 2011;82(4):427-432.	Observational-Dx	23 THA patients (23 hips) and 17 uninfected THA patients (23 hips; control group)	To determine whether the results of tissue examinations in THA patients are affected by the sampling location, classified as major, minor, or no-uptake sides in terms of F-18 fluoride uptake.	17 revision patients showed major uptake and all were diagnosed as having septic loosening from intraoperative tissue results. Minor uptake was observed in the other 6 revision patients and all were diagnosed as having aseptic loosening. Apart from 3 cases that showed minor uptake regions, control subjects showed no uptake. In the revision group, the sensitivities of histopathology, microbiological culture, real-time polymerase chain reaction (PCR) separately and also in combination were 0.78, 0.58, 0.96, and 0.96, respectively, on the major F-18 fluoride uptake sides, 0.0, 0.0, 0.1, and 0.1 on the minor-uptake sides, and 0, 0, 0.18, and 0.18 on the no-uptake sides.	3

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
95. van Holsbeeck MT, Eyler WR, Sherman LS, et al. Detection of infection in loosened hip prostheses: efficacy of sonography. *J Bone Joint Surg Am.* 1994;163:381-384.	Observational-Dx	33 patients	To determine the efficacy of sonography in the detection of infection in loosened hip prostheses.	On sonograms, the normal pseudocapsule is adherent to the proximal part of the anterior femoral cortex, and the capsule-to-bone distance is <3.2 mm (average, 2.6 mm). No hips with a capsule-to-bone distance <3.2 mm were infected. Sonograms in the 6 patients with infection showed marked intra-articular effusion with a mean capsule-to-bone distance of 10.2 mm. 5/6 had extracapsular fluid collections. 2 patients with hip dislocations and 4 with aseptic loosening of the prosthesis had capsular distension on sonograms and cultures of aspirated material that showed no growth.	3
96. Gibbon WW, Long G, Barron DA, O'Connor PJ. Complications of orthopedic implants: sonographic evaluation. *J Clin Ultrasound*. 2002;30:288-299.	Review/Other-Dx	N/A	To demonstrate the sonographic appearances of orthopedic implants and their complications.	Sonography is a versatile method of diagnosing the soft tissue complications of joint replacement and internal fracture fixation without the significant artifacts from which other modalities suffer.	4
97. Lachiewicz PF, Rogers GD, Thomason HC. Aspiration of the hip joint before revision total hip arthroplasty. Clinical and laboratory factors influencing attainment of a positive culture. *J Bone Joint Surg Am*. 1996;78:749-754.	Review/Other-Dx	150 revision total hip arthroplasties	Results of routine aspiration of the hip joint before revision of a hip arthroplasty were reviewed to determine clinical or laboratory factors that could help the surgeon to identify hips that are infected and that should be aspirated preoperatively.	14 aspirations were repeated for various reasons, most commonly to confirm the presence of an unusual organism. The repeat aspiration did not change the diagnosis for these hips. When the 2 hips with a false-positive intraoperative culture were excluded, preoperative aspiration had a sensitivity of 92%, a specificity of 97%, and an accuracy of 96%. 17/19 truly infected hips were associated with an abnormally elevated erythrocyte-sedimentation rate (mean, 80.8 mL/h). However, 58 (50%) of the 116 hips that were not infected, and for which the results were available, also had an abnormally elevated erythrocyte-sedimentation rate (mean, 32.0 mL/h). This difference was significant (P=0.001, Fischer exact test). The peripheral leukocyte count was not helpful in predicting infection. Hips in which the implants had been in situ for more than 5 years were less likely to be infected (P=0.008, Fisher exact test) than those in which the implants had been in situ for 5 years or less.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
98. Somme D, Ziza JM, Desplaces N, et al. Contribution of routine joint aspiration to the diagnosis of infection before hip revision surgery. *Joint Bone Spine.* 2003;70:489-495.	Observational-Dx	109 aspirations 100 patients	To define the sensitivity and specificity of routine preoperative hip aspiration for diagnosing hip prosthesis infection and to separately analyze subgroups with and without a clinical suspicion of hip prosthesis infection before aspiration.	The study patients had had multiple surgical procedures. Hip prosthesis infection was suspected clinically in 39.4% of cases. Of the 109 patients who underwent aspiration, 54 had true-negative results, 9 had false-negative results, and 44 had true-positive results (there were no false-positive results), yielding a sensitivity of 83% and a specificity of 100%. Diagnostic efficiency was 91.6%, PPV was 100%, and NPV was 85.7%. In the subset of 43 patients with a clinical suspicion of hip prosthesis infection, aspiration identified all the causative organisms in 60.5% of cases. Of the 66 patients with no clinical suspicion of hip prosthesis infection, 12 had hip prosthesis infection, and aspiration provided the diagnosis preoperatively in 7 of these patients, radically changing their management plans. Restricting routine aspiration to patients whose prosthesis had been implanted within the last 5 years or whose erythrocyte sedimentation rate was above 30 mm/h would not have modified our findings.	3
99. Williams JL, Norman P, Stockley I. The value of hip aspiration versus tissue biopsy in diagnosing infection before exchange hip arthroplasty surgery. *J Arthroplasty.* 2004;19:582-586.	Observational-Dx	273 patients	To compare the results of aspiration vs tissue drill biopsy against tissue specimens obtained at open surgery.	71/273 (26%) hips were infected. Overall accuracy of aspiration was 90.1% and tissue biopsy 87.9%. The sensitivity and specificity was 80% and 94% for aspiration and 83% and 90% for tissue biopsy. PPV and NPVs were 81.4% and 93.1% for aspiration and 73.8% and 93.8% for tissue biopsy.	3

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
100. Smith TO, Williams TH, Samuel A, Ogonda L, Wimhurst JA. Reliability of the radiological assessments of radiolucency and loosening in total hip arthroplasty using PACS. *Hip Int.* 2011;21:577-582.	Review/Other-Dx	33 patients	To evaluate the reliability of 3 commonly used radiological assessments of THA using the electronic picture archiving and communications system.	The findings indicated that the intra- and inter-observer reliability of the Barrack, Gruen and Hodgkinson methods were questionable. Inter-observer reliability using the Gruen system was poor, using the Barrack system it was moderate to good, and fair to good using the Hodgkinson assessment. Intra-observer reliability was moderate to good for Barrack assessment, poor to good using Gruen zone assessments, but good to very good for the Hodgkinson assessment. The use of Barrack, Gruen and Hodgkinson assessments to evaluate femoral and acetabular loosening should be questioned since these exhibit limited inter- and intra-observer reliability on picture archiving and communications system radiographs, but of the 3, the Hodgkinson system is the most reliable.	4
101. Temmerman OP, Raijmakers PG, Berkhof J, et al. Diagnostic accuracy and interobserver variability of plain radiography, subtraction arthrography, nuclear arthrography, and bone scintigraphy in the assessment of aseptic femoral component loosening. *Arch Orthop Trauma Surg.* 2006;126:316-323.	Observational-Dx	78 patients	To evaluate the diagnostic accuracy and interobserver reliability of plain radiography, subtraction arthrography, nuclear arthrography, and bone scintigraphy in patients (mean age 70 years, range 29-88 years) referred for evaluation of their femoral hip prostheses.	Overall, plain radiography had a sensitivity and specificity of 81% and 74%, respectively. Subtraction arthrography had a sensitivity of 47% and a specificity of 78%. Nuclear arthrography had a sensitivity of 69% and a specificity of 76%, and bone scintigraphy had a sensitivity of 88% with a specificity of 50%.	3
102. Temmerman OP, Raijmakers PG, Berkhof J, Hoekstra OS, Teule GJ, Heyligers IC. Accuracy of diagnostic imaging techniques in the diagnosis of aseptic loosening of the femoral component of a hip prosthesis: a meta-analysis. *J Bone Joint Surg Br.* 2005;87:781-785.	Meta-analysis	32 articles	A meta-analysis was performed to determine the accuracy of diagnostic imaging techniques in the diagnosis of aseptic loosening of the femoral component, using criteria based on the Cochrane systematic review of screening and diagnostic tests.	The mean sensitivity and specificity were, respectively, 82% (95% CI, 76 to 87) and 81% (95% CI, 73 to 87) for plain radiography and 85% (95% CI, 75 to 91) and 83% (95% CI, 75 to 89) for nuclear arthrography. Pooled sensitivity and specificity were, respectively, 86% (95% CI, 74 to 93) and 85% (95% CI, 77 to 91) for subtraction arthrography and 85% (95% CI, 79 to 89) and 72% (95% CI, 64 to 79) for bone scintigraphy. Although the diagnostic performance of the imaging techniques was not significantly different, plain radiography and bone scintigraphy are preferred for the assessment of a femoral component because of their efficacy and lower risk of patient morbidity.	M

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
103. Temmerman OP, Raijmakers PG, David EF, et al. A comparison of radiographic and scintigraphic techniques to assess aseptic loosening of the acetabular component in a total hip replacement. *J Bone Joint Surg Am*. 2004;86-A(11):2456-2463.	Observational-Dx	86 patients	To evaluate the sensitivity, specificity, and interobserver reliability of plain radiography, subtraction arthrography, nuclear arthrography, and bone scintigraphy in patients suspected of having aseptic loosening of the acetabular component.	Plain radiography had a sensitivity of 85% (95% CI, 71 to 94) and a specificity of 85% (95% CI, 66 to 96) in detecting aseptic loosening of the acetabular component, but it had only fair interobserver variability (ICC, 0.37). For subtraction arthrography, the sensitivity was 72% (95% CI, 57 to 84), the specificity was 70% (95% CI, 50 to 86), and there was good interobserver variability (ICC, 0.71). For nuclear arthrography, the sensitivity was 57% (95% CI, 41 to 71), the specificity was 67% (95% CI, 46 to 84), and there was fair interobserver variability (ICC, 0.24). For bone scintigraphy, the sensitivity was 83% (95% CI, 69 to 92), the specificity was 67% (95% CI, 46 to 84), and there was moderate interobserver variability (ICC, 0.43).	3
104. Buckwalter KA. Optimizing imaging techniques in the postoperative patient. *Semin Musculoskelet Radiol.* 2007;11:261-272.	Review/Other-Dx	N/A	To review role of CT and MRI in postoperative patients.	No results stated in abstract.	4
105. Temmerman OP, Raijmakers PG, Deville WL, Berkhof J, Hooft L, Heyligers IC. The use of plain radiography, subtraction arthrography, nuclear arthrography, and bone scintigraphy in the diagnosis of a loose acetabular component of a total hip prosthesis: a systematic review. *J Arthroplasty.* 2007;22:818-827.	Review/Other-Dx	28 studies	To summarize and compare the diagnostic performance and diagnostic accuracy of radiographic and scintigraphic techniques in the evaluation of patients suspected of having aseptically loose acetabular components.	The pooled sensitivity and specificity rates for plain radiography were 70% (95% CI, 59%-79%) and 80% (95% CI, 73%-86%), respectively; those for subtraction arthrography were 89% (95% CI, 84%-93%) and 76% (95% CI, 68%-82%), respectively; and those for nuclear arthrography were 87% (95% CI, 57%-97%) and 64% (95% CI, 40%-82%), respectively. Finally, bone scintigraphy had a sensitivity of 67% (95% CI, 57%-76%) and a specificity of 75% (95% CI, 64%-83%).	4

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
106. Swan JS, Braunstein EM, Wellman HN, Capello W. Contrast and nuclear arthrography in loosening of the uncemented hip prosthesis. *Skeletal Radiol.* 1991;20:15-19.	Observational-Dx	21 patients	To evaluate a combination of positive contrast and nuclear arthrography to see whether these studies could accurately detect loosening of uncemented femoral components of hip prostheses.	Results were surgically confirmed in 12 patients. The contrast arthrogram was true positive in 5 and false negative in 5. There were no false positives and 2 true negatives. The nuclear arthrogram was true positive in 7 patients, false negative in 3, and true negative in 2. Taken together, there was only 1 patient in whom both contrast and nuclear arthrography were false negative, and there were no false positives. Thus, when either contrast or nuclear arthrography is positive, the sensitivity of the combined procedures is 90%; when both studies are negative, the specificity is 100%.	3
107. Oyen WJ, Lemmens JA, Claessens RA, van Horn JR, Slooff TJ, Corstens FH. Nuclear arthrography: combined scintigraphic and radiographic procedure for diagnosis of total hip prosthesis loosening. *J Nucl Med.* 1996;37:62-70.	Observational-Dx	105 patients (107 prostheses)	To evaluate the usefulness of radiographic contrast arthrography (including photographic subtraction) and scintigraphic studies (bone scan and nuclear arthrography) to define guidelines for optimal assessment of a painful total hip prosthesis.	In both cemented and uncemented acetabular and femoral components, nuclear arthrography performed better than or equal to radiographic arthrography (70%-90% and 60%-75%, respectively). Nuclear arthrography had higher diagnostic accuracy than Tc-99m MDP images alone.	3
108. Manthey N, Reinhard P, Moog F, Knesewitsch P, Hahn K, Tatsch K. The use of [18 F]fluorodeoxyglucose positron emission tomography to differentiate between synovitis, loosening and infection of hip and knee prostheses. *Nucl Med Commun.* 2002;23(7):645-653.	Review/Other-Dx	23 patients with 28 prostheses, 14 hip and 14 knee prostheses	To describe FDG-PET findings in patients referred for evaluation of painful hip or knee prostheses.	PET correctly identified 3 hip and 1 knee prostheses as infected, 2 hip and 2 knee prostheses as loosening, 4 hip and 9 knee prostheses as synovitis, and 2 hip and 1 knee prostheses as unsuspected for loosening or infection. In 3 patients covered with an expander after explantation of an infected prosthesis PET revealed no further evidence of infection in concordance with the clinical follow-up. PET was false negative for loosening in 1 case.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
109. Maus TP, Berquist TH, Bender CE, Rand JA. Arthrographic study of painful total hip arthroplasty: refined criteria. *Radiology.* 1987;162:721-727.	Observational-Dx	170 patients 178 arthrograms	To refine the criteria for the diagnosis of loosening and infection of the joint. The authors also attempted better documentation of the presence of bursal filling and its role in evaluation of loosening and infection.	97 arthroplasties that were surgically evaluated form the basis of this report. With the refined criteria, subtraction arthrography had a sensitivity of 96% and specificity of 92% for demonstrating loosening of the femoral component and a sensitivity of 97% and a specificity of 68% for demonstrating loosening of the acetabular component. Pseudocapsule size and the presence of bursae were important factors influencing arthrographic interpretation. Arthrographic findings of pseudocapsule irregularity and the presence of nonbursal cavities were suggestive of infection but were not sensitive or specific. Laboratory evaluation of aspirated material was a more reliable predictor of infection, although its sensitivity was only 71%.	4
110. Ostlere S, Soin S. Imaging of prosthetic joints. *Imaging* .2003;15:270-285.	Review/Other-Dx	N/A	To review imaging of prosthetic joints.	No results stated in abstract.	4
111. Braunstein EM, Cardinal E, Buckwalter KA, Capello W. Bupivicaine arthrography of the post-arthroplasty hip. *Skeletal Radiol.* 1995;24:519-521.	Review/Other-Dx	12 patients	To report the use of arthrography of total hip prostheses with the adjunct injection of bupivicaine (Marcaine), a medium-acting local anesthetic, to distinguish successfully between pain localized within the postoperative pseudocapsule and either lumbar nerve root pain or pain in the adjacent soft tissue.	In 12 surgically proven cases, complete relief of pain after bupivicaine injection correctly identified an intracapsular source of pain in 10, with only 1 false-positive and 1 false-negative. These results compare favorably with the results of the contrast arthrograms in these patients in localizing the pain even if a specific diagnosis could not be reached. Bupivicaine as an adjunct to contrast material during arthrography provides additional information useful in management decisions regarding the necessity of revision arthroplasty.	4
112. Dumbleton JH, Manley MT, Edidin AA. A literature review of the association between wear rate and osteolysis in total hip arthroplasty. *J Arthroplasty.* 2002;17(5):649-661.	Review/Other-Dx	N/A	The authors surveyed the literature on wear and osteolysis after THA to present the data in comparative fashion and to determine whether the concept of a polyethylene wear rate threshold for osteolysis at the hip can be supported by published results.	The incidence of osteolysis increases as the rate of wear increases. The literature indicates that osteolysis rarely is observed at a wear rate of <0.1 mm/year.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
113. Goetz DD, Smith EJ, Harris WH. The prevalence of femoral osteolysis associated with components inserted with or without cement in total hip replacements. A retrospective matched-pair series. *J Bone Joint Surg Am*. 1994;76:1121-1129.	Review/Other-Dx	41 hips in 39 patients	Retrospective matched-pair study was performed to compare the prevalence of femoral osteolysis in hips in which a femoral component had been inserted without cement with that in hips with a cemented component.	Osteolysis developed in 12 (29%) of the hips that had a femoral component without cement compared with none of the hips that had a cemented component ($P<0.0002$). At the latest follow-up examination, none of the femoral components that had been inserted with cement were loose and none had been revised, while 8 (20%) of the femoral components that had been inserted without cement were loose and 5 (12%) had been revised.	4
114. Park JS, Ryu KN, Hong HP, Park YK, Chun YS, Yoo MC. Focal osteolysis in total hip replacement: CT findings. *Skeletal Radiol*. 2004;33:632-640.	Review/Other-Dx	30 total hip replacements	To describe the CT findings of focal osteolysis following total hip replacement.	Focal osteolysis was common in the superior part of acetabular and femoral components. CT features of focal osteolysis were multiple, expansile, oval, or round radiolucencies, which were conglomerated into multilobular shape. The cortex adjacent to the osteolytic lesions revealed irregular thinning and discontinuity (29/30, 97%) accompanied by a few tiny fragments. Liner wear was common (27/30, 90%), and metallosis was frequent (8/30, 26.7%). Pathologic results were foreign body reaction in 20 patients, chronic inflammation in 8, and fibrosis in 2.	4
115. Claus AM, Totterman SM, Sychterz CJ, Tamez-Pena JG, Looney RJ, Engh CA, Sr. Computed tomography to assess pelvic lysis after total hip replacement. *Clin Orthop Relat Res*. 2004:167-174.	Review/Other-Dx	4 human pelvis	To assess the accuracy of a computer-assisted CT image analysis program in determining the location and volume of periacetabular osteolysis, the authors designed an osteolysis model by implanting bilateral total hip replacements in human pelvic cadavers and creating osteolytic lesions of varying sizes.	81% (39 lesions) were identified correctly from the CT scans. Detection was location-dependent. More lesions were detected in the ilium (100%) and at the rim (89%) than in the ischium (78%) or the pubis (50%). CT overestimated lesion volume by a mean of 0.5 +/- 2.3 cm. The volumetric error was unrelated to lesion location but was dependent on lesion size. As lesion size increased above 10 cm, the mean percentage error decreased to 1.8%. CT image analysis can be used more accurately than plain radiographs to investigate the effectiveness of treatment and the natural history of pelvic osteolysis.	4

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
116. Malan DF, Botha CP, Kraaij G, et al. Measuring femoral lesions despite CT metal artefacts: a cadaveric study. *Skeletal Radiol.* 2012;41(5):547-555.	Review/Other-Dx	27 periprosthetic lesions in 10 human cadaver femora	To investigate to what extent metal artefacts interfere with the segmentation of lesions adjacent to a metal femoral implant and whether metal artefact reduction improves the manual segmentation of such lesions.	The authors achieved accurate delineation of periprosthetic lesions in the metal-free images. The presence of a metal implant led the authors to underestimate lesion volume and introduced geometrical errors in segmentation boundaries. Although projection interpolation metal artefact reduction reduced streak artefacts, it led to greater underestimation of lesion volume and greater geometrical errors than without its application.	4
117. Hayter CL, Koff MF, Shah P, Koch KM, Miller TT, Potter HG. MRI after arthroplasty: comparison of MAVRIC and conventional fast spin-echo techniques. *J Bone Joint Surg Am.* 2011;197:W405-411.	Observational-Dx	122 patients	To evaluate the quality of images obtained with a prototype imaging technique, multiacquisition variable-resonance image combination, compared with fast spin-echo images in the evaluation of patients who have undergone hip, shoulder, or knee arthroplasty.	Visualization of the synovium was significantly better on multiacquisition variable-resonance image combination images than on fast spin-echo images of the hip ($P<0.0001$), shoulder ($P<0.01$), and knee ($P<0.01$). Synovitis was detected only on the multiacquisition variable-resonance image combination images of 9 subjects (12%) who had undergone hip arthroplasty and 5 subjects (18%) who had undergone shoulder arthroplasty. Visualization of the periprosthetic bone was significantly better on multiacquisition variable-resonance image combination images of the hip ($P<0.0001$), shoulder ($P<0.0001$), and knee ($P<0.01$). Osteolysis was detected only on the multiacquisition variable-resonance image combination images of 12 subjects (16%) who had undergone hip arthroplasty, 6 (22%) who had undergone shoulder arthroplasty, and 5 (24%) who had undergone knee arthroplasty. Visualization of the supraspinatus tendon was significantly better on multiacquisition variable-resonance image combination images ($P<0.0001$). Supraspinatus tendon tears in 12 subjects (44%) were detected only on multiacquisition variable-resonance image combination images.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
118. Walde TA, Weiland DE, Leung SB, et al. Comparison of CT, MRI, and radiographs in assessing pelvic osteolysis: a cadaveric study. *Clin Orthop Relat Res.* 2005:138-144.	Observational-Dx	3 complete pelves	To compare the accuracy of radiography, CT, and MRI in assessing periacetabular osteolytic lesions.	The sensitivity for detecting lesions was 51.7% for radiography, 74.7% for CT, and 95.4% for MRI. For all 3 techniques, sensitivity increased as lesion size increased. MRI emerged as the most effective tool for detecting small periacetabular osteolytic lesions (≤3 cm). For lesions >3 cm, which are of more concern clinically, CT and MRI were effective in identifying lesions with detection rates >80%. For radiography and CT, lesion detection was dependent on lesion location, whereas MRI had consistently good sensitivity in all lesion locations. Although the mean volumetric errors for CT and MRI (0.3 cm and 0.8 cm) were small compared with mean lesion volume (6.1 cm), CT was more accurate than MRI at measuring lesion volume, with a lower mean absolute error.	3
119. Nguyen BD, Ram PC, Roarke MC. Hip arthroplasty with mass-like pelvic granulomatous disease: PET imaging. *Clin Nucl Med.* 2006;31(1):30-32.	Review/Other-Dx	1 patient	PET findings of pelvic mass-like granulomatous disease in a patient with suspected recurrent melanoma.	No results stated in abstract.	4
120. Bozic KJ, Kurtz S, Lau E, et al. The epidemiology of bearing surface usage in total hip arthroplasty in the United States. *J Bone Joint Surg Am*. 2009;91:1614-1620.	Review/Other-Dx	51,345 revision THA procedures	To evaluate the mechanisms of failure and the types of revision THA procedures performed in the United States with use of newly implemented ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification) diagnosis and procedure codes related specifically to revision THA in a large, nationally representative population.	The most common type of revision THA procedure performed was all-component revision (41.1%), and the most common causes of revision were instability/dislocation (22.5%), mechanical loosening (19.7%), and infection (14.8%). Revision THA procedures were most commonly performed in large, urban, nonteaching hospitals for Medicare patients 75-84 years of age. The average length of hospital stay for all types of revision arthroplasties was 6.2 days, and the average total charges were $54,553. However, the average length of stay, average charges, and procedure frequencies varied considerably according to census region, hospital type, and type of revision THA procedure performed.	4
121. Bestic JM, Berquist TH. Current concepts in hip arthroplasty imaging: metal-on-metal prostheses, their complications, and imaging strategies. *Semin Roentgenol.* 2013;48(2):178-186.	Review/Other-Dx	N/A	To review complications and imaging strategies of MoM prostheses.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
122. Kwon YM, Ostlere SJ, McLardy-Smith P, Athanasou NA, Gill HS, Murray DW. "Asymptomatic" pseudotumors after metal-on-metal hip resurfacing arthroplasty: prevalence and metal ion study. *J Arthroplasty.* 2011;26:511-518.	Review/Other-Dx	201 hips in 158 patients	To determine the prevalence of asymptomatic pseudotumors after MoM hip resurfacing arthroplasty and to measure metal ion levels in these patients.	Pseudotumors found in 7 patients (4%) were associated with significantly higher cobalt and chromium levels and inferior functional scores. Elevated levels of cobalt and chromium ions suggest that pseudotumors are associated with increased wear generated from MoM articulations.	4
123. Matthies AK, Skinner JA, Osmani H, Henckel J, Hart AJ. Pseudotumors are common in well-positioned low-wearing metal-on-metal hips. *Clin Orthop Relat Res.* 2012;470:1895-1906.	Review/Other-Dx	105 patients	To determine whether pseudotumor formation was associated with (1) adverse cup position, (2) raised metal ion levels, and (3) increased wear rates of the retrieved components.	The proportion of patients demonstrating evidence of a pseudotumor in well-positioned hips was similar to those with adverse cup positions (67% and 66%, respectively). Patients revised with pseudotumors had similar whole-blood metal ion levels and component wear rates to those who were not revised.	4
124. Watters TS, Cardona DM, Menon KS, Vinson EN, Bolognesi MP, Dodd LG. Aseptic lymphocyte-dominated vasculitis-associated lesion: a clinicopathologic review of an underrecognized cause of prosthetic failure. *Am J Clin Pathol.* 2010;134:886-893.	Review/Other-Dx	3 cases	To report 3 cases of aseptic, lymphocyte-dominated vasculitis-associated lesion with clinical, radiographic, and histologic findings.	No results stated in abstract.	4
125. Williams DH, Greidanus NV, Masri BA, Duncan CP, Garbuz DS. Prevalence of pseudotumor in asymptomatic patients after metal-on-metal hip arthroplasty. *J Bone Joint Surg Am*. 2011;93:2164-2171.	Review/Other-Dx	31 asymptomatic patients with a MoM THA, 24 asymptomatic patients with a metal-on-polyethylene THA, and 20 asymptomatic patients with a MoM hip resurfacing arthroplasty	To assess the prevalence of pseudotumor formation in asymptomatic patients with a MoM total hip replacement after a minimum duration of follow-up of 2 years. A secondary purpose was to assess whether a correlation exists between elevated serum metal ion levels and pseudotumor formation.	10 patients (32%) in the MoM THA group had a solid or cystic mass, with another 3 patients (10%) having a substantial fluid collection. 5 patients (25%) in the hip resurfacing arthroplasty group had a solid or cystic mass, with another patient (5%) having a fluid collection. Pseudotumor formation was significantly more frequent in the MoM THA group compared with the metal-on-polyethylene THA group (P=0.015). The authors did not detect a significant correlation between the serum metal ion levels and the size of pseudotumor abnormality. The median serum metal ion level was greater in patients with pseudotumor formation than it was in those without pseudotumor formation, but the difference was not significant.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
126. Pandit H, Vlychou M, Whitwell D, et al. Necrotic granulomatous pseudotumours in bilateral resurfacing hip arthoplasties: evidence for a type IV immune response. *Virchows Arch.* 2008;453:529-534.	Review/Other-Dx	4 patients	To analyze clinical, radiological and histological findings in patients who developed bilateral pseudotumors following MoM resurfacing arthroplasties of both hips.	Bilateral masses developed in periprosthetic soft tissues following the second MoM arthroplasty; these were characterized histologically by extensive coagulative necrosis, a heavy macrophage infiltrate and the presence of granulomas containing macrophages and giant cells; there was also a diffuse lymphocyte and variable plasma cell and eosinophil polymorph infiltrate. Immunohistochemistry showed strong expression of HLA-DR, CD14 and CD68 in both granulomatous and necrotic areas; lymphocytes were predominantly CD3+/CD4+ T cells. The clinical, morphological and immunophenotype features of these necrotic granulomatous pseudotumors, which in all cases develop following a second resurfacing hip arthroplasty, is suggestive of a type IV immune response, possibly to MoM metal alloy components.	4
127. Macnair RD, Wynn-Jones H, Wimhurst JA, Toms A, Cahir J. Metal ion levels not sufficient as a screening measure for adverse reactions in metal-on-metal hip arthroplasties. *J Arthroplasty.* 2013;28:78-83.	Observational-Dx	57 patients (62 hips)	To assess the accuracy of metal ion analysis in the diagnosis of adverse reaction to metal debris in patients with MoM hip arthroplasties by comparing the cobalt and chromium levels in 57 patients (62 hips) to findings on MAR MRI.	An adverse reaction to metal debris was detected using MRI in 18 (29%) of the hips. 40 patients had cobalt levels <7 micrograms/L, and 33 had chromium levels <7 micrograms/L, but 8 of these had an adverse reaction to metal debris on MRI and only minimal symptoms (Oxford Hip Score ≥44/48). The incidence of adverse reaction to metal debris was significantly higher when chromium concentration was above 7 micrograms/L (P=.02), but normal metal ion levels can be misleading and MAR MRI is advised in all patients.	4
128. Ostlere S. How to image metal-on-metal prostheses and their complications. *J Bone Joint Surg Am.* 2011;197:558-567.	Review/Other-Dx	N/A	To review the role of imaging in the diagnosis and management of complications related to MoM arthroplasty.	Imaging plays an important role in the investigation of symptomatic MoM arthroplasty. Radiographs will identify fracture and loosening, but cross-sectional imaging is required to diagnose and stage periprosthetic reactive masses.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
129. Yanny S, Cahir JG, Barker T, et al. MRI of aseptic lymphocytic vasculitis-associated lesions in metal-on-metal hip replacements. *J Bone Joint Surg Am.* 2012;198:1394-1402.	Review/Other-Dx	N/A	To describe the clinical, histopathologic, and MRI features of aseptic lymphocytic vasculitis-associated lesions in total hip replacements.	The introduction of modern MoM hip arthroplasty has been accompanied by a newly described disease, aseptic lymphocytic vasculitis-associated lesions, which is characterized histologically by bland necrosis and dense perivascular lymphocytic infiltrates. Conventional radiographic findings are often normal, but the typical MRI findings include periprosthetic fluid collections, soft-tissue masses, gluteal tendon avulsion, bone loss, periosteal stripping, neurovascular involvement, and periprosthetic fractures.	4
130. Park YS, Moon YW, Lim SJ, Yang JM, Ahn G, Choi YL. Early osteolysis following second-generation metal-on-metal hip replacement. *J Bone Joint Surg Am*. 2005;87:1515-1521.	Review/Other-Dx	165 patients (169 hips)	To observe early osteolysis in a cohort of patients who had been managed with second-generation MoM hip replacements and investigate the possible etiologic role of metal hypersensitivity.	The patients with early osteolysis had a significantly higher rate of hypersensitivity reaction to cobalt compared with controls (P=0.031). The retrieved periprosthetic tissues showed no evidence of metallic staining, but histologic analysis revealed a perivascular accumulation of CD3-positive T-cells and CD68-positive macrophages and an absence of both particle-laden macrophages and polymorphonuclear cells. Immunohistochemical analysis demonstrated that bone-resorbing cytokines such as IL-1beta and TNF-alpha were produced mainly by infiltrating lymphocytes and activated macrophages.	4
131. Chang EY, McAnally JL, Van Horne JR, et al. Metal-on-metal total hip arthroplasty: do symptoms correlate with MR imaging findings? *Radiology.* 2012;265:848-857.	Review/Other-Dx	192 hips (174 patients)	To determine the prevalence of MRI abnormalities after MoM THA and to determine whether presence of symptoms correlates with findings at MRI.	Prevalence of pseudotumors per patient and per hip was 69% (120/174 patients, 132/192 hips). Bone marrow edema (present in 6 asymptomatic patients and 19 patients with pain, P<.01) and tendon tearing (present in 5 asymptomatic patients and 13 patients with pain, P<.05) were predictors of pain. Presence of symptoms was not correlated with presence (P=.4151) or size of pseudotumors. Anderson MR grade binarized into normal vs abnormal showed moderate agreement between readers (kappa = 0.439) but was also not correlated with symptoms (P=.6648).	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
132. Chen Z, Pandit H, Taylor A, Gill H, Murray D, Ostlere S. Metal-on-metal hip resurfacings--a radiological perspective. *Eur Radiol.* 2011;21:485-491.	Review/Other-Dx	N/A	The following imaging findings are illustrated and their significance discussed; uncomplicated hip resurfacing arthroplasty, radiolucency around the femoral peg, femoral neck fracture, loosening and infection, suboptimal component position, femoral notching, dislocation, HO, femoral neck thinning and reactive masses.	Complications following resurfacing arthroplasty are rare and are mainly related to suboptimal surgical technique resulting in impingement or femoral neck fracture. Infection and aseptic loosening are unusual. Reactive masses, occurring predominately in women, are increasingly being recognized as a cause of symptoms.	4
133. Sabah SA, Mitchell AW, Henckel J, Sandison A, Skinner JA, Hart AJ. Magnetic resonance imaging findings in painful metal-on-metal hips: a prospective study. *J Arthroplasty.* 2011;26:71-76, 76 e71-72.	Review/Other-Dx	31 patients	To report MARS MRI findings in a prospective series of 31 patients with unexplained painful MoM hips.	The abnormalities identified were fluid collection (20 patients), solid mass (2 patients), moderate to severe muscle atrophy (23 patients), and muscle edema (8 patients). Soft tissue lesions and muscle atrophy appear to be prevalent in unexplained painful MoM hips. MARS MRI may be useful to diagnose and monitor at-risk hips but requires validation in well-functioning MoM hips before it can guide clinical decision making.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
134. Toms AP, Marshall TJ, Cahir J, et al. MRI of early symptomatic metal-on-metal total hip arthroplasty: a retrospective review of radiological findings in 20 hips. *Clin Radiol.* 2008;63:49-58.	Review/Other-Dx	19 patients who had undergone 20 hip arthroplasties	To perform a retrospective review of all the conventional radiographic and MRI studies performed in patients with early postoperative pain following cobalt-chrome MoM THA.	Measures of implant placement on the immediate postoperative radiographs were all within the normal ranges (n=20). Where more than 1 postoperative radiograph was available statistical analysis revealed no evidence of progressive change before the MRI examination (14). The median postoperative time to MRI was 35 months (range 11-63 months). Abnormalities were demonstrated using MRI in all symptomatic hips (n=20). These comprised: periprosthetic fluid collections (20), which were isointense to muscle on T1-weighted images in 19 cases and hyperintense on T2-weighted images in 18 cases, periprosthetic bone marrow oedema (n=6), muscle oedema (n=4), avulsion of the gluteus minimus and medius tendons (n=5), atrophy of piriformis (n=15) and obturator internus (n=17), and fracture of the medial calcar (n=1). Operative findings in patients who had undergone revision surgery (n=15) included: fluid-filled cavities (n=11), soft tissue necrosis (n=8), gluteal tendon avulsion (n=5), proximal femoral diaphyseal necrosis (n=4), and pitting and corrosion of the femoral stems (n=8), which were, in all cases, firmly fixed to the cement mantle. Histology revealed viable tissue in 6 hips with necrosis (n=12) and fibrin deposition (n=15) being the predominate findings. Other findings included a perivascular lymphocytic infiltrate (n=5), features of active inflammation (n=4), and metallosis (n=1).	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
135. Wynn-Jones H, Macnair R, Wimhurst J, et al. Silent soft tissue pathology is common with a modern metal-on-metal hip arthroplasty. *Acta Orthop.* 2011;82:301-307.	Review/Other-Dx	79 large-head MoM hip arthroplasties in 68 patients	To assess the incidence of both symptomatic and asymptomatic adverse reactions in a consecutive series of patients with a modern large-head MoM hip arthroplasty.	27/75 hips had MRI-detected metal debris-related abnormalities, of which 5 were mild, 18 moderate, and 4 severe. 8 of these hips have been revised, 6 of which were revised for an adverse reaction to metal debris, diagnosed preoperatively with MRI and confirmed histologically. The mean Oxford hip score for the whole cohort was 21. It was mean 23 for patients with no MRI-based evidence of adverse reactions and 19 for those with adverse reactions detected by MRI. 6/12 patients with a best possible Oxford hip score of 12 had MRI-based evidence of an adverse reaction.	4
136. Hauptfleisch J, Pandit H, Grammatopoulos G, Gill HS, Murray DW, Ostlere S. A MRI classification of periprosthetic soft tissue masses (pseudotumours) associated with metal-on-metal resurfacing hip arthroplasty. *Skeletal Radiol.* 2012;41(2):149-155.	Review/Other-Dx	33 hips in 17 female (7 bilateral) and 8 male patients (1 bilateral)	To present a radiological classification system for symptomatic reactive periprosthetic soft tissue mass, dividing them into 3 groups: Type I are thin-walled cystic masses (cyst wall <3 mm), Type II are thick-walled cystic masses (cyst wall >3 mm, but less than the diameter of the cystic component) and Type III are predominantly solid masses.	Periprosthetic masses were seen in 33 hips in 17 female (7 bilateral) and 8 male patients (1 bilateral). The Type I lesions were the most common and more likely to be posterior to the hip joint. The Type III masses were significantly larger than the cystic lesions and were more likely to be located anterior to the hip joint. To date 22 patients have undergone revision surgery with conversions to total hip replacement. Severity of symptoms and revision rates were lowest in the Type I group and highest in the Type III group.	4
137. Anderson H, Toms AP, Cahir JG, Goodwin RW, Wimhurst J, Nolan JF. Grading the severity of soft tissue changes associated with metal-on-metal hip replacements: reliability of an MR grading system. *Skeletal Radiol.* 2011;40:303-307.	Observational-Dx	73 hips in 59 patients	To measure the reliability of a grading system designed for scoring the severity of MoM disease on MRI.	There was substantial agreement among all 3 observers; the correlation coefficient between the 2 most experienced observers was kappa = 0.78 [95% CI: 0.68-0.88] and when compared with the least experienced observer coefficients were kappa = 0.69 (95% CI: 0.57-0.80) and kappa = 0.66 (95% CI: 0.54-0.78). The strongest correlation occurred for grades A, C2 and C3. The weakest correlations occurred for grades B and C1.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
138. Nawabi DH, Gold S, Lyman S, Fields K, Padgett DE, Potter HG. MRI predicts ALVAL and tissue damage in metal-on-metal hip arthroplasty. *Clin Orthop Relat Res*. 2014;472(2):471-481.	Observational-Dx	68 patients	To identify which MRI characteristics correlated with histologically confirmed adverse local tissue reactions (using the aseptic lymphocytic vasculitis-associated lesions score) and intraoperative tissue damage and develop a predictive model using modified MRI to detect aseptic lymphocytic vasculitis-associated lesions and quantify intraoperative tissue damage.	Maximal synovial thicknesses and synovial volumes as determined on MRI correlated with the aseptic lymphocytic vasculitis-associated lesions score and were higher in cases of severe intraoperative tissue damage. Our MRI predictive model showed sensitivity and specificity of 94% and 87%, respectively, for detecting aseptic lymphocytic vasculitis-associated lesions and 90% and 86%, respectively, for quantifying intraoperative tissue damage.	3
139. Nawabi DH, Nassif NA, Do HT, et al. What Causes Unexplained Pain in Patients With Metal-on metal Hip Devices? A Retrieval, Histologic, and Imaging Analysis. *Clin Orthop Relat Res.* 2014;472(2):543-554.	Observational-Dx	88 patients (94 hips)	To compare the (1) articular wear rates; (2) histologic findings; (3) synovial response on MRI; and (4) graded intraoperative tissue damage between well-positioned, MoM hips revised for unexplained pain and MoM hips revised for other reasons and to (5) determine whether the presence of a taper junction on a MoM articulation affects these 4 parameters in unexplained pain.	Articular wear rates in the unexplained pain group were lower than in the control group (median 2.6 micrometers/year vs 12.8 micrometers/year, $P<0.001$). 66% of patients in the unexplained pain group had histologic confirmation of aseptic lymphocyte-dominated vasculitis-associated lesion compared with 19% in the control group ($P<0.001$). The synovial thickness on MRI was higher in the unexplained pain group ($P=0.04$) and was highly predictive of aseptic lymphocyte-dominated vasculitis-associated lesion. Severe intraoperative tissue damage was noted in more cases in the unexplained pain group ($P=0.01$). There were no differences in articular wear, histology, MRI, and tissue damage between resurfacings and THAs revised for unexplained pain.	2
140. Nishii T, Sakai T, Takao M, Yoshikawa H, Sugano N. Is ultrasound screening reliable for adverse local tissue reaction after hip arthroplasty? *J Arthroplasty*. 2014;29(12):2239-2244.	Observational-Dx	131 hips of 105 patients	To examine reliability of US screening for adverse local tissue reaction in 131 hips of 105 patients who received both US and MRI examinations after hip arthroplasty with MoM or highly cross-linked polyethylene bearings.	Using the MRI results as reference, sensitivity, specificity and accuracy of US were 74%, 92% and 84% around MoM bearings, and 90%, 83%, and 85% around highly cross-linked polyethylene bearings. US detected adverse local tissue reaction in 11 hips that were not shown with MRI. US examination is assumed to be a reliable screening tool for detecting clinically important adverse local tissue reaction lesions developing in the anterior region around MoM or highly cross-linked polyethylene bearings.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
141. Steinert L, Zanetti M, Hodler J, Pfirrmann CW, Dora C, Saupe N. Are radiographic trochanteric surface irregularities associated with abductor tendon abnormalities? *Radiology.* 2010;257(3):754-763.	Observational-Dx	150 patients	To assess the association between trochanteric surface irregularities seen on conventional radiographs and MRI evidence of abductor tendon abnormalities.	The PPV of surface irregularities >2 mm for MR tendinopathy or a partial- or full-thickness tear was 90% (37/41 patients). The sensitivity of radiographic changes was 40%; the specificity, 94%; the accuracy, 61%; the NPV, 49%; and the positive likelihood ratio, 5.8. Interobserver agreement for detection of trochanteric surface irregularities on conventional radiographs ranged from 0.28 to 0.76.	2
142. Muller M, Tohtz S, Springer I, Dewey M, Perka C. Randomized controlled trial of abductor muscle damage in relation to the surgical approach for primary total hip replacement: minimally invasive anterolateral versus modified direct lateral approach. *Arch Orthop Trauma Surg.* 2011;131(2):179-189.	Experimental-Tx	44 patients	To compare the influence of the surgical approach on abductor muscle trauma and to analyze the relevance to postoperative pain and functional recovery.	Muscle and tendon damage occurred in both groups, but more lateral gluteus medius tendon defects [modified direct lateral 3/12 months: 6 (37%)/4 (25%); minimally invasive anterolateral approach: 3 (14%)/2 (9%)] and muscle atrophy in the anterior part of the gluteus medius [mean-standard (12): 1.75 +/- 1.8; mean-MIS (12): 0.98 +/- 1.1] were found in patients with the modified direct lateral approach. The clinical outcome was also poorer compared to the minimally invasive anterolateral approach group. Significantly, more Trendelenburg's signs were evident and lower clinical scores were achieved in the modified direct lateral group. No differences in muscle and tendon damage were found for the gluteus minimus muscle. A higher serum myoglobin concentration was measured 6 and 24 h postoperatively in the modified direct lateral group (6 h: 403 +/- 168 mug/l; 24 h: 304 +/- 182 mug/l) compared to the minimally invasive anterolateral approach group (6 h: 331 +/- 143 mug/l; 24 h: 268 +/- 145 mug/l).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
143. Pfirrmann CW, Notzli HP, Dora C, Hodler J, Zanetti M. Abductor tendons and muscles assessed at MR imaging after total hip arthroplasty in asymptomatic and symptomatic patients. *Radiology.* 2005;235(3):969-976.	Observational-Dx	25 asymptomatic patients and 39 symptomatic patients	To prospectively evaluate MRI findings of abductor tendons and muscles in asymptomatic and symptomatic patients after lateral transgluteal THA.	Tendon defects were uncommon in asymptomatic patients and significantly more frequent in symptomatic patients: 2 asymptomatic vs 22 symptomatic patients had gluteus minimus defects (P<0.001); 4 asymptomatic vs 24 symptomatic patients, lateral gluteus medius defects (P<0.001); and no asymptomatic vs 7 symptomatic patients, posterior gluteus medius defects (P=0.025). In both patient groups, tendon signal intensity changes were frequent, with the exception of those in the posterior gluteus medius tendon, which demonstrated these changes more frequently in symptomatic patients (in 23 vs 5 asymptomatic patients, P=0.002). Tendon diameter changes were frequent in both groups but significantly (P=0.001 to P=0.009) more frequent in symptomatic patients (all tendon parts). Fatty atrophy was evident in the anterior two-thirds of the gluteus minimus muscle in both groups, without significant differences. In the posterosuperior third of the gluteus minimus muscle, however, differences in fatty atrophy between the 2 groups were significant (P=0.026). Fatty atrophy of the gluteus medius muscle was present in symptomatic patients only, with significant differences among all muscle parts. Bursal fluid collections were more frequent in symptomatic patients (n = 24) than in asymptomatic patients (n = 8, P=0.021). The MRI-based diagnosis was confirmed in all 14 patients who underwent revision surgery.	2
144. Twair A, Ryan M, O'Connell M, Powell T, O'Byrne J, Eustace S. MRI of failed total hip replacement caused by abductor muscle avulsion. *AJR Am J Roentgenol.* 2003;181(6):1547-1550.	Review/Other-Dx	8 patients	To describe the use of MRI and associated MAR techniques to detect abductor muscle avulsion from the greater trochanter, a complication unusual to the anterolateral approach for total hip replacement.	MRI facilitates the detection of abductor muscle avulsion in patients who have undergone the anterolateral approach during total hip replacement. MRI is considered a valuable diagnostic tool when this condition is suspected.	4

Imaging After Total Hip Arthroplasty
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
145. Long SS, Surrey D, Nazarian LN. Common sonographic findings in the painful hip after hip arthroplasty. *J Ultrasound Med*. 2012;31(2):301-312.	Review/Other-Dx	N/A	To highlight commonly encountered sonographic findings in patients with hip pain after hip arthroplasty.	Sonography plays an important role in the diagnosis and management of patients with hip arthroplasty because the soft tissues surrounding the prosthetic joint are not obscured by artifacts and because sonography enables hands-on examination of the painful site, dynamic evaluation of moving structures, and comparison with the opposite side. Another advantage of sonography is the ability to perform sonographically guided diagnostic and therapeutic procedures.	4
146. Garcia FL, Picado CH, Nogueira-Barbosa MH. Sonographic evaluation of the abductor mechanism after total hip arthroplasty. *J Ultrasound Med.* 2010;29(3):465-471.	Review/Other-Dx	34 patients	To determine the frequency of abductor mechanism avulsion by US after THA with the Hardinge approach (J Bone Joint Surg Br 1982; 64:17-19) and its relationship to the presence of insufficiency of this musculature in the postoperative period.	8 patients presented clinical insufficiency of the abductor musculature as detected by the Trendelenburg test. 4/8 patients with abductor insufficiency presented tendinous avulsion detected by sonography. 1 of the 4 patients with abductor insufficiency and normal sonographic findings had a decrease in the femoral offset caused by the arthroplasty itself. 2 patients presented electromyographic changes of the abductor musculature, with no tendinous avulsion detected by sonography and no abductor insufficiency.	4
147. Ylinen P, Tallroth K, Konttinen YT, Landtman M, Paavilainen T. Arthrography for the diagnosis of abductor avulsion after total hip arthroplasty: a comparison of arthrographic and surgical findings in 33 patients. *Acta Orthop.* 2007;78(3):340-343.	Observational-Dx	33 patients	To determine accuracy of arthrography in the diagnosis of abductor avulsion after THA.	After a mean follow-up time of 22 (2–57) months after THA, 14/33 patients had a positive (pathological) arthrogram whereas 19 had a negative (normal) result. All 14 patients with a positive arthrogram were verified to have an avulsion of the abductor muscle at the operation. 10/19 patients with a negative arthrogram had an intact abductor insertion, but 9 had an avulsion. All of these 9 patients with the preoperatively disclosed avulsion had a fibrous capsule, which obstructed the fistula leading from the joint cavity to the trochanteric bursa region.	3
148. Lachiewicz PF, Kauk JR. Anterior iliopsoas impingement and tendinitis after total hip arthroplasty. *J Am Acad Orthop Surg*. 2009;17(6):337-344.	Review/Other-Dx	N/A	A review on anterior iliopsoas impingement and tendinitis after THA.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
149. Bancroft LW, Blankenbaker DG. Imaging of the tendons about the pelvis. *AJR Am J Roentgenol.* 2010;195(3):605-617.	Review/Other-Dx	N/A	To review the normal anatomy of the pelvic tendons as well as abnormalities such as tendinopathy, partial- and full-thickness tendon tears, myotendinous injuries, snapping hip syndrome, osseous avulsive injuries at tendinous attachments, calcific tendinitis, and tumor.	MRI and US are useful imaging methods to directly evaluate suspected abnormalities of the pelvic tendons, although tendinous mineralization and associated osseous injuries can also be detected with radiography and CT.	4
150. O'Sullivan M, Tai CC, Richards S, Skyrme AD, Walter WL, Walter WK. Iliopsoas tendonitis a complication after total hip arthroplasty. *J Arthroplasty.* 2007;22(2):166-170.	Review/Other-Dx	15 patients	To present a series of 15 patients (16 cases) who presented with pain related to the iliopsoas tendon.	Release of the iliopsoas tendon from the lesser trochanter gave good symptomatic relief in all except 1 patient who required reposition of acetabular prosthesis, with the average Harris Hip Score improving from 58 (range, 44–70) to 91 (range, 78–95) postoperatively. This relatively uncommon condition should be considered in the differential diagnosis of all patients who present with groin pain after THA. Surgical release of the iliopsoas tendon can give excellent results in these patients.	4
151. Cyteval C, Sarrabere MP, Cottin A, et al. Iliopsoas impingement on the acetabular component: radiologic and computed tomography findings of a rare hip prosthesis complication in eight cases. *J Comput Assist Tomogr.* 2003;27(2):183-188.	Observational-Dx	8 cases of iliopsoas impingement 2 control populations (8 patients with painless total hip prosthesis and 16 patients with other complications)	To describe the radiographic and CT scan features of iliopsoas impingement on the acetabular component in THA.	An oversized cup was found in 4 hips with iliopsoas impingement on the acetabular component (50%) and in 1 hip with another complication (6%). Coronal inclination of the acetabular cup was normal in the iliopsoas impingement on the acetabular component group and in the 2 control groups, with a similar mean cup size. All patients with iliopsoas impingement on the acetabular component had an acetabular cup overhang of >12 mm. Conversely, in the 2 control groups, the overhang, present in 3 and 2 cases, respectively, was always <8 mm. Iliopsoas bursal effusion was present in 4 hips with iliopsoas impingement on the acetabular component and 3 hips with other complications and was never present in normal prostheses.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
152. Adler RS, Buly R, Ambrose R, Sculco T. Diagnostic and therapeutic use of sonography-guided iliopsoas peritendinous injections. *AJR Am J Roentgenol.* 2005;185(4):940-943.	Review/Other-Dx	39 patients	The authors describe their experience using sonography guidance to perform therapeutic injections of the iliopsoas bursa.	US-guided iliopsoas bursal/peritendinous injections are useful in determining the cause of hip pain. They can provide relief to most patients with iliopsoas tendinosis/bursitis after hip replacement. The results of injection alone are not as successful in cases of idiopathic iliopsoas tendinosis/bursitis, but the technique can help determine which patients may benefit from a surgical tendon release.	4
153. Della Valle CJ, Rafii M, Jaffe WL. Iliopsoas tendinitis after total hip arthroplasty. *J Arthroplasty.* 2001;16(7):923-926.	Review/Other-Dx	1 patient	The case of a patient with an unusual cause of groin pain after THA, iliopsoas tendinitis, is presented.	The patient failed nonoperative treatment and underwent surgical release of the iliopsoas tendon with complete resolution of symptoms.	4
154. Wunderbaldinger P, Bremer C, Schellenberger E, Cejna M, Turetschek K, Kainberger F. Imaging features of iliopsoas bursitis. *Eur Radiol.* 2002;12(2):409-415.	Observational-Dx	18 patients	Firstly, to describe the spectrum of imaging findings seen in iliopsoas bursitis, and secondly to compare cross-sectional imaging techniques in the demonstration of the extent, size and appearance of the iliopsoas bursitis as referenced by surgery.	US, CT and MR all demonstrated enlarged iliopsoas bursae. The bursal wall was thin and well defined in 83% and thickened in 17% of all cases. The 2 cases with septations on US were not seen by CT and MRI. A communication between the bursa and the hip joint was seen, and surgically verified, in all 18 patients by MRI, whereas US and CT failed to demonstrate it in 44 and 40% of the cases, respectively. Hip joint effusion was seen and verified by surgery in 16 patients by MRI, whereas CT (4 of 5) and US n=12) underestimated the number. The overall size of the bursa corresponded best between MRI and surgery, whereas CT and US tended to underestimate the size. Contrast enhancement of the bursal wall was seen in all cases.	3
155. Schmalzried TP, Noordin S, Amstutz HC. Update on nerve palsy associated with total hip replacement. *Clin Orthop Relat Res.* 1997(344):188-206.	Review/Other-Dx	N/A	A review on nerve palsy associated with total hip replacement.	No results stated in abstract.	4
156. Khan T, Knowles D. Damage to the superior gluteal nerve during the direct lateral approach to the hip: a cadaveric study. *J Arthroplasty.* 2007;22(8):1198-1200.	Review/Other-Dx	44 hips in 31 adult human cadavers	To determine the risk of physical damage to the superior gluteal nerve in a cadaveric model during the lateral approach. The authors also measured the distance between various fixed landmarks on the bony skeleton and superior gluteal nerve in an attempt to quantify the safe zone during surgery.	The inferior division of the superior gluteal nerve was found to be damaged in 3 (6.8%) of 44 cases. The authors conclude that a true "safe zone" does not exist when using a direct lateral approach. The authors also found out that the incidence of physical damage to the superior gluteal nerve is rare and depends largely on the branching pattern of the nerve.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
157. Hayter CL, Koff MF, Potter HG. Magnetic resonance imaging of the postoperative hip. *J Magn Reson Imaging.* 2012;35(5):1013-1025.	Review/Other-Dx	N/A	To discuss the technical aspects of MRI around metallic implants as well as the appearance of potential complications following hip arthroplasty, including osteolysis, wear-induced synovitis, infection, hemarthrosis, fracture, loosening, component displacement, HO, tendinopathy, and neurovascular impingement. The specific complication of metal hypersensitivity following MoM prostheses is reviewed.	MRI is the most accurate imaging modality in the assessment of periprosthetic osteolysis and wear-induced synovitis, and can also assess regional tendons and neurovascular structures.	4
158. Tagliafico A, Podesta A, Assini A, et al. MR Imaging of total hip arthroplasty: comparison among sequences to study the sciatic nerve at 1.5 T. *Magn Reson Imaging.* 2010;28(9):1319-1326.	Observational-Dx	25 patients	To test a series of MR sequences for evaluating the sciatic nerve after THA.	MR examination time was approximately 40 minutes. No patients reported pain, heat or symptoms related to nerve stimulation. The visibility index ranged between 88% and 70% for the first 4 sequences. The T1-weighted turbo spin-echo-high bandwidth sequence had the best visibility index ($P<.05$). The visibility indexes of the first 4 sequences were significantly higher ($P<.004$, sign test) than those of the remaining 3 sequences.	3
159. Chhabra A, Flammang A, Andreisek G. Magnetic resonance neurography technique. In: Chhabra A, Andreisek G, eds. *Magnetic resonance neurography*. New Delhi: Jaypee Brothers Medical Pub.; 2012:10-23.	Review/Other-Dx	N/A	Book chapter.	N/A	4
160. Brooker AF, Bowerman JW, Robinson RA, Riley LH, Jr. Ectopic ossification following total hip replacement. Incidence and a method of classification. *J Bone Joint Surg Am.* 1973;55(8):1629-1632.	Review/Other-Dx	100 consecutive patients	To present a system whereby ectopic-bone formation following total hip replacement may be classified and to report the incidence of ectopic-bone formation following total hip replacement at The Johns Hopkins Hospital using this classification method.	A method to classify the degree of ectopic-bone formation about the hip following THA revealed that 21% of 100 consecutive patients treated by THA had ectopic-bone formation about the hip of various degrees when reviewed 6 months following the operation.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
161. Della Valle AG, Ruzo PS, Pavone V, Tolo E, Mintz DN, Salvati EA. Heterotopic ossification after total hip arthroplasty: a critical analysis of the Brooker classification and proposal of a simplified rating system. *J Arthroplasty.* 2002;17(7):870-875.	Observational-Dx	169 THAs	To assess the intraobserver and interobserver reproducibility of the Brooker classification among physicians with different training backgrounds and, based on the results and weaknesses detected, propose a modified system.	For the Brooker classification, interobserver kappa averaged 0.43 (range, 0.74–0.18) (poor). Intraobserver kappa averaged 0.74 (fair). For the modified classification, interobserver kappa averaged 0.59 (range, 0.51–0.76) (fair). Intraobserver kappa averaged 0.78 (good). Interobserver differences were significant (P=.0085). Interobserver consistency to detect severe HO (Brooker 3 and 4, or grade C) improved from 52% to 76% with the modified system. The new classification showed adequate interobserver reproducibility, less variability, and improved consistency for classification of significant HO.	3
162. Schmidt J, Hackenbroch MH. A new classification for heterotopic ossifications in total hip arthroplasty considering the surgical approach. *Arch Orthop Trauma Surg.* 1996;115(6):339-343.	Review/Other-Dx	75 cementless hip arthroplasties	To introduce a new classification for HOs after THA, which also considers ossifications within the region of the surgical approach.	The authors found a total of 40 HOs. Only 24 could be exactly classified by the known methods. The classification considers 3 regions and 4 grades and is relevant for all 40 HOs. Electrocauterisation to dissect the muscles in the lateral approach reduced the rate of HOs: overall 64.3% to 39.4%; clinically relevant ossifications were reduced to 3.0% from 16.7%. The new classification considers all HOs concerned with THA, especially those localized in the intertrochanteric region. The rate of HOs can be reduced by using electrocauterisation for muscle dissection in the lateral approach.	4
163. Ritter MA, Vaughan RB. Ectopic ossification after total hip arthroplasty. Predisposing factors, frequency, and effect on results. *J Bone Joint Surg Am.* 1977;59(3):345-351.	Review/Other-Dx	398 patients with 507 THAs	Statistical analysis of patients with total hip arthroplasties to identify factors predisposing to ectopic ossification and to determine the frequency of ossification and its effect on the results.	Study found that male patients with considerable bilateral osteophytic osteoarthritis were statistically most likely to have ectopic ossification, especially if ossification had existed before arthroplasty consequent to previous surgery. Ectopic ossification which was first noted 6 weeks after THA in 96% of the cases did not change in amount thereafter, though the bone did mature. Both the range of motion of the hip and the function of the patient were affected by the ectopic bone during the first postoperative year, but after that only the range of hip motion was influenced.	4

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164. Cahir JG, Toms AP, Marshall TJ, Wimhurst J, Nolan J. CT and MRI of hip arthroplasty. *Clin Radiol.* 2007;62(12):1163-1171; discussion 1172-1163.	Review/Other-Dx	N/A	To describe the optimization of CT and MRI protocols for imaging hip arthroplasties.	Improvements in metal artefact reduction protocols mean that diagnostic CT and MRI examinations can be produced on standard equipment available in most radiology departments. CT probably remains the technique of choice for evaluating the volume and extent of osteolysis while planning revision surgery. MRI promises to be an increasingly useful diagnostic technique, particularly for soft-tissue disease associated with THA.	4
165. Shehab D, Elgazzar AH, Collier BD. Heterotopic ossification. *J Nucl Med.* 2002;43(3):346-353.	Review/Other-Dx	N/A	To review current concepts of classification, etiology, pathophysiology, diagnosis, and treatment of heterotopic ossification.	Although clinically significant HO occurs infrequently, appropriate use of laboratory and imaging data, particularly alkaline phosphatase values, PGE2, and bone scintigraphy, permits early detection and more successful management of this fascinating yet troublesome ailment. For many patients at risk for HO, either a nonsteroidal anti-inflammatory drug or local radiation therapy is recommended.	4
166. Muheim G, Donath A, Rossier AB. Serial scintigrams in the course of ectopic bone formation in paraplegic patients. *Am J Roentgenol Radium Ther Nucl Med.* 1973;118(4):865-869.	Review/Other-Dx	36 patients	To determine by serial scintigrams the earliest possible moment for removal of ectopic bone without risk of recurrence.	25 paraplegic patients without clinical or roentgenographic evidence of ectopic bone formation had between 1 and 4 Sr87m scintigraphies of the pelvis. In most cases, the uptake ratios tended to decrease with time. Surgical removal of ectopic bone, when indicated, was not followed by recurrence. In some rare cases, however, strontium uptake remained high over several years and the uptake ratios increased. In these cases removal of ectopic bone was followed by recurrence.	4
167. Popken F, Konig DP, Tantow M, Rutt J, Kausch T, Peters KM. [Possibility of sonographic early diagnosis of heterotopic ossifications after total hip-replacement]. *Unfallchirurg.* 2003;106(1):28-31.	Observational-Dx	53 patients	To evaluate the sonographic early diagnosis of HOs after total hip replacement.	In the sonographic examination, positive findings were shown in 49.1% (n=26) 1 week, 66% (n=35) 3 weeks, 73.6% (n=39) 6 weeks and 77.3% (n=41) 12 weeks after surgery. 88.5% of patients showing positive results in the sonographic examination carried out 1 week after surgery, later on showed positive x-ray findings ($P<0.001$). Of the 3-week positive x-ray findings (n=19), 78.9% had condensations in the sonographic examination ($P<0.001$).	3

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168. Thomas EA, Cassar-Pullicino VN, McCall IW. The role of ultrasound in the early diagnosis and management of heterotopic bone formation. *Clin Radiol.* 1991;43(3):190-196.	Review/Other-Dx	8 patients	To evaluate the use of US to determine its role in reaching a diagnosis at a time when symptoms are maximal and the radiological diagnostic features absent.	Serial US examination identified unique 'zone phenomena' in a heterogeneous group of 8 patients before the classic radiological features appeared. The zone transformation matches the evolution and maturation process described pathologically and forms the basis of an early definitive diagnosis in all cases. The US features are specific for the condition. Although CT confirms the peripheral location of the calcification, the low cost, safety, and general availability of US scanning make it the optimum imaging method for diagnosing and monitoring heterotopic bone formation.	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.
- M = Meta-analysis

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

AP = Anteroposterior

BMD = Bone mineral density

CI = Confidence interval

CT = Computed tomography

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

HMPAO = Hexamethyl-propylamine-oxime

HO = Heterotopic ossification

ICC = Intraclass correlation coefficient

MAR = Metal artifact reduction

MARS = Metal artifact reduction sequence

MDP = Methylene diophosphate

MoM = Metal-on-metal

MRI = Magnetic resonance imaging

NPV = Negative predictive value

PPV = Positive predictive value

SD = Standard deviation

STIR = Short tau inversion-recovery

SUV = Standardized uptake value

THA = Total hip arthroplasty

TPBS = Triple-phase bone scanning

US = Ultrasound

WBC = White blood cell