Diagnostic and Therapeutic Joint Injections

**Salvatore Masala, Ph.D., M.D.,¹ Roberto Fiori, M.D.¹
Dario Alberto Bartolucci, M.D.¹ Matteo Mammucari, M.D.¹
Giorgios Angelopoulos, M.D.¹ Francesco Massari, M.D.¹
and Prof. Giovanni Simonetti¹**

ABSTRACT

Joint injection is a useful tool in the diagnosis of intra-articular pathology that may improve diagnostic performance of computed tomography (CT) and magnetic resonance (MR) imaging. Historically, conventional arthrography under fluoroscopy was the first method to be used to image indirectly the intra-articular soft tissues, but with the advent of CT, CT arthrography offered better soft tissue depiction. The development of conventional MR allowed even better visualization of soft tissues, and in the early 1990s, MR arthrography surpassed CT arthrography in popularity. Joint injections may also be performed for therapeutic reasons with different drugs, such as corticosteroids, anesthetics, or hyaluronic acid, which have been shown to provide pain relief in various circumstances. In this article, the technical principles for joint injection of the shoulder, knee, elbow, hip, ankle, and wrist, used for therapeutic or diagnostic reasons, are discussed. Indications, expected benefits, and risks are also analyzed.

KEYWORDS: Joint, arthrography, injection, shoulder, wrist, knee, hip, ultrasonography, magnetic resonance

Objectives: Upon completion of this article, the reader should be able to recall the indications and the technical principles of joint injections used for diagnostic or therapeutic reasons.

Accreditation: Tufts University School of Medicine (TUSM) is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians.

Credit: TUSM designates this educational activity for a maximum of 1 *AMA PRA Category 1 Credit*TM. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Joint injection has been used for many years as a diagnostic and/or therapeutic tool and even today remains a valid examination for detection and treatment of intra-articular pathology.

Diagnostic arthrography is often indicated when there is persistent and unexplained pain, discomfort, and/or malfunction of a joint. Administering intra-articular contrast (iodine, gadolinium, saline, and air) media can improve the diagnostic performance of fluoroscopy, computed tomography (CT), and magnetic

resonance (MR) imaging in many circumstances. Conventional arthrography, which has been used for many years to provide diagnostic information and identify abnormalities within the joints, today has been replaced by CT and more frequently by MR arthrography. MR arthrography may extend conventional MR capabilities because contrast solution distends the joint capsule, outlining intra-articular structures such as ligaments, cartilage, and joint capsules and their abnormalities. MR arthrography is also useful to assess the stability of

¹Department of Diagnostic Imaging, Interventional Radiology, Radiotherapy, and Nuclear Medicine, Policlinico Tor Vergata, Rome, Italy.

Address for correspondence and reprint requests: Dario Alberto Bartolucci, M.D., Department of Diagnostic Imaging, Interventional Radiology, Radiotherapy and Nuclear Medicine; Policlinico Tor Vergata, v.le Oxford 81,00133, Rome, Italy (e-mail: bartolucci.md@gmail.com).

Musculoskeletal Interventions; Guest Editors, Tarun Sabharwal, F.R.C.R., F.R.C.S.I., and Afshin Gangi, M.D., Ph.D.

Semin Intervent Radiol 2010;27:160–171. Copyright © 2010 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

DOI: <http://dx.doi.org/10.1055/s-0030-1253514>.

ISSN 0739-9529.

osteochondral lesions in the articular surface and delineating loose bodies.

MR arthrography of the shoulder is frequently used for detection of labral-ligamentous complex abnormalities and of partial or full-thickness tears in the rotators cuff. It can also help demonstrate labral tears in the hip and partial or full-thickness tears of the collateral ligament of the elbow. MR arthrography may also identify residual or recurrent tears in the knee following meniscectomy and may increase the certainty of perforations of the ligaments and triangular fibrocartilage in the wrist. Ligament tears of the ankle are correctly identified, and sensitivity for ankle impingement syndromes is increased.

Indirect MR arthrography with intravenous administration of diluted gadolinium may also be performed when direct arthrography is inconvenient or not feasible.

Therapeutic joint injections for pain management have been used for many years and are usually performed to treat inflammatory conditions such as rheumatoid arthritis, psoriatic arthritis, gout, tendonitis, bursitis, and osteoarthritis. The success rate and clinical improvement depends greatly on the overall condition of the joint and the medication administered during the injection, as well as the accurate placement of the needle tip into the joint. The drugs that are most frequently used and may relieve patients' symptoms are corticosteroids, hyaluronic acid (HA), and anesthetics.

HA is an organic polysaccharide that induces normalization of the viscoelasticity of the synovial liquid and activation of the tissue regeneration of the articular cartilage.

Corticosteroids reduce the inflammatory reaction by limiting the capillary dilation and permeability of the vascular structures. These compounds restrict the accumulation of polymorphonuclear leukocytes and macrophages and reduce the release of vasoactive kinins. Additionally, corticosteroids may inhibit the release of arachidonic acid from phospholipids, thereby reducing the formation of prostaglandins, which contribute to the inflammatory process.

Local anesthesia into joints is used primarily in the symptomatic treatment of patients affected by osteoarthritis or inflammatory synovial processes and provides short-term pain relief. It may also have a diagnostic role in the preoperative evaluation of patients undergoing joint arthrodesis or arthroplasty by providing a more comprehensive examination of the affected area without the limitation of pain. Bupivacaine or lidocaine are the most frequently used; bupivacaine is preferred in our department because it offers extended anesthetic effect.

Joint aspiration (or arthrocentesis) is another procedure that may be either therapeutic or diagnostic and often is performed at the knee. Among the indica-

tions for arthrocentesis are crystal-induced arthropathy, hemarthrosis, unexplained joint effusion, and septic arthritis.

HIP

The high rate of diagnostic uncertainty and the therapeutic needs regarding hip articulation have increased the use of intra-articular injection for diagnostic and/or therapeutic reasons.

The influence on hip pain resulting from spine, sacroiliac joint, and soft tissues is high and can make the diagnosis difficult. The injection of anesthetics, steroids, and hyaluronate with an improvement of symptomatology is a useful indicator for coxofemoral disease.

Although MR is a proven imaging technique for the evaluation of cartilage, labrum, ligamentum tears, and capsule involvement, the combination of gadolinium with a local anesthetic may suggest a nonvisible intra-articular change such as chondral defects or loose bodies, which are better visualized with MR arthrography. Hip arthrography is also important in preoperative evaluations and before prosthesis revisions associated with an aspiration of the pseudocapsule fluid to identify infected prosthetic devices. The use of digital subtracted fluoroscopic injection of contrast media in cemented femoral stem prosthesis is useful to assess prosthetic loosening or bone fistulae connecting the stem-bone space to soft tissue abscesses.¹ In some cases, the loosening can be demonstrated by extending the contrast medium along the prosthesis after a short patient ambulation.²

Nowadays, the main benefit of using intra-articular gadolinium is the correct evaluation of labral pathology. Czerny et al in 1996 found that sensitivity and accuracy of MR arthrography in diagnosis of labral tears and detachments was 90% and 91%, respectively, and in nonarthrographic MR imaging was just 30% and 36%.³ The MR aspect of acetabular labrum is a low-signal-intensity triangular structure on the rim of acetabulum, although it can have variable shape⁴ and has a tendency to become rounded and irregular with age.⁵

During the movement of rotation associated with a slight flexion and abduction of the hip, the normal iliopsoas tendon moves effortlessly over the pelvic brim.⁶ In anterior snapping hip, the sonographic exam demonstrates an abnormal sudden movement of the tendon,⁷ which in some cases is associated with ultrasonographic signs of iliopsoas tendinopathy or bursitis.⁸ Treatment options for this disease include clinical management (drugs, physical therapy), injection of anesthetics and corticosteroids into the iliopsoas bursa, and surgery.⁹⁻¹² Iliopsoas bursitis may be present in the absence of a snapping iliopsoas tendon.¹³

MR arthrography may be requested also in femoral acetabular impingement, which is another cause of hip pain. This condition is linked to the presence of

Figure 1 Hip joint injection: anteroposterior approach. The patient is in supine position, and the needle tip is along the lateral aspect of the femoral bone at the head-neck junction. The confirmation of the needle placement has been made after injection of 3 to 5 mL of contrast medium (Omnipaque 300, GE Healthcare S.r.l., Milan, Italy).

anatomic abnormalities of the proximal femur or acetabulum. Sometimes the impingement overlaps with the labral tears, as some tears and detachments may be due to femoral acetabular impingement.¹⁴ Differential diagnosis should also be performed between other alterations such as cartilage lesions and premature degenerative joint diseases; in these cases, MR arthrography is very useful for the final diagnosis. In other cases, a combination of pelvis radiographic examination and plain MR imaging is enough to depict the hip defect.¹⁴

The hip injection may be performed under imaging guidance or not. Nowadays, the use of ultrasonography is increasing and together with the fluoroscopic guidance is the most frequently used in our department.

An anteroposterior approach, under fluoroscopic guidance, is generally the most frequently used method; the patient must be in supine position with the tip of the needle positioned along the lateral aspect of the femoral bone at the head-neck junction (Fig. 1). This maneuver grants the minimum risk of contrast extravasation and vessel or femoral nerve injury. In obese patients, a cranial angulation of the radiograph beam can help to exclude the pannus, although the operator has to pay attention not to go through the peritoneum.¹³

Some authors suggest performing the puncture in the middle of the femoral neck, because injection and aspiration are easier in this part of capsule. A prospective study by Duc et al found a 3 times greater risk for extravasation of contrast media in soft tissue with this approach, so we agree that this approach should be avoided.¹⁵

In case of femur prosthesis, the anteroposterior approach has to be modified, placing the skin entryway

Figure 2 Anterior approach of the hip under ultrasound guidance. The needle is inserted between the acetabular rim (*) and the femoral head (§) inside the capsule.

lateral to the prosthesis, to make the needle visible during positioning. In these cases, aspiration is necessary before the injection of contrast media or drugs to check the fluid of the prosthetic pseudocapsule.

The other important aid to using contrast media or drug administration is the use of ultrasonographic guidance. The approach is usually the same as in fluoroscopic technique: an anterior approach with the skin entry site 8 to 10 cm under the inguinal ligamentum, angling the needle toward the femur head (Fig. 2). Following the needle with the ultrasound (US) probe, the tip has to reach the capsule near the head-neck junction.¹⁶ Aspiration performed before injection helps ensure correct positioning of the needle. This approach is helpful not only in MR arthrography, but also in viscosupplementation, anesthetics, and corticosteroid intra-articular administration, which may be performed and repeated in time without utilizing X-rays.¹⁷ The simplest way to inject contrast media or drugs in the iliopsoas bursa is the US technique, which permits not only the diagnosis but also the treatment of the bursitis. The bursa is injected at the acetabular rim level. If the bursa is not stretched by fluids, the needle is advanced from a lateral approach, positioning the tip posteriorly to the iliopsoas tendon and close to the acetabular rim. The use of contrast media within the bursa and fluoroscopy may allow the diagnosis of snapping hip.

KNEE

There are several indications for diagnostic and therapeutic injection of the knee joint. Although conventional single- and double-contrast arthrography of the knee has

been mostly replaced by conventional MR imaging, there are several other indications for image-guided interventions. Most frequently, MR arthrography is used for the detection of osteochondral lesions and in the postoperative knee, for evaluation of the meniscus (recurrent meniscal tear). Also, MR arthrography is the gold standard for the detection of intra-articular bodies in the knee.¹⁸ CT arthrography is an alternative technique that provides accurate diagnosis to identify chondral, fibrocartilaginous, and intra-articular lesions ligaments,¹⁹ but in our department is preferred only in patients who cannot be evaluated by MR imaging.

Therapeutic knee injections are widely used to alleviate joint pain, and the drugs most frequently injected are HA, corticosteroids, and/or anesthetics. The ideal candidate for HA administration has yet to be defined, but nowadays it is widely accepted that HA should be used in patients with significantly symptomatic osteoarthritis, who have not responded adequately to standard treatments (pharmacological or nonpharmacological) or are intolerant of these therapies (e.g., gastrointestinal problems related to anti-inflammatory medications, etc.).²⁰ Lohmander et al²¹ noticed that mainly patients more than 60 years and with severe symptoms obtained beneficial effects from the hyaluronan injections. Patients who are not candidates for total knee replacement or who are unwilling to undergo surgery may also be candidates for viscosupplementation. Additionally, a total knee replacement in younger patients may be delayed with the use of HA.

Indications for corticosteroid injection include advanced osteoarthritis and other inflammatory arthritis, such as gout or calcium pyrophosphate deposition diseases.

Knee joint aspirations can be used for diagnostic and therapeutic reasons at the same time, relieving patients' symptoms and aiding in the diagnosis of an unexplained effusion with fluid analysis. Another indication for joint aspiration of the knee is the popliteal cyst or inflamed bursae, which may cause a relief of tension and discomfort (Fig. 3).

When knee effusion is present, the lateral patellofemoral approach may have a high success rate of placement of the needle in up to 93%²² of the patients injected. Lower success rates may be observed with the anterolateral and anteromedial approaches (71% and 75%, respectively)²³ (Fig. 4). When the puncture of the joint is performed under US or fluoroscopic guidance, the success rate of the needle placement is even higher.^{22,23}

To perform the lateral patellofemoral approach (the most commonly reported²⁴), the patient is placed in supine position with a small pillow placed under the knee to place the articulation in slight flexion. The lateral aspect of the suprapatellar recess is punctured with a standard 20- to 22-gauge needle after lateral subluxation

of the patella. The intra-articular position of the needle tip can be confirmed by the aspiration of joint fluid or by a test injection of contrast medium. In either case, any excess of joint effusion within the articulation should be aspirated before the injection.

Contrast agents used for MR arthrography include a dilute solution of paramagnetic contrast medium with normal saline or Ringer's solution, to maintain a standard concentration of contrast agent within the joint.²⁵ According to other colleagues, we prefer to dilute 1 mL of gadolinium in 200 mL of normal saline (0.9%) solution for a total injection of 20 to 25 mL of diluted contrast medium. The suggested concentration of a gadopentetate dimeglumine solution is 2 mmol/L. Iodinated contrast media can also be included in the solution (when fluoroscopic guidance of the needle is preferred), which allows confirmation of initial needle placement, verifies an entirely intra-articular injection, and allows assessment of the distribution of fluid within the articulation. After injection, we also suggest that our patients perform gentle exercise in the form of walking, which may help increase intra-articular pressure, driving contrast media into meniscal lesions.

ANKLE

Due to the complexity of the ankle, it is often difficult to discern the source of pain between tibiotalar joint, subtalar joint, or talocalcaneonavicular joint from a periarticular soft tissue abnormality. The use of anesthetics and contrast media injections in the ankle provide valuable diagnostic information to localize the abnormal joint.

MR arthrography has superior sensitivity and accuracy compared with conventional MR in evaluation of ligament tears²⁶; it is also useful in the evaluation of chronic pain, as it improves the visualization of the lateral collateral ligament complex, which is frequently involved in ankle sprains. The distension of the capsule separates the ligaments from bone, improving their visualization and the assessment of the thickness and integrity at insertion sites.²⁷

In 10% of the population, there is a communication between the subtalar and ankle joint,²⁸ and similarly, but in a pathological way, a communication may be established between the hind foot and the midfoot after trauma.²⁸ This consideration is really important in surgical planning. In the presence of a communication between the subtalar and ankle joint, the injection of anesthetics in the ankle could hide a subtalar abnormality. In this case, the contrast medium shows the possibility of a subtalar abnormality.

In ankle impingement syndromes, MR arthrography is useful for depicting osteochondral abnormalities and the soft tissue material that usually develops. Additionally, MR arthrography has a very high accuracy

Figure 3 Magnetic resonance lateral view (T2-Fast Field Echo weighted images) that depicts gastrocnemius-semimembranosus bursa fluid distension (A). Under ultrasound guidance, the needle is correctly placed inside the bursa (B, C) and the final ultrasound demonstrates complete fluid aspiration (D).

(92%) in the diagnosis of loose bodies (conventional MR imaging has a lower accuracy, 57 to 70%).¹⁸ Adhesive capsulitis is another indication for MR arthrography, which may show the reduction of joint volume, the high intra-articular pressure, and the obliteration of the anterior, posterior, and syndesmotic recesses of the ankle.^{30,31} MR arthrography currently represents the best diagnostic method, putting together at the same time the MR imaging high-grade soft tissue evaluation and arthroscopy criteria.²⁷

Therapeutic joint injection of the ankle is not frequently used, but when it is performed, corticosteroids are the drugs usually injected in athletes with a history of trauma or in older patients with arthritis. Other indications for therapeutic joint injection, be-

sides osteoarthritis, include rheumatoid arthritis and acute traumatic arthritides, crystalloid deposition disease, and synovitis.

In our department, US or fluoroscopic guidance (lateral view) is preferred for correct needle (22- to 25-gauge) placement. The most common skin entry site is medial to the anterior tibial tendon or medial to extensor hallucis longus tendon. The dorsalis pedis artery should be avoided, and its path should be marked on the skin. The needle then is placed slightly cranial beneath the anterior lip of the tibia, and is advanced until its tip is between tibia and talus (Figs. 5, and 6).

Before the joint injection of 1 to 2 mL of iodinated contrast media, aspiration has to be performed to confirm correct position and to avoid dilution of the contrast

Figure 4 Anteromedial approach to knee arthrogram with intra-articular contrast media distribution.

media. Afterward, a 6- to 10-mL mixture of gadolinium, saline solution, and anesthetic (lidocaine or bupivacaine) is used to stretch the joint capsule.²⁹ The injection must be stopped if the patient expresses discomfort. In 25% of cases, the contrast media seeps into the flexor hallucis longus or flexor digitorum longus tendon sheaths or into the subtalar joint. No entrance into tendon sheaths should be seen on the lateral side of the ankle. Manipulation of the ankle is performed after removing the needle. MR images should be acquired within 45 minutes to reduce the absorption of contrast solution.

The subtalar joint may also be approached with arthrography. This joint includes an anterior and a posterior portion; the latter is injected with a lateral approach underneath the fibula (Fig. 7). Before the injection, the peroneal tendon has to be palpated to

Figure 5 Anterior approach to ankle arthrogram. Under fluoroscopy (lateral view) the needle tip is correctly placed slightly cranial beneath the anterior lip of the tibial bone.

Figure 6 Anterior approach of the ankle under ultrasound guidance. The needle tip is positioned in the interarticular space between the tibial distal epiphysis (*) and the talus (§).

avoid its puncture. The same contrast solution is used to distend the joint capsule and observe the contrast agent distribution within the articular space.

SHOULDER

Joint injection is a proven procedure for the diagnosis and treatment of several shoulder diseases and nowadays is the preferred imaging technique for the investigation of patients with shoulder instability.³²

Intra-articular administration of contrast media for direct MR arthrography allows better visualization of the labroligamentous complex and the capsule.³³ In fact, extension of contrast medium into the joint permits separation of the structures, depicts subtle lesions of the labroligamentous complex, and improves accuracy in diagnosis of full-thickness and partial-thickness articular

Figure 7 Lateral approach of subtalar arthrogram demonstrating contrast media distribution within the articular space.

Figure 8 Anterior approach to shoulder arthrogram performed with the patient in supine position and the shoulder slightly externally rotated. The needle is advanced vertically to the junction between the middle and lower third of the humeral head's medial part. The extracapsular contrast medium extension demonstrates the labor-ligamentous complex thickness (A), which has been confirmed by magnetic resonance arthrogram (B).

surface tears.³⁴ MR arthrography also distinguishes tears from postoperative granulation tissue, a very difficult discrimination with conventional MR imaging.³⁵

Glenohumeral joint injection may be "blind" or performed under imaging guidance. In the literature, the accuracy of "blind" injection, usually performed with a palpation-guided posterior approach, varies from 26 to 97%.^{36,37} Among the image-guided procedures, the anterior approach under fluoroscopic guidance (FLa) is the most commonly used. This kind of approach, first described by Oberholzer, was subsequently modified by Schneider and colleagues.³⁸ As in other joint injections, other image-guided techniques using the aid of US, CT, and MR have been described. Other approaches that may be used are the posterior approach under fluoroscopic guidance (FLp) and the rotator interval approach (RIA; a modified anterior approach).

FLa injection is usually performed with the patient in supine position and the shoulder slightly externally rotated. The partial external rotation allows a wider view of the articular surface; extreme external rotation increases tension on the anterior capsule with the risk of extra-articular leak of the injected contrast agent. Under fluoroscopic guidance, the 20-gauge spinal needle (Fig. 8) is advanced vertically to the junction between the middle and lower thirds of the humeral head's medial part. The main disadvantage of this approach is the potential damage of the glenohumeral ligaments and the subscapular tendon.

RIA is executed with a short needle (3.5 cm) inserted into the superomedial quadrant of the humeral head. To reduce the penetration into the long head of the biceps, it is very important to avoid internal arm rotation. The main advantage of this approach is that it is easily learned and performed with a standard size of needle³⁹; additionally, this approach passes over the subscapularis tendon, thus avoiding the labrum and glenohumeral ligaments.

FLp, which is generally preferred to FLa when posterior labral pathology is suspected, is executed with the patient in prone position and the shoulder slightly raised until the glenohumeral joint is seen tangentially. With the shoulder in neutral position or partially internally rotated, the needle (18-gauge) is advanced vertically into the inferomedial quadrant of humeral head⁴⁰ (Fig. 9).

When joint injection is performed under US guidance, the anterior or posterior approach is preferred. In the posterior US approach, the patient lies obliquely prone on the contralateral shoulder or sits with his or her back toward to the operator and the homolateral hand on the contralateral shoulder. The needle is inserted at midlevel of the humeral head, from lateral to medial, and advanced under US guidance (linear transducer is

Figure 9 Posterior approach for shoulder arthrogram with patient in prone position and the arm internally rotated. The needle is advanced medially to the articular surface of humeral head.

preferred) into the joint between the humeral head and the glenoid labrum.⁴¹ The anterior US approach, which was first described by Valls, is executed with the patient in supine position; the needle is inserted at the level of the coracoid, with a lateral-to-medial direction toward the medial edge of the humeral head⁴² (Fig. 10).

Indications for glenohumeral therapeutic joint injection include osteoarthritis, adhesive capsulitis, and rheumatoid arthritis. After the correct intra-articular needle placement, a mixture of anesthetics and steroid is injected. The goal of a local, intra-articular steroid injection is to improve joint function while reducing inflammation and pain, such as in bursitis or fibromyositis. Several weeks of symptomatic and functional improvement have been reported after intra-articular steroid injection of the shoulder joint, even though in some cases patients presented with moderate pain and discomfort in the days following this procedure.⁴³

Acromioclavicular arthropathy is another indication for therapeutic joint injection and is generally performed with the patient in supine position, under fluoroscopic guidance, using an anterior or superior approach. Also, for this joint mid- to long-term pain relief and functional improvement were observed after intra-articular administration of a mixture of steroids and anesthetic.

Subacromial injections are also useful for a range of conditions including adhesive capsulitis, subdeltoid bursitis, impingement syndrome, and rotator cuff tendinosis.

Figure 10 Anterior approach of the shoulder under ultrasound guidance. The needle is inserted just under the coracoid process between the coracoid (§) and the humeral head (*), passing through the subscapular muscle (£).

ELBOW

Many abnormalities seen in the elbow are a result of trauma, often from sports such as baseball and tennis. Elbow problems are frequently related to the medial tension-lateral compression phenomenon, where repeated valgus stress produces flexor-pronator strain, ulnar collateral ligament sprain, ulnar traction spurring, and ulnar neuropathy. The lateral compression causes osteochondritis dissecans of the capitellum, degenerative arthritis, and loose bodies. Varus stress produces radial collateral ligament and extensor tendon injuries.^{44,45}

With the advent of MR imaging, MR arthrography gained widespread use in the late 1980s, and by the early 1990s, in many countries it surpassed CT arthrography in popularity.

The use of conventional and CT arthrography nowadays is limited only for evaluation of full-thickness and partial-surface ligament tears, and this is because tears can only be identified by the extra-articular flow of contrast medium before they seal off. CT arthrography is useful also for demonstrating cartilaginous and osseous loose bodies, cartilage disruption, osteochondral loosening, fracture fragments, synovial abnormalities, periarthritic processes, and ligament disruption within 24 to 48 hours. The patient is injected with fluoroscopic guidance using a double-contrast protocol (0.5 mL of iodinated contrast medium and 10 mL of air) or alternatively, 10 mL of air without contrast medium.

MR examination is the gold standard for evaluation of soft tissues of the elbow and most often is performed without contrast media. MR direct arthrography may distend the joint and provide additional information in some circumstances such as osteochondritis dissecans, loose bodies, chondral-osteochondral fractures, and synovial or capsular abnormalities.

In elbow arthrography, a lateral approach is used most often, and injection may be performed either with or without imaging guidance. When the fluoroscopic guidance is preferred, a lateral view of the elbow is obtained and the needle is placed within the radiocapitellar joint (Fig. 11). The patient is placed in a prone position, with the elbow placed above the head in a 90-degree inflection. When there is no fluoroscopic guidance, the patient should be in a supine position with the elbow flexed to a 45-degree position and the hand in a neutral position, resting on the patient's thigh. Essential landmarks to palpate before performing this injection are the soft tissue at the center of the triangle formed by the lateral olecranon, the head of the radius, and the lateral epicondyle. The main disadvantage of this approach is the diagnostic dilemma that may occur with gadolinium extravasation around the radial collateral ligaments.

When the posteromedial approach is preferred, the patient is positioned supine with the elbow above the head, pronated and flexed to 30 degrees. The medial

Figure 11 Lateral approach to elbow arthrography. X-ray of the elbow (lateral view) confirms that the needle's tip is placed within the radiocapitellar joint.

epicondyle is palpated, and the needle is placed between the medial epicondyle and the olecranon. The needle entry site is almost 1 cm lateral to the medial epicondyle to reduce the chance of inadvertent contact with the ulnar nerve. The needle pathway has an anterolateral orientation with the target being olecranon fossa. Once the needle is in position, contrast agents can be injected. A dilute gadolinium mixture (10 mL of gadolinium and/or saline) is often injected using sterile arthrographic technique. Subsequently, the elbow is flexed and extended several times to distribute the contrast medium.

As far as the therapeutic injections of the elbow, the most frequent indications are osteoarthritis, rheumatoid arthritis, and, to a lower extent, crystal arthropathies. Radial head fractures, resulting from traumatic injury, can also be an indication for aspiration and analgesic injection. Additionally, persistent pain related to inflammatory conditions responds well to injection in the region. The drugs that are most frequently injected are anti-inflammatory (corticosteroids) and anesthetics (bupivacaine).

WRIST

MR wrist arthrography is usually performed for the evaluation of the triangular fibrocartilage complex (TFC) or interosseous ligament diseases. Due the complex anatomy of the wrist joint, MR arthrography combines the advantages of conventional MR imaging to those of arthrography by improving the visualization of small intra-articular structures.^{46,47}

Figure 12 Midcarpal injection. Patient is in prone position with the wrist pronated. The needle's target for the midcarpal compartment is the joint space between the hamate, capitate, lunate, and triquetrum.

Wrist arthrography can be performed using a single-compartment (radiocarpal), double-compartment (radiocarpal and midcarpal or radiocarpal and distal radioulnar), or triple-compartment (midcarpal, radiocarpal, and distal radioulnar joint[DRUJ]) injection technique.⁴⁸ This procedure is generally performed under fluoroscopic guidance, but other techniques such as US, CT, or MR may also be used for needle placement.^{49,50}

Different sites can be chosen for midcarpal and radiocarpal joint injection. The midcarpal injection is usually used to evaluate intrinsic ligaments, and the radiocarpal injection is used for TFC tears.⁵¹ The needle's target for the midcarpal compartment is the scaphocapitate and triquetrohamate spaces. A 25-gauge needle is usually placed at the triquetrolunohamate space from a dorsal approach, and the injection is carried on until the contrast medium flows in the capitulate joint compartment (Fig. 12). Extension of contrast medium into the radiocarpal joint suggests a scapholunate or a lunotriquetral ligament degeneration, and communication between scapholunate and lunotriquetral articulations is frequently found.⁴⁸

Radiocarpal joint injection can be performed simply using a palpable landmark without imaging guidance. This palpable landmark is an anatomic sulcus between the extensor pollicis longus and the index finger extensor digitorum communis tendon.⁵² The puncture site is ~0.5 cm below the dorsal lip of the radius so that the needle angulation (10 to 15 degrees) is parallel to the distal radial articular surface.

For radiocarpal ulnar-sided injection, the needle is advanced from the proximal border of the triquetrum to the pisiform radial edge. For radial-sided injection, the needle's target is instead the radioscapoid space through the scapholunate joint (Fig. 13). Communication

Figure 13 Radiocarpal injection. For radial-sided injection, the needle's target is the radioscaphoid space through the scapholunate joint.

between the radiocarpal and the pisotriquetral joint is commonly seen (75% of patients).

For DRUJ arthrography, the needle should be directed near the radial border of ulnar head (Fig. 14). When the needle reaches the ulnar head, it is inserted deeper into the center of the joint space. With this approach, an irritation of the dorsal branch of ulnar nerve may occur; therefore, patients should be informed of this possibility prior the procedure. Triple-compartment arthrography is performed first with a midcarpal joint injection of 3 to 4 mL of contrast medium. If a communication between midcarpal and radiocarpal is present, an additional 3 to 4 mL is injected, and if a communication with the DRUJ occurs, supplementary 1 to 2 mL is added for a total of 7 to 9 mL.

Figure 14 Midcarpal, radiocarpal, and distal radioulnar joint injection. Needle target is radial border of ulnar head.

If no communication is present, the radiocarpal and DRUJ are sequentially injected with 3 to 4 mL and 1 to 2 mL of contrast medium, respectively. Generally, triple-compartment MR arthrography is executed in patients who present chronic pain of unclear source or instability syndrome of wrist.

Several studies demonstrate that wrist arthrography present a high sensitivity and specificity in distinguishing TFC tears and intrinsic ligament tears if compared with arthroscopy, which is considered the gold standard.

Therapeutic applications are represented by the viscosupplementation that is used for symptomatic osteoarthritis or for rhizarthrosis. Intra-articular injection

Figure 15 Under ultrasound guidance, a spinal needle is inserted into the trapeziometacarpal articulation for viscosupplementation. Ultrasound image demonstrates correct injection of hyaluronic acid (0.3 to 0.5 mL; arrows) into the articulation between the metacarpus (*) and the trapezium (§).

of HA is indicated for the treatment of osteoarthritis in nonresponsive conservative therapy or when patients are not surgical candidates.

To perform therapeutic injections of the wrist, the patient's forearm must be inflected to 90 degrees with the first finger pointing to the face. Under US guidance, a spinal needle (22-gauge) is inserted by a cranial-caudal approach into the trapeziometacarpal articulation (Fig. 15). When the needle is exactly positioned, 0.3 to 0.5 mL of HA is injected.

REFERENCES

- Steinbach LS, Schneider R, Goldman AB, Kazam E, Ranawat CS, Ghelman B. Bursae and abscess cavities communicating with the hip. Diagnosis using arthrography and CT. *Radiology* 1985;156:303-307
- Maus TP, Berquist TH, Bender CE, Rand JA. Arthrographic study of painful total hip arthroplasty: refined criteria. *Radiology* 1987;162:721-727
- Czerny C, Hofmann S, Neuhold A, et al. Lesions of the acetabular labrum: accuracy of MR imaging and MR arthrography in detection and staging. *Radiology* 1996;200:225-230
- Cotten A, Boutry N, Demondion X, et al. Acetabular labrum: MRI in asymptomatic volunteers. *J Comput Assist Tomogr* 1998;22:1-7
- Lecouvet FE, Vande Berg BC, Malghem J, et al. MR imaging of the acetabular labrum: variations in 200 asymptomatic hips. *AJR Am J Roentgenol* 1996;167:1025-1028
- Lyons JC, Peterson LFA. The snapping iliopsoas tendon. *Mayo Clin Proc* 1984;59:327-329
- Cardinal E, Buckwalter KA, Capello WN, Duval N. US of the snapping iliopsoas tendon. *Radiology* 1996;198:521-522
- Pelsser V, Cardinal E, Hobden R, Aubin B, Lafortune M. Extraarticular snapping hip: sonographic findings. *AJR Am J Roentgenol* 2001;176:67-73
- Idjadi J, Meislin R. Symptomatic snapping hip: targeted treatment for maximum pain relief. *Phys Sportsmed* 2004;32:25-31
- White RA, Hughes MS, Burd T, Hamann J, Allen WC. A new operative approach in the correction of external coxa saltans: the snapping hip. *Am J Sports Med* 2004;32:1504-1508
- Jacobson T, Allen WC. Surgical correction of the snapping iliopsoas tendon. *Am J Sports Med* 1990;18:470-474
- Brignall CG, Stainsby GD. The snapping hip. Treatment by Z-plasty. *J Bone Joint Surg Br* 1991;73:253-254
- Malfair D. Therapeutic and diagnostic joint injections. *Radiol Clin North Am* 2008;46:439-453, v
- Blankenbaker DG, Tuite MJ. The painful hip: new concepts. *Skeletal Radiol* 2006;35:352-370
- Duc SR, Hodler J, Schmid MR, et al. Prospective evaluation of two different injection techniques for MR arthrography of the hip. *Eur Radiol* 2006;16:473-478
- Qvistgaard E, Kristoffersen H, Terslev L, Danneskiold-Samsøe B, Torp-Pedersen S, Bliddal H. Guidance by ultrasound of intra-articular injections in the knee and hip joints. *Osteoarthritis Cartilage* 2001;9:512-517
- Carson BW, Wong A. Ultrasonographic guidance for injections of local steroids in the native hip. *J Ultrasound Med* 1999;18:159-160
- Brossmann J, Preidler KW, Daenen B, et al. Imaging of osseous and cartilaginous intraarticular bodies in the knee: comparison of MR imaging and MR arthrography with CT and CT arthrography in cadavers. *Radiology* 1996;200:509-517
- De Filippo M, Bertellini A, Pogliacomini F, et al. Multi-detector computed tomography arthrography of the knee: diagnostic accuracy and indications. *Eur J Radiol* 2009;70:342-351
- Altman RD, Moskowitz R; Hyalgan Study Group. Intra-articular sodium hyaluronate (Hyalgan) in the treatment of patients with osteoarthritis of the knee: a randomized clinical trial. *J Rheumatol* 1998;25:2203-2212
- Lohmander LS, Dalén N, Englund G, et al; Hyaluronan Multicentre Trial Group. Intra-articular hyaluronan injections in the treatment of osteoarthritis of the knee: a randomised, double blind, placebo controlled multicentre trial. *Ann Rheum Dis* 1996;55:424-431
- Bliddal H. Placement of intra-articular injections verified by mini air-arthrography. *Ann Rheum Dis* 1999;58:641-643
- Jackson DW, Evans NA, Thomas BM. Accuracy of needle placement into the intra-articular space of the knee. *J Bone Joint Surg Am* 2002;84-A:1522-1527
- Freiberger RH, Pavlov H. Knee arthrography. *Radiology* 1988;166:489-492
- Binkert CA, Zanetti M, Gerber C, Hodler J. MR arthrography of the glenohumeral joint: two concentrations of gadoteridol versus Ringer solution as the intraarticular contrast material. *Radiology* 2001;220:219-224
- Cerezal L, Abascal F, Canga A, García-Valtuille R, Rolón A. [Magnetic resonance arthrography indications and technique (II). Lower limb]. *Radiologia* 2006;48:357-368
- Cerezal L, Llopis E, Canga A, Rolón A. MR arthrography of the ankle: indications and technique. *Radiol Clin North Am* 2008;46:973-994, v
- Resnick D. Radiology of the talocalcaneal articulations. Anatomic considerations and arthrography. *Radiology* 1974;111:581-586
- Mitchell MJ, Bielecki D, Bergman AG, Kursunoglu-Brahme S, Sartoris DJ, Resnick D. Localization of specific joint causing hindfoot pain: value of injecting local anesthetics into individual joints during arthrography. *AJR Am J Roentgenol* 1995;164:1473-1476
- Cui Q, Milbrandt T, Millington S, Anderson M, Hurwitz S. Treatment of posttraumatic adhesive capsulitis of the ankle: a case series. *Foot Ankle Int* 2005;26:602-606
- Lui TH, Chan WK, Chan KB. The arthroscopic management of frozen ankle. *Arthroscopy* 2006;22:283-286
- Probyn LJ, White LM, Salonen DC, Tomlinson G, Boynton EL. Recurrent symptoms after shoulder instability repair: direct MR arthrographic assessment—correlation with second-look surgical evaluation. *Radiology* 2007;245:814-823
- Palmer WE, Brown JH, Rosenthal DI. Labral-ligamentous complex of the shoulder: evaluation with MR arthrography. *Radiology* 1994;190:645-651
- Meister K, Thesing J, Montgomery WJ, Indelicato PA, Walczak S, Fontenot W. MR arthrography of partial thickness tears of the undersurface of the rotator cuff: an arthroscopic correlation. *Skeletal Radiol* 2004;33:136-141

35. Rand T, Freilinger W, Breitenseher M, et al. Magnetic resonance arthrography (MRA) in the postoperative shoulder. *Magn Reson Imaging* 1999;17:843–850
36. Catalano OA, Manfredi R, Vanzulli A, et al. MR arthrography of the glenohumeral joint: modified posterior approach without imaging guidance. *Radiology* 2007;242:550–554
37. DeMouy EH, Menendez CV Jr, Bodin CJ. Palpation-directed (non-fluoroscopically guided) saline-enhanced MR arthrography of the shoulder. *AJR Am J Roentgenol* 1997;169:229–231
38. Schneider R, Ghelman B, Kaye JJ. A simplified injection technique for shoulder arthrography. *Radiology* 1975;114:738–739
39. Dépelteau H, Bureau NJ, Cardinal E, Aubin B, Brassard P. Arthrography of the shoulder: a simple fluoroscopically guided approach for targeting the rotator cuff interval. *AJR Am J Roentgenol* 2004;182:329–332
40. Farmer KD, Hughes PM. MR arthrography of the shoulder: fluoroscopically guided technique using a posterior approach. *AJR Am J Roentgenol* 2002;178:433–434
41. Cicak N, Matasović T, Bajraktarević T. Ultrasonographic guidance of needle placement for shoulder arthrography. *J Ultrasound Med* 1992;11:135–137
42. Valls R, Melloni P. Sonographic guidance of needle position for MR arthrography of the shoulder. *AJR Am J Roentgenol* 1997;169:845–847
43. Buchbinder R, Green S, Forbes A, Hall S, Lawler G. Arthrographic joint distension with saline and steroid improves function and reduces pain in patients with painful stiff shoulder: results of a randomised, double blind, placebo controlled trial. *Ann Rheum Dis* 2004;63:302–309
44. Timmerman LA, Schwartz ML, Andrews JR. Preoperative evaluation of the ulnar collateral ligament by magnetic resonance imaging and computed tomography arthrography. Evaluation in 25 baseball players with surgical confirmation. *Am J Sports Med* 1994;22:26–31; discussion 32
45. Nakanishi K, Masatomi T, Ochi T, et al. MR arthrography of elbow: evaluation of the ulnar collateral ligament of elbow. *Skeletal Radiol* 1996;25:629–634
46. Braun H, Kenn W, Schneider S, Graf M, Sandstede J, Hahn D. [Direct MR arthrography of the wrist- value in detecting complete and partial defects of intrinsic ligaments and the TFCC in comparison with arthroscopy]. *Rofo* 2003;175:1515–1524
47. Brown RR, Fliszar E, Cotten A, Trudell D, Resnick D. Extrinsic and intrinsic ligaments of the wrist: normal and pathologic anatomy at MR arthrography with three-compartment enhancement. *Radiographics* 1998;18:667–674
48. Linkous MD, Gilula LA. Wrist arthrography today. *Radiol Clin North Am* 1998;36:651–672
49. Grainger AJ, Elliott JM, Campbell RS, Tirman PF, Steinbach LS, Genant HK. Direct MR arthrography: a review of current use. *Clin Radiol* 2000;55:163–176
50. Steinbach LS, Palmer WE, Schweitzer ME. Special focus session. MR arthrography. *Radiographics* 2002;22:1223–1246
51. Zlatkin MB, Rosner J. MR imaging of ligaments and triangular fibrocartilage complex of the wrist. *Magn Reson Imaging Clin N Am* 2004;12:301–331; vi–vii
52. Beaulieu CF, Ladd AL. MR arthrography of the wrist: scanning-room injection of the radiocarpal joint based on clinical landmarks. *AJR Am J Roentgenol* 1998;170:606–608