

# Common Musculoskeletal Procedures: How We Do It

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The ability to perform procedures involving the musculoskeletal (MSK) system is an essential component of a radiologist's overall skillset, whether practicing in a generalized or subspecialized setting. Commonly performed procedures range from joint aspirations to steroid injections and arthrograms, performed under fluoroscopic or ultrasound guidance. These procedures serve multiple purposes: aspirations are critical in excluding infection; arthrograms improve diagnostic accuracy; and joint injections provide temporizing pain relief. This article reviews common musculoskeletal procedures with a focus on techniques using fluoroscopic guidance.

## General Considerations

Prior to beginning any procedure, pertinent images are reviewed to aid in procedural planning. Such images are useful in revealing bulky osteophyte formation, the presence or absence of a loosened prosthesis, antibiotic spacer material, the presence of hip osteonecrosis or fracture prior to performing a therapeutic injection with steroids, or the presence of mass that may prevent entry into the joint. In the pediatric population, ultrasound images are routinely acquired and reviewed for the presence of an effusion prior to subjecting the patient to sedation for a joint aspiration. Informed consent is then obtained, with the benefits, risks, and alternatives dis-

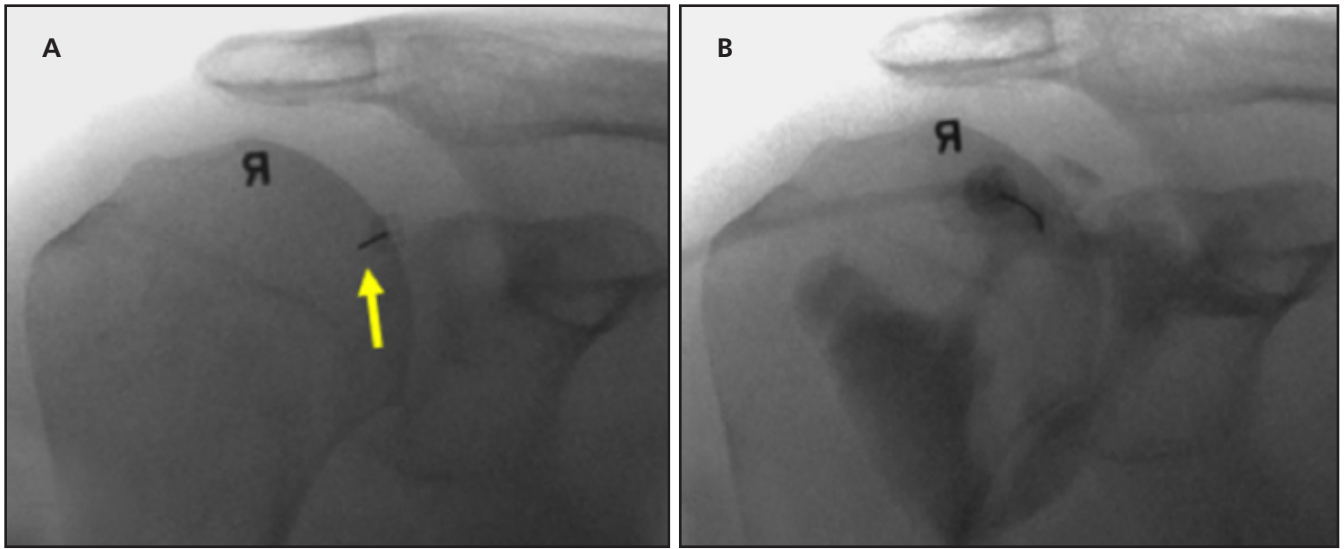
cussed. Risks include introducing an infection into the joint, bleeding, allergic reactions, contrast reactions, damage to adjacent structures including nerves, the possibility of nontherapeutic relief, and chondrolysis with the injection of lidocaine/bupivacaine into joints.

For elective joint injections and arthrograms, the management of anticoagulation is done in concert with the referring clinician.<sup>1</sup> This typically involves holding the anticoagulant for the appropriate number of days and requiring a preprocedural INR of < 2.0 for patients on warfarin. If the patient is on anti-coagulation, physicians must address the increased risk of bleeding, along with the rare possibility of requiring subsequent hematoma evacuation. Also, in patients who must remain on anti-coagulation, use the smallest needle bore possible and consider using lidocaine with epinephrine, which can cause vasoconstriction and theoretically reduce bleeding. Elective spine injections are not performed in patients on anticoagulation.

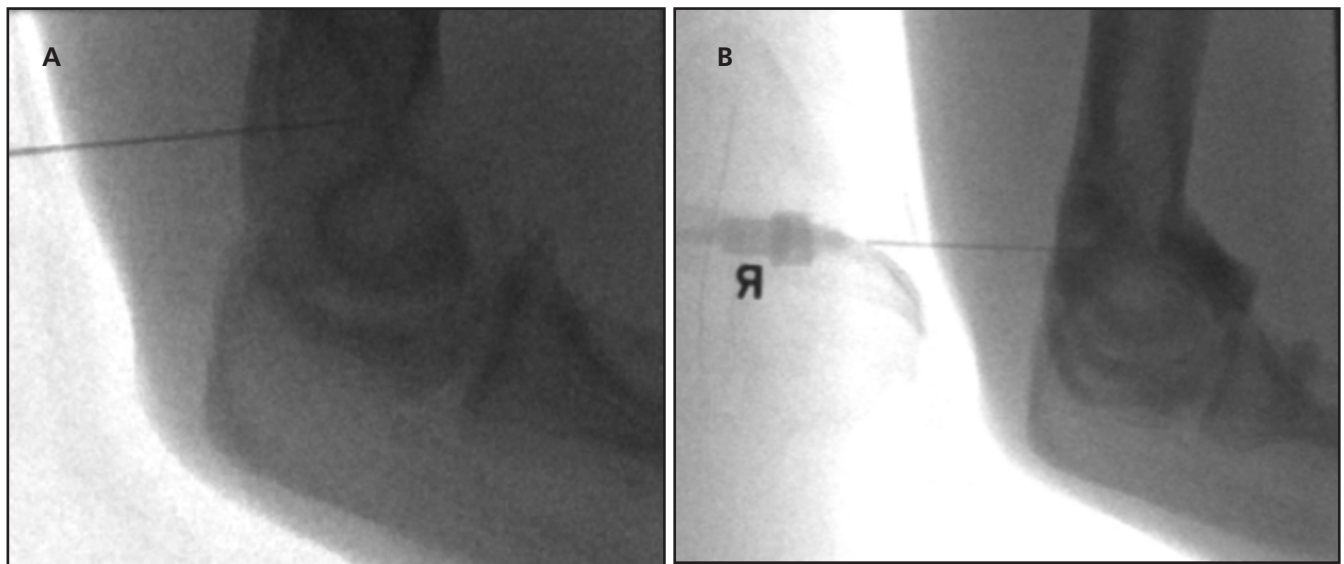
As septic arthritis is generally an emergent procedure, coagulation parameters for aspiration are not routinely evaluated. In a patient that likely has septic arthritis, elevated coagulation values are not a barrier to undergoing the procedure after discussing the risks and benefits with the ordering provider and patient.

The solution injected for MR arthrograms includes 10 mL of preservative-free normal saline, 5 mL of lidocaine, 5 mL of iodinated contrast (iopamidol 200m), and 0.1 mL of gadolinium (**Table**). Depending on the joint size, 2-40 mL of this solution is injected. Occasionally, computed tomography (CT) arthrograms are performed in patients who have a contraindication to MRI (ie, pacemaker). In these patients, the CT arthrogram solution consists of 5 mL normal saline, 5 mL lidocaine, and 10 mL of iodinated contrast.

Joint injection solution involves the use of 1% lidocaine, 0.25% bupivacaine, and 1 mL of 40 mg/mL of methylprednisolone acetate. Depending on patient's tolerance of joint distention and the joint size, 2-10 mL of a 1:1 mixture of lidocaine and bupivacaine is injected. Some radiologists prefer to inject a small amount of intra-articular anesthetic prior to the steroid injection, as steroid particles may not be fully dissolved in solution and may cause pain on injection.<sup>2</sup> Others prefer to inject the longer-acting steroid solution first, as intracapsular pressure from underlying synovitis may limit the overall amount of solution able to be injected. Radiologists are occasionally asked to perform diagnostic injections in which the steroid is omitted. Patients are assessed shortly after the injection of joint anesthetic to determine whether their



**FIGURE 1.** Shoulder arthrogram via the AP rotator interval approach. (A) With the shoulder in external rotation, a “V” is created at the site of projected overlap between the glenoid and humeral head (arrow). A 22-gauge spinal needle is inserted through the rotator interval, with the needle tip landing on the humeral head just lateral and superior to the “V.” (B) Typical appearance of capsular distention under fluoroscopy following intra-articular injection of contrast. Approximately 12 mL is injected.



**FIGURE 2.** Elbow arthrogram via a posterior approach. (A) A 22-gauge spinal needle is advanced into the olecranon fossa (midway between the medial and lateral epicondyles) through the distal triceps using a posterior trans-triceps approach. (B) Contrast should flow smoothly and easily away from the needle and fill the elbow joint. Up to 8 mL is injected.

pain has remitted, helping the clinician localize the pain source.

All procedures require adherence to standard sterile techniques. The skin and subcutaneous tissues are anesthetized with lidocaine. Unless otherwise indicated, intra-articular needle positioning is always verified with the injection of contrast, demonstrating free-flowing contrast within the joint, and absence of contrast pooling in the soft tissues adjacent to the joint (a blob-

like appearance). Occasionally, procedures are performed with conscious sedation, the monitoring of which is outside the scope of this article.

### Shoulder Arthrogram

Distention of the shoulder joint with intra-articular contrast aids in detecting labral and rotator cuff tears.<sup>3</sup> The use of the rotator interval approach is often preferred for shoulder arthrography for its simplicity and ease of teaching.<sup>4</sup> In

this technique, the patient is first placed supine on the fluoroscopic table with the shoulder in external rotation. External rotation is essential to ensure the biceps tendon is not inadvertently injured during the procedure. In this position, a “V” shape is formed by the overlap of the humeral head with the glenoid. A position just lateral to the apex of the “V” is chosen as the skin entry site at the superomedial aspect of the humeral head (**Figure 1**). Utilizing an AP



**FIGURE 3.** Wrist arthrogram via a PA radioscapoid approach. (A) A short 25-gauge spinal needle is advanced into the radioscapoid compartment. (B) Contrast is noted insinuating into the DRUJ, consistent with TFCC tear. Up to 2 mL is injected.

approach, a 22-gauge spinal needle is advanced until its tip firmly lands on the humeral head. Approximately 12 mL of contrast is then injected.

Radiologists are occasionally asked to perform a fluoroscopic arthrogram in patients with a shoulder prosthesis who are suspected of having a full thickness rotator cuff tear. Again, the rotator interval approach is employed over the prosthetic humeral head component. In these patients, gadolinium and saline are omitted from the typical arthrogram solution, with only lidocaine and iodinated contrast injected. After the injection, the needle is removed and the shoulder is taken through various ranges of motion to observe for abnormal extension of contrast into the sub-acromial-subdeltoid bursa.

### Elbow Arthrogram

Elbow arthrography is routinely performed to evaluate for an osteochondral defect, loose bodies, and ligamentous injury, particularly to the ulnar collateral ligament (UCL).<sup>4,6</sup> The posterior transtriceps technique is often preferred for patient comfort and overall ease.<sup>7</sup> The patient lies prone, with the nonevaluated elbow fully extended above the head, and the elbow to be injected flexed at 90 degrees. The tip of

the olecranon process is palpated, and a skin entry site is chosen and marked immediately proximal to that point and equidistant between the epicondyles. With this approach, a 22-gauge spinal needle is advanced posteriorly through the distal triceps until its tip is in the olecranon fossa (**Figure 2**). No more than 8 mL of arthrogram solution is then injected. Also, an elbow injection and/or arthrogram can be done from a lateral approach, accessing the joint between the radial head and the capitellum, if the posterior approach cannot be performed.

### Wrist Arthrogram

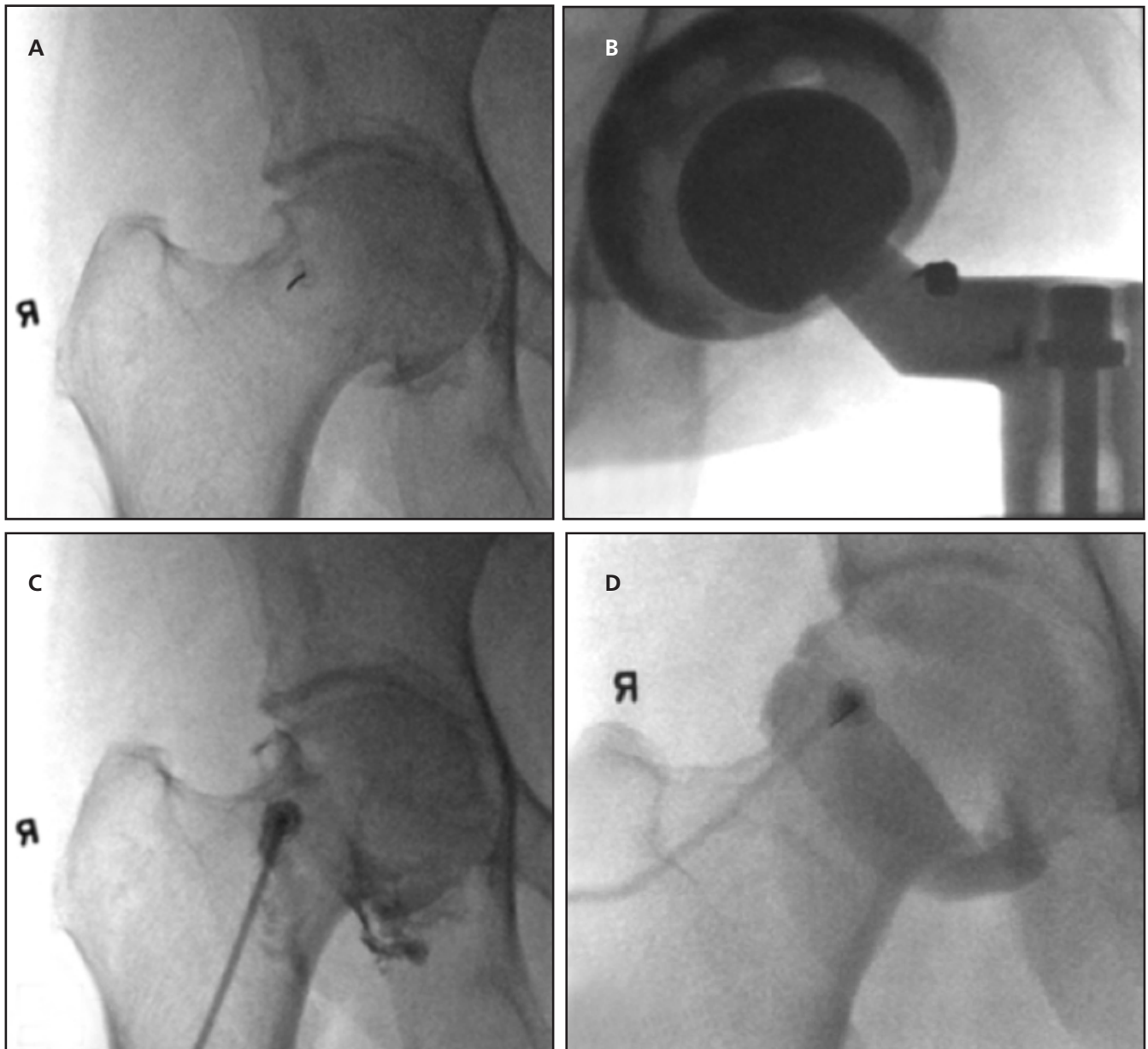
Wrist arthrography is commonly performed to evaluate the integrity of the triangular fibrocartilage complex and intrinsic ligaments of the wrist.<sup>8</sup> Historically, tricompartment wrist arthrography has been the gold standard for evaluating the intrinsic wrist ligaments.<sup>9</sup> However, at our institution, tricompartment wrist arthrography is not routinely requested. This may be because of time constraints and/or the questionable clinical value of the diagnosis of small intrinsic ligament tears.<sup>10</sup> Wrist arthrography through the radioscapoid articulation is routinely performed to identify perforative tears of the triangular fibrocartilage complex.

For this procedure, the patient is placed prone on the fluoroscopy table with both arms extended above the head ("Superman" position), similar but modified compared to the positioning for elbow arthrography. Alternatively, the patient may be placed supine with the arm and wrist at the side of the patient, and the wrist flexed over a rolled towel. The wrist is ulnar-deviated to gap the radioscapoid articulation. The proximal-most cortex of the scaphoid is then identified, and a skin entry site just distal to this is selected (**Figure 3**). A short 25-gauge spinal needle is advanced into the radioscapoid compartment with slight proximal angulation. Proper positioning can be verified with a lateral fluoroscopic image. No more than 2 mL of arthrogram solution is injected.

### Hip Procedures

#### Patient Positioning

Musculoskeletal procedures at the hip are among the most common in our department. These procedures include hip aspirations, intra-articular steroid and anesthetic injections, arthrograms, and trochanteric injections, all of which follow the same patient positioning. The patient is placed supine on the fluoroscopic table, with the hip internally rotated. A skin entry site over



**FIGURE 4.** Illustration of multiple hip procedures. (A) Almost all hip procedures, whether a steroid injection, arthrogram, or aspiration are performed with the same patient positioning and approach. An entry at the superolateral aspect of the femoral head/neck junction is chosen to minimize the possibility of damage to the femoral vessels and nerves. (B) Prosthetic hip joint aspiration involves hubbing the 18-gauge needle deeply against the skin just lateral to the prosthetic femoral head/neck junction. (C) Intra-articular contrast administered to verify needle placement demonstrates beaded appearance of the joint capsule, consistent with underlying synovitis in this patient with osteoarthritis. Up to 10 mL of anesthetic and 1 mL of steroid is injected. (D) Intra-articular contrast for hip arthrogram. Up to 12-14 mL are administered.

the superolateral aspect of the femoral head/neck junction is localized (**Figure 4A**). This location minimizes possible damage to the femoral vessels, nerve, peritoneum, or bowel.<sup>11</sup>

#### **Hip Aspiration**

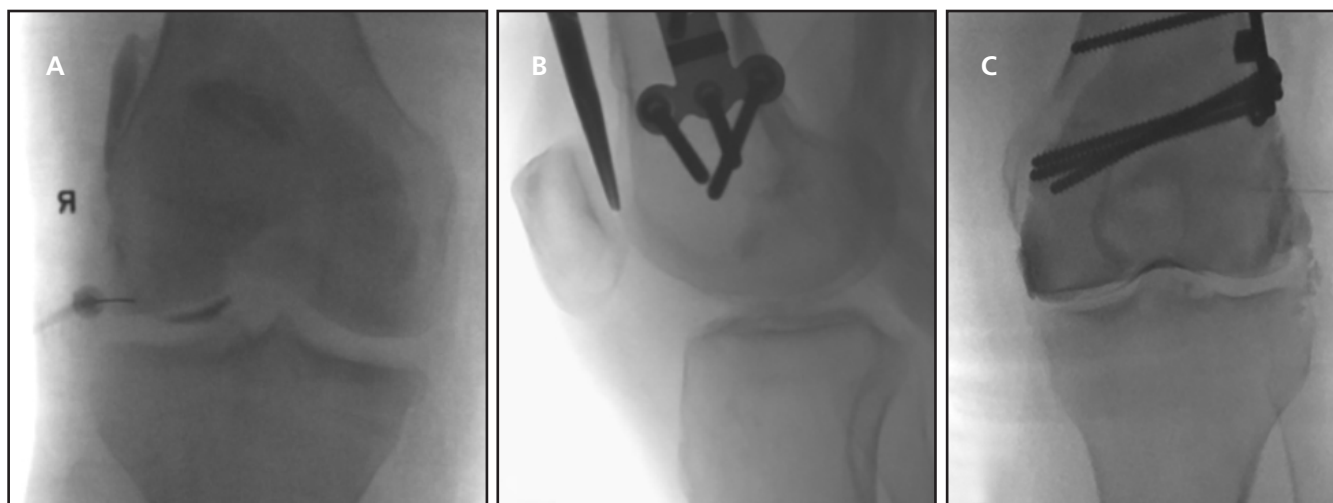
The need to exclude acute septic arthritis or chronic indwelling infection is the most common indication for hip

aspiration. Hip aspiration, in conjunction with clinical history and laboratory parameters, serves as the standard for diagnosing infection. A hip aspirate containing  $> 50,000$  white blood cells (WBCs)/ $\mu\text{L}$ , of which  $> 75\%$  are polymorphonuclear (PMN) leukocytes, is diagnostic of septic arthritis.<sup>12</sup> In patients with a native hip, an 18-gauge spinal needle is advanced to the su-

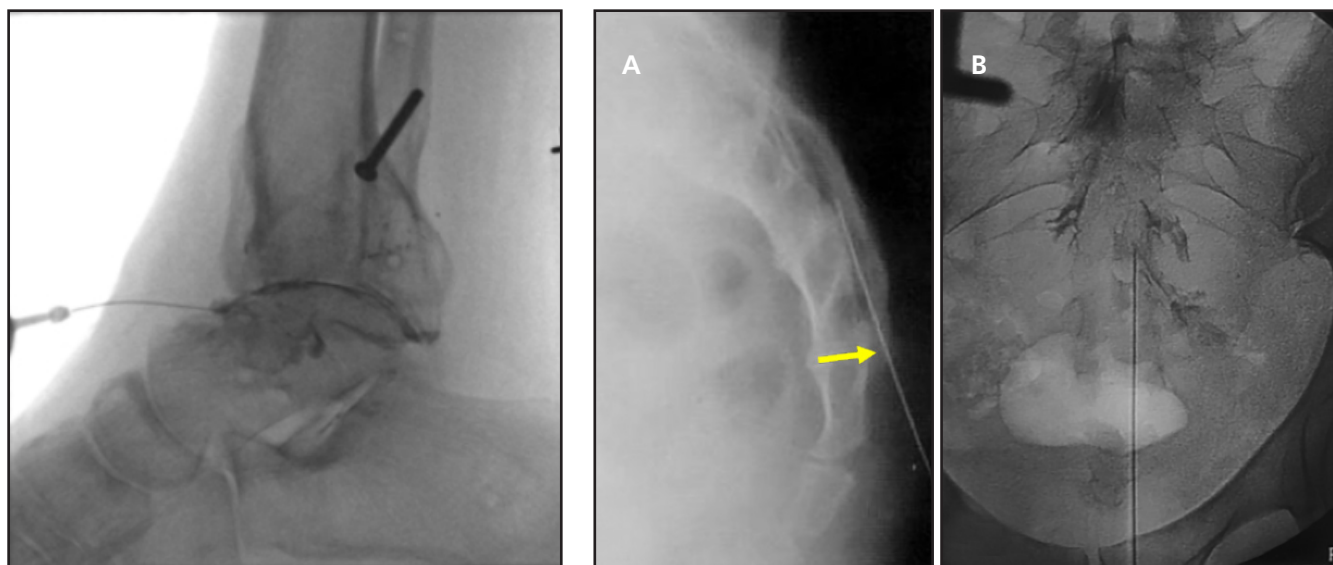
perolateral aspect of the femoral head/neck junction. Once the needle is firmly seated on bone, aspiration is performed; if no fluid is aspirated ("dry tap"), irrigation of the hip joint is performed at the referring clinician's request.

In a patient with a hip prosthesis, the same technique is used. Specifically, the junction of the femoral head and neck prosthesis is localized under fluoroscopy





**FIGURE 5.** Variant approaches to knee injections and arthrograms. (A) Anterior approach to the lateral femoral condyle demonstrates contrast flowing freely away from the needle. (B,C) Lateral patellofemoral approach in a patient for whom the patellofemoral joint space is relatively preserved. Lateral fluoroscopic image (B) is used to guide needle placement. Frontal projection (C) confirms placement in the patellofemoral compartment.



**FIGURE 6.** Ankle injection via the anterior approach. Ankle injections are typically performed with the patient in a lateral decubitus position. The anterior tibialis tendon is palpated and a site lateral to this is chosen for the skin entry site. Under real-time fluoroscopic guidance, the needle is advanced until its tip is in the anterior ankle joint; injection confirms intra-articular position, and 1 mL of steroid and up to 4 mL of anesthetic are injected.

**FIGURE 7.** Epidural steroid injection. (A) Lateral image is taken to verify the needle tip position at the S3-S4 level. Yellow arrow indicates the sacral hiatus. (B) AP image verifies midline positioning between the pedicles with contrast outlining the epidural space in a "Christmas tree fashion," confirming appropriate needle location within the epidural space.

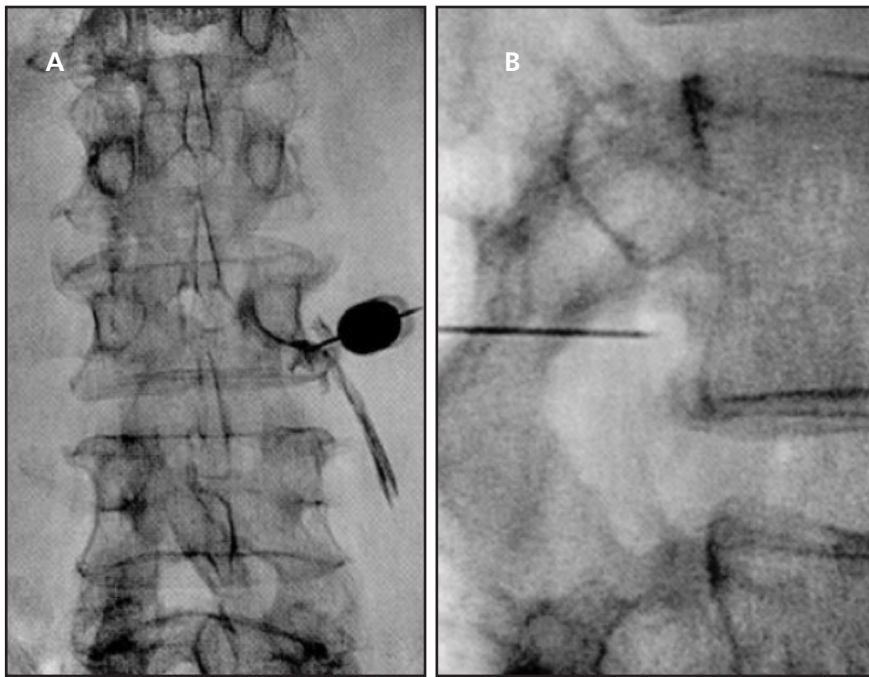
and a direct anteroposterior (AP) approach is utilized. As the prosthesis can cause lateral deviation of the femoral vasculature, the femoral artery is palpated and marked to avoid complication. An 18-gauge needle is directed at the soft tissues just lateral to the femoral head/neck junction ("hub over tip"). The needle is advanced until it is hubbed against the skin.<sup>13</sup> (Figure 4B). The needle is

then incrementally withdrawn until fluid is aspirated. If no fluid is aspirated, the procedure is repeated along the course of the femoral neck prosthesis, or irrigation can be performed. However, if irrigation is performed, then the cell count of the aspirated fluid is unreliable due to dilution. Also, ultrasound should be considered in evaluating the soft tissues along any suspected infected prosthesis to identify a

potential fluid collection amenable to ultrasound-guided aspiration that may not necessarily be within the joint capsule.

### **Hip Arthrogram**

Hip arthrography is a sensitive means for detecting labral tears.<sup>14,15</sup> Using a similar approach to hip aspiration and steroid injections, a skin entry site is chosen at the superolateral aspect of the



**FIGURE 8.** Selective nerve root injection. (A) The “5 o'clock” position inferolateral to the pedicle is localized with the outer 22-gauge needle and slowly advanced until it is at the level of the posterior elements. (B) The inner 25-gauge needle is then advanced under real-time fluoroscopy until it is at the level of the nerve root or the patient’s symptoms are reproduced. A small amount of contrast confirms extravascular placement and nicely outlines the nerve root, as seen on the AP projection in (A); 1.5 mL of a 1:1 ratio of steroid and anesthetic are injected.

femoral head and neck, and a 22-gauge spinal needle is advanced until its tip is firmly on bone. Once a small amount of iopamidol contrast confirms intra-articular needle placement (**Figure 4C**), up to 12–14 mL of the arthrogram solution is injected (**Figure 4D**).

### Hip Injections

Intra-articular injection of anesthetic and anti-inflammatory agents serves two functions. First, it readily identifies the true source of a patient’s pain, which can be difficult when the pain may be originating from a proximal or distal joint. Secondly, it allows for both rapid and long-standing pain relief in osteoarthritis patients who are not candidates for hip replacements.<sup>16</sup> The patient is positioned in an identical fashion to hip aspirations and arthrograms. A 22-gauge spinal needle is advanced until its tip is firmly on bone at the superolateral aspect of the femoral head/neck junction, after which up to 10 mL of anesthetic and 1 mL of steroid are injected.

### Knee Injections and Arthrograms

Typically, knee injections can be performed in the clinic setting. However, patient body habitus or patellofemoral degenerative disease may preclude this and necessitate the use of fluoroscopic guidance. Knee arthrograms are occasionally requested in patients with a history of meniscal repair to evaluate the status of the meniscus. Increased signal on MRI within the meniscus can indicate postsurgical change or recurrent tear, while contrast diffusion or imbibition through the meniscus is consistent with a recurrent tear.<sup>17</sup>

The approach to knee injections and arthrograms depends on patient body habitus and joint space narrowing. Both the lateral patellofemoral approach and the anterior approach are common. In patients for whom the patellofemoral joint can neither be palpated nor readily identified under fluoroscopy, an anterior approach is commonly utilized. In this approach, the knee is slightly flexed about 15 degrees with a roll of towels or cushion beneath the knee. The C-arm

is then adjusted 15 degrees so the x-ray beam is perpendicular to the long axis of the lower leg. A skin entry site at the distal medial or lateral femoral condyle is chosen. Generally, the lateral compartment is favored as it is relatively spared of osteoarthritic change (**Figure 5A**). The patellar tendon is palpated, marked, and avoided during the anterior approach. A 22-gauge spinal needle is then advanced until its tip is seated on the condyle, with the angle paralleling the C-arm.

An alternative is the lateral patellofemoral approach. With the patient’s knee slightly flexed to relax the extensor compartment, the patella is mildly laterally subluxed. A skin entry site is localized along the mid to distal one-third of the lateral patella. A lateral fluoroscopic image is useful to assess for patellofemoral narrowing and to guide needle angulation in the anterior to posterior direction (**Figure 5B**). A 22-gauge spinal needle is advanced medially into the patellofemoral compartment until its tip is seen projecting over the patella on AP projection (**Figure 5C**). A common occurrence is shallow trajectory of the needle, for which frequent reassessment with lateral fluoroscopy can be useful. Also, one can use a medial approach (similar to the lateral approach) if there is lateral patellar tilt, lateral subluxation, or lateral osteophyte formation from osteoarthritis.

In either approach, up to 10 mL of anesthetic and 1 mL of steroid are injected. For arthrograms, we inject 30–40 mL of the arthrogram solution, depending on the patient’s tolerance.

### Ankle Injection

Therapeutic ankle injections can be challenging in patients with post-traumatic deformities or advanced osteoarthritis. The injection can be performed in various ways. Common approaches include the lateral mortise or anterior approach, depending on the degree and location of joint space narrowing. With the lateral mortise approach, the patient is placed supine on the fluoroscopy table with the foot relaxed or in mild

**Table: Solutions Used for Intra-Articular Injections**

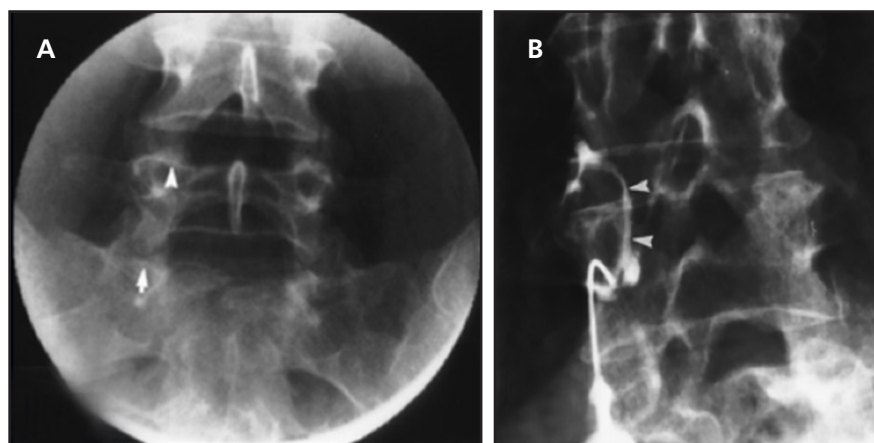
MR Arthrogram	CT Arthrogram	Large Joint Injection (Extremity)	Caudal Epidural Steroid Injection	Nerve Root & Facet Injection (1.5 mL)
0.1 mL gadolinium	5 mL normal saline****	5 mL 1% lidocaine*	2 mL 3 mg/mL betamethasone	1 mL 3 mg/mL betamethasone
10 mL normal saline****	5 mL 1% lidocaine*	5 mL 0.25% bupivacaine*	3 mL normal saline****	1 mL 0.25% bupivacaine
5 mL 1% lidocaine*	10 mL iodinated contrast (iopamidol 200m)	1 mL 40 mg/mL methylprednisolone acetate***		
5 mL iodinated contrast (iopamidol 200m)**				

\*In patients with documented lidocaine allergy, chloroprocaine (or other ester-like anesthetic) is substituted for lidocaine or bupivacaine. Premedication can be performed if the allergy is mild.

\*\*In patients with allergy to iodinated contrast, additional saline is substituted for iodinated contrast.

\*\*\*In diagnostic (nontherapeutic) injections, local anesthetic agents are injected with omission of steroids.

\*\*\*\*The saline used in epidural procedures is sterile, preservative-free, normal saline.



**FIGURE 9.** Facet joint injection. (A) The inferior articular process at the superomedial edge of the pedicle is localized (arrows). The needle is advanced until it reaches bone. (B) A small amount of contrast fills the facet joint space (arrows). As with selective nerve root injections, 1.5 mL of a 1:1 ratio of steroid and anesthetic are injected.

plantar flexion and internally rotated (mortise view). A short 22-gauge spinal needle is then advanced into the lateral clear space.<sup>18</sup> If the injection is intra-articular, contrast will flow freely over the talar dome and lateral clear space.

More commonly, the anterior approach is performed secondary to underlying post-traumatic deformities. In this approach, the patient is placed in the lateral decubitus position. The foot is elevated on a foam block or other material, plantar flexed, and kept parallel to the fluoroscopy table with a small weight such as a sandbag. The anterior tibialis tendon is then palpated and a skin entry site lateral to this is chosen. Under

real-time fluoroscopic guidance, a short 22-gauge spinal needle is advanced along the dorsal talus until its tip is in the tibiotalar joint. Real-time fluoroscopic guidance is critical in “sneaking” the needle tip beyond anterior ankle joint osteophytes. Intra-articular contrast confirms needle tip positioning, with contrast flowing freely over the talar dome (Figure 6), and 1 mL of steroid and up to 4 mL of anesthetic are injected.

### Conservative spine procedures Epidural Steroid Injection

Epidural steroid injections are effective procedures for relieving low back pain and are safest when performed

under fluoroscopic guidance.<sup>19</sup> Before the procedure, prior imaging studies are reviewed to assess for a low-lying thecal sac and large Tarlov cysts, and to ensure the absence of underlying infection.

The patient is placed prone on the fluoroscopy table and the sacral hiatus is palpated. A site a few millimeters distal to this is chosen as a skin entry site. A lateral fluoroscopic image is useful in confirming the sacral hiatus position, particularly in obese patients. Following anesthetization of the skin and subcutaneous tissues, a 22-gauge spinal needle is advanced at a 45-degree angle with the bevel down, until the sacrum is reached. At this point, the needle hub is fully depressed until it is parallel with the floor, and then the needle is advanced 1–2 cm. A lateral image is taken to verify the needle tip position at the S3–S4 level (Figure 7A). A second, AP image is then taken to verify midline positioning between the pedicles (Figure 7B).

Under real-time fluoroscopic guidance, 1–2 mL of intrathecal compatible iodinated contrast is injected to verify epidural positioning. A “Christmas tree pattern” with contrast outlining the nerve roots is typical (Figure 7B). If there is a hazy, diffuse appearance with freely flowing contrast, then the needle is likely intrathecal. If the contrast is loculated without an anatomic appearance, it is superficial. If contrast quickly disappears,

it is likely intrathecal or in the epidural venous plexus. Repositioning into the epidural space generally involves retracting the needle tip a few millimeters. Once proper positioning is verified, 2 mL of 3 mg/mL betamethasone is injected, followed by 3 mL of sterile, preservative-free normal saline (**Table**).

### **Nerve Root Injection**

When a patient's symptoms are isolated to a particular nerve distribution, a selective nerve root injection may be useful. Our preference is to perform this exam using a coaxial needle kit with a larger, outer 22-gauge introducer needle and smaller, inner 25-gauge needle. With the patient prone on the fluoroscopy table, the appropriate level to be injected is identified. A position just inferolateral to the pedicle is targeted, at approximately the 5 o'clock or 7 o'clock position (**Figure 8A**). The 22-gauge needle is advanced in AP fashion a few centimeters, and its position is checked on lateral fluoroscopy. This 22-gauge needle is advanced until its tip reaches the level of the posterior elements. The inner 25-gauge needle is then advanced under real-time fluoroscopy until its tip reaches the expected level of the nerve root (**Figure 8B**) or the patient's symptoms are reproduced. A small amount of contrast is injected to confirm nonvascular location under AP fluoroscopy. A 1:1 mixture of 3 mg/mL betamethasone and 0.25% bupivacaine is prepared, and 1.5 mL of this mixture is injected (**Figure 8A**) (**Table**).

### **Facet Joint Injection**

Degenerative facet disease can result in painful radiculopathy secondary to foraminal narrowing and synovial cyst formation. Steroid injections around the facet joints are an effective form of treatment.<sup>20</sup> With the patient prone on the fluoroscopy table and slightly flexed with a pillow under the abdomen, the in-

ferior articular process at the medial edge of the pedicle is localized (**Figure 9**). A 22-gauge spinal needle is advanced vertically in the center of the field of view to avoid the parallax effect and provide accurate needle trajectory. The needle is advanced until it encounters bone. At this point, approximately 2 mL of iodinated contrast are injected, and will ideally fill the facet joint space (**Figure 9B**). Upon confirming needle location, a 1:1 mixture of 3 mg/mL betamethasone and 0.25% bupivacaine is prepared, and 1.5 mL of this mixture is injected.

### **Conclusion**

Whether practicing as a general radiologist or a subspecialized musculoskeletal radiologist, it is useful to be familiar with the most common musculoskeletal procedures. These procedures provide not only obvious benefits to the patient but also add value to the radiology department as a whole. The approach to aspirations, injections, and arthrograms remains the same with identification of essential landmarks using image guidance and directing the appropriate gauge needle into the joint. The main differences in these procedures is whether or not the joint is aspirated or injected, and if injected, what quantities and ratios are administered. This review provided protocols and illustrative approaches for some of the common musculoskeletal interventions encountered in daily practice.

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