Seminars in ROENTGENOLOGY

Fluoroscopically-guided Joint and Bursa Injection Techniques: A Comprehensive Primer

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Introduction

Fluoroscopic-guided joint and bursa access is an invaluable skill for both diagnostic and therapeutic applications, including CT and MR arthrography, anesthetic challenge, symptomatic relief, as well as fluid aspiration. While various publications exist, reviewing techniques for accessing the most common joints, there is a need for a single, comprehensive primer. In this article, we aim to familiarize both trainees and practicing radiologists on preparations, relevant anatomy, optimal patient positioning, image intensifier (II) location, imaging appearance as well as troubleshoot of common challenges and pitfalls. A range of appendicular joints will be reviewed including the hip, shoulder, knee, elbow, wrist, ankle, talonavicular (TN), naviculocuneiform (NC), tarsometatarsal (TMT), and metatarsophalangeal joints. Additionally, the greater trochanteric, subacromial, iliopsoas, and ischiogluteal bursae will be discussed along with a review of the biceps tendon injection. By increasing preprocedural preparedness, we hope to foster the ideal setting for both the patient and radiologist alike by maximizing patient comfort while providing a safe, expedient procedural experience.

General Technique

This section contains the general approach, including a framework of the steps, common to all the injections in this primer. Techniques described herein are those used at New England Baptist Hospital (NEBH), an orthopaedic specialty hospital in Boston, MA where the musculoskeletal radiologists, as a group, perform approximately 5000 injections per year with 25-30 years of experience.

Preprocedure Preparation

As with any invasive procedure, written informed consent and a formal "time out" should be performed.

Risks to discuss with patients include ones common to invasive procedures such as possible infection, allergic reaction, bleeding, pain, and injury to adjacent structure. Absolute contraindications for joint/bursal injections are active systemic infections, cellulitis over the injection site, or a significantly immunocompromised status.[1] If localized corticosteroid is to be administered, potential systemic side effects are reviewed such as flushing,[2] headache, and insomnia.[3] Additionally, "steroid/cortisone flare" is not an uncommon reaction and can mimic septic arthritis (though infection typically occurs later and lasts longer).[1] Flare symptoms include localized pain (sometimes severe and disabling), aggravation of systemic inflammatory response, and even development or enlargement of a joint effusion.[1,4] Treatment for these symptoms includes icing the affected site coupled with oral Non-steroidal Anti-inflammataory Drug (NSAID) therapy.[5] Flare typically occurs 1-3 days following injection and may persist up to 3-5 days.[1] It is important to emphasize that the development of flare has no effect on the efficacy of the injection.[6] Preemptively discussing the possibility of steroid flare helps to decrease patient anxiety and alleviate confusion should it occur.

Nevertheless, patients are instructed to call if the localized pain persists beyond this time period or there is local erythema or purulent discharge coupled fever, chills, or other systemic infectious indicators. However, the overall risk of septic arthritis is exceedingly low (<0.3%)[1] and this should be enumerated to the patient so as to not cause excessive concern.

Diabetic patients undergoing intra-articular or intrabursal administration of corticosteroid may experience transient elevation of blood glucose levels due to systemic absorption.[7]

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The rise in blood glucose may be delayed for 24-72 hours postinjection and close monitoring of levels is recommended for up to a week. Additionally, patients are advised to contact their physician if blood glucose levels remain persistently abnormally elevated or a safe threshold is traversed.[7]

Given the low risk of hemarthrosis, the cessation of anticoagulation or laboratory coagulation testing is not required prior to the procedure.[3,8] Yet, if patients present with a recently documented supratherapeutic International Normalized Ratio (INR), the procedure should be rescheduled until coagulation values return to therapeutic levels.

Finally, the typical course of symptomatic relief is discussed with the patient in order to set appropriate expectations. Patients are informed that any immediate relief from the injected anesthetics is likely temporary, with the duration being characteristic of the specific agent used, as in the case of bupivacaine lasting 4-6 hours following which the pain level may return to baseline.[9] Onset of pain relief from corticosteroid typically takes 2-5 days with a maximal effect at around 10-14 days. The average duration is 3-6 months but there is substantial variability from patient to patient[10] and we have noted that in a small percentage of patients, therapeutic injections may fail to provide any substantial relief. The authors generally limit the number of intra-articular or intrabursal corticosteroid injections to 3-4 per affected area per year as the cumulative dose may increase risk of systemic side effects and also localized complications such as chondrotoxicity.[10-12]

Procedure Overview

Position the patient as per procedure specific guidelines, discussed in depth below. Place a radiopaque tool, ie, laterality sticker or clamp, and mark skin entry site under fluoroscopic guidance. Adhering to sterile technique, prep the patient per standard protocol and use mask, sterile gloves, and drape.

Set up the procedure tray with the labeled syringes, tubing if contrast will be used, and appropriate size needles as indicated in each section below. Draw up the medications, eg, short-acting anesthesia in 1 syringe, the therapeutic and/or diagnostic mixture in another syringe, and iodinated contrast (if appropriate) in a third (Fig. 1). The composition for the injectate mixtures used at NEBH are shown in Tables 1 and 2; note that the volumes reflect the ideal amount to be infused but they can be scaled proportionally to a larger total volume on an individual basis. For example, when preparing for a wrist MR arthrogram, it may be easier to draw up 0.1 mL of gadolinium rather than 0.025 mL and increase the other components by a factor of 4. Though Bupivacaine is a commonly utilized intra-articular anesthetic, studies in the literature have documented a relatively higher rate of chondrocyte cytotoxicity using this particular agent when compared to Ropivacaine.[13] However, the authors predominantly utilize bupivacaine without any definitive cases of chrondrolysis, but ropivacaine can be substituted per individual preference.

Using a short, small gauge (25-30) needle, anesthetize the dermis and subcutaneous trajectory tract with

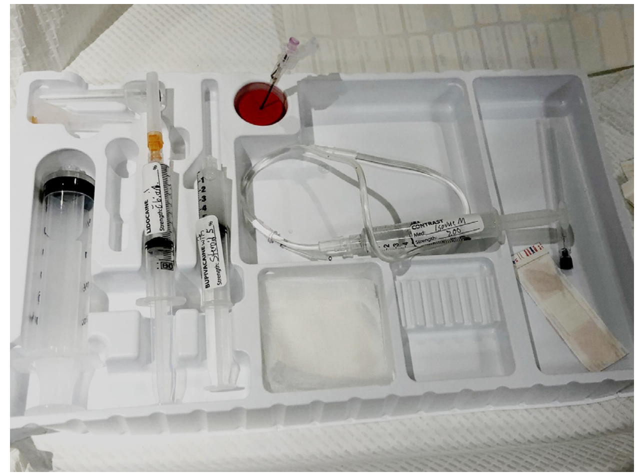

Figure 1 Example of a procedure tray set up. From left to right, 1% lidocaine and sodium bicarbonate syringe connected to a 25 gauge, 1.5 inch needle, 0.5% bupivacaine and corticosteroid syringe, iodinated contrast (Isovue 200) syringe with tubing, and 22 gauge, 3.5 inch spinal needle for access.

lidocaine 1% ideally buffered with sodium bicarbonate 8.4%, if available, in a ratio of 1:10 (sodium bicarbonate to lidocaine). This mixture alkalizes the solution, thereby hastening the onset of analgesia and decreases injection site burning sensation.[3,14] Place the needle tip on the skin surface to fluoroscopically confirm or adjust entry point of the larger gauge needle. As the access needle is inserted, intermittently fluoroscopy to confirm trajectory and location of the tip. The needle should preferably be oriented parallel to the X-ray beam with the hub centered over tip giving a “bullseye” or “dot” morphology. Ideally, osseous structures are utilized as a backstop to gauge and maintain a safe procedural depth.[3] Advance the needle until light bony contact and assess for low resistance using a small test dose (0.5-1.0 mL) of anesthetic. If high resistance is encountered, slightly retract or reposition the needle until there is a loss of resistance. At this point, switch the syringe to the diagnostic medium for intra-articular access or directly to the therapeutic agent for injections where contrast is deemed unnecessary. If using contrast, instill an appropriate volume via a short-extension tubing under pulsed fluoroscopy to verify proper needle location. Once confirmed, infuse the medication mixture under fluoroscopy as necessary to observe appropriate dilution of the contrast in a pattern specific for the joint or bursa. Remove the needle, cleanse the skin of disinfecting agent with alcohol, and apply a clean dressing.

When using needles without a bevel, note that they travel in a straight trajectory when advanced through tissue. However, beveled needles (typically the longer, more flexible spinal needles) will deflect slightly toward the opposite side of the bevel, particularly when travelling/passing through dense tissue such as fascia, muscle or capsule.[15] Knowledge of these characteristics will help the proceduralist to steer the needle in the optimal path, particularly when making fine adjustments.

Table 1 Volumes of Therapeutic Injectate Components

	Anesthetic (mL)		Corticosteroid (mL)	
Joint/Bursa	1% PF lidocaine	0.5% PF bupivacaine	Methylprednisolone acetate (80 mg/mL)	Triamcinolone acetonide (40 mg/mL)
Acromioclavicular		1	0.5	
Ankle (tibiotalar and subtalar)		3	0.75	
Biceps		2	1	
Elbow		3	1	
Greater Trochanter		5	1	
Hamstring		5	1	
Hip*		5		1
Iliopsoas	3			1
Knee		5	1	
Pubic symphysis		1	0.75	
Shoulder		4	1	
Small joint* (foot, hand, etc)		1	0.5	
Subacromial		3	0.75	

PF, preservative-free.
*For diagnostic challenge, forego steroid and replace volume with additional anesthetic.

Table 2 Volumes for MR and CT* Arthrograms +/- Corticosteroids

	Diagnostic (mL)			Therapeutic (mL)		
Joint	Iodinated contrast	Saline solution	Gadolinium contrast	0.5% PF bupivacaine	Depo-Medrol (80 mg/mL)	Kenalog (40 mg/mL)
Elbow	4		0.05			
Hip	4	4	0.1			
Hip + steroid	6		0.1	2		1
Shoulder	6	6	0.1			
Shoulder + steroid	8		0.1	3	1	
Wrist	3		0.025			

PF, preservative-free.
Depo-Medrol (Methylprednisolone acetate, Pfizer); Kenalog (Triamcinolone acetonide, E.R. Sqiubb).
*Same volumes can be used for CT arthrograms with the omission of gadolinium.

Postprocedure Instructions

Discharge instructions vary between institutions, but common guidance include avoiding prolonged submersion in water (eg, baths, pools, and hot tubs) for 48 hours postprocedure and leaving the bandage dressing in place for 24 hours if possible. It is helpful to reiterate to the patients that pain may return as the long acting anesthetic effects wanes since onset of corticosteroid may not be immediate, as well as remind them of the potential side effects, including possibility of “flare” reaction.

At NEBH, patients who receive the anesthetic-only diagnostic injections undergo assessment immediately, as well as at 15 minutes, postprocedure for pain relief, and the degree of symptomatic relief documented in the procedure report.

Hip Joint

Hip joint access is one of the more commonly requested musculoskeletal procedures, therefore it is imperative that the proceduralist is comfortable and facile with this injection. Indications include therapeutic steroid injections for treating entities such as osteoarthritis and inflammatory arthropathy; diagnostic anesthetic-only injections for confirming pain origin; arthrography for MRI or CT for evaluation of intra-articular structures including the acetabular labrum and articular cartilage; and hip aspirations for synovial fluid analysis.

The patient is supine on the fluoroscopic table. We have noted that patients have a tendency for a slight (10-15 degree) external rotation of the hip while supine, which may partially obscure the lateral femoral head neck junction by the overlap of the greater trochanter (Figs. 2A, and 3A). To avoid this, the authors promote a 10-15 degree internal rotation of the hip to provide a direct anterior conduit to the hip joint capsule (Figs. 2B, 3B, and 4).[16] Some patients indicate difficulty remaining in an internally rotated position and in these cases the toes can be taped together to ease patient effort and maintain positioning until procedure conclusion (Fig. 2C).

For the direct anterior approach, mark the skin overlying the lateral aspect of the femoral head/neck junction utilizing fluoroscopic guidance with 0 degree angulation of the II

Figure 2 Positioning of patient for hip injection. Photographs of the right hip in (A) external rotation, (B) internal rotation, and (C) internal rotation with toes taped.

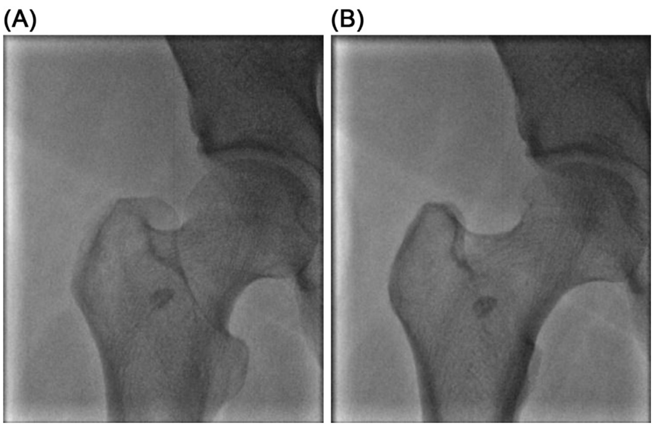

Figure 3 Fluoroscopic positioning of the hip. Frontal images with the II in neutral angulation and the hip (A) in external rotation and (B) in internal rotation.

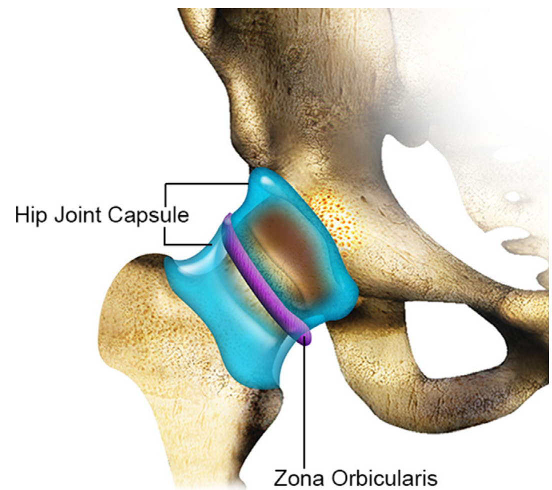

Figure 4 Anatomic rendering depicting the hip joint capsule in aqua and zona orbicularis outlined in purple.

(Fig. 5A) following palpation of the femoral artery to ensure the neurovascular bundle is away from the needle trajectory. Patients with a large panniculus that projects inferiorly overlying the femoral head neck junction can be challenging. In these cases, we find the judicious use of paper tape to temporarily adhere the pannus superiorly to the lower abdomen exceedingly helpful. Another option is to target the femoral head/neck junction using an oblique trajectory with the skin entry site inferior to the pannus, typically around the basicervical region, using a lateral to medial and inferior to superior approach (Fig. 6A and B).

Following infiltration with local anesthetic, advance a 22 gauge 3.5 inch (8.9 cm) spinal needle under intermittent fluoroscopy directly from anterior to posterior toward the lateral femoral head/neck junction maintaining the needle in a bullseye configuration until light osseous contact is felt (Fig. 5B).[17] Administer a small volume test dose of anesthetic and if low resistance is encountered, exchange the syringe and administer the contrast dye to verify intracapsular needle location. The most classic dye pattern is the "ring of Saturn" pattern (Figs. 4, 6B), with contrast pooling above the level of the zona orbicularis, a focal ligamentous thickening of the joint capsule that helps to maintain stability.[18,19] Alternatively, it may collect initially in the dependent portion of the capsule extending inferiorly along the femoral neck (Fig. 5C). Operators should be aware of this alternate appearance so as not to unnecessarily reposition the needle. In addition to confirming needle position, arthrographic images may be useful to detect synovitis, with typical findings including capsular contour irregularities and filling defects (Fig. 7).

In patients with documented contrast allergy, air is substituted for iodinated contrast to confirm intracapsular needle position (Fig. 8). In some cases, especially in patients with a larger body habitus and prominent overlying soft tissue, spot image exposure is helpful to visualize the gas.

Following confirmation of intra-articular location, medication mixture as per Table 1 is infused for therapeutic purposes. Alternatively, for CT or MR arthrography, the injectate mixture as per Table 2 is administered. If diagnostic only injection is requested, refer to Table 1 and replace corticosteroid volume with additional anesthetic.

Troubleshooting Hip Joint Injections

Contrast pooling along the needle tip and not freely flowing away results in a "blob" (Fig. 9A and B), and is due to an extra-articular injection and repositioning is necessary, typically in a more cranial or caudal direction. Of note, the zona orbicularis is present along the superior and central aspect of the femoral neck and can be difficult to penetrate, especially centrally, so it may be best to avoid this zone when attempting capsular puncture.[3] Figure 10 demonstrates a more vertically oriented dye pattern; it is imperative to note this

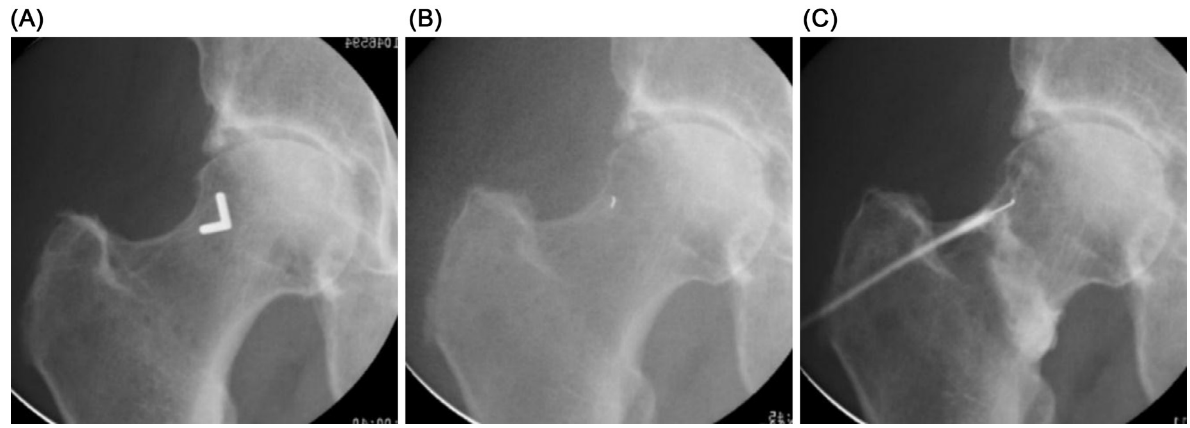

Figure 5 Fluoroscopic hip injection using the direct anterior technique. Frontal images (A) showing L marker over the lateral femoral head neck junction, (B) needle in a bullseye pattern to target, and (C) contrast confirming intra-articular needle location by filling of the inferior recess.

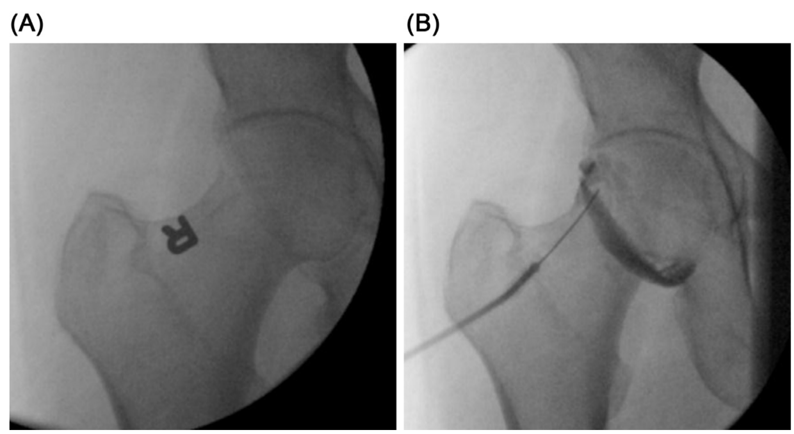

Figure 6 Fluoroscopic hip arthrogram using the oblique anterior approach. Frontal image (A) showing R marker denoting the skin entry site (basicervical region) for targeting the lateral femoral head neck junction in an oblique trajectory and (B) contrast confirming intra-articular needle position with outline of the zona orbicularis.

Figure 7 Hip synovitis. Frontal fluoroscopic image after iodinated contrast injection showing irregular capsular contours and filling defects.

Figure 8 Air arthrogram of the hip. Curvilinear lucency reflecting intra-articular air outlining the zona orbicularis.

appearance necessitates repositioning as it signifies an intramuscular or tendinous needle position, most commonly in the rectus femoris or iliopsoas. In approximately 15% of patients, the iliopsoas communicates with the hip joint and varying degrees of iliopsoas bursal backfilling during hip arthrography can occur, though typically when the joint is maximally distended such as in cases of CT or MR arthrography.[20]

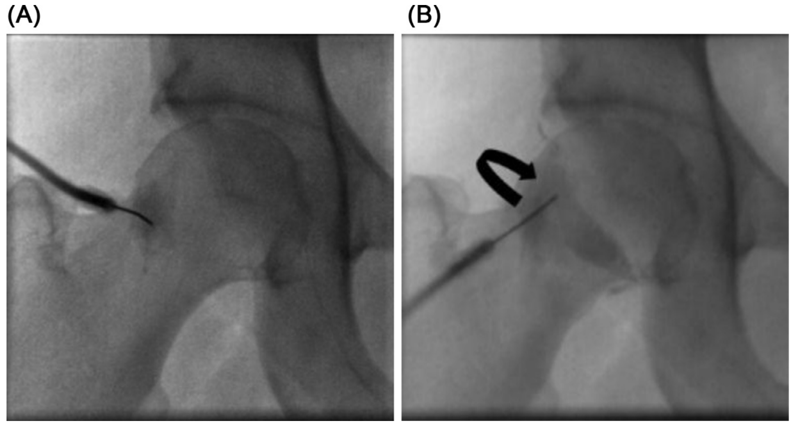

Figure 9 Extracapsular contrast. Fluoroscopic images of the hip showing (A) contrast pooling around the needle tip indicating an extra-articular injection. (B) Superior repositioning of the needle tip and contrast reinjection outlining the zona orbicularis (curved arrow) and confirming intra-articular placement.

Figure 10 Intramuscular contrast. Fluoroscopic image demonstrating vertically oriented dye pattern of extra-articular injection, typically indicating needle tip in the rectus femoris or iliopsoas myotendinous junction.

Hip Aspiration

Similar general concepts and preparations are followed for hip aspiration. The lateral aspect of the native or prosthetic femoral neck is targeted and a 20 gauge 3.5 inch spinal needle is utilized due to the viscosity of synovial fluid which at times can even contain debris. The spinal needle is advanced, after ensuring adequate local anesthesia, until contact with the bone or arthroplasty and joint fluid aspiration is attempted (Fig. 11A and B). With the patient supine, joint fluid lies in a dependent posterior position and if no fluid is obtained at the anterior margin, retract the needle slightly and advance along the lateral margin of the bone or prosthesis in a paraprosthetic approach; bending/deflecting the needle along the bone/prosthesis (Fig. 11B and C) is a sign of it traveling around the hardware in the capsule[3] and there may be a sensation of "scraping" against the metal. Of note, in the postoperative hip, the operator may not perceive a change in resistance from an extracapsular to an intra-articular location due to a combination of capsular disruption by surgery and regional scarring. Attempt to aspirate for native fluid with minor adjustments of the needle tip, ie, advance or withdraw, while maintaining steady suction on the syringe plunger. If unsuccessful, air may be instilled to confirm intra-articular location (Fig. 11C). If no native aspirate is obtained, contrast or sterile saline can be instilled as a lavage. However, an accurate cell count cannot be obtained with a lavaged sample.

Greater Trochanteric Bursa

Trochanteric bursitis, also referred to as greater trochanteric pain syndrome, peaks between the fourth and sixth decade but can affect all age groups. This syndrome is seen in patients with native and postarthroplasty hips alike. Causes of trochanteric bursitis include overuse due to arthritis, obesity, leg length discrepancy, plus direct trauma, and reactive inflammation secondary to gluteus medius and minimus tendinopathy/tear. Characteristic symptoms include pain on the lateral aspect of the hip, typically tender on direct palpation and worsens with activities such as climbing stairs or laying with the affected side down. Additionally, many patients describe worsening of their pain at night.[21-23]

Patients are supine with the affected hip in neutral position (toe up) with II in 0 degree angulation. The area overlying the lateral aspect of the hip is palpated for the bony prominence of the greater trochanter with the osseous landmark confirmed fluoroscopically (Fig. 12). Following local anesthesia, a 22 gauge, 3.5 inch spinal needle is advanced from lateral to medial until osseous contact. The test for loss-of-resistance is done with anesthetic and the needle is slightly retracted, if needed, until low resistance is encountered confirming bursal needle placement (A longer 22 gauge needle may be required, particularly in patients with a predominance of subcutaneous fat along the hip region).[17] Medication mixture as per Table 1 is administered in a split dose amongst the superior, mid, and inferior aspect of the lateral greater trochanter to ensure adequate coverage of the trochanteric bursa (Fig. 13). Due to the large size of the trochanteric bursa and well delineated bony landmarks, we obviate the need for intrabursal contrast confirmation, though this

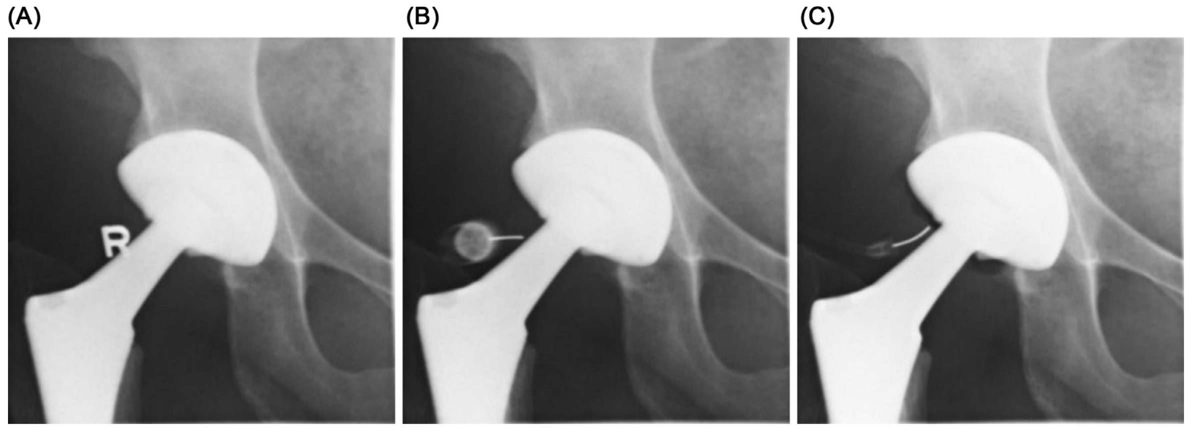

Figure 11 Hip aspiration. Fluoroscopic images showing (A) R marker denoting the skin entry site for targeting the lateral neck of the femoral prosthesis, (B) needle tip positioned along the lateral margin of the femoral prosthesis using a paraprosthetic approach, and (C) air arthrogram confirming intra-articular location of needle tip.

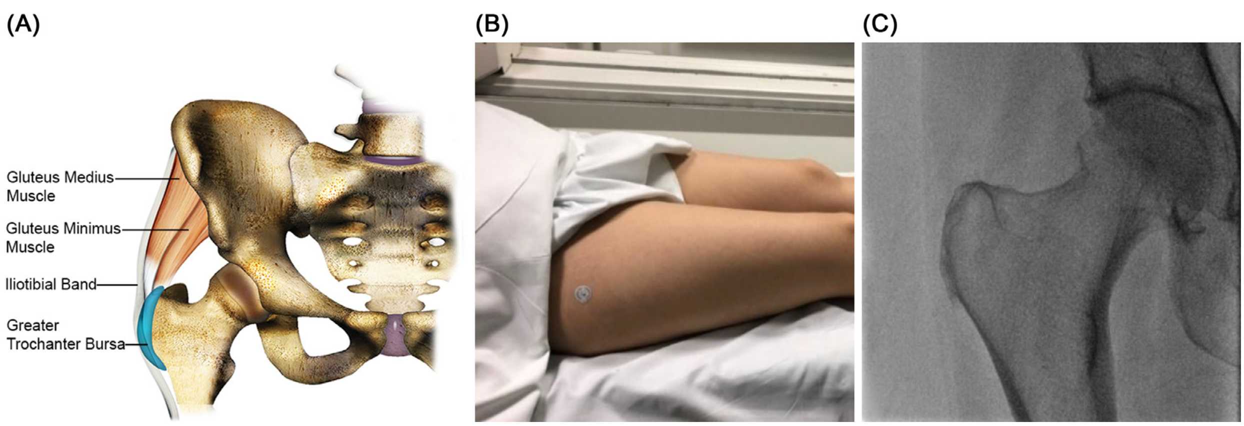

Figure 12 Positioning for greater trochanteric bursal access. Anatomic drawing of the hip (A) depicting the bursa in blue. Photograph (B) and fluoroscopic image (C) showing localization of the greater trochanteric bursa after palpation and with imaging. The radiopaque marker denotes the skin entry site.

decision can be made on an institutional basis. Given the location of the sciatic nerve posteromedial to the greater trochanter, care is made to utilize intermittent fluoroscopy to gauge an accurate depth and safe trajectory avoiding passing the needle tip medial to the lateral cortical margins to decrease risk of iatrogenic neural injury or transient paresthesia.

Pubic Symphysis

The pubic symphysis (Fig. 14) is a cartilaginous joint containing a central fibrocartilaginous disk uniting the medial borders of the pubic bones; the adductor muscle groups insert along the inferior margin of the pubic body and rami.[24] Symphyseal pain may occur secondary to osteitis pubis, adductor-rectus abdominus aponeurotic injury, spondyloarthropathy, multiparity, and symphyseal stressing amongst other causes. Therapeutic injection can be a quick, effective treatment for this particular origin of groin pain.[25]

The patient is supine with the II at 0 angulation. The inferior one-third of the symphysis is marked under fluoroscopic guidance (Fig. 15A). Typically, a 23 gauge, 1.5 inch needle is sufficient for access, however some patients with prominent overlying soft tissue necessitate a 3.5 inch spinal needle. The needle is advanced directly into the radiolucent joint space from anterior to posterior until the operator detects a slight increase in resistance as the tip transitions from soft tissues into the fibrocartilaginous disk. A small volume (approximately 0.5 mL) of contrast is administered to confirm needle location assessing for vertically oriented opacification. In Figure 15B and C, there is extravasation beyond the symphyseal/primary cleft along the inferior aspect of the pubic ramus referred to as a “secondary cleft” sign and is compatible with chronic avulsion injury at the attachment of the adductors, specifically the gracilis and adductor longus.[24,26] Medication mixture as per Table 1 is administered into the symphysis.

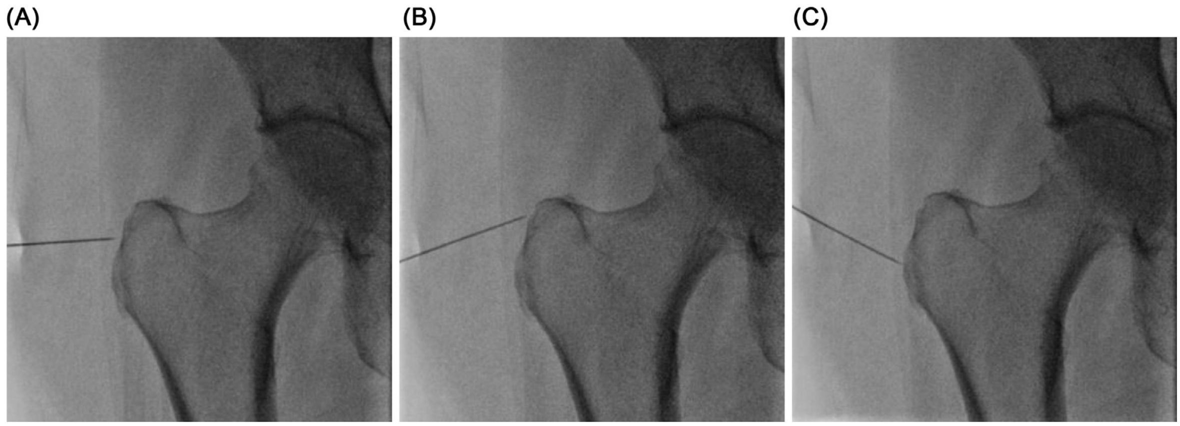

Figure 13 Greater trochanteric bursal injection. Fluoroscopic images showing needle tip along the (A) mid, (B) superior, (C) and inferior thirds of the greater trochanter.

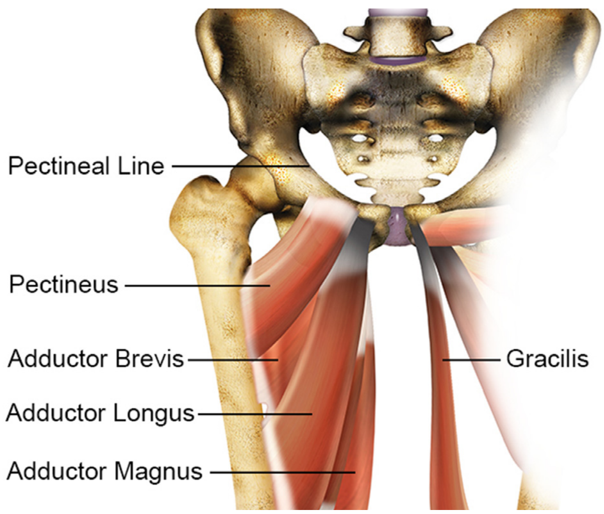

Figure 14 Anatomical schematic of the anterior pelvis depicting adductor, gracilis, and pectineus tendon insertions along the pubic symphysis and pubic rami.

Ischiogluteal Bursa

The ischial or ischiogluteal bursa, is located along the ischial tuberosity, deep to the gluteus maximus muscles, at the site of the origin of the common hamstring complex attachment (Fig. 16). A few causes of bursitis include acute injury, chronic repetitive trauma, prolonged sitting on hard surfaces, inflammatory or crystalline arthropathy, and poor biomechanics.[27] Symptoms include buttocks pain which is worse with palpation and sitting, stiffness, pain radiating down the posterior thigh, and less commonly ipsilateral lower extremity weakness.[28] Additionally, similar symptoms can also occur secondary to proximal hamstring tendinopathy and partial tearing especially in long distance runners.[29] Patients who have failed conservative therapy in these settings may benefit from an ischiogluteal bursa injection.

Patients are prone and the inferior margin of the ischial tuberosity is localized by fluoroscopy (Fig. 17A). Following local anesthesia, a 22 gauge, 3.5 inch spinal needle is advanced under fluoroscopic guidance directly toward the tuberosity until osseous contact (Fig 17B and C).[17] We do not routinely use contrast during this particular procedure, but as with the greater trochanteric bursal injection, this decision can be made on an institutional basis. Medication mixture per Table 1 is administered via a split dose in 2-3 separate locations along the inferior aspect of the ischial tuberosity.

Iliopsoas Bursa

The iliopsoas musculature is formed by the confluence of the iliacus muscle, which arises from the ilium, and the psoas musculature, which arises mainly from the transverse processes of the lumbar vertebra. The center of the iliopsoas bursa is located posterior to the iliopsoas myotendinous junction at the level of the acetabular roof (Fig. 18A and B). Indications necessitating bursal injections include overuse, acute trauma, snapping hip syndrome, inflammatory arthropathies, and postarthroplasty iliopsoas tendinosis/bursitis.[30]

Superficial and typically medial to the iliopsoas bursal and myotendinous junction are the femoral nerve, femoral artery, and femoral vein. Given the close proximity of the neurovascular bundle, there is a slight risk of anesthetic leak from the bursa, and patients should be warned about the risk of transient paresthesia of the ipsilateral lower extremity. At the time of procedure scheduling, patients are informed that they must have a ride home.

The patient is supine with no II angulation. The needle target endpoint is directly over the center of the superior acetabular roof. Two different trajectories are possible. The first involves marking the superolateral aspect of the acetabular rim just inferior to the anterior inferior iliac spine (Fig. 19A) with a lateral to medial trajectory (Fig.18B). The rationale is that the needle would cross at a deeper level than the neurovascular bundle, thereby reducing the risk of inadvertent neural/vascular injury and anesthetic leak around the neurovasculature. The second approach marks directly over the center of the acetabular roof and uses a straight AP trajectory (Fig. 19C and D).

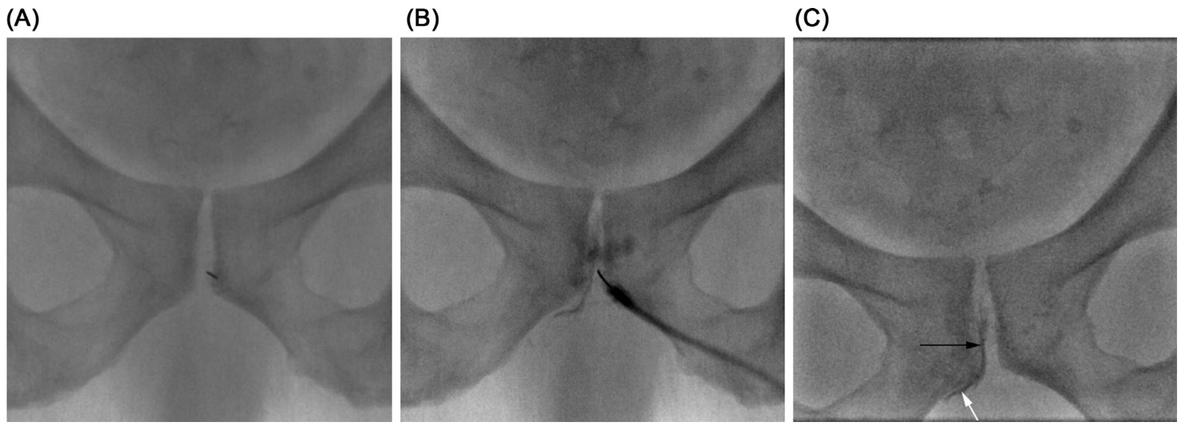

Figure 15 Pubic symphyseal injection. Fluoroscopic images (A) demonstrating needle tip overlying the inferior third of the pubic symphysis, and (B and C) linear vertical contrast pattern within the radiolucent symphyseal cleft confirming intra-articular location (black arrow) and a "secondary cleft" sign (white arrow).

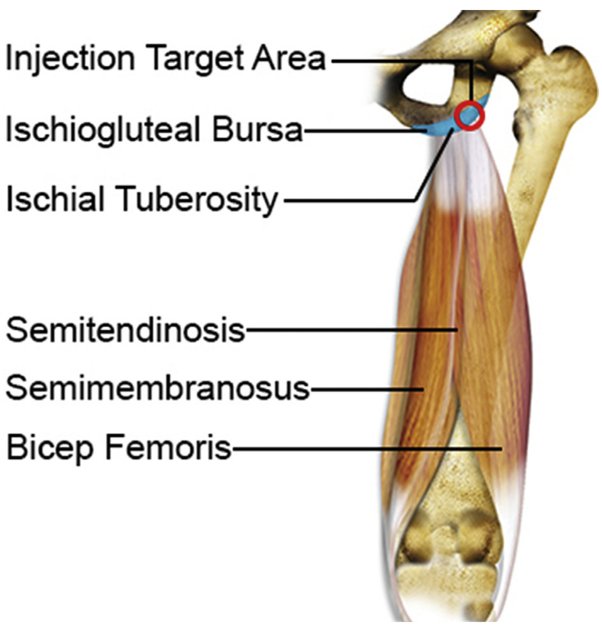

Figure 16 Anatomical schematic of the posterior thigh depicting the ischiogluteal bursa in aqua along the ischial tuberosity at the site of the common hamstring complex origin.

Following local anesthesia, a 22 gauge, 3.5 inch needle is advanced via either of the 2 approaches until osseous contact. A small test dose of lidocaine is administered, assessing for low resistance, after which approximately 2 mL of contrast is administered to assess for bursal opacification, seen as vertically oriented linear pattern (Fig. 19B, C, and D). Following contrast administration, medication mixture per Table 1 utilizing Lidocaine 1% as anesthetic is administered. At NEBH, we previously used a longer acting anesthetic, but following a few cases of prolonged leg paresthesia, have converted to exclusive use of lidocaine.

Additional precautions include instructing the patient to step down from the table, with the help of the staff, contralateral leg first. The patient should test the ipsilateral injected side assessing for lower extremity strength and sensation prior to ambulation and discharge.

Shoulder

Glenohumeral Joint

Common indications include therapeutic injection for the arthropathies, synovitis, and adhesive capsulitis or diagnostic CT/MR arthrography for evaluation of the rotator cuff, labrum and articular cartilage. Two different techniques for glenohumeral joint access are the subscapularis approach (Schneider technique) and the rotator cuff interval approach. The authors favor the rotator interval, though both will be discussed.

The subscapularis technique employs a direct anterior to posterior approach with the target between the middle and inferior thirds of the humeral head medially (Figs. 20, 25) traversing through the subscapularis myotendinous junction.[31] Compared to the rotator interval, disadvantages of the Schneider approach include a longer needle course and going through more structures, namely the subscapularis, which can be more painful, and possible distortion of the anterior stabilizing structures resulting in lower specificity when the anterior/inferior labrum, capsule, or glenohumeral ligaments are interrogated on MR arthrography.[32]

The rotator cuff interval is a triangular space in the anterosuperior aspect of the shoulder bounded by the supraspinatus tendon superiorly, subscapularis tendon inferiorly, and coracoid medially (Fig. 20).[33] The interval approach is well tolerated by patients given there is passage through less structures, and has been described as easier for radiologists to learn and perform consistently and precisely.[34]

Patient is supine with the shoulder in full external rotation, which serves to maximize the rotator interval size along with displacing the biceps tendon and subacromial/subdeltoid bursa laterally away from the needle path. When asked to assume this arm position, patients tend to mainly supinate at the elbow and rotate the forearm rather than fully rotating the shoulder. To circumvent incomplete shoulder external rotation, grasping at or slightly above the elbow can mitigate this tendency (Fig. 21A and B). If needed, a weight can be placed in the patients' hand to maintain the position (Fig. 21C).

Under fluoroscopic guidance, the joint capsule is marked at the superior third of the medial humeral head, which lies

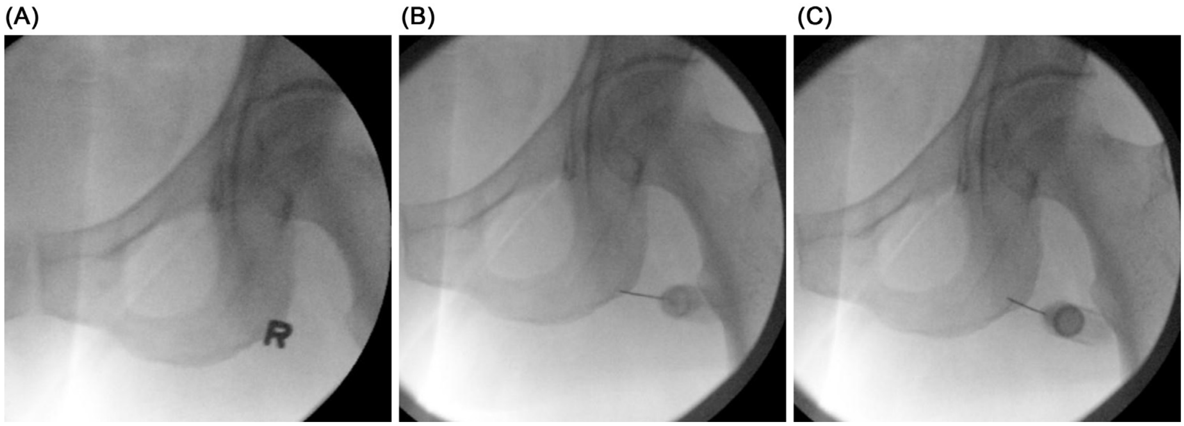

Figure 17 Ischiogluteal bursal injection. Fluoroscopic images (A) showing R marker superimposed over location of the bursa at the inferior ischial tuberosity, and (B and C) with the needle tip contacting 2 different points of the ischial tuberosity/bursa.

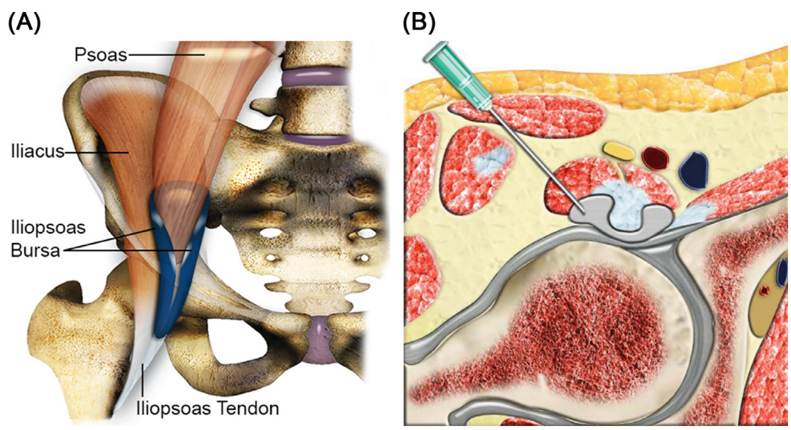

Figure 18 Iliopsoas tendon and bursa. Anatomic schematic (A) demonstrating the contributions from the iliacus and psoas musculature to form the iliopsoas and the location of the bursa in blue. (B) Axial cross-section schematic at the level of the femoral head show optimal lateral to medial oblique needle trajectory to the bursa while avoiding the femoral neurovascular bundle (yellow, red, and blue circles). (Color version of figure is available online.)

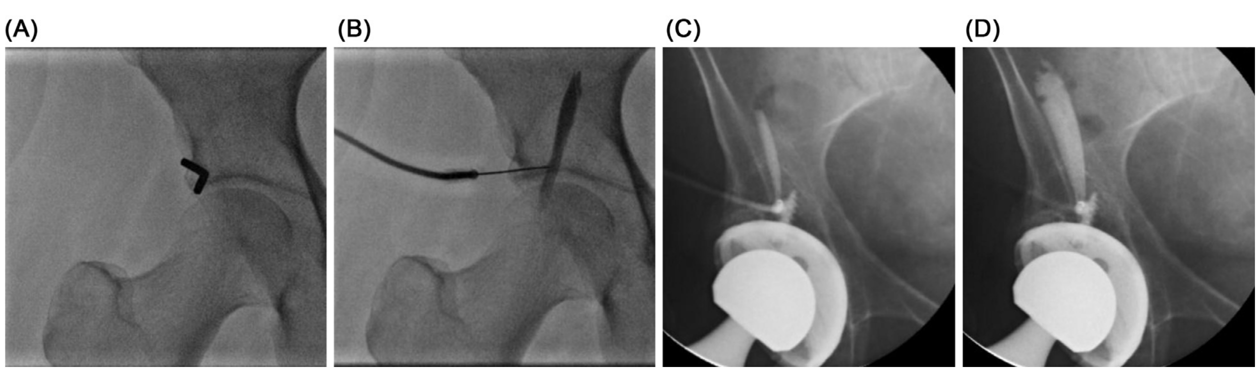

Figure 19 Iliopsoas injection in 2 different patients. Fluoroscopic images in a patient with a native hip showing (A) a L marker over the supero-lateral aspect of the acetabular rim denoting the skin entry site and (B) an oblique needle trajectory with appropriate bursal opacification. A different patient with a total hip prosthesis (C) and (D) undergoing the direct anterior approach showing the needle "bullseyed" over the central acetabular roof and contrast in the bursa.

within the rotator interval with the II in neutral angulation (Fig. 22A and C). Following local anesthetic, a 22 gauge, 1.5 inch needle is advanced to the cortex of the humeral head, followed by a test for loss-of-resistance with anesthetic. In larger, either muscular or obese patients, a longer, 22 gauge, 3.5 inch spinal needle, may be required.

Contrast is used to confirm intra-articular positioning by outlining the radiolucent joint space, capsule and/or

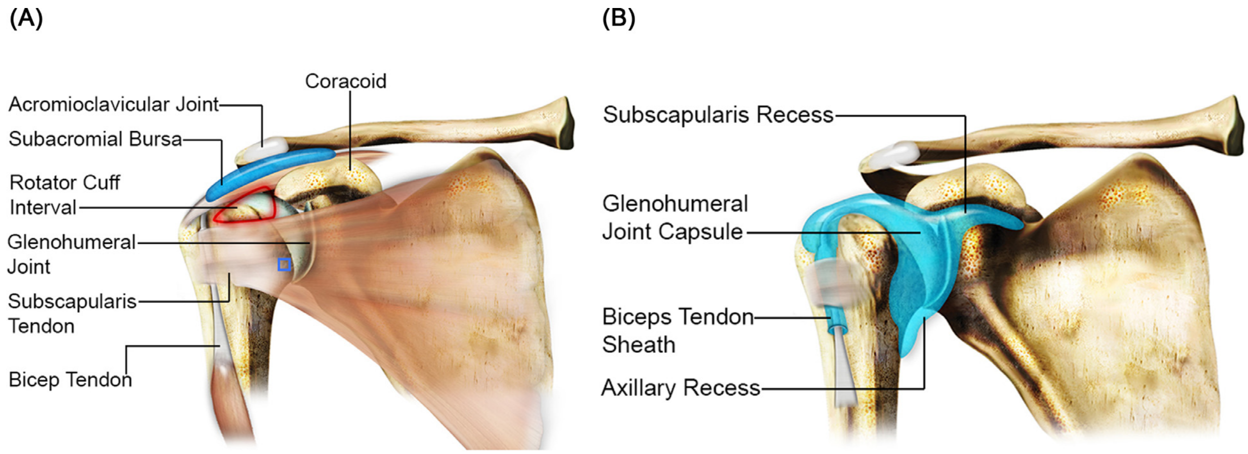

Figure 20 Anatomic schematic depicting the anterior approaches to glenohumeral joint access in relation to osseous structures, joint capsule, rotator cuff, subacromial bursa, and biceps long head tendon. (A) The rotator cuff interval is outlined by the red triangle and the Schneider approach is indicated by the blue square. (B) The glenohumeral joint capsule and recesses are delineated in blue. (Color version of figure is available online.)

Figure 21 Positioning of the shoulder. Photographs (A) and (B) showing the operator grasping the patient's elbow and guiding the shoulder into external rotation, (C) held in place via weights in patient's hand.

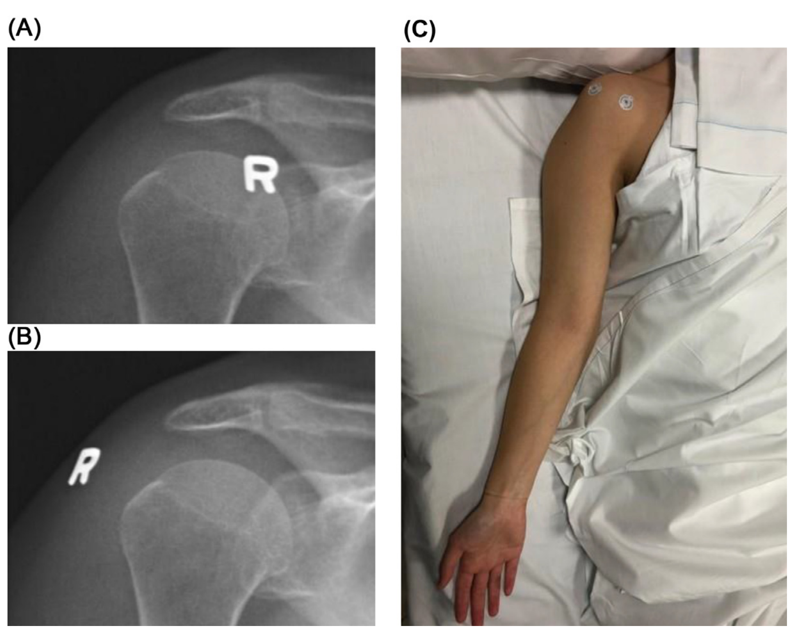

Figure 22 Positioning for glenohumeral and subacromial bursal access. Fluoroscopic images with the R markers depicting target entry site for the (A) glenohumeral joint via the rotator interval and (B) subacromial bursa. Photograph (C) with radiopaque markers depicting skin entry site for glenohumeral joint more anteriorly and subacromial bursa more laterally.

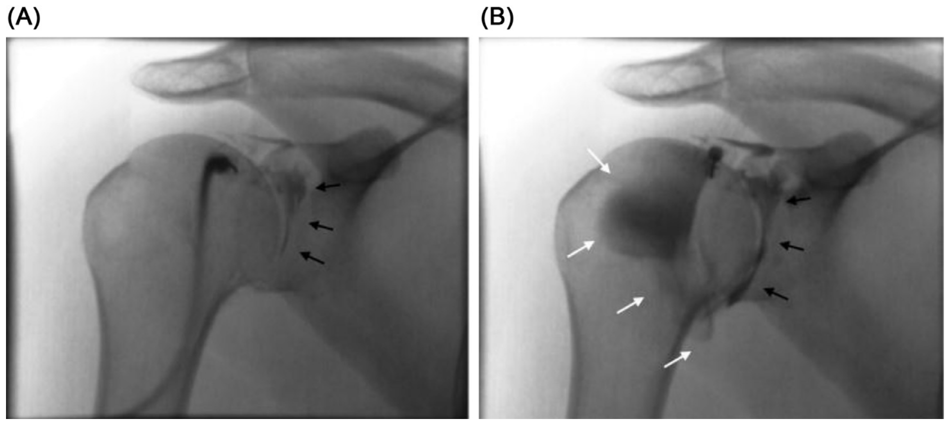

Figure 23 Rotator interval approach glenohumeral joint injection. Arthrographic images (A and B) depicting needle tip at the superior third of the medial humeral head and intra-articular contrast outlining the joint line (black arrows) and posterior dependent portions of the capsule (white arrows).

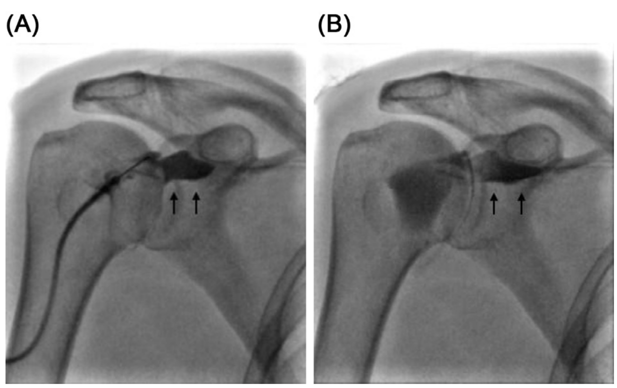

Figure 24 Glenohumeral joint injection with intra-articular contrast. Arthrogram showing (A) preferential filling of the subscapularis recess (black arrows) and (B) subsequent contrast within the joint space and capsule.

Figure 25 Air arthrogram of the shoulder utilizing the Schneider approach. Needle tip at the inferior third of the medial humeral head and gas outlining the joint line and superior capsule.

subscapular recess (Fig. 23). Note that the curvilinear glenohumeral radiolucent articulation may not be outlined first and contrast could preferentially flow to the subscapularis recess denoted by a transversely oriented lobulation inferior to the coracoid (Fig. 24A and 20B); erroneously interpreting this pattern as extra-articular would lead to unnecessary needle manipulation. As additional contrast fills the joint capsule (Fig. 24B), the curvilinear articulation is more clearly opacified. At NEBH, a total of 3 mL of contrast is infused into the joint for the arthrography series explained below.

Therapeutic medication mixture is infused as per Table 1. If diagnostic only injection is requested, operator should refer to Table 1 and replace corticosteroid volume with additional long acting anesthetic. Alternatively, when CT arthrography is the goal, infuse the mixture as per Table 2; some may also prefer to perform a double-contrast technique and replace some of the iodinated contrast with air.

For MR arthrography, initial intra-articular confirmation should be made utilizing iodinated contrast without gadolinium to confirm intracapsular location and prevent iatrogenic gadolinium administration within the subacromial/subdeltoid bursa. Following confirmation of needle tip location within the joint, the mixture as per Table 2 is infused.

Following administration of mixture for either therapeutic or diagnostic purposes, the needle is removed. At NEBH, every patient who receives a glenohumeral contrast injection undergoes a fluoroscopic arthrographic evaluation consisting of external, internal, and external rotation abduction views (Fig. 26), mainly for assessing for the presence of contrast extravasation into the subacromial/subdeltoid bursa indicating full thickness rotator cuff tear (Fig 27A). Contrast within the subacromial bursa can decompress through the acromioclavicular (AC) joint, resulting in the “geyser” sign, suggesting chronic rotator cuff arthropathy and disruption of the acromioclavicular capsule (Fig 27B).

Subacromial Bursa

The subacromial bursa is a synovial cavity which lies directly underneath the acromion, continuous with the subdeltoid bursa. Pain resulting from subacromial impingement syndrome is amenable to injection for symptomatic relief.[35,36]

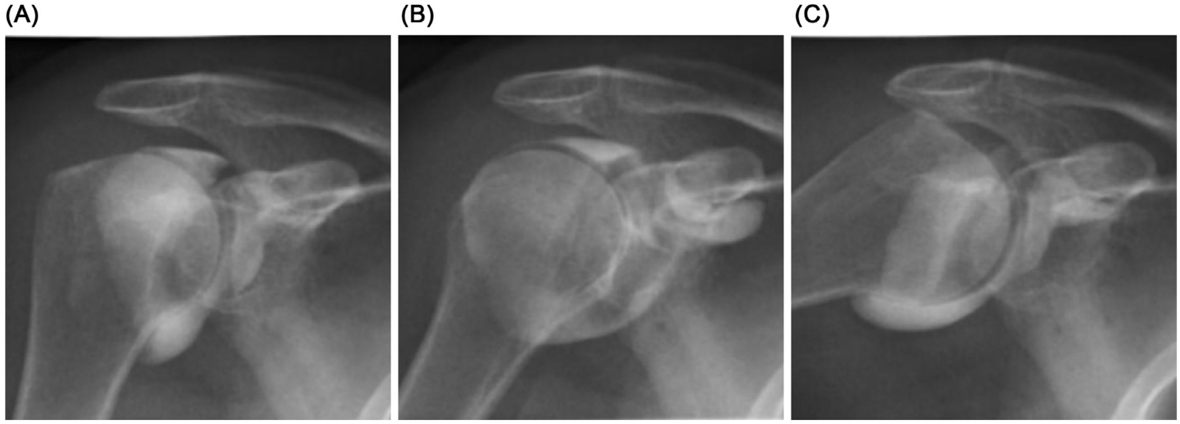

Figure 26 Shoulder arthrographic series. Fluoroscopic images with the shoulder in (A) external rotation, (B) internal rotation, and (C) external abduction. Note redistribution of contrast between the different positions.

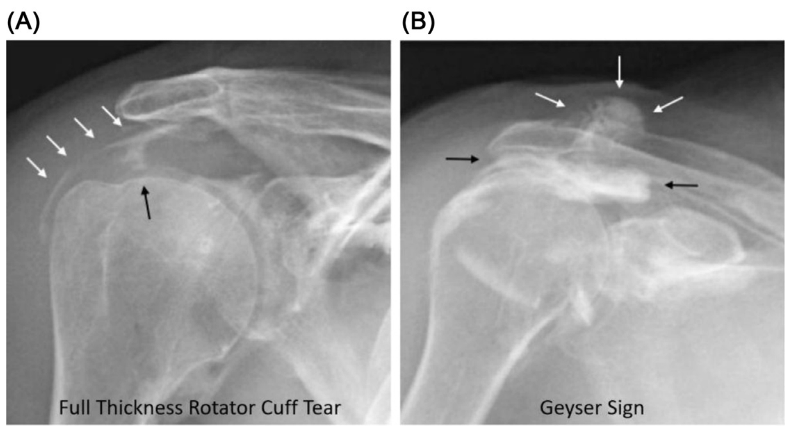

Figure 27 Full-thickness rotator cuff tendon tear. Fluoroscopic arthrogram images depicting (A) vertically oriented contrast/tear through the superior rotator cuff (black arrow) and opacification of the subacromial bursa (white arrows), and (B) contrast within the subacromial bursa (black arrows) with decompression superiorly through the acromioclavicular joint denoting the "geyser" sign (white arrows).

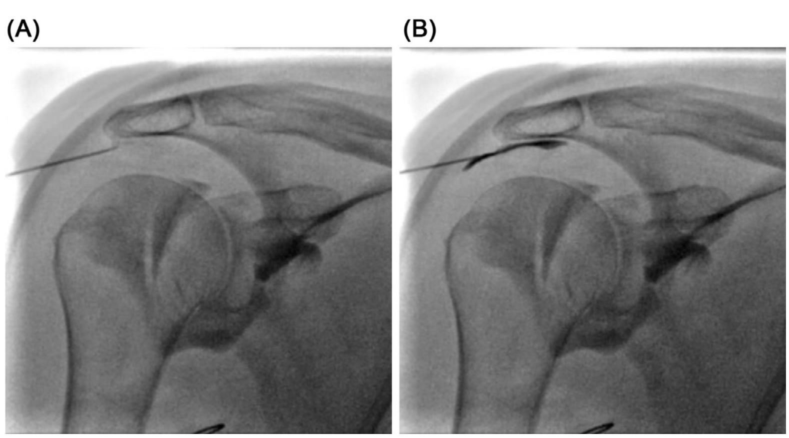

Figure 28 Fluoroscopic subacromial bursa injection demonstrating (A) optimal needle position with tip along the undersurface of the acromion. Note contrast opacifying the glenohumeral joint from a preceding intra-articular injection. Subsequent contrast injection shows (B) curvilinear contrast opacification of the bursa inferior to the acromion.

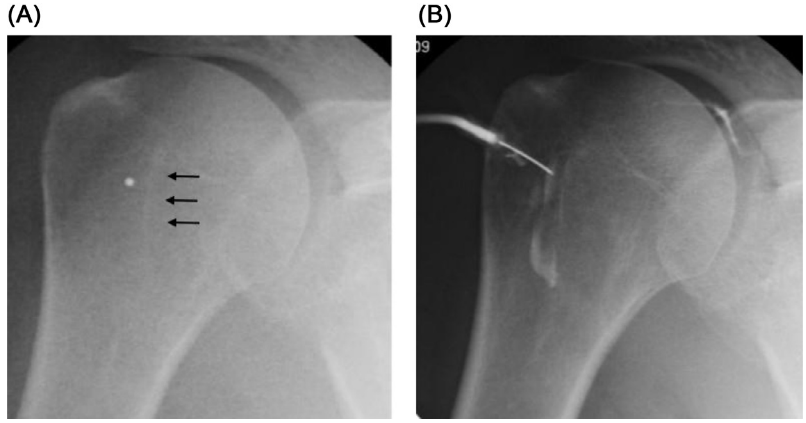

Figure 29 Fluoroscopic biceps tendon sheath injection. Frontal images showing (A) radiopaque marker superimposed over the bicipital groove just lateral to the lesser tuberosity (black arrows), and (B) needle tip within the groove and contrast in the biceps tendon sheath. Note intra-articular glenohumeral contrast due to normal communication with the tendon sheath.

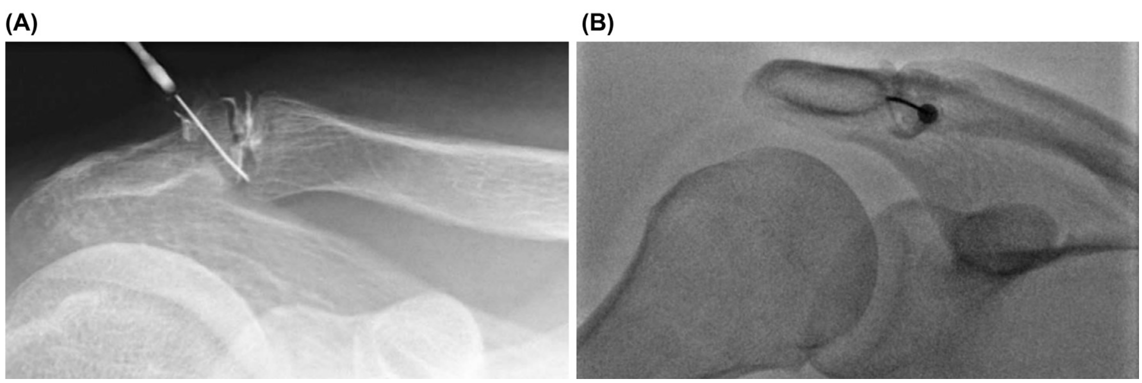

Figure 30 AC joint injection. Fluoroscopic images showing needle tip within the acromioclavicular joint and contrast outlining the joint capsule using the anterior approach.

In our patient population, glenohumeral joint injection is often coupled with subacromial bursa injection. Patients are positioned the same as for the joint injection. The skin is marked along the lateral deltoid, slightly inferior to the level of the acromion (Fig. 22B and C). Following local anesthesia, a 22 gauge, 1.5 inch needle is advanced until contact with the undersurface of the acromion. Following loss of resistance with anesthetic, contrast (approximately 0.5 mL) is used to confirm bursal access seen as a curvilinear spread along the contour of the superior rotator cuff and medication mixture as per Table 1 is infused (Fig. 28).

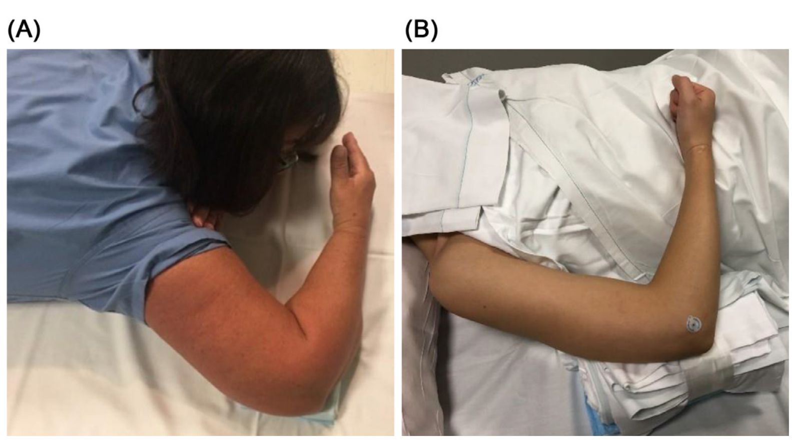

Figure 31 Positioning for elbow joint access. Photographs of the elbow flexed at 90 degrees and neutral, in patient (A) lying prone, arm overhead, and elbow on table, versus patient (B) lying supine, wrist/forearm on abdomen, and elbow elevated by a bolster. The radiocapitellar joint is denoted by the circular marker in (B).

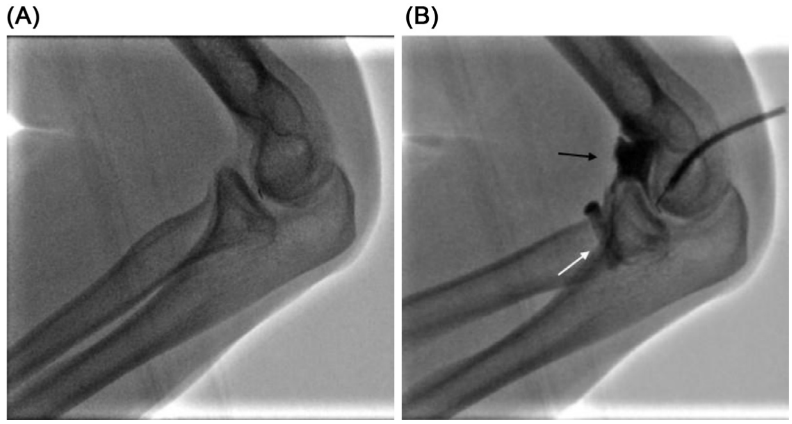

Figure 32 Lateral technique to inject the elbow/radiocapitellar joint. Fluoroscopic images (A) showing the needle "bullseyed" into the radiocapitellar articulation, and (B) intra-articular contrast with filling of the anterior recess (black arrow) and around the annular ligament (white arrow).

Biceps Tendon

Common causes of biceps tendinosis include overuse, degeneration, acute trauma, and can occur concomitantly with glenohumeral osteoarthritis or labral abnormalities. Patient typically presents with a dull ache in the anterior shoulder that is exacerbated by overhead motion. Along with other conservative measures, biceps tendinosis is amenable to a corticosteroid injection.[37]

Under intermittent fluoroscopy, the shoulder is rotated as to optimally visualize and mark a direct anteroposterior skin site to the bicipital groove (Fig. 29A). A 22 gauge, 1.5 inch needle is advanced just lateral to the lesser tuberosity lateral margin until osseous contact. After confirmation with loss-of-resistance, a small volume of contrast (1 mL) is infused documenting the superior-to-inferior longitudinal intra-sheath flow, with communication to the glenohumeral joint normal (Fig. 29B). Medication mixture as per Table 1 is infused.

AC Joint

Degenerative change of the AC joint is exceedingly common, and can result in anterior or superior shoulder pain that may be exacerbated by overhead and cross body activities. Image-guided injection is a safe, nonoperative treatment that provides symptomatic relief prior to more invasive options.[38]

The patient is supine and the anterior aspect of the joint is marked under fluoroscopic guidance with angulation of the II to best profile the radiolucent line. Alternatively, the joint can be accessed from a superior to inferior approach in certain patients, such as ones with abundant anterior soft tissues but relatively less overlying tissues superior to the joint or those with advanced joint space narrowing. In the latter technique, the skin entry is localized by palpation of the distal clavicle and articulating acromion bony prominence with confirmation by fluoroscopy. A 22 gauge, 1.5 inch needle is advanced directly into the joint, with a change in resistance typically perceived as the needle enters the joint. A small dose of contrast (<0.5 mL) is used to confirm intra-articular location (Fig. 30). Medication mixture as per Table 1 is infused.

Elbow

The elbow joint consists of the ulnohumeral, radiohumeral, and proximal radioulnar articulations. Like other synovial joints, it is susceptible to the arthropathies or injury, and may necessitate therapeutic injections for symptomatic relief. The other major reason for accessing the elbow joint is diagnostic, with MR or CT arthrography performed to evaluate for articular cartilage integrity, osteochondral defects, ligamentous injury, and/or presence of intra-articular bodies.[39,40] Two techniques exist for access,

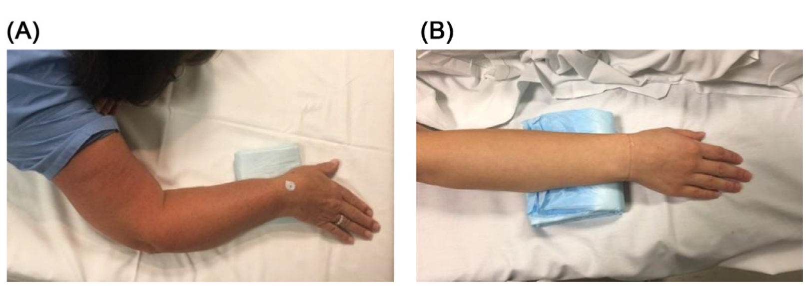

Figure 33 Positioning for wrist (radiocarpal) injection. Photographs of patient (A) prone with elbow partly flexed and wrist ulnarly deviated and lightly supported versus patient (B) supine with arm pronated by side and wrist bolstered in slight flexion.

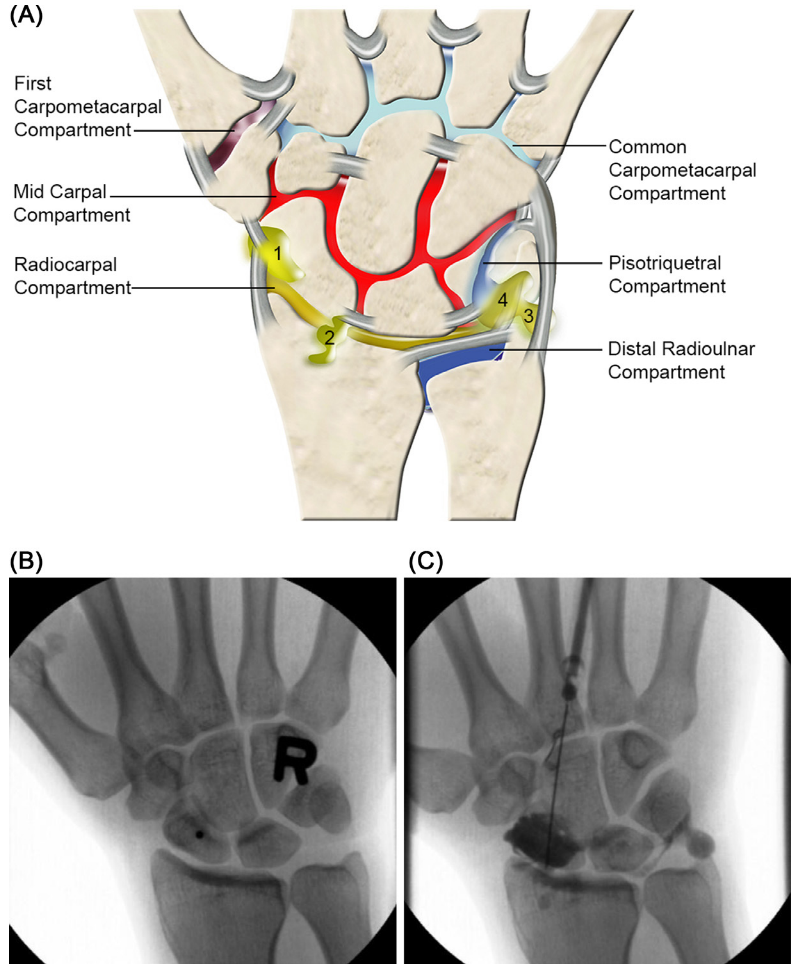

Figure 34 Wrist arthrogram. Anatomic schematic (A) showing the various joint compartments, intrinsic wrist ligaments, and TFCC. The numbers denote potential spaces of the radiocarpal compartment: 1 = radial recess, 2 = volar recess, 3 = prestyloid recess, 4 = entrance to the pisotriquetrial compartment. Fluoroscopic images (B) showing wrist positioned as in Figure 33 with the radioscaphoid, scapholunate, and lunotriquetral joints well profiled. The needle tip target for radiocarpal injection is proximal to the radiopaque dot overlying the scaphoid waist. Arthrogram (C) showing needle tip in the radiocarpal articulation in a distal-to-proximal course and contrast filling the radiocarpal compartment. No evidence of extravasation or abnormal communication.

with the first being the timetested lateral radiocapitellar approach, which will be the one discussed below, and the other the more recently published posterior transtriceps approach.[41,42]

Classically, the patient is prone with the injection arm extended overhead, elbow flexed at 90 degrees, and forearm in a neutral position without pronation or supination (Fig. 31A). However, this can be difficult for patients who experience breathing issues prone, are overweight, or have limited range of motion particularly of the upper extremity. We found that a similarly optimal elbow position can be achieved supine, the elbow flexed at 90 degrees and bolstered by towels/rolls with the wrist resting on the abdomen (Fig. 31B). The radiocapitellar joint is palpated and marked under fluoroscopy and a 22 gauge, 1.5 inch needle is advanced under intermittent fluoroscopy following administration of local anesthetic with intra-articular access confirmed by contrast (Fig. 32), which can fill the anterior, posterior, and/or at the annular ligament recesses.

Following confirmation of intra-articular location, medication mixture as per Table 1 is infused for therapeutic purposes. Alternatively, for CT or MR arthrography, the injectate mixture as per Table 2 is administered.

Wrist

Therapeutic wrist arthrography can be performed for the arthropathies, post-trauma, or in conjunction with MR or CT for evaluation of internal derangement, including intrinsic ligament and triangular fibrocartilage complex disruption (TFCC) injury.[43]

Classically, the patient is prone with arm overhead, elbow partly flexed, and wrist lightly supported (Fig. 33A). However, for similar reasons as the elbow, we found patients tolerate the supine position more. The injection arm is extended and pronated by the patient's side; the wrist is elevated enough to provide slight flexion using towels or pads (Fig. 33B). Slight ulnar deviation of the wrist is ideal, if tolerated, for elongating the scaphoid.

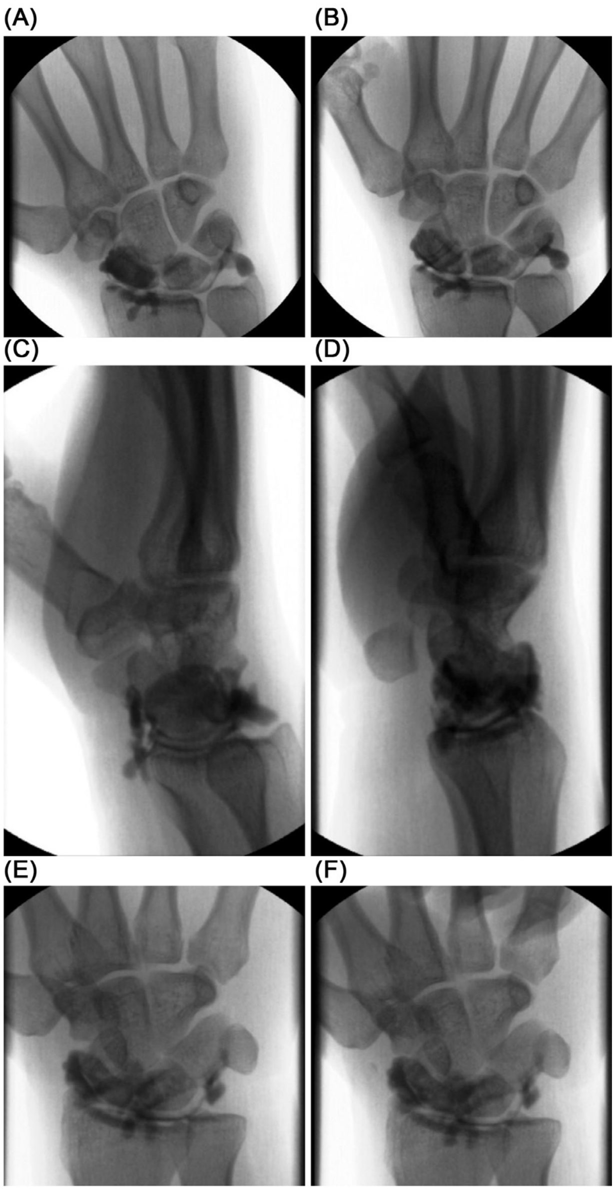

Figure 35 Radiocarpal arthrogram full diagnostic series in (A) radial deviation, (B) ulnar deviation, (C) lateral, (D) semisupinated, (E) supinated open hand, and (F) supinated clenched fist views. Note the filling of the various recesses as denoted by the numbers in figure 34A is normal.

Figure 36 Radiocarpal arthrogram with contrast abnormally in the lunotriquetral interval (white arrows) and distal radioulnar joint (black arrow) indicating intrinsic ligament and TFCC disruption, respectively.

Figure 37 Radiocarpal arthrogram with vertically oriented contrast in the scapholunate (white arrow) and more subtle contrast with the lunotriquetral (black arrow) articulations in keeping with SL and LT ligamentous defects.

Radiocarpal Joint

The proximal cortex over the mid scaphoid pole is marked under fluoroscopic guidance (Fig. 34A) with care to profile the radiolucent scapholunate and lunotriquetral intervals to best evaluate the intrinsic ligaments during arthrography. Avoid marking over/targeting the radial side of the radioscaphoid joint as this proximal-to-distal trajectory is often obstructed by the distal radial lip, the extent of which is often not fully appreciated on the frontal projection. Following administration of local anesthetic, a 23 gauge, 1.0 inch needle is advanced into the radioscaphoid joint space with a distal-to-proximal trajectory. Contrast (and medication mixture if therapeutic as per Table 1) is injected under continuous fluoroscopy (at least 4 fps) with the patient providing feedback about discomfort until sufficient, but not excessive, capsular distension is seen, usually 3 mL (Fig. 34B and C). Following needle removal, spot frontal images are taken during radial and ulnar deviation, and also in the lateral, semisupinated, supinated open hand, and supinated clenched fist positions as a diagnostic arthrography series (Fig. 35). Observe for abnormal extension into the distal radioulnar joint, which is a sign of TFCC, or into the midcarpal row indicating scapholunate and/or lunotriquetral ligament tear (Figs. 36, 37).

Midcarpal Joint

Midcarpal arthrography can be utilized as an adjunct, or standalone evaluation for scapholunate or lunotriquetral intrinsic ligament tear, particularly if a "trapdoor" or unidirectional communicating tear of these ligaments is suspected.

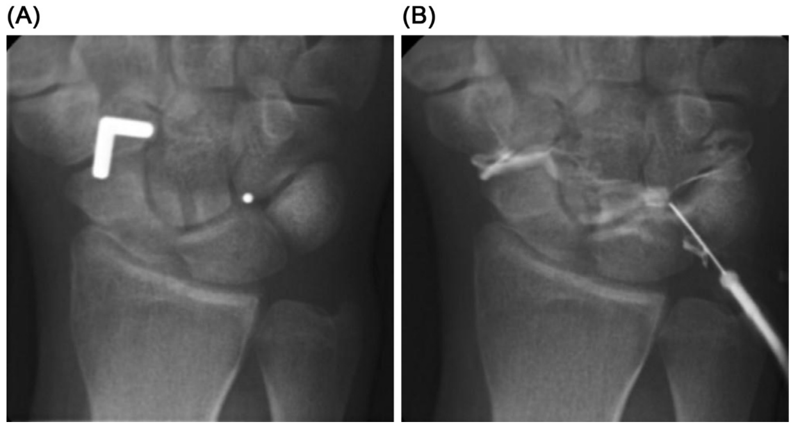

Figure 38 Midcarpal injection. Fluoroscopic images of the wrist showing (A) a radiopaque dot at the junction of the lunate, triquetrum, capitate, and hamate bones, and (B) the needle tip in the "4-corners" and contrast confined to the midcarpal compartment.

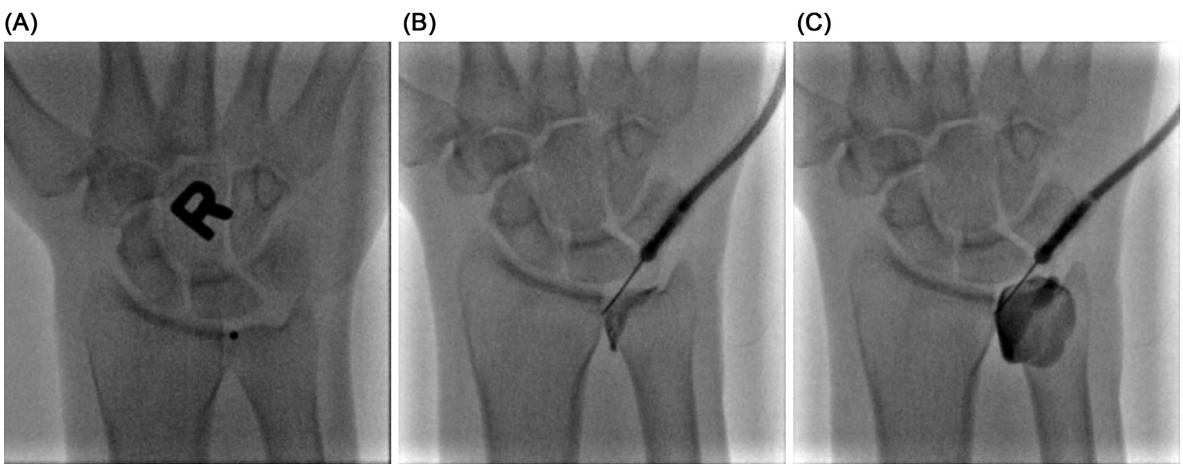

Figure 39 Distal radioulnar joint injection. Fluoroscopic images showing (A) radiopaque dot marking the target. Images (B and C) showing needle tip in the distal radioulnar joint and contrast confirming location. No extension into the radiocarpal space to suggest a complete TFC tear.

Under fluoroscopic guidance, the "4-corner," the junction of the lunate, triquetrum, capitate, and hamate is marked on the dorsal skin surface (Fig. 38A). Following local anesthesia, a 23 gauge, 1.0 inch needle is advanced under fluoroscopic guidance to the target and approximately 3 mL of contrast is infused (Fig. 38B). Continuous fluoroscopy showing

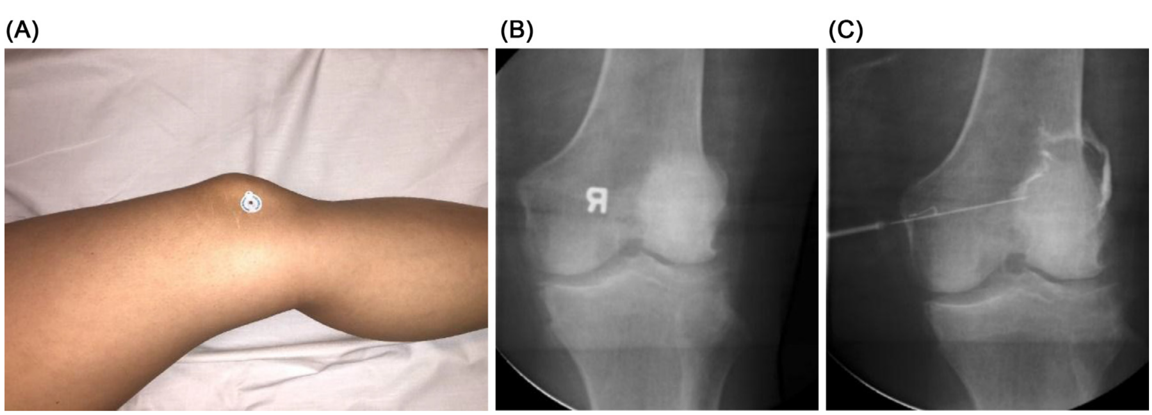

Figure 40 Medial patellofemoral approach to the knee joint. Photograph (A) showing patient supine with slight flexion and external rotation of the knee. "Soft spot" between the mid patella and trochlear is indicated by radiopaque marker found by palpation and (B) confirmed fluoroscopically with radiopaque R marker, (C) arthrogram showing needle tip within the medial aspect of the patellofemoral compartment and intra-articular contrast in the suprapatellar recess.

Figure 41 Medial patellofemoral arthrography in a post total knee arthroplasty patient. Contrast confirms intra-articular needle placement.

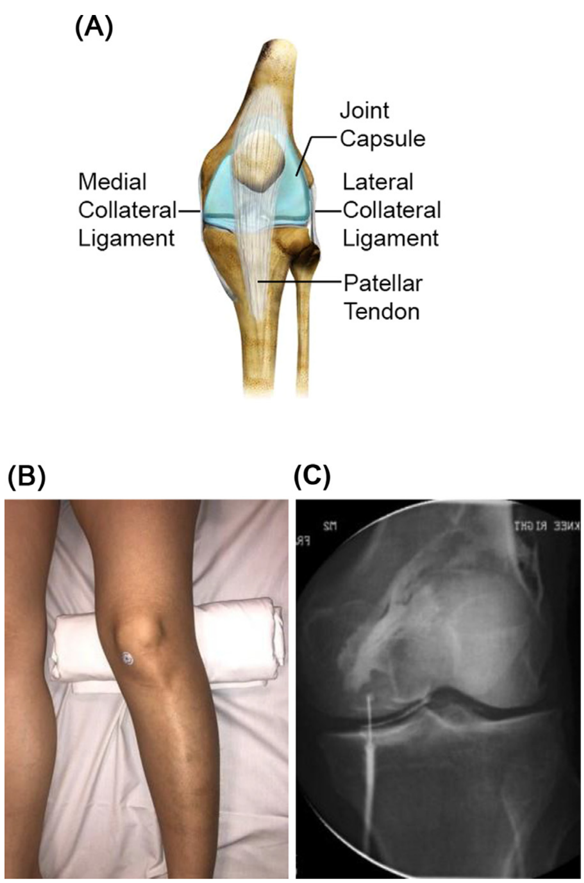

Figure 42 Anterior recess approach to the knee joint. Anatomic drawing (A) depicting the anterior recess, in blue, deep to the patella and collateral ligaments. Photograph (B) showing dot marker at the anteromedial skin entry with the fluoroscopic correlative image (C) showing a needle advanced to the targeted inferior central aspect of the medial femoral condyle. Contrast outlines both the medial tibiofemoral joint line and suprapatellar recess around the superior and medial margins of the patella. (Color version of figure is available online.)

extension of contrast into the proximal carpal row indicates scapholunate and/or lunotriquetral ligament tear in accordance to the observed route of communication. Gentle wrist manipulation also can aid in the detection of a subtle ligamentous injury.[44,45]

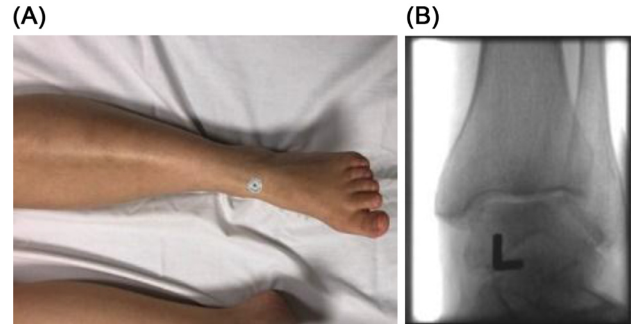

Figure 43 Tibiotalar access via the modified anterior approach. Photograph (A) showing dot marker indicating skin entry site. Fluoroscopic correlation showing (B) the target at the superior tip of the L marker.

Distal Radioulnar Joint

Distal radioulnar joint arthrography can be performed for evaluating the TFCC, ranging from detachment to incomplete tears.[46] Under fluoroscopic guidance, mark the dorsal aspect of the radiolucent joint space erring on the ulnar side, as the lip of the sigmoid notch in the radius can obstruct the needle path (Fig. 39A). Following local anesthesia, a 23 gauge, 1.0 inch needle is advanced into the joint space and contrast is injected under intermittent fluoroscopy; typical joint capacity is variable (0.5-2.0 mL) and the infusion is stopped when the patient feels a tight sensation or pain (Fig. 39B and C). Extension into the proximal carpal row indicates a complete TFCC tear.[45,46]

Knee

Therapeutic knee injections include administration of corticosteroids, viscosupplements, and more recently platelet-rich plasma therapy.[47] Diagnostic injections include joint aspiration for synovial fluid analysis (may also be therapeutic as large volume aspirates may result in symptomatic relief) and arthrography either via CT or MR. Indications for CT arthrography include evaluation for internal derangement in a patient unable to undergo MRI and can also be utilized for assessment of component loosening in a postarthroplasty patient. MR arthrography is most commonly performed in the assessment of postoperative menisci for tears.[48]

The authors utilize 2 different techniques for knee joint access. The first is the patellofemoral approach, typically from the medial aspect, with the patient supine and the knee extended.[49,50] The lower extremity is in slight external rotation with palpation of the “soft spot” along the medial border of the mid patella, and marked after confirmation by fluoroscopy (Fig. 40A and B).

After skin anesthesia, the soft tissues are infiltrated utilizing a 25 gauge, 1.5 inch needle during which the tract into the joint can be probed to ensure the path is adequately anesthetized. A 22 gauge, 1.5 inch (though a longer length might be necessary in obese patients) needle is then advanced into the patellofemoral compartment toward the equator of the patella.[3] Lidocaine can be attached and slowly infused as the

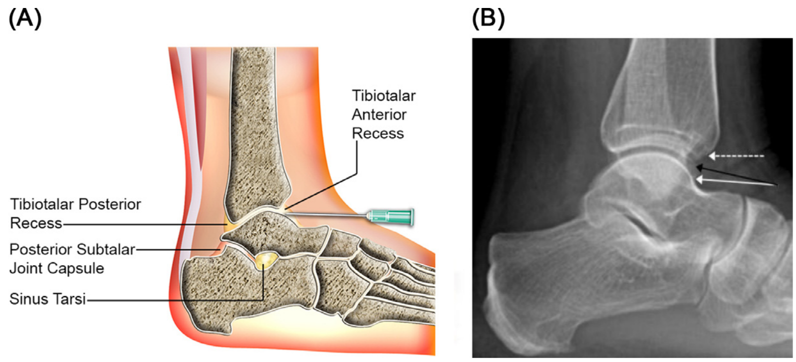

Figure 44 Lateral ankle images demonstrating the potential needle trajectories. Anatomic rendering (A) showing the extent of the tibiotalar joint capsule and anterior recess. (B) Lateral ankle radiograph showing the oblique needle trajectory (black arrow) for intra-articular access and less oblique course (solid white arrow) for capsular recess access using the anterior talar approach. If the radiolucent tibiotalar space (dotted white arrow) is targeted directly on the frontal view (not shown), this results in a more superior needle path with joint access more difficult due to the distal tibial lip particularly in patients with large overhangs or osteophytes.

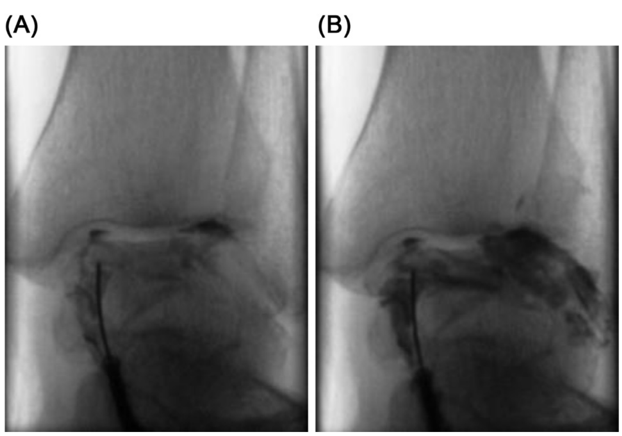

Figure 45 Ankle arthrography. Initial injection image (A) and further injection (B) demonstrating needle tip terminating at the superior third of the medial talus. Contrast progressively distends the tibiotalar joint capsule.

needle is advanced until loss of resistance suggests intra-articular access, which is then confirmed with contrast (Fig. 40C). Alternatively, attempt to aspirate a small volume of synovial fluid as a secondary confirmation of intra-articular needle position can be utilized, an option that can be especially useful in postarthroplasty patients due to distortion of tissue planes/scarring altering the tactile signs, eg, resistance, and metallic components obscuring anatomic landmarks and the needle tip (Fig. 41). Typical II angulation is 0, however it can be obliquely rotated to profile the patellofemoral joint and the needle can then be bullseyed into the joint if the standard approach fails.

The alternative technique is a straight anterior posterior approach targeting the anterior recess (Fig. 42A). Advantages are decreased patient discomfort and technical benefits, the latter including accessibility even when joint space loss is advanced, ability to perform bilateral knee injections more efficiently as this obviates moving the patient between knees, and when the patellofemoral junction cannot be confidently palpated.[3] The patient is supine with the knee extended and ideally neutral without rotation. The central anteroinferior aspect of the medial (or lateral) femoral condyle, near the

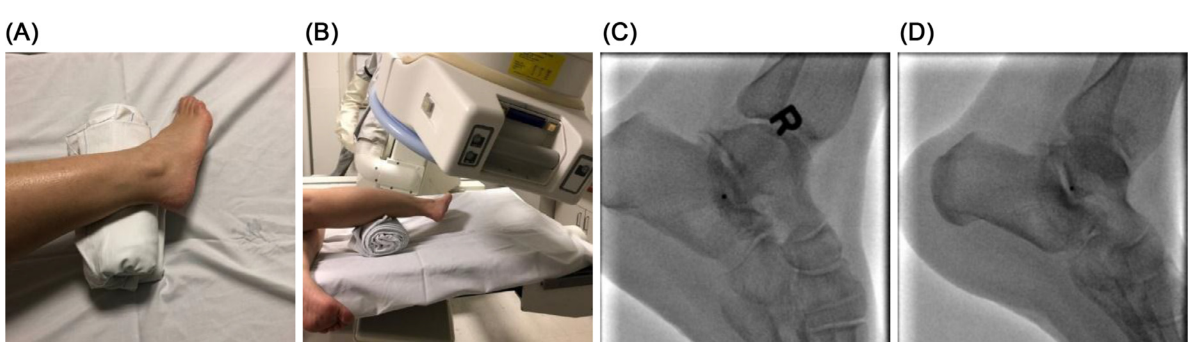

Figure 46 Positioning for subtalar joint access. Photographs (A) depicting lateral decubitus position with the injection foot elevated and slightly inverted and (B) the II rotated caudally and obliquely towards the calcaneus. Fluoroscopic image (C) with the II in neutral position (no angulation) showing the distal fibular overlapping and obstructing the target. Image (D) with the II properly rotated and displacing the fibular tip away from the lateral talar process. There is improved visualization of the angle of Gissane and radiolucent posterior facet with the target slightly inferior to the radiopaque dot marker.

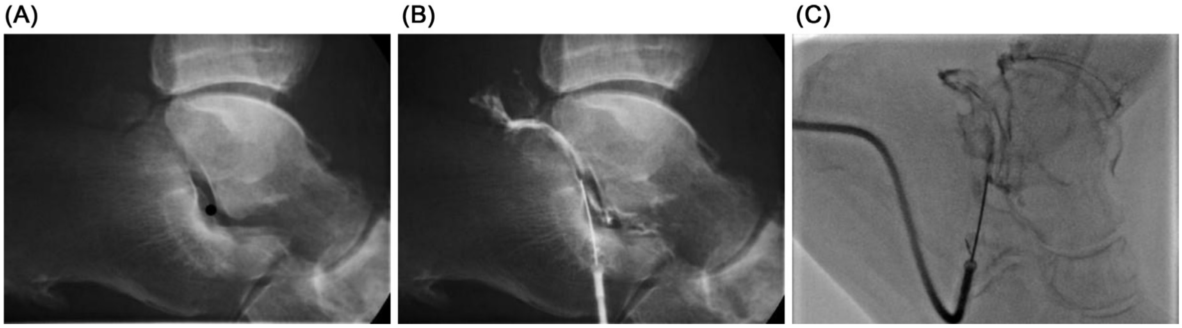

Figure 47 Subtalar joint injection. Fluoroscopic images in one patient (A) demonstrating optimal positioning with the black dot indicating the target, and (B) the needle tip at target with contrast opacifying the posterior subtalar joint. In a different patient (C), arthrogram showing extension of contrast from the posterior subtalar joint to the tibiotalar compartment.

joint line, is marked under fluoroscopic guidance (Fig. 42B). Following local anesthesia, a 22 gauge, 1.5 inch (sufficient in a majority of cases, even in obese patients) needle is advanced until osseous contact and loss-of-resistance is achieved (Fig 42C).

Following confirmation of intra-articular location, medication as per Table 1 is infused for therapeutic purposes. Alternatively, for CT or MR arthrography, the mixture as per Table 2 is administered. If diagnostic only injection is requested, refer to Table 1 and replace corticosteroid volume with additional long acting anesthetic.

Ankle

Tibiotalar

Aside from the arthropathies, other indications for ankle injection include trauma, postoperative pain, and synovitis.[51] The patient is supine with the lower extremity extended and ankle in neutral AP position. The course of the dorsalis pedis artery is palpated and noted. The traditional technique is an anterior approach targeting the medial tibiotalar joint space using a lateral projection of the ankle for guidance.[52,53] The authors predominantly use a modified version of the anterior technique, which is detailed below. A more recently published approach targets the lateral mortise.[54]

For the modified anterior technique, the region between the superior to mid third of the talar body is targeted, typically medially (Fig. 43) but laterally is also acceptable as long as the needle path does not overlap the dorsalis pedis. If the radiolucent joint space is targeted on the frontal projection, the entry site would be more superior and has a high likelihood of contacting the anterior tibial lip (black arrow in Fig. 44), often hindering joint access particularly in patients with anterior osteophytes or large overhang (lungu).

A 22 gauge, 1.5 inch needle is inserted in a flat or slightly oblique, inferior to superior, trajectory via the skin entry at the talus to the capsular recess (Figs. 44, 45).[16] Once loss of resistance is confirmed, a small dose of contrast (approximately 1 mL) is instilled. Following confirmation, medication mixture as per Table 1 is infused for therapeutic purposes. If diagnostic only injection is requested, refer to Table 1 and replace corticosteroid volume with additional long acting anesthetic.

Subtalar

Sinus tarsi syndrome, tarsal coalition, along with the arthropathies and trauma, can be causes of ankle pain and are

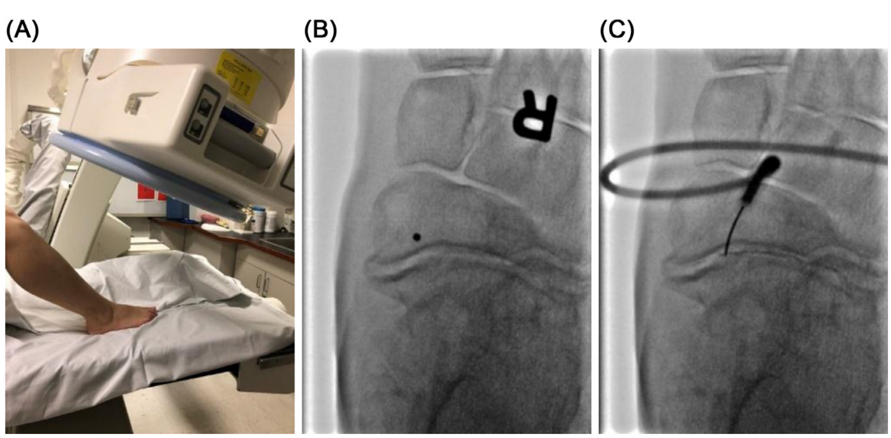

Figure 48 Talonavicular injection. Photograph (A) showing patient positioned with knee flexed, foot flat on table, and caudal tilt of the II. Fluoroscopic images (B) depict the TN joint with the target endpoint in the lucent joint space proximal to the radiopaque dot and (C) showing the needle tip and contrast in the joint line.

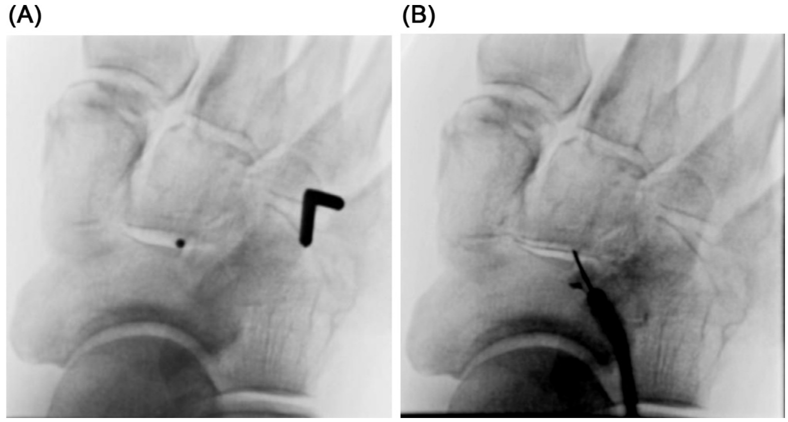

Figure 49 Naviculocuneiform injection. Fluoroscopic image (A) showing the radiolucent joint space well delineated through manipulation of the II angulation. A radiopaque dot overlies the target site. NC arthrography (B) depicting the needle tip in the joint with contrast flowing across the articulation.

amenable to therapeutic injections.[55] Access to the subtalar joint, however, can be technically challenging particularly when patient and/or II positioning are not optimized prior to starting the procedure. Proper setup can significantly improve the success rate and decrease procedure time.

Patient is in the lateral decubitus position facing away from the operator with injection leg extended and lateral side up; the foot is elevated and slightly inverted by supporting the ipsilateral knee with the patient's contralateral flexed leg and bolstering the ipsilateral distal tibia with towels or roll (Fig. 46A and B). Profiling the posterior subtalar facet is essential by rotating the II caudally and obliquely toward the calcaneus; the caudal tilt displaces the fibular tip from the trajectory and target, which is a point just posterior to the junction of the lateral talar process and angle of Gissane (Fig. 46C, and D).

A 23 gauge, 1.5 inch needle is directed to the target with a slight inferior-to-superior trajectory until a change of resistance is felt as the tip enters the joint space. Approximately 1 mL of contrast is used to confirm proper location (Fig. 47) and medication mixture as per Table 1 is infused for therapeutic purposes. If diagnostic only injection is requested, refer to Table 1 and replace corticosteroid volume with additional long acting anesthetic. Assess for communication of the subtalar joint with the tibiotalar articulation with a final spot image after the needle is removed unless opacification of the tibiotalar joint capsule was seen earlier (Fig. 47C).

Midfoot

The midfoot is composed of the talonavicular (TN), naviculocuneiform (NC) and tarsometatarsal (TMT) joints. Besides the arthropathies, additional entities that affect the midfoot include pes planovalgus alignment and coalition.[56] Several sources state that up to 63% of adults experience a degree of foot pain.[57] Given the complexity of the midfoot anatomy, the source may be difficult to delineate and necessitate a diagnostic injection prior to surgical interventions.[57,58]

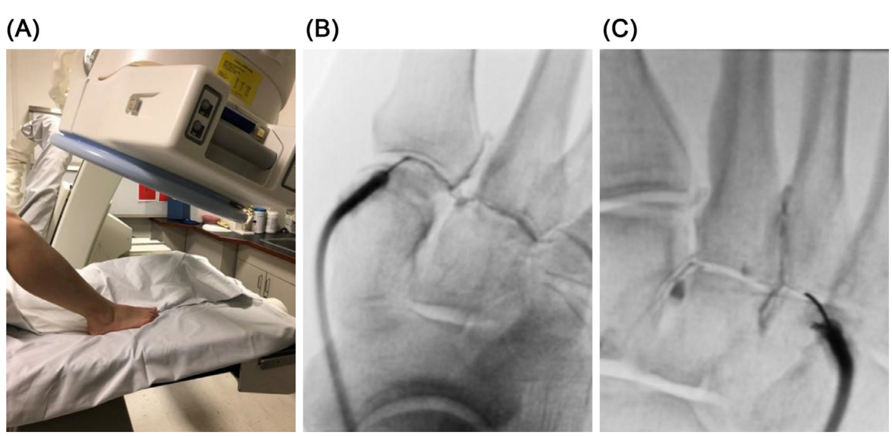

Figure 50 TMT injection. Photograph (A) showing standard positioning for TMT joint injection with knee flexed and foot flat. Typically, caudal tilt of the II is helpful in profiling the radiolucent TMT articulations as shown in the fluoroscopic image (B). The needle tip in the 1st TMT radiolucent joint space and contrast confirms intra-articular location but also demonstrates abnormal communication to the second and third TMT articulations. In a different patient, fluoroscopic image (C) shows needle tip in the 3rd TMT with contrast outlining not just the 3rd but the 2nd TMT joint as well.

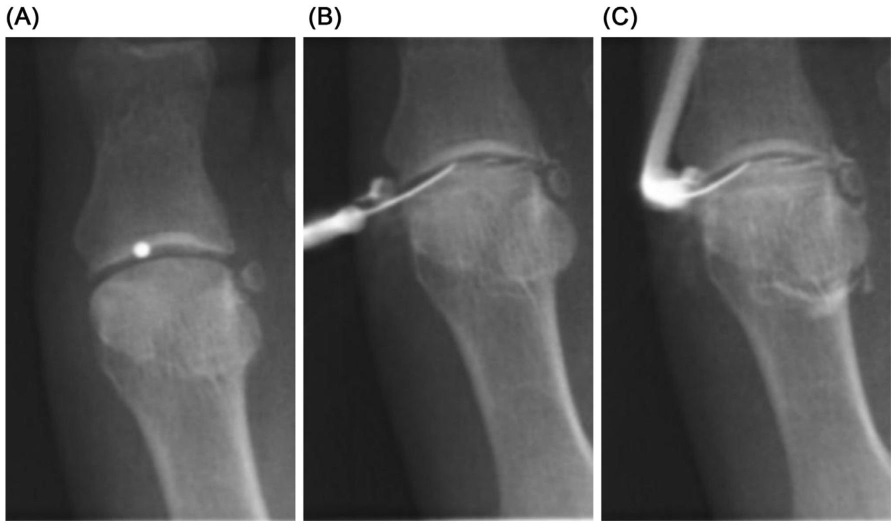

Figure 51 First MTP joint injection targeting the joint line. Fluoroscopic images (A) showing a radiopaque dot over the center of the radiolucent 1st MTP joint line, (B) needle tip at the target and contrast in the radiolucent joint line. Further injection of contrast (C) now also fills the dorsal and plantar capsular recesses.

TN and NC Joints

Similar patient and II positioning is used to access the TN and NC joints. Patient is supine with the knee flexed and foot flat on the table (Fig. 48A). Typically, a slight (5-15 degree) caudal angulation is used to splay overlapping structures and optimally profile the joint space; fluoro intermittently as the II is adjusted until the radiolucent joint line is well visualized (Figs. 48B and 49A).

Following administration of local anesthesia, a 23 gauge, 1.5 inch needle is advanced into the joint under intermittent fluoroscopy and assessed for loss of resistance with anesthetic and then contrast (Figs. 48C and 49B). In cases of advanced joint space loss or obstructing osteophytes, the needle can be "walked" along the joint margins while assessing for "slippage" into the joint; however, ensure adequate anesthetization of the periosteum to minimize discomfort.

Following confirmation of intra-articular placement, medication mixture as per Table 1 is infused for therapeutic purposes. If diagnostic only injection is requested, refer to Table 1 and replace corticosteroid volume with additional long acting anesthetic.

TMT Joints

The TMT joint complex is formed by the articulation of the tarsals (cuneiform and cuboid) and metatarsals. It is divided into 3 longitudinal columns that represent distinct synovial compartments, though variants exist. The medial column is comprised of the first metatarsal and medial cuneiform, the middle column the 2nd and 3rd metatarsals along with the intermediate and lateral cuneiforms, while the lateral column contains the 4th and 5th metatarsals and cuboid bone.[59] Knowledge of the synovial compartments prior to TMT arthrography may help reduce unnecessary needle

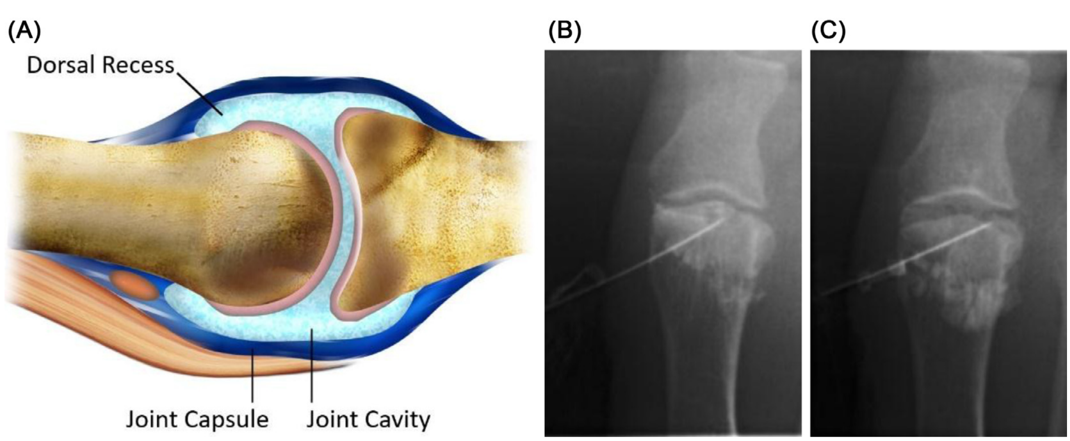

Figure 52 First MTP injection targeting the dorsal recess. Anatomic schematic (A) showing the metatarsophalangeal joint capsule from a lateral projection with the dorsal and volar recesses typically extending along the proximal phalangeal base and metatarsal head to the neck. Fluoroscopic images (B) showing needle tip at the distal metatarsal head with contrast filling the dorsal joint recess, and (C) MTP articular distraction from infusion of medication mixture, a secondary confirmation of intra-articular needle placement.

repositioning/additional puncture. For example, a single access for combined 2nd/3rd TMT arthrography is usually sufficient as these typically communicate (Fig. 50C). Of note, increasing severity of osteoarthritis may increase the probability of abnormal communication between these compartments (Fig. 50B) and thus injections should be tailored to each patient based on individual arthrographic findings.[60]

The patient is supine with the knee flexed and foot flat on the table; optimal profiling of the radiolucent joint space typically necessitates a caudal angulation of the II (Fig. 50A). Following local anesthesia a 23 gauge, 1.5 inch or shorter needle is advanced into the joint space under fluoroscopic guidance. After the appropriate change of resistance, contrast is infused (Fig. 50B and C). Typically, only a minute amount of contrast, usually less than 0.5 mL, is needed to confirm proper location; minimizing the volume avoids excessive capsular distention with contrast that may limit space for subsequent therapeutic medication administration (Table 1). If diagnostic only injection is requested, replace corticosteroid volume with additional long acting anesthetic.

Metatarsophalangeal Joint

Besides the arthropathies, specific indications for metatarsophalangeal injections include hallux rigidus and hallux valgus related degenerative changes.

Patient positioning is similar to the midfoot injection technique, with the exception that II craniocaudal angulation is typically minimal to none; oblique II angulation is variable dependent on patient anatomy but is adjusted to best profile the joint. A 23 gauge, 1.0 cm needle attached to the anesthetic syringe is advanced into the radiolucent joint space and after loss-of-resistance is detected, a small amount of contrast is injected to confirm intra-articular placement (Fig. 51).

Knowledge of articular recesses and their location is helpful in small joints of the foot, especially when direct placement into the radiolucent joint line is not possible secondary to complete joint space loss or prominent osteophytes.[16] As depicted in Figure 52, the dorsal recess overlying the metatarsal head was targeted and contrast injection demonstrates capsular distention. With progressive distension, there is distraction of the metatarsal head and phalangeal base distance, a secondary confirmation of intra-articular placement.

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