Imaging in Pre- and Post-operative Assessment in Joint Preserving and Replacing Surgery

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KEYWORDS

• Arthroplasty • Cartilage repair • High tibial osteotomy
• Computed tomography • Magnetic resonance imaging

The number of joint replacement surgeries performed throughout the world continues to rise annually. Joint replacements are among the most common surgical procedures in most developed countries. From 1% to 5% of these patients develop such complications as fracture, particle disease, and infection, which may require revision.[1] A basic understanding of these surgical procedures and devices is important for imaging evaluation.

The detection of complications can be challenging because these patients usually present with nonspecific and subtle clinical symptoms, such as pain and decreased range of motion. Conventional radiography, arthrography, scintigraphy, ultrasound, CT, and MRI can be used to assess the orthopedic prosthesis and, to some degree, the adjacent osseous and soft tissue structures. With the transition from salvage to reconstruction techniques, the role of imaging in the preoperative assessment increases. The knowledge of utility, limitations, and optimization of technique is essential to diagnose pathology in postoperative patients. This article reviews the radiographic, ultrasound, CT, and MRI appearance of knee and hip joint–preserving surgeries.

IMAGING TECHNIQUES

Conventional Radiography

Conventional radiography remains the cornerstone of postoperative musculoskeletal imaging. A minimum of two views of the affected joint should be obtained to assess the orthopedic hardware and adjacent bone. Serial radiographs play an important role in the evaluation of hardware complications. Fracture and osteolysis can be more easily diagnosed when baseline imaging is available. The radiographic findings of hardware loosening include lucency of greater than 2 mm at the bone-metal or cement-bone interface, fracture of the cement, and change of alignment or migration of the component.[2,3] Well-defined radiolucencies around a hardware component suggest particle disease. Most cases of loosening from modern arthroplasties are sequelae of particle disease. Careful attention should be paid to the relative position of the femoral head within the acetabulum component to assess for polyethylene wear.

Arthrography

Arthrography can be performed concurrently with aspiration to distinguish infection from loosening. The presence of contrast material between the bone-metal or cement-bone interface suggests loosening,[4–6] especially as it goes more distal. This is not diagnostic. The major role of arthrography is to guide and confirm joint aspiration. The more contrast fills sacculations around the joint, however, the more likely there is to be secondary loosening.

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Scintigraphy

Scintigraphy can be used in the assessment of painful arthroplasty. Although technetium Tc 99m methylene diphosphonate (Tc-MDP) can show increased uptake around the arthroplasty component in the early postoperative period, little imaging is done during that time. When the first two phases are normal, a three-phase bone scan is more useful to exclude infection than it is to diagnose infection. The more unilateral the uptake is, the closer it is to the joint line, and the more lateral the uptake is, the more likely the changes are related to particle disease. The presence of increased activity after an injection of gallium- or indium-labeled leukocytes suggests infection.[7,8] However, usually these studies should be combined with sulfur colloid scanning to distinguish this ''inflammatory'' uptake from displaced marrow. All scintigraphic examinations are more accurate in the hip than the knee, with knee arthroplasties especially prone to false-positive scintigraphies. Currently, gallium is infrequently used even for chronically infected arthroplasties.

Ultrasound

Ultrasound can also be used in the assessment of painful arthroplasty as it's an excellent modality to assess soft tissues. Ultrasound can be used in the assessment and therapeutic intervention of periprosthetic collection and bursitis.[9–11] The integrity of the adjacent tendons and ligaments can also be assessed. Ultrasound plays mainly a secondary role to see if joint fluid is present and to guide the aspiration of this fluid.

CT

In the past, CT was considered to be of limited utility in patients with metallic hardware. The present-generation multidetector CT, along with improved computer software, is able to overcome the attenuation of x-ray beam by the metal.[9,12] The type of metal also has an effect on these artifacts. The more recent titanium prosthesis has a lower x-ray coefficient compared with steel and cobalt-chrome devices.[10] Radiation dose is drastically increased when an arthroplasty is present. CT is helpful in the evaluation of fracture mapping and assessment of osteolytic lesions.[10] Metal artifact reduction techniques include:

- Positioning the patient in the gantry such that the x-ray beam courses through the smallest diameter of the hardware
- Using high kilovolts and milliamperes with thin overlap slices, thus minimizing noise, which contributes to degradation of image quality
- Reformatting the images in multiple planes with slice thickness greater than originally acquired, which decreases streak artifact and thereby improves visualization of structures around the hardware
- Using soft tissue reconstruction kernels rather than bone algorithm and wide windows when viewing images to reduce metal artifact[9–11]

MRI

MRI once had a limited role in postoperative assessment due to severe susceptibility artifact. However, the modification of imaging parameters has led to less motion degradation of image quality and improved diagnostic images. MRI is currently widely used in postoperative patients because of its multiplanar imaging capability, better contrast resolution, and lack of ionizing radiation when compared with CT.[9,13] The metallic artifact can be reduced by:

- Using a higher bandwidth
- Using fast spin echo instead of spin echo sequences
- Avoiding gradient echo sequence
- Using short tau inversion recovery (STIR) instead of a T2 fat-saturated sequence
- Lowering echo time
- Using a large-frequency encoding matrix
- Orienting frequency encoding direction along the longitudinal axis of the implant[9–11,14,15]

ARTHROPLASTY

Arthroplasty is an orthopedic procedure to partially or completely resurface, remodel, rebuild, or replace an arthritic, dysfunctional, or necrotic joint. We focus on the hip and knee joints in this article. The components of arthroplasty are held in position using a cemented, noncemented, or hybrid procedure, depending on the clinical indication and age of the patient.

In a cemented procedure, the components are fixed with polymethyl-methacrylate, which allows the implant to fit to the irregularities of the bone. This type of replacement is stable and immediate full weight bearing is possible. However, should the component become loose, some bone will grind away, making revision more difficult.[15] In a noncemented procedure, the components have a roughened porous surface to allow bone to grow into it. These types of implants are press fit against the bone. In case of loosening, bone loss