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# Fundamentals of Joint Injection

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**OBJECTIVE.** Using image guidance for joint access is a valuable fundamental skill. The purpose of this article is to review fluoroscopic and ultrasound-guided techniques and the medications used for injection into the glenohumeral, elbow, wrist, hip, knee, and ankle joints.

**CONCLUSION.** Thorough understanding of basic injection principles, knowledge of the underlying anatomy, and consideration of the advantages and disadvantages of the imaging approaches should facilitate selection of the most appropriate technique for any clinical scenario.

Image-guided joint access is a commonly used and valuable skill. It can be used for therapeutic injections or for diagnostic purposes, such as injections for MR and CT arthrography, anesthetic testing for pain relief, and aspiration for fluid analysis. This article reviews the most common fluoroscopic and ultrasound-guided approaches for accessing the glenohumeral, elbow, wrist, hip, knee, and ankle joints. The basic principles of image-guided joint access are discussed, as are considerations for arthrography, use of intraarticular medications, and potential complications.

## General Technique

Careful patient positioning before the procedure facilitates patient comfort and safe and efficient access to the joint. For fluoroscopy, a radiopaque object is placed on the skin overlying the target to mark an appropriate skin entry site. For ultrasound-guided injections, preprocedural scanning is used to plan the needle trajectory, identify the target site, and localize adjacent neurovascular structures and tendons to avoid. Sterile technique is used, including mask, sterile gloves, and sterile preparation. Cutaneous and tract anesthesia are achieved with local anesthetic (1% lidocaine buffered with sodium bicarbonate) and small-gauge needles (25–30 gauge). The needle is advanced into the joint with either intermittent fluoroscopic guidance or under direct ultrasound visualization. Appropriate needle gauge and length depend on the joint being targeted (Table 1). Imaging provides an invaluable visual reference, but it is also important to develop a tactile sense of the needle encountering different tissue types and entering the joint.

The fluoroscopic approaches described in this article rely on aligning the fluoroscopic beam with the needle trajectory so the needle appears as a small dot (bull's-eye technique). Centering the beam on the skin entry site avoids parallax and distortion. In addition to adjustment of the needle hub to direct the position of the tip, the tendency of the needle tip to migrate away from its bevel allows the radiologist to steer the needle path to achieve subtle corrections, especially when muscle spasm or tissue planes divert the needle from the target. An osseous backstop should be used whenever possible to ensure correct depth. Intraarticular position is confirmed when contrast medium can be injected with little resistance and flows freely into the joint recesses rather than clustering around the needle tip. For patients with an allergy to iodinated contrast material, full-strength gadolinium or air may be used, or the injection may be performed under ultrasound guidance.

Ultrasound guidance has several advantages: patient positioning and needle trajectory are more easily fine-tuned; soft-tissue anatomic features are directly visualized and either avoided (nerve, vessel) or targeted (effusion); the needle can be maneuvered in real time instead of intermittently observed; and ionizing radiation is avoided. An in-plane approach, with the needle positioned parallel to the midline of the long axis of the transducer, is generally preferable to the out-of-plane technique so that the needle can be seen throughout the pro-

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**TABLE 1: Needle Sizes and Lengths Used for Joint Access**

| Location | Gauge | Length (in) |
|---|---|---|
| Shoulder (rotator interval or posterior approach) | 22 | 1.5 > 3.5 |
| Shoulder (anterior approach) | 22 | 3.5 |
| Elbow | 25 | 1.5 |
| Wrist | 25 | 1.5 |
| Hip | 22 | 3.5 > 6 |
| Knee | 22 | 1.5 >> 3.5 |
| Ankle | 25 | 1.5 |

Note—The symbol > indicates more commonly used than, >> indicates much more commonly used than.

cedure. Planning a skin entry site that allows a shallow needle trajectory maximizes needle visibility: visualization markedly diminishes with angles approaching 40°. One strategy to accomplish this is to place the puncture site farther from the probe to achieve a longer but flatter trajectory with respect to the transducer. "Toeing-in" the probe (Fig. 1) can also help to produce an angle between the transducer and the needle that is closer to parallel. Beam steering can also be used to improve nedle visibility. If a steep angle cannot be avoided, other methods of improving needle visibility include jiggling the needle and hydrodissection with anesthetic to locate the tip.

The intraarticular position of the needle tip is confirmed by direct visualization: injected fluid moves away from the needle tip with little resistance. Selection of an appropriate ultrasound probe depends on the joint being studied and habitus. In general, a mid- to high-frequency linear probe works best, except in the hip, which often requires a low-frequency linear or even a curved probe.

## Arthrography

The clinical utility of both MR and CT arthrography has been well described [1], and the access techniques we describe apply to both modalities. Joint-specific contrast preparations and injection volumes are summarized in Table 2. The volume should be tailored to adequately distend the joint but avoid extraarticular extravasation.

For MR arthrography, although a range of dilutions of gadolinium may be used, a 1:200 dilution affords excellent imaging in most cases. The mixture contains iodinated contrast medium, local anesthetic, and saline solution to achieve the correct dilution. Inclusion of iodinated contrast medium allows fluoroscopic visualization during the injection. Local anesthetic increases patient comfort and decreases motion artifacts on subsequently obtained MR images [2]. Lidocaine or ropivacaine or both should be used rather than bupivacaine, which is cytotoxic to chondrocytes in vitro [3, 4] and at least theoretically poses a small risk to articular cartilage in vivo. Steroids may be included in the mixture if requested by the clinician for concurrent therapeutic injection because mixing of these substances is safe and does not degrade the MRI signal characteristics [5, 6]. Some radiologists prefer to use two solutions for the injection: one syringe of iodinated contrast medium to show intraarticular location and a second of dilute gadolinium. We prefer to combine the iodinated contrast medium and gadolinium in one mixture (Table 2) to simplify the procedure and decrease the risk of injecting air into the joint.

## Medications

Therapeutic joint injections most commonly are performed with corticosteroids, an anesthetic, or a viscosupplement such as hyaluronic acid. Corticosteroids are gen-

**TABLE 2: Examples of Medications Used and Volumes (mL) for Arthrography**

| Location | 1% Lidocaine | Iodinated Contrast Medium | 0.5% Ropivacaine[a] | Normal Saline Solution | Gadolinium | Total Volume Injected[b] |
|---|---|---|---|---|---|---|
| MRI arthrography | | | | | | |
| Shoulder | 10 | 5 | | 5 | 0.1 | 12 |
| Elbow | 10 | 5 | | 5 | 0.1 | 2–4 |
| Wrist | 10 | 5 | | 5 | 0.1 | 1–3[c] |
| Hip | 5 | 5 | 5 | 5 | 0.1 | 12 |
| Knee | 20 | 10 | | 10 | 0.2 | 40 |
| Ankle | 10 | 5 | | 5 | 0.1 | 2–4 |
| CT arthrography | | | | | | |
| Shoulder | 10 | 10 | | | | 12 |
| Elbow | 5 | 5 | | | | 2–4 |
| Wrist | 5 | 5 | | | | 1–3[c] |
| Hip | 5 | 5 | 5 | | | 12 |
| Knee | 20 | 20 | | | | 40 |
| Ankle | 5 | 5 | | | | 2–4 |

[a]Ropivacaine may be added to allow a longer period for the patient to test improvement in pain with typical provocative activities, a key test for acetabular labral tears for some surgeons.
[b]To keep the dilutions for each joint straightforward, 20 mL of contrast solution can be mixed for all joints except the knee, and then only the quantity needed is injected.
[c]Injection volume is generally 2–3 mL for the radiocarpal and midcarpal joints and 1 mL for the distal radioulnar joint.

erally safe and effective for short- to medium-term treatment of joint pain [7–10]. The mechanism of action is complex but includes decreasing synovial blood flow, the numbers of leukocytes and the release of inflammatory mediators [11, 12]. Although there is little evidence to guide the selection of a specific steroid, clinical duration of effect is theoretically inverse to solubility [11]. Thus, we use a relatively insoluble steroid, triamcinolone acetonide (Kenalog, E. R. Squibb), for most joints. Dexamethasone is preferable for injection into superficial structures because steroids that are more soluble are less likely to cause atrophy of subcutaneous fat or depigmentation of skin [13]. Combining a corticosteroid with an anesthetic increases injectate volume, better distributes the steroid throughout the joint, and reduces periprocedural discomfort. Particulate corticosteroids should be mixed only with preservative-free anesthetics to prevent particulate precipitation. Sample joint-specific injection recommendations are summarized in Table 3. Referring providers may also request joint injection with anesthetic only to assist in determining a patient's source of pain when multiple possibilities exist.

The intraarticular injection of hyaluronic acid derivatives is an effective treatment for patients with pain from osteoarthritis refractory to more conservative measures and has a low rate of adverse effects [14]. Although most commonly used in the knee, hyaluronans may be effective for osteoarthritis of other joints, including the hip and shoulder [15]. The mechanism of action is incompletely understood and likely multifactorial, involving improved viscoelasticity of synovial fluid, reduction of chondrocyte wear, and improved cartilage matrix stability [16]. The technique of injection is not substantially different from that of any other intraarticular injection, although particular care should be taken to avoid extravasation because it can cause inflammation of periarticular tissues. The risk of acute local soft-tissue reaction is also increased in patients who undergo multiple repeat injections.

## Complications

The complication rate for intraarticular injections is low. The most frequently reported complications, including pain and bleeding at the injection site [17], are easily managed. More serious complications, such as septic arthritis, are exceedingly rare, occurring in fewer than 1 in 10,000 cases in one series [18]. Elective injections should be deferred if the patient may have bacteremia, and joint access should not be performed through infected overlying skin or soft tissues. One also must consider the local and systemic effects of intraarticular steroids. A variety of systemic effects have been reported, although clinically significant adverse reactions are infrequent [19]. Several less serious short-term symptoms are common enough that we specifically caution patients about these possibilities. These include a transient increase in pain (steroid flare), mild headache, insomnia, and facial flushing, which occurs in as many as 40% of patients, particularly women. Patients with diabetes should also be warned to expect a transient spike in blood glucose level, which can last as long as 5 days [19]. Although measurable suppression of the adrenopituitary axis may occur in some patients after steroid injection, this rarely has clinical manifestations. Iatrogenic Cushing syndrome is infrequent and has been mostly reported in the setting of frequent repeat injections in younger patients with juvenile idiopathic arthritis [19].

Potential local adverse effects, such as cartilage degradation and tendon weakening, are not well understood. The long-term effects of intraarticular steroids on cartilage in animal models are mixed [20–22]. One prospective trial with human subjects [23] showed no joint space narrowing in the knee after steroid injection every 3 months over 2 years. The rate of tendon rupture after steroid injection has been reported but is rare, less than 1 in 1000, even with direct peritendinous injections for treatment of tendinopathy [24]. Still, we recommend caution and discussion with the referring clinician when administering injections to patients with known tendon lesions, such as rotator cuff tears.

Because of the low risk of hemarthrosis during joint injection, anticoagulants are typically not discontinued, nor are coagulation laboratory values routinely measured [25]. Nonetheless, for patients taking warfarin, the most recent international normalized ratio should be within the therapeutic range.

## Joint-Specific Considerations

### *Shoulder*

The glenohumeral joint is commonly injected for diagnostic and therapeutic purposes. The three most commonly used image-guided approaches are the anterior (Schneider technique), rotator interval, and posterior approaches. The first two of these approaches are the most common fluoroscopic techniques for glenohumeral joint access [26]. The patient lies supine with the arm externally rotated, and an anteroposterior image of the shoulder is obtained. A light weight may be placed in the patient's palm to help maintain external rotation. For the anterior approach [27], the needle is advanced to the cortex of the junction of the middle and inferior thirds of the medial humeral head, thus avoiding the glenoid labrum (Fig. 2A). Because of the course of the needle, the anterior stabilizing structures can appear distorted on MR arthrography when this technique is used. The technique also can be painful because the needle traverses the subscapularis tendon.

The rotator interval approach targets the space between the subscapularis and supraspinatus tendons along the superomedial quadrant of the humeral head (Figs. 2B–2D). This approach reduces patient discomfort, procedure time, and fluoroscopic exposure time compared with those of other common approaches [28]. This technique avoids the subscapularis muscle, and external rotation of the arm draws the biceps tendon out of the needle path. A potential pitfall of this method is unintentional injection of the subacromial-sub-

**TABLE 3: Examples of Medications Used and Volumes (mL) for Therapeutic Injections**

| Location | 1% Lidocaine (Preservative-Free)[a] | 0.5% Ropivacaine | Triamcinolone Acetonide (40 mg/mL) | Total Volume Injected |
|---|---|---|---|---|
| Shoulder | 2 | 2 | 1 | 5.0 |
| Elbow | 2 | 2 | 1 | 2.5 |
| Wrist | 2 | 2 | 1 | 2.5 |
| Hip | 2 | 2 | 1 | 5.0 |
| Knee | 4 | 4 | 1 | 9.0 |
| Ankle | 2 | 2 | 1 | 2.5 |

[a]Because of their complementary natures, both lidocaine and ropivacaine are used, providing more rapid onset and longer-lasting anesthetic properties.

deltoid bursa with shallow needle placement because the bursa overlies the rotator interval. This could lead to a diagnostic dilemma in attempts to diagnose a full-thickness rotator cuff tear during subsequent MR arthrography. In addition, contrast medium may fill the area and obscure rotator interval abnormalities.

An anterior approach may also be performed with ultrasound. The transducer is placed in the transverse plane at the level of the coracoid process, and the humeral head is identified. The needle is advanced from a lateral approach toward the medial edge of the humeral head [29].

A posterior approach to glenohumeral joint access may be preferred when there is concern about anterior instability because any extraarticular contrast injection or extravasation will be posterior and thus not interfere with evaluation of the anterior labroligamentous structures [30]. Although it may be performed with fluoroscopy, the posterior approach is most commonly performed under ultrasound guidance and is generally the preferred technique when ultrasound guidance is used [31, 32]. For this approach, the patient lies prone with the arm neutral or slightly internally rotated, and the shoulder elevated with a triangular foam pad placed under the torso. The transducer is aligned in an oblique axial orientation along the long axis of the infraspinatus muscle. The humeral head, infraspinatus myotendinous junction, posterior glenoid rim, and posterior labrum are identified. The needle is then advanced into the glenohumeral joint space from either a lateral-to-medial or a medial-to-lateral approach. The tip penetrates the infraspinatus between the free edge of the posterior labrum and the hypoechoic articular cartilage of the posterior humeral head [32] (Fig. 2E). Risks of this technique include injury to neurovascular bundles, mainly the suprascapular nerve and circumflex scapular vessels, if the needle is placed too far medially [30, 31].

### *Elbow*

Elbow joint MR or CT arthrography may be requested for diagnosis of collateral ligament tears, chondral defects, or the presence of intraarticular bodies. The two major injection methods are the lateral and posterior approaches. For the lateral approach, the target is the anterior half of the radiocapitellar joint (Fig. 3A). The patient can be positioned either prone with the arm over the head or seated beside the table with the arm abducted, flexed 90°, and placed flat on the table with the lateral aspect of the elbow facing upward. The hand is supinated with the thumb up to maximally open the joint. The radiocapitellar joint should be positioned parallel to the beam to avoid overlap of the radial head and capitellum and facilitate entry into the joint.

For the posterior transtriceps approach [33], the elbow is flexed, and a point is marked just above and lateral to the olecranon. The needle is advanced until it contacts the olecranon fossa of the humerus (Fig. 3B). This approach decreases the likelihood of iatrogenic contrast leakage in the lateral aspect of the elbow, potentially avoiding a diagnostic dilemma during subsequent CT or MRI, particularly in cases in which injury to the lateral elbow structures is suspected [33].

Injecting into the elbow under ultrasound guidance can be accomplished by use of approaches and landmarks similar to those for the fluoroscopic approach (Fig. 3C). For aspiration of the elbow under ultrasound guidance, evaluating the recesses for fluid is imperative in obtaining a sample. The olecranon recess is most likely to contain a joint effusion [18, 34].

### *Wrist*

MR and CT arthrography of the wrist are used in the evaluation of the intrinsic ligaments, triangular fibrocartilage complex, and articular cartilage. A single-compartment (radiocarpal joint), double-compartment (radiocarpal plus either a midcarpal or distal radioulnar joint), or triple-compartment injection technique may be used depending on the diagnostic indications and structures of interest (Fig. 4A).

Injection into the radiocarpal joint aids in evaluation of both the triangular fibrocartilage complex and intrinsic ligaments for complete tears. If no communication between compartments is present and there is concern about a partial tear of the proximal surface of the triangular fibrocartilage, the distal radioulnar joint should also be injected. A midcarpal injection is another aid to examining the interosseous ligaments. It is typically performed as part of a triple-compartment injection in patients with confounding symptoms and an indeterminate source of pain at clinical examination.

For injection of the wrist joints, the patient may lie prone on the table with the wrist overhead or sit on a stool with the arm abducted and elbow flexed with the palm facing down on the table. A dorsal approach is used for all wrist compartments. To improve profiling of the radiocarpal joint and avoid the dorsal lip of the radius, a sponge or soft towel is placed beneath the wrist to maintain passive flexion. Any osseous overlap that persists can be corrected by slight craniocaudal tilt of the fluoroscope. Ulnar deviation opens the joint space along the radial aspect, the most common site of injection. For radial-side injections of the radiocarpal joint, the needle is advanced to the proximal cortex of the scaphoid, ulnar to the tubercle (Fig. 4B). Further advancement into the joint is not required. For patients with radial-side pain, an ulnar-side injection of the radiocarpal joint may be performed to avoid obscuring potential abnormalities. In this setting, the needle is directed to the proximal edge of the triquetrum, adjacent to the pisiform [35].

For injection into the distal radioulnar joint, the radial margin of the distal ulna is targeted just proximal to its physeal scar to ensure intraarticular placement (Fig. 4C). The typical target for injection of the midcarpal compartment is the confluence of the triquetrum, lunate, capitate, and hamate (Fig. 4D). This space may normally communicate with the common carpometacarpal joint but not with the radiocarpal joint unless one of the interosseous ligaments is torn.

Fluoroscopy can complement MR arthrography in the detection of ligamentous injuries by delineating the site of abnormal communication between compartments at the time of contrast injection [36]. Dynamic maneuvers such as radial and ulnar deviation under fluoroscopic guidance may unmask small full-thickness tears and show diastasis of the intercarpal spaces and instability.

For ultrasound-guided injections into the wrist, the dorsal recesses of the radiocarpal and midcarpal joints are targeted (Fig. 4E). These are best visualized in the long axis, but the injection may be performed in either the long or the short axis for needle entry. The distal radioulnar joint is best delineated in the short axis.

### *Hip*

Indications for hip joint access include joint aspiration, alleviation of pain, diagnostic evaluation with anesthetic to determine the source of pain, and MR and CT arthrography. The anterior approach is most commonly used: the patient is positioned supine, and the lower extremity is internally rotated approximately 10–15°. To avoid the neurovascular structures and iliopsoas tendon, the lateral aspect of the femoral head-neck junction should be targeted [37]

(Fig. 5A). Selecting a target a few millimeters inside the lateral edge of the bone is easiest, although many radiologists target the lateral cortex and slide along it a couple millimeters after making contact (paracortical approach) (Fig. 5B). Although technically more challenging, an oblique (lateral-to-medial or inferior-to-superior) approach to the femoral head-neck junction may be useful to facilitate needle visualization in obese patients with a panniculus overlying the conventional skin entry site or in patients with a hip prosthesis. The radiologist should refrain from placing the needle along the central and inferior portion of the femoral neck because the zona orbicularis, a prominent bandlike thickening of the joint capsule that overlies this site, is difficult to penetrate [37].

Similar techniques may be used to aspirate the hip to assess for infection. In this scenario, the lateral cortex is generally targeted, and the needle is passed alongside the cortex into the more dependent portion of the joint space. If no fluid can be aspirated, the joint may be lavaged with contrast medium or nonbacteriostatic saline solution, although an accurate cell count cannot be obtained using this method.

Ultrasound can be invaluable as an alternative to fluoroscopy in patients with allergies to iodinated contrast medium or for localizing small joint effusions or periarticular fluid collections requiring aspiration. The transducer is placed anteriorly, parallel to the long axis of the femoral neck. The needle is advanced in plane with the transducer, traveling from distal to proximal, targeting the part of the femoral head-neck junction where the distance between the femur and overlying capsule is greatest (Fig. 5C). If present, a joint effusion may also be targeted.

### *Knee*

MR or CT arthrography of the knee is usually reserved for postoperative evaluation of the meniscus. The knee is commonly accessed for therapeutic joint injection or viscosupplementation and less commonly for joint aspiration. Several techniques have been described for injecting into the knee joint. In the lateral patellofemoral approach (Fig. 6A), the patient lies supine with a small pillow or bolster under the knee to place the joint in mild flexion [38]. The needle should pass between the patella and femoral condyle until reaching the midpoint of the patellar equator. If a syringe of local anesthetic is connected to the needle and gentle pressure is applied to the plunger during needle insertion, loss of resistance indicates an intraarticular position within the retropatellar space. Care should be taken to ensure proper positioning of the needle because too low a position may lead to injection within the fat-pad. Although a medial subpatellar approach can be used, the lateral is generally preferred [26] because the soft tissues are thinner, and the medial approach requires traversing the vastus medialis obliquus.

An anterior approach (Fig. 6B) can be used as an alternative, especially in morbidly obese patients or patients with severe patellofemoral compartment osteoarthritis [12]. In this case, the anteroinferior aspect of the trochlear articular surface is targeted; needle positioning starts just medial or lateral to the patellar tendon. Mild cephalic angulation may be used but is not necessary.

Joint injection (or aspiration) of the knee can also be performed easily with ultrasound. The most straightforward method is a suprapatellar approach. The probe is initially placed parallel to the long axis of the distal quadriceps tendon, revealing the underlying suprapatellar recess and distal femur. During the procedure, positioning the probe transversely optimizes needle visualization as the needle passes into the suprapatellar recess from a lateral-to-medial approach (Fig. 6C). The presence of joint fluid in the lateral or medial gutters can be helpful, providing an additional target for needle placement.

### *Ankle*

Ankle MR or CT arthrography is used to assess articular cartilage lesions, intraarticular bodies, and anterolateral and anteromedial impingement. Other indications include diagnostic anesthetic injection and therapeutic injection of steroids. For fluoroscopic ankle joint injections, the patient lies supine with the foot plantar flexed. Care should be taken to avoid the dorsalis pedis artery. Tube angulation helps to avoid contacting the anterior lip of the tibia, which often blocks access to the joint from a straight anterior approach.

A common anterior approach (Figs. 7A and 7B) is to use the space between the extensor hallucis longus and the extensor digitorum longus tendons, at the anteromedial ankle joint [39]. Because the anterior ankle capsule inserts on the talar neck, the talar dome represents an intraarticular structure and can be targeted, rather than inserting the needle between the tibial and talar articular surfaces.

Another approach to ankle injection is to target either the medial or the lateral clear space (Figs. 7C and 7D). The ankle is profiled in a mortise view, and the injection site is marked between the articulating surfaces of the medial malleolus and medial talar dome (medial clear space) or the upper half of the talofibular articulation.

In performance of ankle injection or aspiration under ultrasound guidance, an anterior long-axis approach is simplest (Fig. 7E). Initially the dorsalis pedis artery and extensor tendons are marked. A long-axis view of the tibialis anterior tendon is obtained, the transducer is translated just medial to the tendon, and the anterior recess is localized. The needle is advanced under ultrasound guidance into the recess to contact the talar dome.

## Conclusion

Multiple approaches exist for accessing each of the major joints of the body. Although only six joints are included in this article, the principles discussed can be applied and adapted to any of the less commonly encountered smaller joints. Most often, the technique chosen is based on the comfort level of the person performing the procedure, available equipment, and the specific clinical indication. Fluoroscopy or sonography can be used to guide joint injection. A thorough understanding of basic injection principles, knowledge of the underlying anatomy, and consideration of the advantages and disadvantages of each approach facilitate selection of the most appropriate technique for any clinical scenario.

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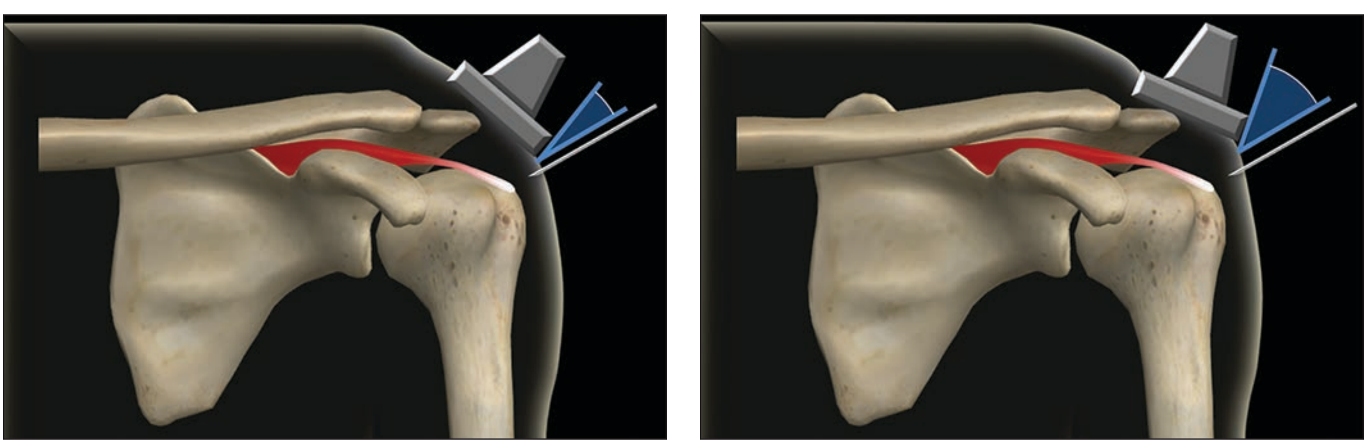
## References

1. Steinbach LS, Palmer WE, Schweitzer ME. Special focus session: MR arthrography. *RadioGraphics* 2002; 22:1223–1246
2. Fox MG, Petrey WB, Alford B, Huynh BH, Patrie JT, Anderson MW. Shoulder MR arthrography: intraarticular anesthetic reduces periprocedural pain and major motion artifacts but does not decrease imaging time. *Radiology* 2012; 262:576–583
3. Piper SL, Kim HT. Comparison of ropivacaine and bupivacaine toxicity in human articular chondrocytes. *J Bone Joint Surg Am* 2008; 90:986–991
4. Chu CR, Izzo NJ, Coyle CH, Papas NE, Logar A. The in vitro effects of bupivacaine on articular chondrocytes. *J Bone Joint Surg Br* 2008; 90:814–820
5. Ugas MA, Huynh BH, Fox MG, Patrie JT, Gaskin CM. MR arthrography: impact of steroids, local anesthetics, and iodinated contrast material on gadolinium signal intensity in phantoms at 1.5 and 3.0 T. *Radiology* 2014; 272:475–483
6. Brown RR, Clarke DW, Daffner RH. Is a mixture of gadolinium and iodinated contrast material safe dur-

ing MR arthrography? *AJR* 2000; 175:1087–1090
7. Stephens MB, Beutler AI, O'Connor FG. Musculoskeletal injections: a review of the evidence. *Am Fam Physician* 2008; 78:971–976
8. Buchbinder R, Green S, Youd JM. Corticosteroid injections for shoulder pain. *Cochrane Database Syst Rev* 2003; 1:CD004016
9. Arroll B, Goodyear-Smith F. Corticosteroid injections for osteoarthritis of the knee: meta-analysis. *BMJ* 2004; 328:869
10. Kullenberg B, Runesson R, Tuvhag R, Olsson C, Resch S. Intraarticular corticosteroid injection: pain relief in osteoarthritis of the hip? *J Rheumatol* 2004; 31:2265–2268
11. Caldwell JR. Intra-articular corticosteroids. *Drugs* 1996; 52:507–514
12. Snibbe JC, Gambardella RA. Use of injections for osteoarthritis in joints and sports activity. *Clin Sports Med* 2005; 24:83–91
13. DiStefano V, Nixon JE. Steroid-induced skin changes following local injection. *Clin Orthop Relat Res* 1972; 87:254–256
14. Bellamy N, Campbell J, Robinson V, Gee T, Bourne R, Wells G. Viscosupplementation for the treatment of osteoarthritis of the knee. *Cochrane Database Syst Rev* 2006;2:CD005321
15. Zhang W, Moskowitz R, Nuki G, et al. OARSI recommendations for the management of hip and knee osteoarthritis. Part 1. Critical appraisal of existing treatment guidelines and systematic review of current research evidence. *Osteoarthritis Cartilage* 2007; 15:981–1000
16. Goldberg VM, Buckwalter JA. Hyaluronans in the treatment of osteoarthritis of the knee: evidence for disease-modifying activity. *Osteoarthritis Cartilage* 2005; 13:216–224
17. Kumar N, Newman RJ. Complications of intra- and peri-articular steroid injections. *Br J Gen Pract* 1999; 49:465–466
18. Gray RG, Gottlieb NL. Intra-articular corticosteroids: an updated assessment. *Clin Orthop Relat Res* 1983; 177:235–263
19. Habib GS. Systemic effects of intra-articular corticosteroids. *Clin Rheumatol* 2009; 28:749–756
20. Pelletier JP, Martel-Pelletier J. Protective effects of corticosteroids on cartilage lesions and osteophyte formation in the Pond-Nuki dog model of osteoarthritis. *Arthritis Rheum* 1989; 32:181–193
21. Gibson T, Burry H, Poswillo D, Glass J. Effect of intra-articular corticosteroid injections on primate cartilage. *Ann Rheum Dis* 1977; 36:74–79
22. Behrens F, Shepard N, Mitchell N. Alterations of rabbit articular cartilage by intra-articular injections of glucocorticoids. *J Bone Joint Surg Am* 1975; 57:70–76
23. Raynauld JP, Buckland-Wright C, Ward R, et al. Safety and efficacy of long-term intraarticular steroid injections in osteoarthritis of the knee: a randomized, double-blind, placebo-controlled trial. *Arthritis Rheum* 2003; 48:370–377
24. Coombes BK, Bisset L, Vicenzino B. Efficacy and safety of corticosteroid injections and other injections for management of tendinopathy: a systematic review of randomised controlled trials. *Lancet* 2010; 376:1751–1767
25. Thumboo J. A prospective study of the safety of joint and soft tissue aspirations and injections in patients taking warfarin sodium. *Arthritis Rheum* 1998; 41:736–739
26. Shortt CP, Morrison WB, Roberts CC, Deely DM, Gopez AG, Zoga AC. Shoulder, hip, and knee arthrography needle placement using fluoroscopic guidance: practice patterns of musculoskeletal radiologists in North America. *Skeletal Radiol* 2009; 38:377–385
27. Schneider R, Ghelman B, Kaye J. A simplified technique for shoulder arthrography. *Radiology* 1975; 114:738–739
28. Redondo MV, Berná-Serna JD, Campos PA, et al. MR arthrography of the shoulder using an anterior approach: optimal injection site. *AJR* 2008; 191:1397–1400
29. Valls R, Melloni P. Sonographic guidance of needle position for MR arthrography of the shoulder. *AJR* 1997; 169:845–847
30. Farmer KD, Hughes PM. MR Arthrography of the shoulder: fluoroscopically guided technique using a posterior approach. *AJR* 2002; 178:433–434
31. Gokalp G, Dusak A, Yazici Z. Efficacy of ultrasonography-guided shoulder MR arthrography using a posterior approach. *Skeletal Radiol* 2010; 39:575–579
32. Zwar RB, Read JW, Noakes JB. Sonographically guided glenohumeral joint injection. *AJR* 2004; 183:48–50
33. Lohman M, Borrero C, Casagranda B, et al. A posterior transtriceps approach for elbow arthrography: a forgotten technique? *Skeletal Radiol* 2009; 38:513–516
34. De Maeseneer M, Jacobson JA, Jaovisidha S, et al. Elbow effusions: distribution of joint fluid with flexion and extension and imaging implications. *Invest Radiol* 1998; 33:117–125
35. Cerezal L, Abascal F, García-Valtuille R, Del Piñal F. Wrist MR arthrography: how, why, when. *Radiol Clin North Am* 2005; 43:709–731
36. Bille B, Harley B, Cohen H. A comparison of CT arthrography of the wrist to findings during wrist arthroscopy. *J Hand Surg Am* 2007; 32:834–841
37. 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
38. Freiberger RH, Pavlov H. Knee arthrography. *Radiology* 1988; 166:489–492
39. Cerezal L, Llopis E, Canga A. MR arthrography of the ankle: indications and technique. *Radiol Clin North Am* 2008; 46:973–994



A B

**Fig. 1**—Concept of toeing-in of ultrasound probe.
**A,** Three-dimensional image shows probe before it is pressed into skin.
**B,** Three-dimensional image shows edge of probe opposite needle has been pressed into skin while nearer edge is gently lifted. Maneuver flattens angle between probe and needle, facilitating visualization of needle.

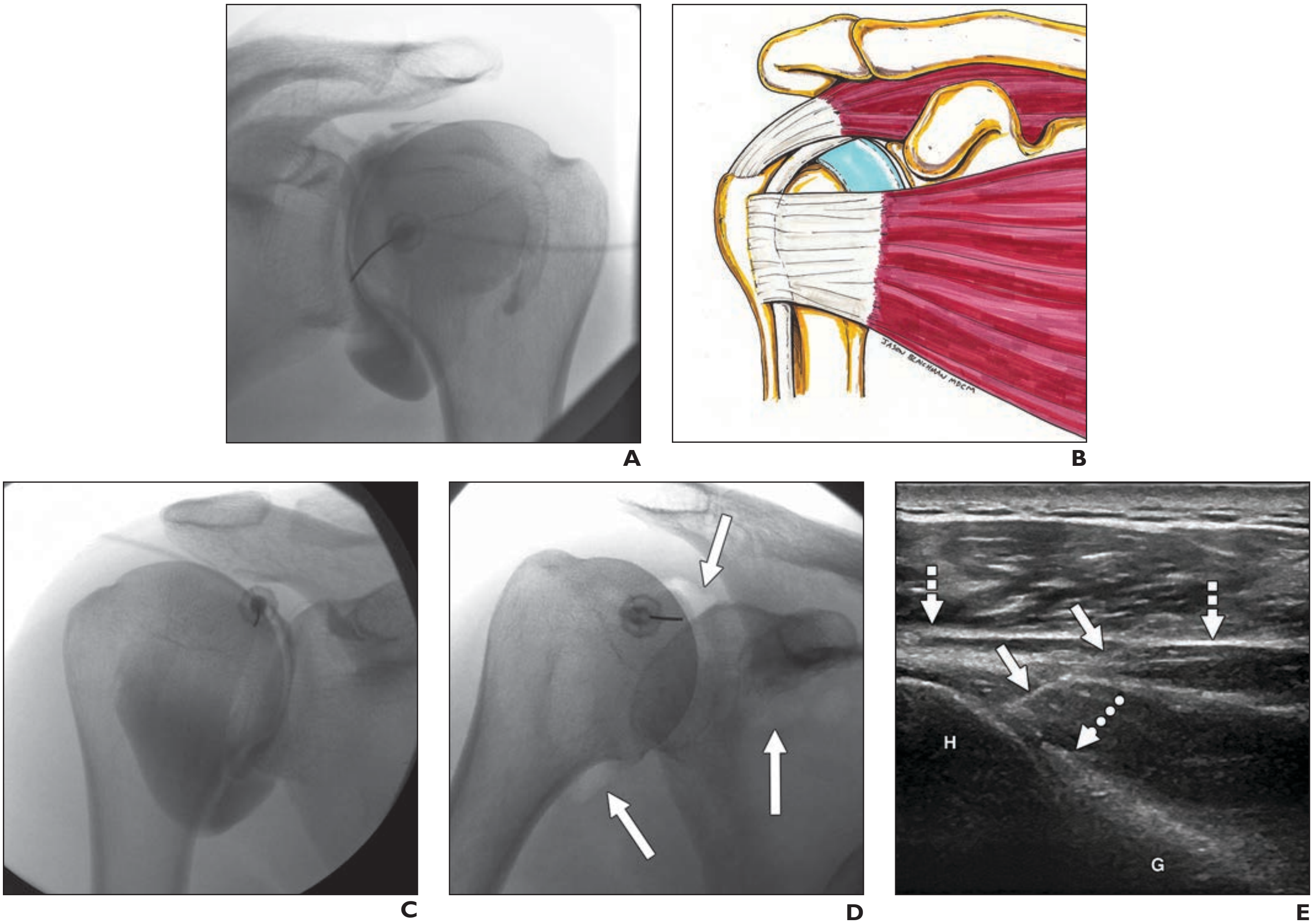



**Fig. 2**—Shoulder injection approaches.
**A,** Anterior (Schneider) approach. Fluoroscopic image shows target is medial humeral cortex, approximately two-thirds distance down opposite glenoid. Once cortex is contacted, bevel is turned toward bone, and needle slides few more millimeters into joint. With this technique, subscapularis often spasms and drags needle tip medially. Caution must be taken to guard against driving needle too far medially and piercing glenoid labrum.
**B,** Drawing of anterior aspect of shoulder depicts rotator interval, which is space bounded by subscapularis tendon below and supraspinatus tendon above. Biceps tendon passes through rotator interval before passing into bicipital groove. Radiologist can move biceps out of needle path by having patient externally rotate shoulder. Target is superior medial quadrant of humeral head, between 1- and 2-o'clock positions for right shoulder and 3–5 mm in from edge of cortex.
**C,** Rotator interval approach. Fluoroscopic image shows avoidance of biceps long head tendon by targeting spot on humeral head below top of glenoid with shoulder externally rotated. When level above bottom of coracoid is targeted, injection passes above subscapularis. Contrast medium flows away from needle and fills joint recesses.
**D,** Fluoroscopic image obtained during corticosteroid injection in patient with allergies to iodinated contrast material and gadolinium shows injection via rotator interval approach using air. Injected air (*arrows*) can achieve sufficient negative contrast to assure placement of needle within joint. Ultrasound-guided injection is another option in this situation, especially if injection is for MR arthrography, in which case this quantity of air would be unacceptable.
**E,** Ultrasound image with probe transverse in relation to body at level of midhumeral head (H) and glenoid (G). Infraspinatus muscle (*dashed arrows*) appears in long axis, underlying the deltoid muscle. In this medial-to-lateral approach, needle (*solid arrows*) contacts humeral head just lateral to glenoid labrum (*dotted arrow*). Injectate should flow smoothly into joint and not extravasate backward along needle into infraspinatus.

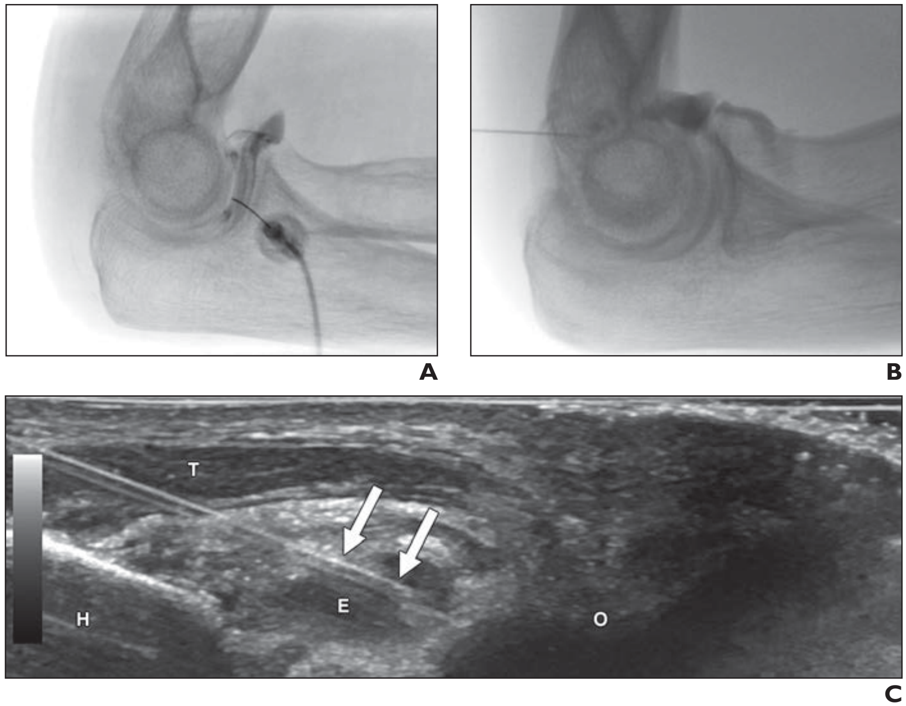



**Fig. 3**—Elbow injection approaches.
**A,** Lateral fluoroscopic approach. Fluoroscopic image shows 25-gauge needle placed into space between radial head and capitellum. When needle enters joint, it may feel like needle is passing into block of cheese. Contrast medium flows away from needle tip into joint. Slightly more anterior placement of needle from this approach allows even easier passage. Similar approach works well for ultrasound-guided injections because lateral joint space is usually readily accessible.
**B,** Posterior fluoroscopic approach. Fluoroscopic image shows needle directed toward posterior humeral cortex within olecranon fossa. Some authors advocate central approach traversing triceps tendon; we prefer approach that starts lateral to tendon and heads centrally. Contrast medium should flow quickly away from needle tip. Contrast medium is evident in coronoid fossa in anterior aspect and within joint recess around radial neck.
**C,** Ultrasound-guided elbow aspiration. Longitudinal ultrasound image of posterior elbow shows needle (*arrows*) passing through triceps muscle (T) along distal humerus (H) through hyperechoic joint capsule into hypoechoic joint effusion (E). Olecranon (O) is obscured by artifact. Small-to-moderate elbow effusions are usually most visible and accessible from posterior approach.

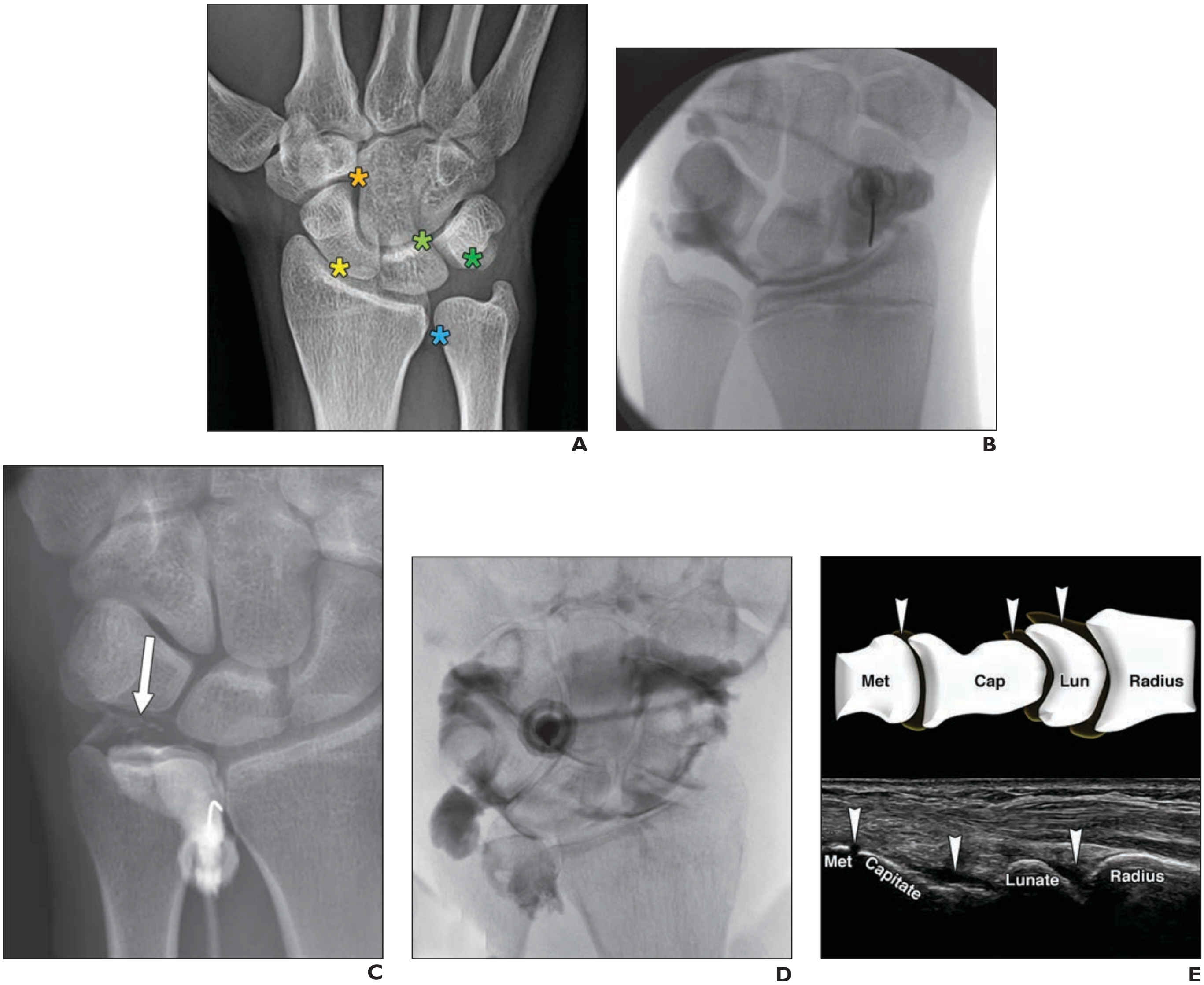



**Fig. 4**—Wrist injection approaches.

**A,** Posteroanterior wrist radiograph shows target sites for different compartments. Yellow indicates radial side of radiocarpal joint; dark green, ulnar side of radiocarpal joint; blue, distal radioulnar joint; light green, four-corners approach to midcarpal compartment; orange, alternative approach to midcarpal compartment.

**B,** Radiocarpal compartment injection. Fluoroscopic image shows needle targeting proximal cortex of scaphoid. If cortex is struck within few millimeters of joint space, contrast medium flows into joint; that is, needle does not have to be perched between distal radius and scaphoid. If there is concern about pathology on radial side of wrist, proximal triquetrum can be targeted instead.

**C,** Distal radioulnar joint (DRUJ) injection. Fluoroscopic image shows needle tip targeting radial edge of ulna at level of physeal scar and veering into joint after making contact with bone. Contrast medium fills DRUJ and blankets head of ulna. Small amount of contrast medium has passed through perforation in triangular fibrocartilage complex and lies within radiocarpal joint (*arrow*).

**D,** Midcarpal compartment injection. Fluoroscopic image shows needle targeting four-corners location between hamate, capitate, lunate, and triquetrum. In this case, contrast medium not only fills midcarpal and common carpometacarpal compartments, which is normal, but also extends into radiocarpal joint and DRUJ, implying interosseous ligament tear and triangular fibrocartilage complex tear, respectively.

**E,** Ultrasound wrist targets. Schematic and longitudinal dorsal ultrasound image show joint recesses (*arrowheads*) accessible for injection. Met = metacarpal, Cap = capitate, Lun = lunate.

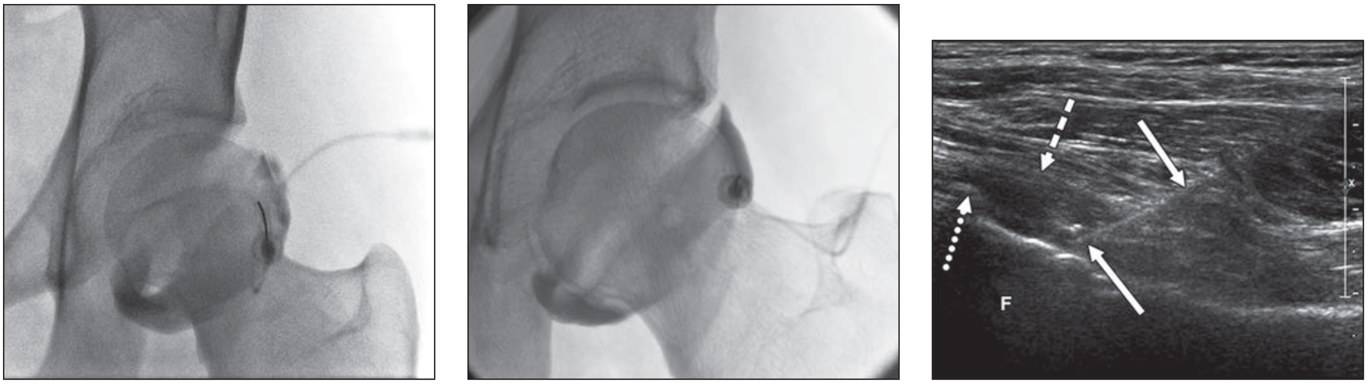



**Fig. 5**—Hip injection approaches.
**A,** Anterior approach. Fluoroscopic image shows needle being advanced toward lateral aspect of femoral head-neck junction. When needle contacts bone, it is inside joint capsule. Jiggling or twisting needle helps to penetrate last layer of capsule. Contrast medium fills joint. Constriction of capsule at level of midfemoral neck is zona orbicularis, which is thick portion of capsule that should be avoided during needle placement.
**B,** Paracortical approach. Fluoroscopic image shows needle targeting edge of cortex at lateral femoral head-neck junction. After initial osseous contact, needle is advanced 2–3 mm farther before injection is administered. This is also common approach for hip aspiration.
**C,** Ultrasound-guided hip injection. Oblique longitudinal ultrasound image oriented along femoral neck (F) shows needle (*solid arrows*) entering hypoechoic joint effusion, which is deep to joint capsule (*dashed arrow*). Dotted arrow points to osteophytes at femoral head-neck junction.

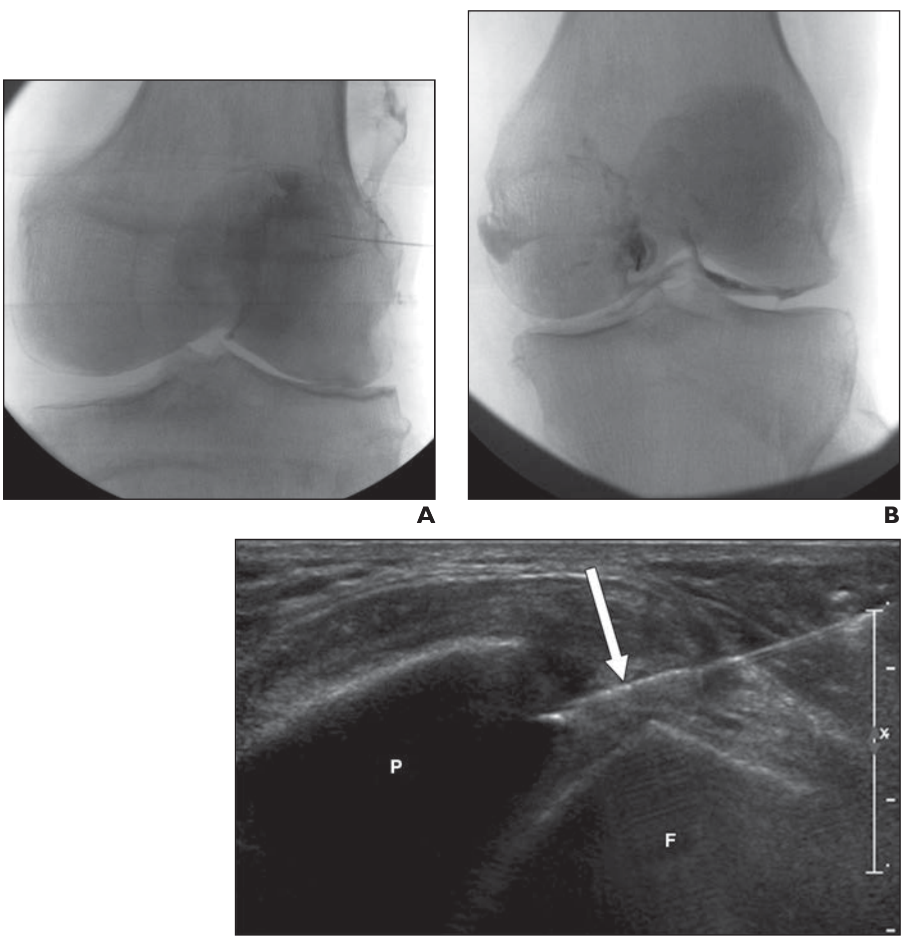



**Fig. 6**—Knee injection approaches.
**A,** Lateral subpatellar approach to knee. Fluoroscopic image shows needle driven into space between patella and anterior femur, starting at about equator of patella. If anesthetic is injected as needle advances, when needle enters joint, anesthetic begins to flow quickly. This is usually near center of patella.
**B,** Anterior fluoroscopic approach. Fluoroscopic image shows trochlea being targeted 2–4 mm above joint space near intercondylar notch. Needle is guided medial (or lateral) to patellar ligament until it strikes bone. Even in most large patients, 1.5-inch needle suffices. Contrast medium often quickly shoots into distant joint recesses.
**C,** Ultrasound-guided knee injection. Because suprapatellar recess is superficial, knee effusions are usually readily accessible, and injection or aspiration is straightforward. If there is no effusion, finding recess may be challenge, but small pockets of fluid may lie alongside lateral patellofemoral joint space, as in this injection. Needle (*arrow*) has entered small anechoic fluid recess between lateral margins of patella (P) and femur (F).

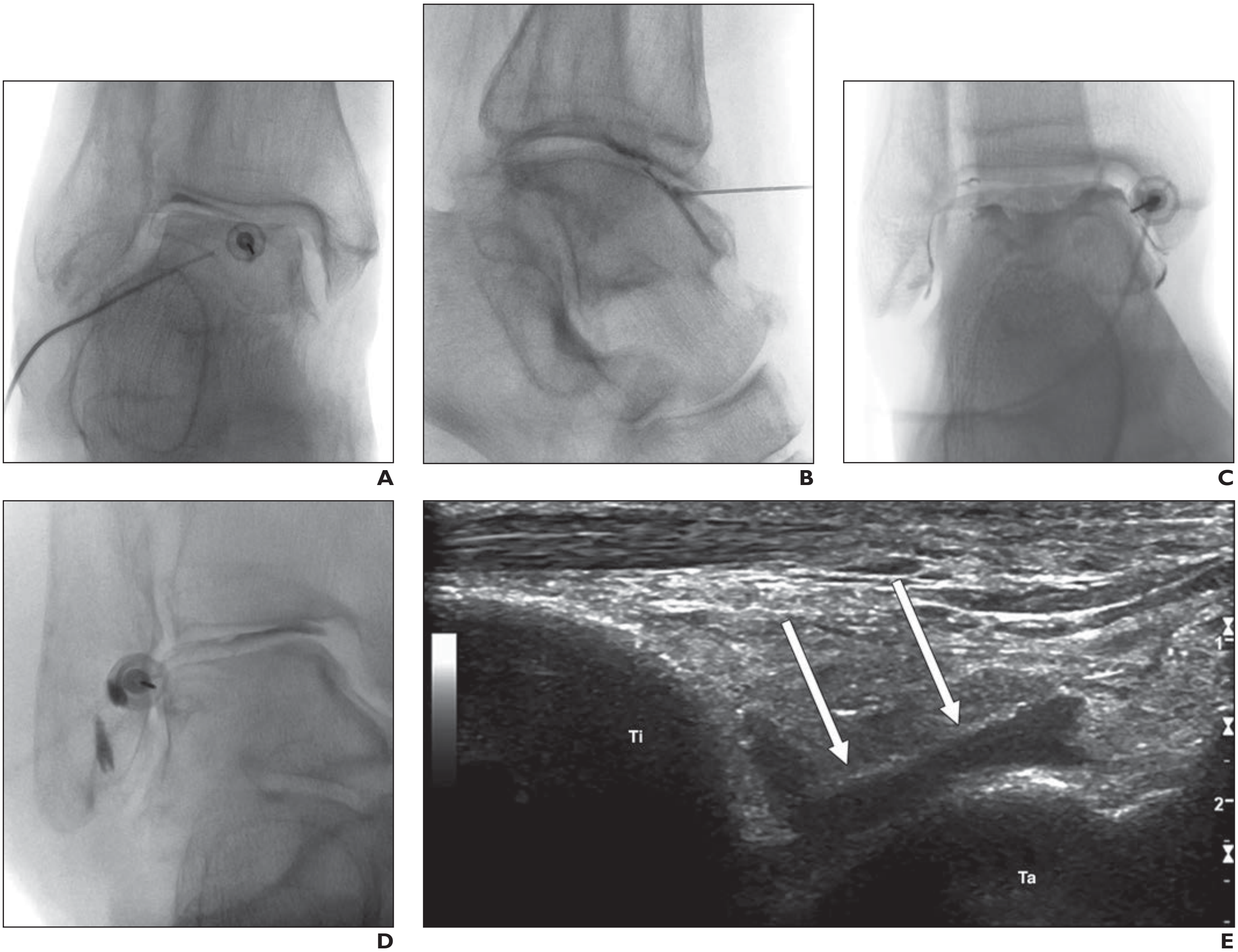



**Fig. 7**—Ankle injection approaches.
**A** and **B,** Anterior approach. Anteroposterior (**A**) and lateral (**B**) fluoroscopic images show needle passing near midline of ankle. Dorsalis pedis artery and extensor tendons must be palpated and avoided. Lateral view shows how needle has only to contact articular surface of talar dome to be intraarticular. It does not have to be squeezed between tibia and talus.
**C,** Medial clear space approach. Fluoroscopic image shows approach to upper half of medial clear space is straightforward. This approach avoids anterior tendons, major nerves, and dorsalis pedis artery.
**D,** Lateral clear space approach. Fluoroscopic image shows needle is advanced in upper third to upper half of space between fibula and talus.
**E,** Anterior longitudinal ultrasound image shows needle (*arrows*) within anterior joint space during ankle injection. Hypoechoic fluid is mostly injectate. Ti = tibia, Ta = talus.