Magnetic Resonance Arthrography

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KEYWORDS

• MRI • Joint • Arthrography
• MR arthrography • Direct arthrography

The contrast medium injected for MR arthrography separates the articular capsule from other structures and, due to considerable T1 shortening, outlines intraarticular structures on T1-weighted images.[1] Direct MR arthrography has been successfully used in many joints of the body for a variety of conditions. Compared with standard MR imaging, MR arthrography improves the detection of intraarticular bodies and osteochondral lesions in any of the peripheral joints. Moreover, direct MR arthrography improves the assessment of internal joint derangements, such as the detection of labral and ligamentous abnormalities in the shoulder and hip. In the wrist, MR arthrography improves confidence in the diagnosis of interosseous ligament tears and tears of the triangular fibrocartilage complex (TFCC).[1–7]

HISTORY

Historically, fluoroscopic arthrography with the addition of postinjection radiographs was used to indirectly image the soft tissues within and around joints. CT arthrography then followed with better soft tissue depiction. The development of conventional MR allowed even better visualization of soft tissues. However, even with MR imaging's superior visualization of soft tissues, some areas remained obscure, including areas where capsular structures fold upon themselves. As orthopedic surgery started concentrating more on soft tissue injuries, the need to image smaller parts of the joint became more important. MR arthrography gained widespread use in the United States in the late 1980s and by the early 1990s, it surpassed CT arthrography in popularity.

Hajek and colleagues[8] first injected a gadopentetate dimeglumine/saline mixture into cadaver shoulder joints, resulting in superb delineation of anatomic structures on postinjection T1-weighted images. Subsequently, they studied the effect of gadopentetate dimeglumine on the synovial lining of joints in animals and found no toxic effects.[9] As direct MR arthrography gained popularity, indirect MR arthrography subsequently developed as a less invasive alternative. That technique involves the intravenous administration of gadolinium and it is not discussed in this article.

Direct MR arthrography refers specifically to the administration of dilute gadolinium solution directly into a joint, followed by MR imaging. MR arthrography enhances the capabilities of conventional MR imaging in numerous ways. By administering gadolinium directly into the joint, the capsule becomes distended, and small, complex intraarticular structures can be better delineated. Furthermore, gadolinium causes T1 shortening, resulting in high signal intensity fluid on T1-weighted images. With the application of fat-saturation to the T1-weighted sequences, the signal from fat is nulled and the

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precise distribution of gadolinium can be seen more easily. The fluid also remains high-signal intensity on T2-weighted images.

Early papers by Gylys-Morin and colleagues[10] showed cartilage defects as small as 2 mm in diameter in cadaver knees. Engel[11] showed that MR arthrography accurately depicted intraarticular bodies and meniscal abnormalities. This study also showed that MR arthrography enabled more reliable estimation of cartilage thickness than did nonenhanced spin-echo or gradient-refocused imaging.

ADVANTAGES

There are several advantages of MR arthrography. These include (1) demonstration of abnormal communication between joint compartments; (2) the ability to see tears, perforations, and intraarticular bodies to better evaluate the surfaces of small structures due to improved delineation between various components of the joint that lie in close apposition; and (3) high-signal-to-noise and contrast resolution.

A major advantage of direct MR arthrography is the delineation of abnormal communication among joint compartments through defects in soft tissue structures. The presence of dilute gadolinium contrast agent within a location that is normally separated from the area of injection confirms that the fluid within the adjacent joint compartment is due to abnormal communication between the two regions rather than representing a separate process such as a bursitis. For example, when a routine shoulder MR is performed and fluid is present within the subacromial–subdeltoid bursa, it cannot safely be assumed that it represents communication with the glenohumeral joint. This fluid can represent a reactive bursitis in the absence of a full-thickness rotator cuff tear. On the MR arthrogram however, the fluid in a noncommunicating bursa will remain dark on the T1 sequence confirming the absence of communication with the adjacent joint. If there is increased signal intensity fluid in the subacromial–subdeltoid bursa on T1-weighted images, the presence of a full-thickness rotator cuff tear is confirmed, even in subtle cases.

Similarly, contrast can be seen to extend into tears of small structures. A labral tear and a meniscal tear can be confirmed when contrast signal visibly extends into these structures. This is especially helpful in postoperative joints where there may be increased T1 or T2 signal in tendons, ligaments, and fibrocartilage from intrasubstance degeneration or scarring.

Aside from the physical advantage of joint distension, the T1 shortening caused by the gadolinium, with the addition of fat suppression, results in a signal that is similar to, but higher in signal-to-noise than, a T2-weighted fat-suppressed image.

DISADVANTAGES

There are some minor disadvantages with MR arthrography, the most important being the usual need for image localization of the joint via fluoroscopy or ultrasound. This limits the examination to facilities such as multimodality centers and hospitals, excluding many freestanding centers that otherwise offer subspecialty expertise. The need for extra time to perform the injection also causes logistical scheduling delays. To get around this inconvenience, some centers choose not to institute MR arthrography in their practice or they perform nonimage-guided (“blind”) injections or indirect MR arthrography with intravenous gadolinium.

Other factors that affect the choice of MR arthrography include a negligible small radiation dose if fluoroscopy is used as a method of injection, minimal invasiveness that can be painful and leads to patient anxiety, and the possibility for very rare complications from injection such as bleeding, synovitis, allergy, and infection.

Ideally, MR imaging should be performed promptly after the administration of gadolinium injection to minimize contrast absorption and loss of capsular distension.[1] To prevent this, some centers administer intraarticular epinephrine (ratio 1:1000). This should be considered in busy hospital centers where there is risk of delay between injection and scanning. A recent study evaluating the contrast-to-noise ratio related to time elapsed between intraarticular injection of contrast agent and MR imaging showed decreasing values of contrast-to-noise ratio over time. Contrast material in the joint is eliminated by transsynovial diffusion. For the shoulder and hip, MR arthrography should be performed within 90 minutes of intraarticular injection. For the wrist, no more than 45 minutes should be allowed between injection and MR.[12]

CONTRAINDICATIONS AND PRECAUTIONS

The following precautions are important to consider in all patients potentially undergoing a joint injection.[13]

Infections

MR arthrography should not be performed where there is suspected infection involving the skin