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REVIEW ARTICLE

Current applications of advanced cross-sectional imaging techniques in evaluating the painful arthroplasty

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Abstract Patients with a painful arthroplasty can present a clinical diagnostic dilemma. Aspirates are often negative for infection and alignment of the prosthesis on conventional radiographs is usually satisfactory. These patients can have a myriad of soft tissue as well as osseous pathologies, which may be clinically unsuspected or radiographically occult. The ability of advanced cross-sectional imaging to diagnose osseous and soft tissue injuries has been well documented, but applications to arthroplasty imaging are often limited by regional metallic artifacts. Adjustment of standard imaging parameters can make CT and MR imaging useful adjuncts in imaging the painful arthroplasty, especially in the setting of normal radiographs. Ultrasound can be used to evaluate the periprosthetic soft tissues and provide a real-time method of evaluating the dynamic relationship of the periprosthetic soft tissues to the arthroplasty components, and it also can be used as a guide for diagnostic and therapeutic interventions.

Keywords Arthroplasty · Osteolysis · Periprosthetic soft tissues · Metallic artifact · Interventional sonography

Introduction

The painful arthroplasty is often a diagnostic dilemma. Clinical signs and symptoms are often nonspecific and radiographs are often negative. In some centers, arthrocentesis for evaluation of subclinical infection is often performed; however, this is usually noncontributory [1].

Causes of pain after arthroplasty placement can include mechanical loosening, osteolysis, infection, periprosthetic fractures and surrounding soft-tissue pathology, either acute or chronic [2]. Potential soft tissue injuries, regional tendinopathy or tears, are clearly not adequately evaluated on radiographs; and even osseous complications such as stress fractures and osteolysis, may not be visualized on radiographs until advanced stages in the disease process, when there is remodeling or displacement of the fracture or extensive burdens of osteolysis destroying the bone.

Computed tomography (CT) and, to a greater degree, magnetic resonance imaging (MRI) can evaluate the periprosthetic soft tissues and osseous pathology such as osteolysis. The inherent metallic artifact generated by bulky arthroplasty components; however, can degrade image quality if technical adjustments to counteract the metal artifact are not employed. Sonography, an ever evolving method for the evaluation of the musculoskeletal system, is ideal for evaluating the periprosthetic soft tissues as it is essentially unaffected by metallic artifact. With its dynamic, real-time capabilities, ultrasound can provide real-time guidance for image-guided aspirations of periprosthetic collections.

This review will outline the current status of CT, MRI and ultrasound in the evaluation of the patient with a painful arthroplasty and discuss the appropriate utilization of each imaging modality. The utility and limitations of each of the cross-sectional imaging modalities for evaluating a painful arthroplasty have generated publications in their own right. Space limitations prohibit an all-inclusive comprehensive discussion of each modality and the reader is encouraged to review the source primary references.

This review received Institutional Review Board approval.

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Computed tomography (CT)

Factors in the immediate periprosthetic soft-tissue interface (intrinsic factors) and those more distant, both within and outside the patient (e.g., technical factors; hereafter cumulatively termed extrinsic factors) affect the ultimate amount of artifact generated by a prosthesis at CT imaging. Intrinsically, the metallic composition and the geometry of the prosthesis both directly affect the amount of artifact generated. Unfortunately, neither of these variables can be modified by the radiologist. In general, titanium prostheses will result in the least artifact on CT imaging, with other metal alloys such as cobalt chrome resulting in more significant artifacts and image degradation [3–5].

Extrinsically, factors both within and outside the patient will affect the degree of artifact generated. Within the patient, factors that may or may not be able to be adjusted include the presence of orthopedic hardware, other implantable devices or the inability to move the contralateral extremity out of the plane of imaging. Pre-imaging consultation with the referring clinician regarding these factors will contribute to a more reasonable prognosis regarding ultimate diagnostic image quality of the scan. External to the patient, technical factors such as the detector capabilities of the CT unit and the availability of post-processing workstations, will also affect the final image quality.

Both beam hardening and projection data noise, the latter of which being a result of low detected photon counts, are inherent CT artifacts encountered in the presence of metal [6]. Streak artifacts occurring in the presence of metal at CT imaging are problematic, especially in the presence of bilateral prostheses [3, 7]. The regional geometry of the implanted hardware compounds the amount of beam attenuation and the degree of artifact generated. For example, when performing a CT of a total hip arthroplasty, it is more difficult to diminish metallic artifacts about complex acetabular revisions with metal backing, given the complex spherical nature of the hardware in contrast to evaluating the periprosthetic soft tissues about the relatively simple tubular structure of the femoral component.

The effects of hardware geometry and design with respect to streak artifacts should be considered when positioning the patient in the gantry. If possible, the patient (extremity) should be positioned such that the radiographic beam passes through the shortest axis of the hardware. For example, in a simple total hip arthroplasty, the patient should be positioned such that the radiographic beam traverses the short axis of the femoral component. In the setting of bilateral prostheses, positioning the patient such that the contralateral prosthesis is removed from the imaging field as much as possible should be attempted. It has been advised when evaluating the knee in the setting of bilateral total knee arthroplasties, one knee should be flexed with a pillow placed under the knee to eliminate streak artifact from the contralateral prosthesis [8].

Despite the inability to control the intrinsic, and often the extrinsic, factors affecting metallic artifacts, there are scanning parameter modifications the musculoskeletal radiologist can make that can limit the degree of overall artifact [3, 9]. In general, increasing the peak kilovoltage (kVp) and milliamperes of tube current (mAs) can help to improve visualization of the periprosthetic tissues, increasing the amount of the radiographic beam passing through the hardware, producing a more diagnostic image [8, 10]. Consideration to overall radiation dose, however, should be maintained especially in young patients as well as those patients potentially receiving serial examinations. Recent technological advances in CT imaging such as multidetector scanners with multiple overlapping slices and automatic tube current modulation, allow for more detailed imaging of periarthroplasty tissues without significant increases in overall radiation exposure [3, 11, 12].

In addition to potentially adjusting kVp and mAs settings, some authors have revisited the concept of pitch, and its affect on image quality in the presence of metal, noting that artifacts generated by higher pitch settings are further accentuated in the presence of metal [8]. Lower pitch settings or, alternatively, a lower table feed speed, yielding a lower pitch equivalent, have subjectively resulted in improved image quality in the setting of orthopedic and neurologic implants [8, 10].

Paralleling the advances in CT hardware technology with faster and multichannel detector scanners, are the advances in post-processing software, further improving overall image quality and visualization of periprosthetic tissues in the setting of orthopaedic implants [13]. Viewing arthroplasty images with a bone algorithm is generally most useful for evaluating the surrounding soft structures; however, some authors have noted that in the setting of large, bulky metallic implants, viewing the images with window center and level settings adjusted for soft tissue affords better visualization of periprosthetic soft tissues [3] (Fig. 1). Moreover, post-processing workstations which allow for reformatting images in multiple orthogonal planes, can further improve diagnostic yield [3, 14] (Fig. 2).

As a tomographic imaging technique, CT has proven to demonstrate areas of osteolysis for a multitude of joints with greater sensitivity than radiographs [7, 15, 16]. CT affords better visualization of regional bone stock than radiographs, thus demonstrating areas of bone replacement with osteolysis earlier than radiographs. Yian et al., for example, have shown CT to be more sensitive for detection of glenoid component loosening in total shoulder arthroplasty patients compared to radiography in a series of 43

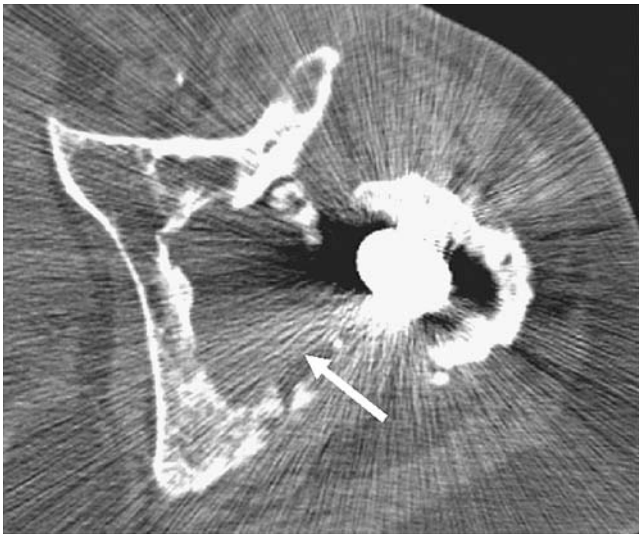

Fig. 1 53-year-old male 8 years after total hip arthroplasty. Direct axial acquisition viewed with soft tissues windows demonstrates extensive destruction of the superior acetabular dome, extending into the medial wall due to osteolytic involvement (*arrow*)

patients (47 shoulders) [16]. Cadaver models using parameter modifications for metal (120 kV and 150 mAs) have also demonstrated improved ability to diagnose pelvic osteolysis, attributed largely to the three-dimensional tomographic abilities of CT, in contrast to conventional radiographs [15]. The clinical applications for multidetector CT scanning of total hip arthroplasty patients has been expanded in some centers to include pre-operative planning for the evaluation of bone stock and defining remodeling of bone after placement of bone graft substitutes in the setting of revision arthroplasty surgery for osteolysis [17]. Math and colleagues have further found CT useful in the clinical evaluation of a painful total knee arthroplasty, with CT being more sensitive than conventional radiographs in the detection of loosening and osteolysis as well as in the detection of periprosthetic fractures [18] (Fig. 3).

In summary, CT scanning affords a reliable, sensitive method of evaluating the periprosthetic tissues. Pre-imaging consultation with the clinician regarding the type of prosthesis implanted and potential regional anatomic factors that might affect the image quality as well as a “hands-on” approach by the radiologist throughout the scanning process, spanning from deciding how the patient is positioned in the scanner to post-processing of the images, will have a cumulative positive effect on the diagnostic quality of the images in the setting of metal.

Magnetic resonance imaging

The sensitivity and specificity of magnetic resonance imaging (MRI) for diagnosis of articular and periarticular pathology has been well documented. In the setting of a total joint replacement, however, the magnetic susceptibility induced by the prosthesis can be problematic, often hindering the ability to evaluate the surrounding soft tissues. Knowledge of the way metal affects MR image quality and consideration of technical factors that can diminish these artifacts can make MRI a sensitive and reliable all-inclusive method for evaluating the painful arthroplasty.

The metallic composition of the type of implant placed affects the amount of artifact generated during an MR examination as well as the morphology of the implant and the relationship of the implanted material to the main magnetic field [19]. Titanium implants yield the least artifact while those that have a higher degree of ferromagnetism (stainless steel) result in considerably larger artifacts [20, 21].

The morphology of the implant also has a direct relationship with the total amount of artifact generated. Implants that are fairly simple in design typically result in fewer artifacts than those that are non-uniform such as those often encountered in the setting of revision arthroplasty [21, 22]. If possible, orienting and increasing the

Fig. 2 52-year-old male 7 years after total hip arthroplasty. Coronal reformatted CT demonstrates extensive periprosthetic osteolysis, with greatest involvement at the superior margin of acetabulum, approximately in DeLee and Charnley zone I (*arrow*)

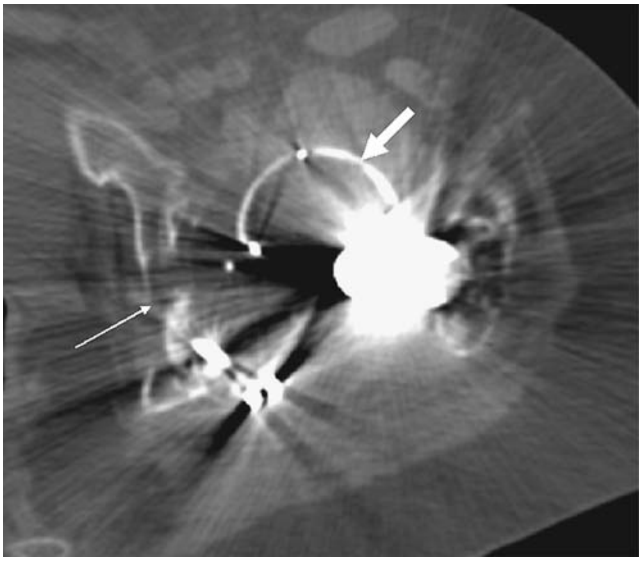

Fig. 3 43-year-old female status post left total-hip arthroplasty revision and open reduction internal fixation for acetabular fracture. Axial CT image demonstrates a fracture through the quadrilateral plate of the acetabulum (*thin arrow*) as well as dislodgement and displacement of the polyethylene liner into the anteroinferior margin of the pseudocapsule (*thick arrow*)

frequency encoding direction along the main longitudinal axis of the prosthesis will result in improved image quality and overall decreased artifact [23, 24] (Fig. 4).

The degree of magnetization induced by the prosthesis is related not only to the inherent metallic properties of the substance or implant, but also to the strength of the applied magnetic field (B_0) [25]. Considering this, higher field strength (3.0 T) magnets are generally not employed for imaging of patients with implants, with most clinical work performed at 1.0 or 1.5 T. Conversely, imaging at lower field strength is in general limited by poor signal-to-noise (SNR); however, a recent study has demonstrated potential clinical applicability of imaging implants at lower clinical field strengths while maintaining acceptable SNR using pre-polarized techniques [26].

Conventional spin echo (CSE) imaging should be avoided in the post-operative setting and, instead, faster techniques should be employed. With fast spin-echo (FSE) imaging, the multiple 180° refocusing pulses allow less time for dephasing of spins to occur, thus decreasing the chances of misregistration and resulting in overall less image distortion with bulky metallic implants [21–23, 27].

In addition to employing FSE techniques, the use of a wider receiver bandwidth when imaging patients with metal is suggested [28]. While there is an inverse relationship between receiver bandwidth and SNR, this is counteracted by the more noticeable decrease in artifact due to the inverse relationship between the readout bandwidth and the ultimate degree of distortion and linear misregistration [19, 23, 28].

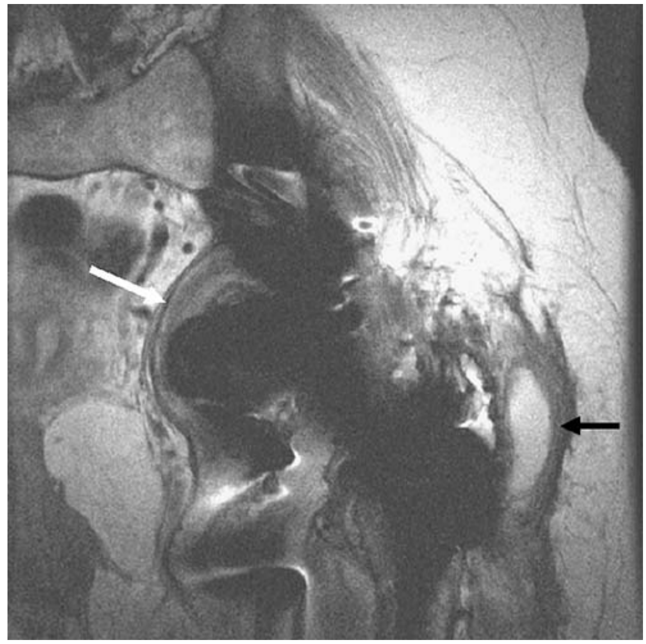

Fig. 4 42-year-old female status post revision hip arthroplasty. Coronal fast spin-echo MR image is diagnostic in spite of the presence of metal backing and nonspherical hardware. Osteolysis is seen in the medial acetabular wall (*white arrow*) in addition to moderately severe greater trochanteric bursitis (*black arrow*)

Additional MRI considerations when imaging the patient with metal include the use of a fluid-sensitive pulse sequence to evaluate for potential marrow pathology. In the setting of metal implants, a fast-inversion recovery

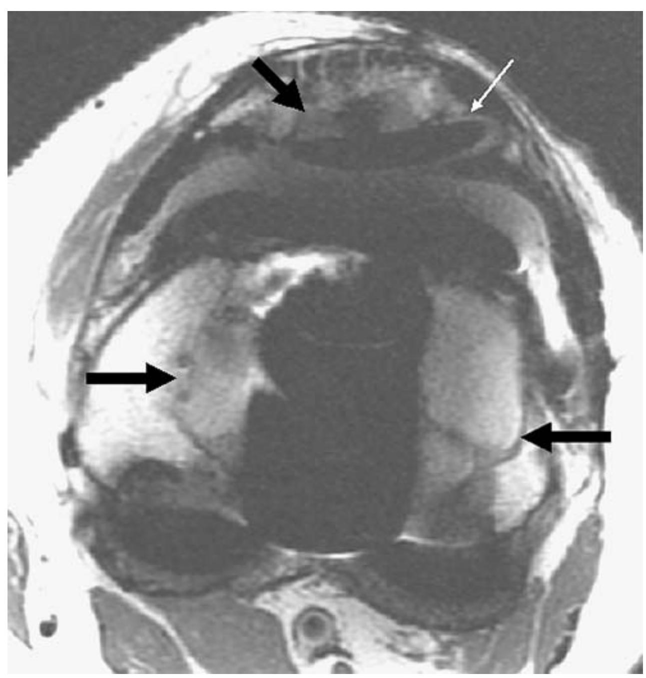

Fig. 5 49–year-old female 10 years status post total knee arthroplasty with pain and locking. Axial fast spin-echo image demonstrates multifocal osteolysis (*black arrows*) and loosening of the patellar component (*white arrow*)

Fig. 6 65-year-old female 12 years after total hip arthroplasty with hip pain. Coronal fast spin-echo MR image demonstrates extensive periacetabular osteolysis (*arrows*)

sequence should be employed instead of frequency selective fat suppression, which is often the standard fluid sensitive pulse sequence in many centers. There is limited ability to perceive fat and water molecules as different resonant frequencies with frequency selective fat suppression in the setting of metal implants due to the resultant inhomogeneous magnetic field, resulting in significant image distortion and the characteristic 'flare' seen around metallic implants [23, 29, 30].

Lastly, gradient echo (GRE) imaging is not useful in the setting of prosthetic implants, as any area of regional magnetic field inhomogeneity will result in considerable signal void due to increased intravoxel dephasing (T2* decay) [31, 32].

MRI can evaluate both osseous and soft-tissue pathology around a prosthesis. Periprosthetic fatigue fractures and component failure have been identified with MRI and reported in the literature [33] (Fig. 5). The ability to diagnose these injuries in the early stages, before protracted patient symptomatology or completion of the fracture, with associated increased morbidity, is a distinct advantage to MRI imaging in the context of a painful arthroplasty in the setting of negative radiographs.

The ability of MRI to evaluate the periprosthetic soft tissues affords the ability to diagnose periprosthetic collections, muscle or tendon tears, soft-tissue extension of osteolysis and heterotopic ossification, documenting the relationship of heterotopic ossification or soft-tissue osteolytic foci to regional neurovascular structures [34–36] (Figs. 6, 7, 8, 9 and 10). In patients with painful shoulder arthroplasty, MRI demonstrated the regional soft tissues including the integrity and quality of the rotator cuff with high diagnostic yield in a series of 42 patients with greater than 50% having surgical validation of the findings [34].

Tendon injuries about the knee and hip can also be evaluated with MRI, including potential extensor mechanism or hip abductor injuries [35–37]. Knowledge of the

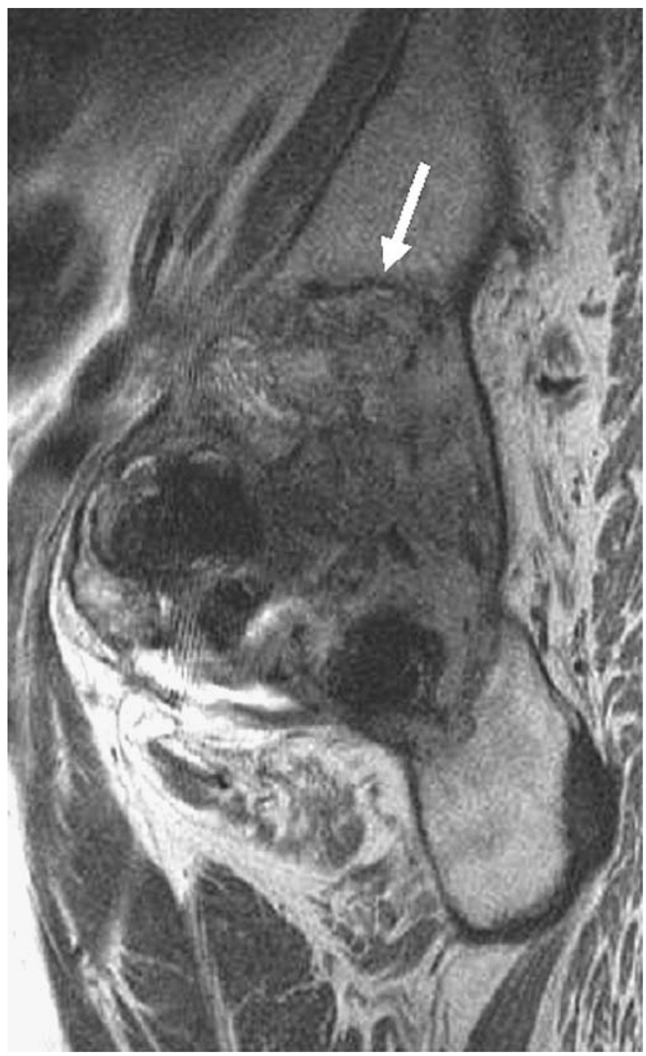

Fig. 7 Parasagittal MR image through the medial acetabular wall in the same patient demonstrates the near circumferential osteolytic involvement (*arrow*)

Fig. 8 55-year-old female status post total-hip arthroplasty and recent posterior dislocation. Coronal fast spin-echo MR image demonstrate extensive synovitis (*black arrow*)

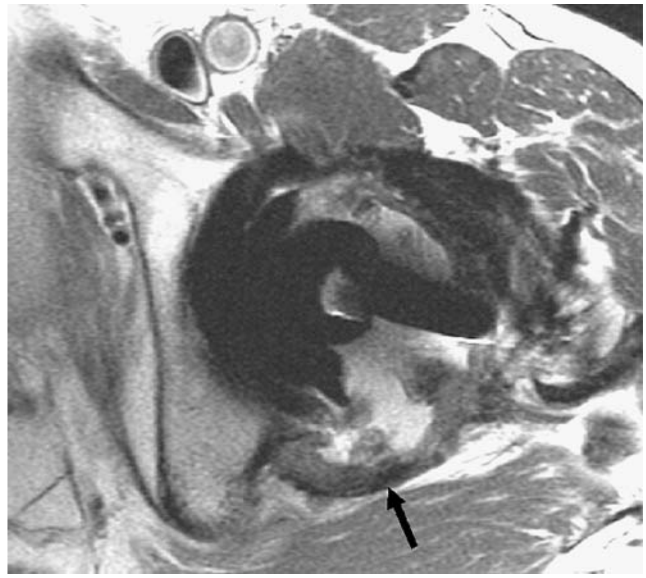

Fig. 10 55-year-old female status post total hip arthroplasty and recent posterior dislocation. Axial fast spin-echo image demonstrates a partially remodeled posterior pseudocapsule after subacute disruption from posterior dislocation (*arrow*)

Fig. 9 55-year-old female status post total hip arthroplasty and recent posterior dislocation. Sagittal fast spin-echo MR image demonstrates osteolysis of the medial acetabular wall (*black arrow*). Clear depiction of the anatomic relationship between the polyethylene liner and the acetabular cup is also demonstrated (*white arrow*)

normal post-operative appearance of the regional soft tissues is of importance when evaluating clinical MR scans of a painful arthroplasty. A degree of atrophy and attritional change of the regional musculature can be expected especially involving the soft tissue envelope around a total hip arthroplasty; however, a knowledge of the surgical approach utilized as well as patient symptomatology will help in improving diagnostic accuracy. Pfirrmann and colleagues for example have reported that while changes in the ipsilateral hip abductor musculature are common after total hip arthroplasty, especially after a lateral trans-gluteal approach, abnormalities of the more posterior musculature and tendons such as the gluteus medius tendon, are more common in symptomatic patients [38].

Clinical studies have shown that MRI can demonstrate the presence and extent of osteolysis to better advantage than radiographs in the setting of total shoulder, knee and total hip arthroplasties, thus aiding in pre-surgical planning [34–36]. The ability of MRI to evaluate the extent of periacetabular osteolysis has also been validated using a cadaver model, with MRI yielding 95% sensitivity, 98% specificity and 96% accuracy in evaluating periprosthetic osteolysis in comparison to conventional radiographic analysis, including both standard anteroposterior as well as 45° oblique (Judet) views [39].

Osteolysis is typically seen on MRI as geographic, often mildly expansile, areas of intermediate signal intensity, replacing the normal marrow signal, usually with a sclerotic low signal intensity margin [36] (Figs. 5, 6 and 7). Occasionally osteolytic foci may be relatively isosignal to bone, especially around the knee [35]. Osteolysis and implant reaction can result in an exuberant soft tissue as well as an intraosseous response. With MRI's ability to visualize the regional osseous structures and the surrounding soft tissues, potential extraosseous involvement of osteolysis and its relationship to the regional neurovascular structures, can be discerned [36].

In conclusion, MRI in regards to modifying sequence parameters in the setting of metal, including the use of FSE imaging, employing a wide receiver bandwidth, using fast inversion recovery instead of frequency selective fat suppression as a fluid sensitive pulse sequence and avoiding GRE imaging, provides an all inclusive method of evaluating a painful arthroplasty and diagnosing intraosseous, intraarticular and periarticular pathology in one imaging examination.

Ultrasound

The general application of ultrasound in the evaluation of the musculoskeletal system has continued to evolve. Ultrasound can be applied to evaluate the periprosthetic soft tissues as it is essentially not affected by metallic artifacts. The integrity of regional muscles and tendons after arthroplasty placement can be reliably evaluated with sonography [40] (Figs. 11, 12a-d).

Ultrasound can evaluate the integrity of the surrounding muscles and tendons in the presence of a joint replacement [40]. All major soft-tissue structures, including those in a relatively deep location such as around the hip in a total hip replacement, are generally amenable to sonographic evaluation, if proper transducer frequencies are employed, considering the need to decrease transducer frequency when evaluating deep seated structures. Structures that are relatively superficial, are readily amenable to sonographic evaluation. For example, the subscapularis, which often fails in the setting of a total shoulder arthroplasty, can clearly be evaluated with sonography as it is an anterior, and usually relatively superficial, structure [40, 41] (Fig. 11, 12d).

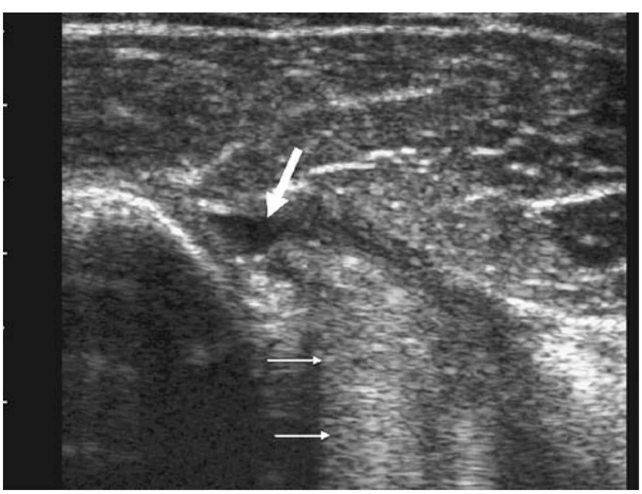

Fig. 11 63-year-old male status post total shoulder arthroplasty with clinical concern of subscapularis failure. Longitudinal ultrasound image of the anterior shoulder demonstrates a complete tear of the subscapularis tendon, with a frank fluid-filled defect (*thick arrow*). Note also the characteristic posterior reverberation from the metallic prosthesis (*small thin arrows*)

An advantage of sonography over other cross-sectional imaging modalities is its dynamic capabilities. While plain film radiographs and other static imaging modalities can visualize the relationship of orthopaedic hardware and the osseous structures, they cannot always determine the dynamic relationship between the hardware and the surrounding ligaments and tendons [42]. Sometimes patients with regional pain after arthroplasty placement have pain only with motion of the joint. While intrinsic mechanical factors may be a cause, often this is the result of regional soft tissues impinging against the prosthetic components. One area where this has been extensively studied is iliopsoas impingement, where patients present with pain with hip flexion after total hip arthroplasty [43, 44]. In this setting, there is impingement of the myotendinous junction of the iliopsoas against a component of the prosthesis, usually the acetabular component, but also occasionally extruded cement or a cup fixation screw [44]. Static examination techniques such as MRI, may not demonstrate an abnormal relationship between the iliopsoas tendon and the prosthesis; however, with dynamic ultrasound scanning, the iliopsoas may be observed to impinge against one of the prosthetic components, with this friction yielding the patient's pain [43, 44].

Ultrasound can be used not only to diagnose iliopsoas impingement, but also to provide guidance for treatment at the same sitting. Peritendinous injections for iliopsoas impingement has been described both in the setting of the native hip as well after total hip arthroplasty [43–46]. Ultrasound guided iliopsoas injection at the level of the iliopectineal eminence in the native hip and at the level of direct impingement in the setting of total hip arthroplasty, usually at the acetabular cup, have demonstrated good pain relief in two clinical series, including the ability to potentially guide surgical management such as potential iliopsoas tendon release [43, 45, 46].

Sonography can function as a guide for a variety of diagnostic and therapeutic interventions in the setting of a painful arthroplasty. Regional fluid collections can be aspirated in the context of potential infection, and the popliteal or other regional synovial cysts can be drained and the periprosthetic tendons can be injected for pain relief [47, 48]. Power Doppler can be a useful imaging adjunct when using sonography, directing the radiologist to areas of potential active inflammation such as synovitis or tendini-

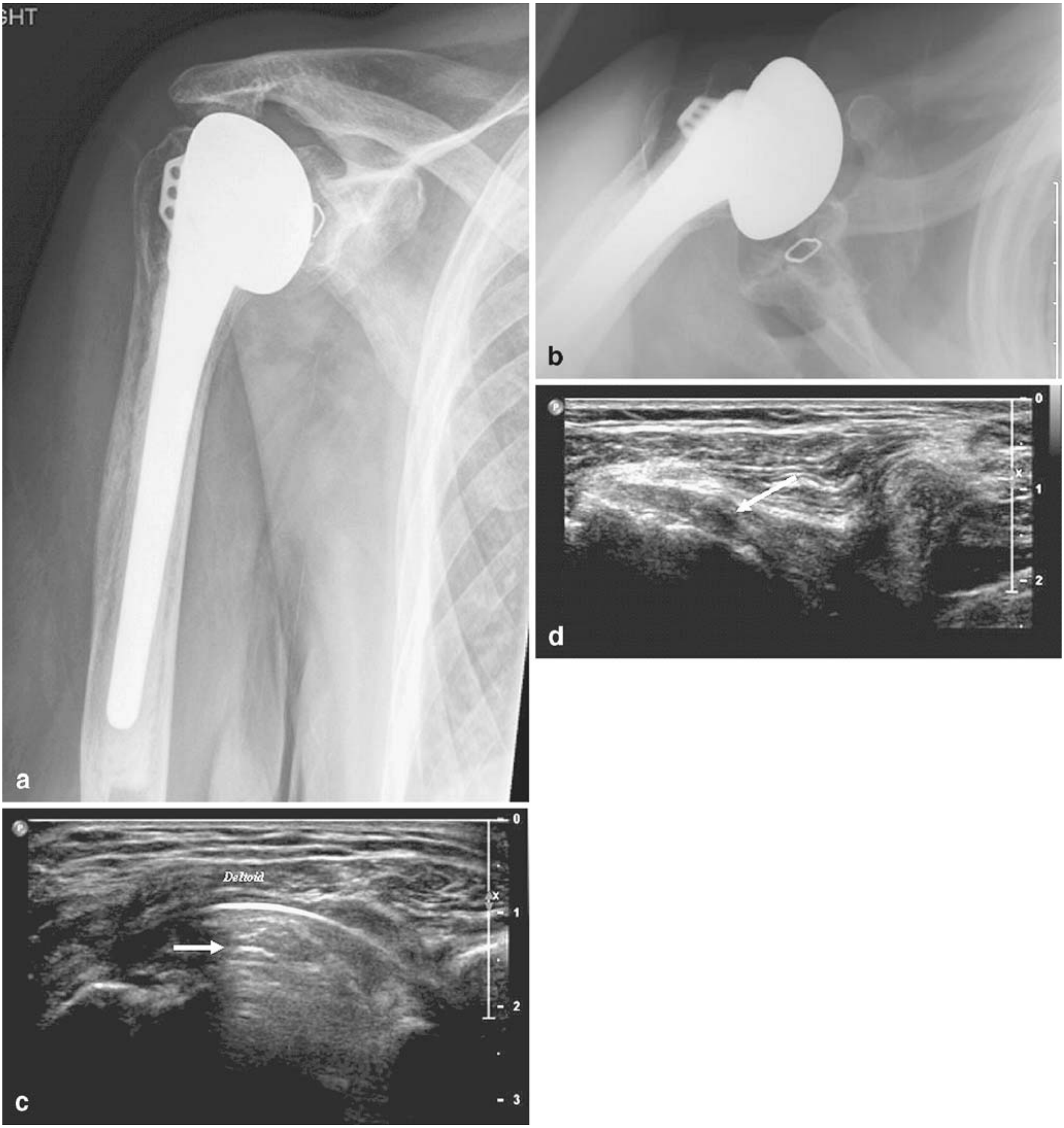

Fig. 12 69-year-old female 4 years status post total shoulder arthroplasty with pain and limited range of motion. **a** Externally rotated radiograph of the right shoulder demonstrates superior migration of the metallic humeral head. **b** Axillary view demonstrates relative anterior subluxation of the humeral head suggesting subscapularis insufficiency. **c** Longitudinal ultrasound image demonstrates superior migration of the metallic humeral head with characteristic reverberation artifact (*white arrow*). Direct apposition of the humeral head to the undersurface of the deltoid (*labeled*) is consistent with chronic rotator cuff insufficiency. **d** Transverse ultrasound image in the same patient demonstrates a markedly degenerated subscapularis tendon with a high-grade partial, essentially complete, degenerative tear of the deep fibers of the subscapularis (*arrow*)

tis, thus suggesting areas of potential sonographic-guided therapeutic interventions. One specific application of the use of color or power Doppler in the post-operative setting is the diagnosis of active synovitis from a bland joint effusion or thickened pseudocapsule, both of which can appear as a relatively thick hypoechoic band around the prosthesis on routine gray-scale imaging [49].

As sonography is limited by depths of penetration, and inability to directly visualize osseous pathology, it is of limited use in directly evaluating mechanical component loosening. Secondary signs such as periprosthetic collections, and potential extracapsular spread of polyethylene granulomas can be evaluated with sonography. Since sonography is not limited by regional artifacts, sonography can visualize the integrity of the superficial components of a joint arthroplasty in some settings such as the periphery of the polyethylene liner in the setting of total knee arthroplasty. Also, it can visualize the relationship of the components to each other and the surrounding soft tissues in a total shoulder arthroplasty [40, 50]. The appearance of the components of the prosthesis can be discerned due to the inherent differences in reflection coefficients, with metal identified as a linear echogenic interface with posterior reverberation artifact, while bone and polyethylene demonstrate linear echogenic surfaces with posterior acoustic shadowing [50].

In summary, sonography has a broad range of applications in the evaluation of the patient with pain following an orthopaedic surgical procedure such as arthroplasty placement. Sonography can be used to evaluate for periprosthetic collections as well as the integrity of the regional tendons and ligaments. The dynamic capabilities of sonography allow it to be used as a guide for various therapeutic and diagnostic injections, as well as evaluate the regional relationships between the soft-tissue structures and implantable hardware.

Conclusions and recommendations

The use of advanced imaging modalities to evaluate the painful arthroplasty should be employed based both on the clinical question posed, as well as patient driven factors such as mobility, claustrophobia, and cost considerations. For young patients (e.g., adolescent and pediatric patients), examinations utilizing ionizing radiation should ideally be avoided and ultrasound or MRI employed. Considering this, the musculoskeletal radiologist asked to image the painful arthroplasty should have some knowledge of the strengths, weaknesses and limitations of each advanced cross-sectional imaging modality.

Technical scanning parameter modifications can make CT a diagnostic examination for the evaluation of a painful arthroplasty. Adjusting the area of interest such that the short axis of the hardware is perpendicular to the radiographic beam, adjusting the pitch and increasing the kVp as necessary and viewing images with post-processing software and multiplanar reformatting will result in better image quality. The strengths of CT lie in its ability to exquisitely evaluate cortical bone and to evaluate for possible subtle fractures. Also, with its tomographic abilities, it can often visualize the extent of osteolysis better than conventional radiographs.

MRI provides detailed visualization and anatomic evaluation of the surrounding soft tissues. An advantage of MRI over CT is that MRI provides a morphologic evaluation of the internal matrix of bone, identifying areas of subtle bone marrow changes, thus indicating areas of possible intramedullary (stress or insufficiency) fractures. FSE techniques should be employed, as the multiple 180° refocusing pulses result in overall less image distortion with metallic implants. GRE imaging should be avoided in the post-operative patient, as even subtle regional field inhomogeneities will result in marked signal void and fast inversion recovery imaging should be utilized instead of frequency selective fat suppression, as it is less susceptible to regional field inhomogeneities.

Lastly, ultrasound has distinct advantages over other cross-sectional imaging modalities in that it is globally less expensive, employs no ionizing radiation, and is dynamic. The dynamic capabilities of sonography provide the ability to perform a diagnostic examination and a therapeutic or diagnostic sonographic-guided intervention at the same time. The dynamic capabilities of sonography can also be applied to evaluate ligament and tendon dynamics, and their relationship to adjacent orthopaedic implants.

Ultrasound should be considered as a first-line imaging modality if there is a targeted clinical question to a specific area of interest (e.g., quadriceps tear status post total knee arthroplasty) or if a therapeutic or diagnostic intervention is likely to be needed. If an acute osseous injury is suspected, and radiographs are negative, CT is fast, sensitive and accurate for fractures. For nonspecific symptoms or a confusing clinical picture with pain potentially generated from the arthroplasty proper, surrounding soft tissues, or regional nerve injury, MRI with its ability to provide a global anatomic overview is suggested.

An understanding of the basic imaging principles and suggested technical parameter modifications of CT and MRI, as well as the applications of ultrasound, should direct the radiologist to the appropriate imaging modality to answer the posed clinical question.

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