

Focused Anatomy: Musculoskeletal for Joint Injection Procedures

Storyboard for eLearning Development

CE Microcredential — Advanced Practice Providers

Slide 1: Title Screen

Objective: N/A — Introduction

Visual / Background

Full-screen title card with module branding.

Possible Image Labeled: Image 1, Image credit: AI-generated (e.g., Gemini/Midjourney)

Module Title: Focused Anatomy: Musculoskeletal for Joint Injection Procedures

Author: [Author Name]

CE Microcredential

Actions

None

Narration

Welcome to Focused Anatomy: Musculoskeletal for Joint Injection Procedures. Accurate, confident joint injections begin long before the needle touches the skin — they begin with a thorough understanding of what lies beneath the surface.

Whether you are injecting a shoulder for subacromial bursitis, a knee for osteoarthritis, or a hip for trochanteric pain, your success depends on knowing the anatomy: where the joint space actually is, which soft tissue structures surround it, and how patient factors like obesity, prior surgery, or degenerative change can shift the landmarks you rely on.

In this module, we will systematically review the surface landmarks, bony architecture, ligamentous and soft tissue anatomy, and sonoanatomy relevant to the three most commonly injected joints in clinical practice: the shoulder, the knee, and the hip. We will also address the clinical consequences of anatomic variation and landmark error — including inadvertent intratendinous injection, vascular puncture, and failed joint entry.

Throughout the module, you will follow a progressive case study featuring a patient presenting to a multispecialty clinic for evaluation and management of joint pain. Each section includes a knowledge check to reinforce key concepts. You can always go back, but to move forward you must complete the knowledge check correctly. Let's get started.

Student Actions

Click or auto-advance to begin module.

Developer Notes: Ensure institutional branding guidelines are followed. Include required logos or disclaimers.

Slide 2: Overview of Joint Injection Anatomy: Why It Matters

Objective: Learners will explain why precise anatomical knowledge reduces injection failure, complication rates, and patient harm during common joint injection procedures.

Visual / Background

[Case Study] Your first patient today is Marcus, a 58-year-old male with a BMI of 31 who presents with a three-month history of right shoulder pain. He has failed conservative management and has been referred for a subacromial corticosteroid injection. As you review his chart and prepare your supplies, you reflect on how often injection accuracy is assumed rather than verified — and how anatomy is the difference between a therapeutic procedure and a missed opportunity.

[Visual Description] Split-screen illustration: Left — labeled diagram of correct intra-articular needle placement in the shoulder joint. Right — diagram showing a missed injection with needle in deltoid muscle belly. Below both images, a bar graphic showing 'Landmark-guided accuracy rates' vs. 'Ultrasound-guided accuracy rates' for shoulder, knee, and hip injections.

Possible Image Labeled: Image 2, Image credit: AI-generated

Actions

Narration starts automatically after learner clicks Continue on the case study.

Bar graphic with accuracy comparison animates in after narration segment.

Narration

Before we review the anatomy of each joint, it is worth pausing to understand why anatomical knowledge matters so much for injection procedures.

Studies have shown that landmark-guided injection accuracy — meaning the needle actually enters the target space rather than adjacent soft tissue — varies widely by joint and provider experience. For the glenohumeral joint, landmark-guided accuracy has been reported as low as 40 to 70 percent in some series. For the hip, rates can be even lower without imaging guidance. The knee is generally more forgiving, but even there, inadvertent injection into the infrapatellar fat pad or patellar tendon occurs.

The consequences of a misplaced injection are not trivial. Corticosteroid deposited into a tendon rather than a bursa can accelerate tendon degeneration. Repeat failed injections delay effective treatment, increase cumulative steroid exposure, and erode patient confidence. Inadvertent vascular injection carries the risk of systemic absorption, fat embolism with particulate steroids, and nerve or tissue injury.

Student Actions

Ultrasound guidance significantly improves accuracy, and in this module we will cover both landmark-guided and ultrasound-guided approaches. But imaging guidance does not eliminate the need for anatomical knowledge — it depends on it. You cannot interpret what you see on the ultrasound screen if you do not understand the underlying structures.

Learner reads case study to themselves. Continue button under case study.

Once clicked, narration starts and bar graphic animates.

Developer Notes: References: 1, 2, 3. Key teaching point: inject accuracy varies significantly by joint and guidance method.

Slide 3: Surface Landmarks of the Shoulder

Objective: Learners will accurately identify the surface landmarks of the shoulder girdle and correctly associate each with its underlying bony structure and clinical relevance for injection.

Visual / Background

[Case Study] You position Marcus seated upright with his arm in his lap. Before palpating, you mentally map out the key surface landmarks of the shoulder. You know that identifying these landmarks correctly is the foundation for any approach — anterior, lateral, or posterior.

[Visual Description] Anterior and posterior views of the shoulder with labeled surface landmarks: acromion (anterior and lateral borders), acromioclavicular (AC) joint, coracoid process, greater tubercle of the humerus, and the posterior glenohumeral joint line. Labels appear sequentially as narration progresses.

Possible Image Labeled: Image 3, Image credit: AI-generated

Actions

Student reads case study. Continue button under case study. Once clicked, narration starts and labels appear sequentially on image.

Landmarks to label:

- Acromion (anterior border, lateral border, posterolateral corner)
- Acromioclavicular joint
- Coracoid process
- Greater tubercle of the humerus
- Posterior glenohumeral joint line (soft spot)

Narration

Let's walk through the key surface landmarks of the shoulder that guide injection approaches.

The acromion is the most critical landmark for shoulder injections. It is the flat bony shelf that forms the roof of the shoulder. Palpate along the lateral clavicle until you feel it step down — that step is the AC joint. Continue laterally and slightly posteriorly and you will reach the acromion itself. The anterior border, lateral border, and posterolateral corner of the acromion each serve as reference points for different injection approaches.

Just medial to the anterior border of the acromion, you can palpate the acromioclavicular joint — a common injection target in its own right. Tenderness directly over this joint, worsened by cross-body adduction, is a hallmark of AC joint pathology.

Approximately 2 to 3 centimeters inferior and medial to the anterolateral acromion is the coracoid process. This is an important landmark because the subacromial bursa lies just lateral to it, and the

brachial plexus and axillary artery lie medial to it. Pressure directly on the coracoid is typically tender and identifies subcoracoid structures.

The greater tubercle of the humerus can be palpated just lateral to the bicipital groove with the arm in neutral rotation. This is where the supraspinatus, infraspinatus, and teres minor tendons insert — the primary sites of rotator cuff pathology.

Finally, the posterior glenohumeral joint line is identified at the soft spot just inferior to the posterior acromion and medial to the humeral head. This is the entry point for the posterior glenohumeral approach.

Student Actions

Learner reads case study. Clicks Continue to begin narration.

Labels appear sequentially on image as narration progresses.

Developer Notes: References: 1, 2, 4. Key teaching point: surface landmarks guide both landmark-based and US-assisted approaches.

Slide 4: Knowledge Check 1 — Shoulder Surface Landmarks

Objective: Learners will accurately identify the surface landmarks of the shoulder girdle and correctly associate each with its underlying bony structure and clinical relevance for injection.

Visual / Background

Posterior and anterior views of the shoulder with five unlabeled landmarks indicated by numbered markers.

Possible Image Labeled: Image 4, Image credit: AI-generated

Actions

Drag and drop labels to correctly identify all five shoulder landmarks.

Labels to place:

- Acromion
- Acromioclavicular joint
- Coracoid process
- Greater tubercle of the humerus
- Posterior glenohumeral joint line (soft spot)

Feedback:

- Acromion: The flat bony shelf forming the roof of the shoulder. Its anterior, lateral, and posterolateral borders are entry reference points for multiple injection approaches.
- AC joint: Palpable as a slight step-off at the lateral end of the clavicle; injection target for AC joint pathology.
- Coracoid process: 2–3 cm inferior and medial to the anterolateral acromion; the subacromial bursa lies lateral to it, making it a key orientation landmark.
- Greater tubercle: Lateral to the bicipital groove; site of supraspinatus, infraspinatus, and teres minor insertion — the rotator cuff footprint.
- Posterior joint line: The soft spot inferior to the posterior acromion and medial to the humeral head; posterior glenohumeral injection entry point.

Narration

[No narration during question — learner-directed activity]

Student Actions

Drag and Drop interaction: Learner drags text labels to the correct anatomical location on the image.

Student must get all correct to move on.

Developer Notes: Assessment type: Formative (not graded). Ensure drop zones are clearly defined. References: 1, 2, 4.

Slide 5: Bony Architecture of the Shoulder

Objective: Learners will correctly describe the bony architecture of the glenohumeral joint, subacromial space, and AC joint and explain how each relates to needle trajectory and target space during injection.

Visual / Background

[Case Study] With your landmarks identified, you take a moment before opening your tray. You mentally picture the bony structures beneath the surface — the glenohumeral articulation, the subacromial space formed between the humeral head below and the coracoacromial arch above, and the small synovial AC joint medially.

[Visual Description] Labeled coronal cross-section and anterior 3D view of the shoulder showing: glenohumeral joint (glenoid, humeral head, joint capsule), subacromial space (below acromion, above supraspinatus/rotator cuff), coracoacromial arch (acromion, coracoacromial ligament, coracoid), and AC joint (distal clavicle, acromion, intra-articular disc).

Possible Image Labeled: Image 5, Image credit: AI-generated

Actions

Build the shoulder cross-section anatomy structure-by-structure with each narration segment.

Highlight each structure as it is discussed.

Narration

Now let's look at the bony architecture that defines the shoulder injection targets.

The glenohumeral joint is a ball-and-socket synovial joint with inherently poor bony stability. The glenoid is shallow — a shallow dish — and the humeral head is large. Most of the stability comes from the rotator cuff and capsuloligamentous complex, not the bony architecture. The joint capsule surrounds the joint and is reinforced anteriorly by the glenohumeral ligaments.

The subacromial space is the region between the undersurface of the coracoacromial arch superiorly and the rotator cuff tendon inferiorly. The coracoacromial arch is formed by the acromion, the coracoid, and the coracoacromial ligament connecting them. The subacromial bursa lies within this space and is a common injection target for impingement syndrome and rotator cuff tendinopathy.

The AC joint is a small diarthrodial joint between the distal clavicle and the medial facet of the acromion. It contains a fibrocartilaginous disc and is reinforced by the acromioclavicular and coracoclavicular ligaments. Because of its small volume — typically less than 1 mL — it is easy to inadvertently miss during injection if landmarks are imprecise.

Student Actions

Understanding the three-dimensional geometry of these spaces — and how a needle must be directed to enter each one — is the foundation of accurate shoulder injection technique.

Learner reads case study. Clicks Continue to begin narration and watch structure build.

Developer Notes: References: 1, 2, 4, 5.

Slide 6: Rotator Cuff and Bursal Anatomy

Objective: Learners will identify the four rotator cuff muscles and their tendons, describe the anatomy of the subacromial-subdeltoid bursa, and explain how this anatomy affects injection approach selection.

Visual / Background

[Case Study] As you palpate Marcus's shoulder, he winces when you press on the anterolateral acromion during supraspinatus palpation. His pain is reproduced with the empty can test. You confirm your injection target is the subacromial-subdeltoid bursa and the supraspinatus tendon, and you plan a lateral subacromial approach.

[Visual Description] Labeled oblique lateral and superior views of the shoulder showing: four rotator cuff muscles (supraspinatus, infraspinatus, teres minor, subscapularis) with their footprints on the greater and lesser tubercles, the subacromial-subdeltoid bursa draped over the rotator cuff, and the bicipital groove with the long head biceps tendon.

Possible Image Labeled: Image 6, Image credit: AI-generated

Actions

Labels highlight as each structure is mentioned in narration.
Toggle button: 'Show bursa overlay' to reveal bursa draped over cuff.

Narration

The rotator cuff is composed of four muscles whose tendons coalesce to form a cuff around the humeral head. The acronym SITS is a useful memory aid: Supraspinatus, Infraspinatus, Teres minor, and Subscapularis.

The supraspinatus originates from the supraspinous fossa of the scapula and inserts on the superior facet of the greater tubercle. It abducts the arm in the scapular plane and is the most commonly injured rotator cuff tendon. The infraspinatus originates from the infraspinous fossa and inserts on the middle facet of the greater tubercle, providing external rotation. The teres minor inserts on the inferior facet of the greater tubercle and also externally rotates the arm. The subscapularis is the only anterior cuff muscle, inserting on the lesser tubercle and internally rotating the arm.

The subacromial-subdeltoid bursa is a large, flat synovial sac that extends from beneath the acromion laterally to beneath the deltoid muscle. It is not a joint space — it is a bursa — but it communicates directly with the subacromial space and drapes over the superior surface of the supraspinatus tendon. In rotator cuff pathology, the bursa is almost always inflamed and fluid-filled, making it both the primary pain generator and the primary injection target.

The bicipital groove, located between the greater and lesser tubercles, contains the long head of the biceps tendon. This tendon can be a

source of anterior shoulder pain and is a separate injection target in biceps tenosynovitis. Inadvertent injection directly into the tendon — rather than the sheath — can cause tendon rupture and must be avoided.

Student Actions

Learner reads case study. Clicks Continue to begin narration.

Learner activates bursa overlay toggle to visualize bursa position.

Developer Notes: References: 1, 2, 4, 5. Clinical pearl: injection directly into a tendon rather than bursa or sheath increases risk of rupture.

Slide 7: Glenohumeral and Subacromial Injection Approaches

Objective: Learners will describe the landmark-guided needle trajectory for the posterior glenohumeral, lateral subacromial, and anterior glenohumeral injection approaches and identify the target space for each.

Visual / Background

[Case Study] With your target confirmed, you decide to use a lateral subacromial approach. However, you want to mentally walk through the other approaches as well — both to compare and to have an alternative if your first attempt is unsuccessful.

[Visual Description] Side-by-side diagrams showing three approaches:

1. Lateral subacromial: Needle directed medially and slightly superiorly under the lateral acromion
2. Posterior glenohumeral: Needle directed anteriorly and slightly superiorly from the posterior soft spot
3. Anterior glenohumeral: Needle directed posteriorly between coracoid and humeral head

Possible Image Labeled: Image 7, Image credit: AI-generated

Actions

Animation for each approach plays when learner clicks the corresponding button.

Needle path animates from skin entry through each tissue layer to target space.

Narration

Let's review the three primary injection approaches for the shoulder.

The lateral subacromial approach targets the subacromial-subdeltoid bursa. The patient is seated with the arm relaxed at the side. The needle is inserted at the posterolateral corner of the acromion and directed medially and slightly superiorly parallel to the undersurface of the acromion. The target is the subacromial bursa. The needle should advance without resistance until it enters the soft bursal space — if you hit resistance, you are likely in the rotator cuff tendon and should redirect.

The posterior glenohumeral approach targets the glenohumeral joint space. The patient is seated with the arm in internal rotation. The needle is inserted at the posterior soft spot — approximately 2 cm inferior and 1 cm medial to the posterolateral corner of the acromion — and directed anteriorly and slightly superiorly toward the coracoid process, which can be palpated anteriorly. This approach is widely used for glenohumeral osteoarthritis, adhesive capsulitis, and inflammatory arthritis.

The anterior glenohumeral approach is an alternative for glenohumeral injection. The patient is seated with the arm externally rotated. The

Student Actions

needle is inserted just medial and inferior to the coracoid process and directed posteriorly. Care must be taken to stay lateral to the coracoid to avoid the neurovascular bundle medially.

Learner reads case study. Clicks Continue to begin narration.

Learner clicks each approach button to view the corresponding animation.

Developer Notes: References: 1, 2, 4, 5. Animations should clearly show redirection needed when bone or tendon is contacted.

Slide 8: Knowledge Check 2 — Shoulder Injection Approach

Objective: Learners will describe the landmark-guided needle trajectory for the posterior glenohumeral, lateral subacromial, and anterior glenohumeral injection approaches and identify the target space for each.

Visual / Background

No background image needed.

Actions

Scenario: A provider is using a lateral subacromial approach for a right shoulder subacromial corticosteroid injection. After inserting the needle at the posterolateral corner of the acromion and advancing medially, the provider encounters significant resistance at 3 cm depth. What is the most likely explanation, and what should the provider do?

- A. The needle has entered the glenohumeral joint space — acceptable resistance, proceed with injection.
- B. The needle tip is within the rotator cuff tendon — withdraw slightly and redirect superiorly toward the acromion undersurface.
- C. The needle has reached the posterior capsule — redirect anteriorly toward the coracoid.
- D. The resistance is from the deltoid muscle — insert the needle 1 cm more distally.

Correct answer: B.

Feedback:

- A. Incorrect. The glenohumeral joint is not the target for a lateral subacromial approach and does not typically communicate with the subacromial bursa in intact rotator cuffs. Resistance here does not indicate joint entry.
- B. Correct. Resistance during subacromial injection typically indicates the needle tip is within the rotator cuff tendon. The correct maneuver is to withdraw slightly and redirect superiorly, so the needle travels along the undersurface of the acromion into the bursal space.
- C. Incorrect. The posterior capsule is not encountered during a lateral subacromial approach and is not the source of resistance here.
- D. Incorrect. At 3 cm, the needle is well past the deltoid layer. Advancing more distally would not resolve intratendinous positioning.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: Formative. References: 1, 2, 4, 5. Tests clinical application of subacromial anatomy to injection technique.

Slide 9: Shoulder Sonoanatomy: Subacromial-Subdeltoid Bursa

Objective: Learners will identify the sonoanatomical landmarks of the subacromial-subdeltoid bursa and describe the ultrasound-guided lateral subacromial injection technique.

Visual / Background

[Case Study] After the landmark-guided injection, you decide to review ultrasound guidance for the next patient — an obese woman with a BMI of 42 presenting for the same procedure. You know that at this BMI, surface landmarks will be unreliable and the subacromial space will be difficult to palpate with confidence.

[Visual Description] Ultrasound image of the lateral shoulder with probe in coronal/coronal-oblique plane showing: deltoid muscle (superficial hyperechoic layer with fibrillar texture), subacromial-subdeltoid bursa (thin anechoic or hypoechoic stripe), supraspinatus tendon (fibrillar, hyperechoic), and humeral head (hyperechoic cortex with acoustic shadow). Probe position diagram on patient silhouette.

Possible Image Labeled: Image 9, Image credit: AI-generated

Actions

Interactive animation: Learner clicks 'Scan' button to watch probe move from lateral acromion distally.
At each position, key structures are labeled on the ultrasound image. Learner must identify the bursa before advancing.

Narration

Let's look at the shoulder under ultrasound.

For ultrasound-guided subacromial injection, the probe is placed in the coronal or coronal-oblique plane over the lateral shoulder, just below the acromion. On this view you will see several distinct layers.

The most superficial layer is the deltoid muscle, which appears as a fibrillar, moderately echogenic band. Deep to it is the subacromial-subdeltoid bursa. In a normal shoulder, the bursa appears as a thin, dark stripe — thin anechoic or hypoechoic — between the deltoid fascia and the supraspinatus tendon. In inflammatory conditions, the bursa is thickened and may contain fluid.

Deep to the bursa is the supraspinatus tendon, which has a characteristic fibrillar echogenic texture when the probe is aligned properly. The tendon inserts on the greater tubercle, which appears as a bright hyperechoic cortical line with posterior acoustic shadowing. The footprint of the tendon at the greater tubercle is a key landmark.

For injection, the needle is inserted in-plane from lateral to medial, targeting the bursal space between the deltoid fascia and the supraspinatus tendon. Real-time needle visualization allows you to confirm that the tip is in the bursal space rather than within the tendon

Student Actions

— a critical distinction that is not possible with landmark-guided technique.

Learner reads case study. Clicks Continue to begin narration.

Learner must interact with scan animation and identify bursa before advancing.

Developer Notes: References: 2, 4, 6. Key teaching point: ultrasound confirms needle tip is in bursa, not tendon.

Slide 10: Knowledge Check 3 — Shoulder Sonoanatomy

Objective: Learners will identify the sonoanatomical landmarks of the subacromial-subdeltoid bursa and describe the ultrasound-guided lateral subacromial injection technique.

Visual / Background

Display an unlabeled ultrasound image of the lateral shoulder in coronal-oblique plane for visual reference during the question.

Actions

During an ultrasound-guided lateral subacromial injection, the provider identifies a thin dark stripe between the deltoid muscle and the supraspinatus tendon. What structure does this represent, and what is the correct next step?

- A. The glenohumeral joint capsule — advance the needle deeper to enter the joint space.
- B. The subacromial-subdeltoid bursa — advance the in-plane needle tip into this stripe and confirm with a small test injection.
- C. The coracoacromial ligament — redirect the needle medially to bypass it.
- D. Anisotropy artifact in the supraspinatus tendon — rotate the probe to resolve it before injecting.

Correct answer: B.

Feedback:

- A. Incorrect. The glenohumeral joint space is not visible in this lateral coronal-oblique view. The joint line is posterior or anterior. A thin dark stripe in this view represents bursal fluid, not joint space.
- B. Correct. The thin anechoic or hypoechoic stripe between the deltoid fascia and the supraspinatus tendon is the subacromial-subdeltoid bursa. The correct technique is to advance the in-plane needle into this stripe. A small test injection of saline should confirm correct placement by expanding the bursal space without resistance.
- C. Incorrect. The coracoacromial ligament is not typically visible in this view and is not a barrier to the lateral subacromial approach.
- D. Incorrect. Anisotropy in the supraspinatus tendon appears as focal hypoechoogenicity within the tendon substance, not as a stripe between tissue layers. Adjusting the probe angle would resolve true anisotropy, but this stripe is a real anatomical finding.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: Formative. References: 2, 4, 6.

Slide 11: Surface Landmarks of the Knee

Objective: Learners will accurately identify the surface landmarks of the knee and correctly associate each with its clinical relevance for intra-articular and periarticular injection.

Visual / Background

[Case Study] Your next patient is Diana, a 67-year-old woman with bilateral knee osteoarthritis, right greater than left. She has grade III OA by Kellgren-Lawrence scale on X-ray and presents for an intra-articular corticosteroid injection. You position her supine with her knee in 20 degrees of flexion and begin identifying landmarks.

[Visual Description] Anterior and lateral views of the knee with labeled surface landmarks: patella (superior pole, inferior pole, medial border, lateral border), patellar tendon, tibial tuberosity, medial and lateral joint lines, medial and lateral femoral condyles, and the suprapatellar pouch. Labels appear sequentially as narration progresses.

Possible Image Labeled: Image 11, Image credit: AI-generated

Actions

Student reads case study. Continue button under case study. Once clicked, narration starts and labels appear sequentially.

Landmarks to label:

- Superior and inferior poles of the patella
- Medial and lateral patellar borders
- Patellar tendon
- Tibial tuberosity
- Medial and lateral joint lines
- Suprapatellar pouch (midway between superior patella and distal femur)

Narration

Let's move to the knee, one of the highest-volume joints for injection in clinical practice.

The patella is the central landmark for all knee injection approaches. Identify the superior pole of the patella — the upper edge — and the inferior pole, where the patellar tendon originates. The medial and lateral borders of the patella are palpated by pushing the patella slightly to the opposite side. These borders are the entry points for the medial and lateral patellar approaches.

The patellar tendon runs from the inferior pole of the patella to the tibial tuberosity. Injecting directly into the patellar tendon should be avoided, as this risks tendon damage. The fat pad deep to the patellar tendon — the infrapatellar fat pad of Hoffa — is another important structure to recognize, as inadvertent injection into it is both painful and non-therapeutic.

The joint line is palpated with the knee in slight flexion. Run your thumb along the medial and lateral aspects of the knee just below the femoral condyle — the soft depression you feel is the joint line. The medial joint line is typically easier to palpate than the lateral.

The suprapatellar pouch is the proximal extension of the knee synovial cavity, located between the quadriceps muscle and the distal femur. This is the preferred injection target for approaches that use the suprapatellar or proximal patellar technique, as it is the most consistently accessible and fluid-filled part of the joint.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Labels appear sequentially on image as narration progresses.

Developer Notes: References: 1, 2, 3. Key teaching point: joint line palpation accuracy depends on knee flexion angle.

Slide 12: Bony Architecture and Joint Space of the Knee

Objective: Learners will describe the bony architecture of the knee joint and identify the three joint compartments, explaining how compartmental anatomy influences injection technique and target selection.

Visual / Background

[Case Study] As you confirm Diana's joint line, you recall the X-ray showing predominant medial compartment narrowing. You plan an intra-articular injection and consider which approach will most reliably access the joint space in the setting of significant medial compartment OA.

[Visual Description] Anterior and lateral diagrams of the knee joint showing: femoral condyles (medial, lateral), tibial plateau (medial, lateral), patellofemoral joint, tibiofemoral joint, fibular head, and the three compartments (medial, lateral, and patellofemoral). Cross-sectional axial view showing the patellofemoral joint and retropatellar space.

Possible Image Labeled: Image 12, Image credit: AI-generated

Actions

Structure labels highlight as each is mentioned in narration.
Toggle: 'Show joint compartments' to color-code medial, lateral, and patellofemoral compartments.

Narration

The knee joint is technically three joints sharing one synovial cavity: the medial tibiofemoral compartment, the lateral tibiofemoral compartment, and the patellofemoral compartment. Because they share a continuous synovial space, a correctly placed intra-articular injection will distribute throughout all three compartments.

The medial tibiofemoral compartment articulates the medial femoral condyle with the medial tibial plateau and is separated from the lateral compartment by the anterior and posterior cruciate ligaments. In OA, the medial compartment bears greater load and degenerates preferentially — this is the compartment most commonly narrowed on X-ray.

The lateral tibiofemoral compartment articulates the lateral femoral condyle with the lateral tibial plateau. The lateral compartment is separated from the fibular head by the lateral collateral ligament and popliteus tendon.

The patellofemoral compartment articulates the patella with the trochlear groove of the femur. The retropatellar cartilage is the largest articular surface in the body. Significant patellofemoral OA or chondromalacia patella can cause anterior knee pain that is distinct from tibiofemoral OA.

Student Actions

For intra-articular injection, the key principle is to target the joint cavity — not the cartilage, meniscus, or ligament. Approaches that access the suprapatellar pouch or the midpatellar joint line provide reliable access to the continuous synovial cavity regardless of which compartment is most affected.

Learner reads case study. Clicks Continue to begin narration.

Learner toggles compartment overlay to visualize three-compartment anatomy.

Developer Notes: References: 1, 2, 3. Key teaching point: all three compartments share one synovial space — correct intra-articular placement distributes throughout.

Slide 13: Soft Tissue Anatomy of the Knee: Bursae, Menisci, and Ligaments

Objective: Learners will identify the major soft tissue structures of the knee relevant to injection, including bursae, menisci, and collateral ligaments, and describe how these structures can be injection targets or inadvertent injection sites.

Visual / Background

[Case Study] As you prepare Diana's skin, you think about the structures you do NOT want to inject — the medial collateral ligament, the pes anserine bursa, and the meniscus. Each is a potential source of pain on its own, and each could be inadvertently targeted if surface anatomy is not carefully respected.

[Visual Description] Anterior and medial views of the knee showing: medial and lateral menisci, medial collateral ligament (MCL), lateral collateral ligament (LCL), infrapatellar fat pad, suprapatellar bursa, prepatellar bursa, and pes anserine bursa. Labels highlight as each is mentioned.

Possible Image Labeled: Image 13, Image credit: AI-generated

Actions

Labels highlight as each structure is mentioned in narration.

Clicking each structure name in a sidebar panel shows a close-up inset of that structure.

Narration

Several soft tissue structures in and around the knee are both potential injection targets in their own right and potential sites of inadvertent injection.

The menisci are fibrocartilaginous wedges sitting between the femoral condyles and tibial plateau. They are not vascular and will not show inflammatory change on imaging in early degeneration. Injecting into the meniscus is painful, non-therapeutic, and potentially harmful. The meniscus is positioned at the joint line — which is why precise joint line identification is so important.

The medial collateral ligament runs from the medial femoral epicondyle to the medial tibial shaft. It can be mistakenly injected instead of the joint space if the needle is angled too far posteriorly during a medial approach. The lateral collateral ligament is thinner and cord-like, connecting the lateral femoral epicondyle to the fibular head.

The pes anserine bursa lies approximately 2 to 3 centimeters below the medial joint line, at the insertion of the pes anserine tendons — the sartorius, gracilis, and semitendinosus. Pes anserine bursitis is a common source of medial knee pain and is a distinct injection target from the intra-articular space. Confusing pes anserine bursitis with intra-articular OA is a common clinical error.

The prepatellar bursa sits anterior to the patella and is inflamed in kneeling occupations — housemaid's knee. The infrapatellar bursa is below the patellar tendon and can be accessed separately from the joint. The suprapatellar bursa communicates with the joint cavity and is the target for suprapatellar injections.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Learner clicks each structure in sidebar panel to view close-up insets.

Developer Notes: References: 1, 2, 3. Key teaching point: *pes anserine bursitis is a common mimicker of intra-articular knee OA.*

Slide 14: Knee Injection Approaches: Medial and Lateral Midpatellar

Objective: Learners will describe the landmark-guided needle trajectory for the medial and lateral midpatellar knee injection approaches, and identify the common error patterns for each.

Visual / Background

[Case Study] You decide to use a medial midpatellar approach for Diana. You position the knee in 20–30 degrees of flexion, identify the medial border of the patella, and plan your needle trajectory.

[Visual Description] Diagrams showing medial and lateral midpatellar approaches:

1. Medial midpatellar: Needle directed posteriorly at the midpoint of the medial patellar border, angled slightly lateral
2. Lateral midpatellar: Needle directed posteriorly at the midpoint of the lateral patellar border, angled slightly medial

Error pattern inset: Needle angled too posteriorly contacts the articular surface of the patella or medial femoral condyle.

Possible Image Labeled: Image 14, Image credit: AI-generated

Actions

Animation for medial and lateral approaches plays when learner clicks each corresponding button.

Error pattern animation activates with 'See common error' button.

Narration

The midpatellar approach is the most commonly used and most consistently accurate landmark-guided knee injection technique.

For the medial midpatellar approach, the patient is positioned supine or sitting with the knee in 20 to 30 degrees of flexion — this partially opens the medial joint space. The needle is inserted at the midpoint of the medial border of the patella and directed posteriorly, parallel to the underside of the patella, with a slight lateral angulation. This directs the needle through the retropatellar space and into the joint cavity.

A key technical point: the needle must be directed parallel to the patella's undersurface, not angled toward the femoral condyle. If the needle is directed too posteriorly or inferiorly, it will contact cartilage or the medial femoral condyle and produce sharp pain. If resistance is felt immediately on insertion, the needle tip is likely in the medial retinaculum — withdraw and redirect.

The lateral midpatellar approach is the mirror image, inserting at the midpoint of the lateral patellar border and directing the needle medially. This approach has slightly lower accuracy in some studies, as the lateral retinaculum is thicker and the lateral joint space is somewhat narrower in medial-compartment OA. However, it remains a valid and commonly used technique.

Student Actions

Regardless of approach, smooth, low-resistance injection of the total volume confirms correct intra-articular placement. If resistance is felt, the needle should be repositioned before injecting.

Learner reads case study. Clicks Continue to begin narration.

Learner clicks each approach button to view animation. Must view error pattern before advancing.

Developer Notes: References: 1, 2, 3. Animations should clearly show both correct trajectory and error redirection.

Slide 15: Knowledge Check 4 — Knee Injection Anatomy

Objective: Learners will describe the landmark-guided needle trajectory for the medial and lateral midpatellar knee injection approaches, and identify the common error patterns for each.

Visual / Background

No background image needed.

Actions

A provider performs a medial midpatellar intra-articular knee injection with the patient supine and the knee in 20 degrees of flexion. After inserting the needle at the medial patellar border and advancing posteriorly, the patient reports sharp focal pain and the provider feels firm resistance. Which of the following best explains this finding, and what is the appropriate response?

- A. The needle has entered the joint space — the resistance is from synovial fluid. Proceed with injection.
- B. The needle tip is contacting articular cartilage or the medial femoral condyle — withdraw the needle 1–2 mm and redirect slightly anteriorly and laterally.
- C. The needle has entered the pes anserine bursa — this is an acceptable alternate target; proceed.
- D. The resistance is from the medial collateral ligament — redirect the needle 1 cm more posteriorly.

Correct answer: B.

Feedback:

- A. Incorrect. Correct intra-articular placement is characterized by minimal resistance and smooth injection. Sharp focal pain with firm resistance indicates contact with a solid structure, most commonly articular cartilage.
- B. Correct. Contact with articular cartilage — either the patellar undersurface or the medial femoral condyle — produces sharp pain and firm resistance. The correct maneuver is to withdraw 1–2 mm and redirect slightly anteriorly and laterally to navigate the needle into the joint space rather than onto the cartilage surface.
- C. Incorrect. The pes anserine bursa is located 2–3 cm distal to the medial joint line, well below the midpatellar insertion point. The needle in this scenario is not at the pes anserine location.
- D. Incorrect. Redirecting more posteriorly would increase the likelihood of contacting the femoral condyle or the posterior capsule — not resolve the problem.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: *Assessment type: Formative. References: 1, 2, 3.*

Slide 16: Knee Sonoanatomy: Suprapatellar Approach

Objective: Learners will identify the sonoanatomical landmarks for the suprapatellar knee injection approach and describe how ultrasound guidance improves accuracy in difficult cases.

Visual / Background

[Case Study] Diana's injection proceeds well via the medial midpatellar approach with good flow. You reflect that for your next knee patient — a 74-year-old man with severe OA, a large knee effusion, and difficulty extending his knee — you would prefer a suprapatellar ultrasound-guided approach to confirm needle placement in the joint fluid.

[Visual Description] Longitudinal ultrasound image of the suprapatellar region with probe in sagittal plane showing: quadriceps tendon (hyperechoic, fibrillar), suprapatellar pouch (anechoic, fluid-filled in effusion), prefemoral fat pad, and distal femoral cortex. Probe position diagram on patient silhouette.

Possible Image Labeled: Image 16, Image credit: AI-generated

Actions

Interactive animation: Learner clicks 'Scan' to watch probe placement over the suprapatellar region.

Ultrasound image displays with progressive labeling as narration proceeds.

Toggle: 'No effusion / With effusion' to compare sonoanatomy in both states.

Narration

The suprapatellar approach is one of the most accurate and forgiving knee injection techniques, particularly for patients with effusion.

To obtain the suprapatellar ultrasound view, place the probe in the sagittal plane over the anterior distal thigh, just proximal to the superior pole of the patella. The probe should be aligned with the quadriceps tendon. On this view you will see the quadriceps tendon as a bright, fibrillar structure anteriorly. Deep to it is the suprapatellar pouch — the proximal extension of the knee joint synovial cavity.

In a normal knee, the suprapatellar pouch may appear as a thin compressed space or may not be easily visualized. In a knee with effusion — which is common in OA, inflammatory arthritis, and post-traumatic knees — the pouch fills with anechoic fluid and becomes clearly visible as a dark, fluid-filled pocket between the quadriceps tendon and the prefemoral fat pad.

The prefemoral fat pad is a hyperechoic structure deep to the pouch that sits adjacent to the distal femoral cortex. It appears brighter than fluid and helps distinguish the bottom of the pouch from the fat pad.

Student Actions

For injection, the needle is inserted in-plane from the lateral or medial aspect, targeting the anechoic fluid-filled space. In patients with effusion, a small amount of fluid aspiration before injection confirms correct placement. In dry knees, a small test injection of saline can be used to confirm that the solution distends the pouch rather than spreading as a soft tissue bleb.

Learner reads case study. Clicks Continue to begin narration.
Learner must interact with both effusion toggle states before advancing.

Developer Notes: References: 2, 3, 6. Key teaching point: suprapatellar US approach is highly accurate and forgiving — preferred for obese patients and those with significant effusion.

Slide 17: Knowledge Check 5 — Knee Sonoanatomy

Objective: Learners will identify the sonoanatomical landmarks for the suprapatellar knee injection approach and describe how ultrasound guidance improves accuracy in difficult cases.

Visual / Background

Display an unlabeled suprapatellar longitudinal ultrasound image for visual reference during the question.

Possible Image Labeled: Image 17, Image credit: AI-generated

Actions

A provider is performing an ultrasound-guided suprapatellar knee injection on a patient with a large knee effusion. The probe is placed in the sagittal plane over the anterior distal thigh. On the ultrasound image, a large anechoic space is visible deep to the quadriceps tendon. Which structure does this represent, and is it the correct injection target?

- A. The prefemoral fat pad — do not inject here, redirect the needle distally.
- B. The suprapatellar pouch — yes, this is the correct injection target; advance the needle in-plane into the anechoic space.
- C. The patellar tendon bursa — acceptable secondary target if joint access is difficult.
- D. The distal quadriceps muscle belly — this is a hematoma; do not inject.

Correct answer: B.

Feedback:

A. Incorrect. The prefemoral fat pad is a hyperechoic (bright) structure, not anechoic. A large anechoic space in this location represents fluid-filled synovial space, not fat.

B. Correct. The large anechoic space deep to the quadriceps tendon and superficial to the prefemoral fat pad is the fluid-filled suprapatellar pouch — the proximal extension of the knee joint cavity. This is the correct target for intra-articular injection. Aspiration of synovial fluid before injection further confirms correct placement.

C. Incorrect. The patellar tendon bursa is located inferior to the patella, not proximal to it. It is not visualized in the suprapatellar view.

D. Incorrect. Hematoma would have a heterogeneous, mixed echotexture, not a simple anechoic appearance. The location — deep to the quadriceps tendon in a patient with known joint effusion — makes synovial fluid the overwhelmingly likely diagnosis.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: *Formative*. References: 2, 3, 6.

Slide 18: Surface Landmarks of the Hip

Objective: Learners will accurately identify the surface landmarks of the hip and correctly associate each with the underlying bony and soft tissue anatomy relevant to injection procedures.

Visual / Background

[Case Study] Your final patient of the morning is Patricia, a 72-year-old woman with severe right hip OA who presents for an intra-articular hip injection. You position her supine on the exam table. The hip is the deepest and most anatomically challenging of the three joints you will inject today.

[Visual Description] Anterior and lateral views of the hip region with labeled surface landmarks: anterior superior iliac spine (ASIS), inguinal ligament, femoral artery (palpable pulse), greater trochanter, and the femoral triangle (bordered by inguinal ligament, sartorius, and adductor longus). Labels appear sequentially as narration progresses.

Possible Image Labeled: Image 18, Image credit: AI-generated

Actions

Student reads case study. Continue button under case study. Once clicked, narration starts and labels appear sequentially on image.

Landmarks to label:

- Anterior superior iliac spine (ASIS)
- Inguinal ligament
- Femoral artery (femoral pulse)
- Greater trochanter
- Femoral triangle

Narration

The hip is anatomically the most challenging of the three joints we are covering, primarily because the femoral head sits deep to multiple layers of soft tissue and cannot be directly palpated. We rely on surface landmarks to orient us and then on imaging — fluoroscopy or ultrasound — to confirm needle placement.

The anterior superior iliac spine is the most important starting landmark. It is easily palpated at the anterolateral corner of the pelvis and serves as the superior lateral anchor for all anterior hip approaches. The inguinal ligament runs from the ASIS to the pubic tubercle, forming the floor of the abdominal wall and the roof of the femoral triangle.

The femoral artery is palpated at the femoral triangle, which is the triangular depression formed by the inguinal ligament superiorly, the sartorius laterally, and the adductor longus medially. The femoral artery, vein, and nerve pass through this triangle from medial to lateral in the order VAN — vein, artery, nerve. The artery is approximately 2

	to 3 centimeters below the midpoint of the inguinal ligament. This is a critical landmark because it defines the medial danger zone — needle placement medial to the artery risks femoral vein or nerve injury. The greater trochanter is the large lateral bony prominence of the proximal femur. It is the anchor point for the gluteus medius and minimus tendons superiorly and marks the attachment of the iliotibial band. It is the key landmark for lateral hip approaches including greater trochanteric bursa injection.
Student Actions	Learner reads case study. Clicks Continue to begin narration. Labels appear sequentially on image as narration progresses.
<i>Developer Notes: References: 1, 2, 5. Key teaching point: femoral neurovascular bundle defines the medial danger boundary for anterior hip injection.</i>	

Slide 19: Bony Architecture of the Hip Joint

Objective: Learners will describe the bony anatomy of the hip joint including the acetabulum, femoral head, and femoral neck, and explain how this anatomy defines needle trajectory and depth for intra-articular injection.

Visual / Background

[Case Study] With your surface landmarks confirmed and the femoral pulse palpated, you plan your needle insertion point. You remind yourself that the femoral head is significantly deeper than a knee or shoulder injection — typically 4 to 8 cm from the skin in a normal-BMI patient and even deeper in obesity.

[Visual Description] Coronal and axial cross-sectional diagrams of the hip joint showing: acetabulum (labrum, articular cartilage), femoral head (fovea capitis, articular cartilage), femoral neck (with neck-shaft angle labeled), joint capsule, ligamentum teres, and the anterior joint space (the primary injection target). Depth scale on lateral diagram showing approximate 4–8 cm skin-to-joint distance.

Possible Image Labeled: Image 19, Image credit: AI-generated

Actions

Structure labels highlight as each is mentioned in narration.
Animation shows needle advancing from skin surface to anterior joint space, with depth marker.

Narration

The hip is a ball-and-socket joint with inherently high bony stability — the deep acetabular socket and the strong ligamentous capsule make it far more constrained than the shoulder.

The acetabulum is the cup-shaped socket of the pelvis. It is deepened by the acetabular labrum — a fibrocartilaginous rim that extends the socket depth and seals the joint. The labrum is a potential pain generator in labral tears, which may present similarly to hip OA.

The femoral head is the rounded proximal end of the femur. It articulates with the acetabulum and is covered with hyaline cartilage except at the fovea capitis, where the ligamentum teres attaches. The fovea is the round pit visible on the medial femoral head.

The femoral neck connects the head to the shaft at the neck-shaft angle, which averages approximately 120 to 135 degrees in adults. Changes in this angle — coxa valga or coxa vara — alter the biomechanics of the hip and can affect the geometry of injection approaches.

The joint capsule is a strong, fibrous sleeve surrounding the joint from the acetabular rim to the intertrochanteric line anteriorly and just proximal to the lesser trochanter posteriorly. The capsule is reinforced by three major ligaments: the iliofemoral, pubofemoral, and

ischiofemoral. The anterior joint space — between the capsule and the femoral head anteriorly — is the primary target for intra-articular hip injection via an anterior approach.

Student Actions

Learner reads case study. Clicks Continue to begin narration.

Learner must watch depth animation before advancing.

Developer Notes: References: 1, 2, 5. Key teaching point: the anterior joint space, not the femoral head surface, is the injection target.

Slide 20: Knowledge Check 6 — Hip Bony Architecture

Objective: Learners will describe the bony anatomy of the hip joint including the acetabulum, femoral head, and femoral neck, and explain how this anatomy defines needle trajectory and depth for intra-articular injection.

Visual / Background

No background image needed.

Actions

During a landmark-guided anterior hip injection, a provider inserts the needle 2 cm lateral to the femoral pulse and 2 cm distal to the inguinal ligament, directed posterolaterally. The needle is advanced to 6 cm depth, at which point firm resistance is encountered. What is the most likely structure the needle has contacted?

- A. The acetabular labrum
- B. The ligamentum teres
- C. The femoral neck or femoral head cortex
- D. The joint capsule

Correct answer: C.

Feedback:

A. Incorrect. The acetabular labrum is inside the joint, accessible only after successfully entering the joint capsule. Firm resistance at 6 cm without joint entry more likely represents cortical bone.

B. Incorrect. The ligamentum teres is inside the joint, attaching at the fovea capitis. It cannot be contacted before entering the joint space.

C. Correct. Firm resistance at 6 cm depth during a correctly directed anterior hip injection most commonly represents the cortex of the femoral neck or femoral head. The injection target is the anterior joint space — the recess between the femoral head and the capsule. Contacting bone indicates the needle needs to be redirected slightly to slip into the joint recess.

D. Incorrect. The joint capsule is a fibrous sleeve that typically yields to needle pressure without the firm resistance of cortical bone. Crossing the capsule may produce a slight pop, but not the firm, unyielding resistance of bone.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: Formative. References: 1, 2, 5.

Slide 21: Periarticular Soft Tissue of the Hip: Bursae and Tendons

Objective: Learners will identify the major periarticular soft tissue structures of the hip including the greater trochanteric bursa, gluteal tendons, and iliopsoas bursa, and describe each as a potential injection target.

Visual / Background

[Case Study] While reviewing Patricia's imaging, you notice her MRI also shows thickening of the gluteal tendons at the greater trochanter with adjacent bursal fluid. She reports lateral hip pain as well as her groin pain. You note this as a potential secondary injection target in addition to the intra-articular joint.

[Visual Description] Lateral and anterior views of the proximal hip showing: gluteus medius and minimus tendons at the greater trochanter footprint, the subgluteal bursae (subgluteus medius and subgluteus minimus), the iliopsoas tendon and iliopsoas bursa (anterior to joint capsule), and the iliotibial band.

Possible Image Labeled: Image 21, Image credit: AI-generated

Actions

Sidebar panel: Learner clicks each structure name to reveal a close-up inset and clinical description.

Labels highlight as each is mentioned in narration.

Narration

The periarticular soft tissues of the hip contain several important injection targets.

The greater trochanteric region is one of the most commonly injected areas in musculoskeletal medicine. The greater trochanter serves as the insertion site for the gluteus medius and gluteus minimus tendons. The gluteus medius inserts on the lateral and superoposterior facets of the greater trochanter. The gluteus minimus inserts anteriorly. Degenerative tendinopathy and partial tears at this insertion — previously labeled trochanteric bursitis but more accurately termed greater trochanteric pain syndrome — are extremely common, particularly in middle-aged women.

The bursae in this region are the subgluteus medius bursa, located between the gluteus medius tendon and the greater trochanter, and the subgluteus minimus bursa, located between the gluteus minimus tendon and the anterior greater trochanter. These are distinct from the much larger trochanteric bursa described in older texts, which lies superficial to the gluteal tendons.

The iliopsoas bursa is the largest bursa in the body and lies deep to the iliopsoas tendon on the anterior hip, directly anterior to the hip joint capsule. It communicates with the hip joint in approximately 15 percent of adults. Iliopsoas tendinopathy and bursitis produce anterior groin

pain or snapping and are injection targets for ultrasound-guided procedures.

The iliotibial band runs from the ilium along the lateral thigh to Gerdy's tubercle on the tibia. It does not attach to the greater trochanter but glides over it, and IT band syndrome can produce lateral hip-thigh pain that is distinct from trochanteric bursitis.

Student Actions

Learner reads case study. Clicks Continue to begin narration.

Learner clicks each structure in sidebar to view insets. Must view all before advancing.

Developer Notes: References: 1, 2, 5, 7. Key teaching point: 'trochanteric bursitis' is more accurately greater trochanteric pain syndrome involving the gluteal tendons.

Slide 22: Anterior Hip Injection Approach

Objective: Learners will describe the landmark-guided needle trajectory for the anterior hip injection approach and identify the anatomical boundaries that define safe needle placement.

Visual / Background

[Case Study] You decide to proceed with an ultrasound-guided anterior hip injection for Patricia, given the depth of the joint and her BMI of 29. However, you want to understand the landmark-guided approach fully before reviewing the ultrasound technique.

[Visual Description] Anterior view of the hip showing landmark-guided anterior approach: ASIS, inguinal ligament, femoral pulse marked. Needle insertion point shown 2–3 cm lateral to femoral pulse and 2–3 cm distal to inguinal ligament. Needle trajectory directed posterolaterally toward the anterior joint space. Danger zone annotation: medial boundary = femoral artery.

Possible Image Labeled: Image 22, Image credit: AI-generated

Actions

Animation: Needle trajectory from skin to joint space plays when learner clicks 'Show approach'.

Red zone highlights the medial danger boundary (femoral neurovascular bundle) during animation.

Narration

The anterior approach is the most commonly used landmark-guided technique for intra-articular hip injection.

The patient is positioned supine with the leg in neutral rotation. Identify the anterior superior iliac spine and the femoral artery pulse. The insertion point is approximately 2 to 3 centimeters lateral to the femoral pulse and 2 to 3 centimeters distal to the midpoint of the inguinal ligament. At this insertion point, the needle should be directed posterolaterally and slightly superiorly, aiming toward the junction of the femoral head and neck.

The femoral artery defines the medial safety boundary. The needle must always remain lateral to the palpated pulse. Medial placement risks femoral vein or artery puncture and femoral nerve injury. The femoral nerve lies just lateral to the artery — so staying too lateral can also cause nerve contact, which manifests as sharp radiating pain down the thigh.

Depth to the anterior joint space varies considerably by patient habitus. In a normal-BMI adult, depth is typically 4 to 6 centimeters. In patients with higher BMI, depths of 8 to 10 centimeters are common, which is why landmark guidance alone frequently fails and ultrasound or fluoroscopic guidance is strongly recommended for hip injection.

	Correct intra-articular placement is confirmed by smooth injection without resistance. Resistance typically indicates the needle tip is within the joint capsule wall or pressing against bone — retract 1 to 2 mm and retry before injecting.
Student Actions	Learner reads case study. Clicks Continue to begin narration. Learner activates animation and must see danger zone before advancing.
Developer Notes: References: 1, 2, 5. Clinical pearl: landmark-guided hip injection accuracy is below 50% in obese patients — imaging guidance is strongly recommended.	

Slide 23: Hip Sonoanatomy: Anterior Joint Space and Greater Trochanter

Objective: Learners will identify the sonoanatomical landmarks for ultrasound-guided anterior hip injection and greater trochanteric bursa injection.

Visual / Background

[Case Study] You place the ultrasound probe over the anterior hip in a longitudinal plane along the femoral neck. The joint space comes into view. You also scan the lateral hip to confirm the greater trochanteric anatomy before planning a secondary injection.

[Visual Description] Two ultrasound panels:

1. Anterior longitudinal view: femoral neck (hyperechoic, oblique), femoral head (hyperechoic dome), anterior joint capsule (hyperechoic fibrous layer), anterior synovial recess (anechoic space between capsule and neck), and iliopsoas muscle/tendon anterior to the capsule.

2. Lateral view over greater trochanter: greater trochanteric cortex, gluteus medius tendon (fibrillar, hyperechoic), subgluteus medius bursa (thin stripe or fluid pocket), iliotibial band.

Possible Image Labeled: Image 23, Image credit: AI-generated

Actions

Interactive animation: Probe slides from ASIS distally to view anterior joint space.

Second animation: Probe moves laterally to view greater trochanter.

Learner must view and label both views before advancing.

Narration

For ultrasound-guided anterior hip injection, place the probe in the longitudinal oblique plane aligned with the femoral neck, with the probe positioned over the anterior hip. Adjust until you can see the curvilinear hyperechoic line of the femoral neck extending to the round dome of the femoral head.

Deep to the iliopsoas muscle and tendon, you will see the anterior joint capsule as a bright fibrous layer overlying the femoral neck. The anterior synovial recess — your injection target — is the anechoic space between this capsule and the femoral neck. In a normal hip this recess may be very thin. In a hip with OA and synovitis, the recess may be distended with fluid.

The needle is inserted in-plane from lateral to medial, directed toward the anterior synovial recess. A small test injection of saline confirms correct placement by distending the recess. If the saline distributes as a soft tissue bleb rather than distending the recess, the needle is not in the joint.

For the greater trochanteric bursa, place the probe in the coronal plane over the greater trochanter. You will see the bright hyperechoic cortex

	of the trochanter, the overlying gluteus medius tendon with its fibrillar texture, and — if inflamed — the subgluteus medius bursa as a hypoechoic or fluid-filled pocket between the tendon and the trochanter. The needle is inserted in-plane targeting this bursal space.
Student Actions	Learner reads case study. Clicks Continue to begin narration. Learner must interact with both animations and label both views before advancing.
Developer Notes: References: 2, 5, 6, 7. Key teaching point: in-plane visualization of needle tip in the anterior synovial recess confirms correct hip injection placement.	

Slide 24: Knowledge Check 7 — Hip Injection Anatomy

Objective: Learners will identify the sonoanatomical landmarks for ultrasound-guided anterior hip injection and greater trochanteric bursa injection.

Visual / Background

No background image needed.

Actions

A provider is performing an ultrasound-guided anterior hip injection. The probe is in the longitudinal oblique plane over the anterior hip, aligned with the femoral neck. The provider inserts the needle in-plane and injects 1 mL of saline. The ultrasound image shows the saline spreading as a soft tissue bleb just anterior to the joint capsule, without distending the synovial recess. What does this finding indicate?

- A. Correct intra-articular placement — the recess is too narrow in this patient to visibly distend.
- B. The needle tip is anterior to the joint capsule, within the iliopsoas or surrounding soft tissue — the needle needs to be advanced deeper into the synovial recess.
- C. The recess is communicating with the iliopsoas bursa — this is an acceptable injection result.
- D. The saline is too cold and will redistribute once it warms — proceed with corticosteroid injection.

Correct answer: B.

Feedback:

- A. Incorrect. Correct intra-articular placement shows saline distending the synovial recess as a visible anechoic expansion deep to the capsule. A soft tissue bleb anteriorly means the needle is in front of the capsule, not inside the joint.
- B. Correct. Saline spreading as a soft tissue bleb anterior to the capsule means the needle tip is in the soft tissue anterior to the joint capsule — likely in the iliopsoas muscle or overlying fat. The needle needs to be advanced deeper, through the capsule, into the synovial recess. Repeat the test injection once the tip position is adjusted.
- C. Incorrect. Although the iliopsoas bursa communicates with the hip joint in a minority of patients, a soft tissue bleb does not indicate bursal filling — it indicates an extracapsular injection. Proceeding with corticosteroid injection at this location would place the drug in soft tissue, not the joint.
- D. Incorrect. Temperature does not affect the distribution pattern of saline on ultrasound. A bleb is a bleb regardless of temperature.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: *Formative*. References: 2, 5, 6.

Slide 25: Anatomical Variation and Its Clinical Impact

Objective: Learners will identify three anatomical variations that affect joint injection accuracy — obesity, osteoarthritis, and prior surgery — and describe how each requires modification of technique.

Visual / Background

[Case Study] You successfully complete Patricia's hip injection under ultrasound guidance. As you debrief, you reflect that all three of today's patients had factors that modified your approach: Marcus's BMI and rotator cuff pathology, Diana's grade III OA, and Patricia's depth. You think about how anatomical variation is not the exception — it is the rule.

[Visual Description] Three-panel comparison showing the same joint (shoulder, knee, hip) in both standard anatomy and modified anatomy:

1. Obesity: Increased soft tissue depth obscuring bony landmarks
2. OA/joint narrowing: Reduced joint space making needle entry more difficult
3. Post-surgical anatomy: Hardware or scar tissue altering normal tissue planes

Possible Image Labeled: Image 25, Image credit: AI-generated

Actions

Toggle between normal and modified anatomy views for each panel when learner clicks each condition.

Narration plays after Continue click.

Narration

Anatomical variation is one of the most important and underappreciated sources of injection failure. Let's review the three most common modifiers.

Obesity increases soft tissue depth and obscures bony landmarks that are normally palpable. In patients with a BMI above 35, the subacromial space may be undetectable by palpation, the knee joint line may be obscured by a pannus of soft tissue, and the hip joint may be 8 to 10 cm from the skin surface. In these patients, landmark-guided accuracy drops significantly, and ultrasound guidance becomes not just preferable but often necessary.

Severe osteoarthritis changes the architecture of the joint space itself. In grade III to IV knee OA, the medial joint space may be nearly obliterated, making midpatellar approaches that target the medial compartment unreliable. A suprapatellar approach to the suprapatellar pouch, which is less affected by compartment narrowing, may be more reliable. Similarly, in severe hip OA, the anterior joint recess may be very thin and difficult to enter — ultrasound guidance helps identify any residual fluid and target needle placement precisely.

Prior surgery alters normal tissue planes. Scar tissue can make a subacromial space injection feel like tendon throughout, making loss-of-resistance unreliable. Surgical hardware can block normal needle trajectories, and post-arthroplasty anatomy requires specialized approaches. Always review prior surgical records and imaging before injecting a joint with a history of surgery.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Learner toggles each variation panel before advancing.

Developer Notes: References: 2, 3, 5, 6. Key teaching point: anatomical variation is the rule, not the exception — always adapt technique to the patient.

Slide 26: Knowledge Check 8 — Anatomical Variation

Objective: Learners will identify three anatomical variations that affect joint injection accuracy — obesity, osteoarthritis, and prior surgery — and describe how each requires modification of technique.

Visual / Background

No background image needed.

Actions

Arrange the following clinical scenarios from the setting where landmark-guided injection is MOST likely to be accurate to LEAST likely accurate:

1. A 34-year-old female with BMI of 22, no prior surgery, mild knee synovitis
2. A 68-year-old male with BMI of 38, severe hip OA, prior hip arthroscopy
3. A 55-year-old male with BMI of 27, moderate shoulder OA, intact rotator cuff
4. A 71-year-old female with BMI of 41, grade IV knee OA, prior knee replacement

Correct order (most to least accurate): 1, 3, 2, 4

Feedback:

1. Correct most accurate: Normal BMI, no surgery, mild pathology — ideal anatomy for landmark-guided injection. Bony landmarks are palpable and tissue planes are normal.
3. Second: Moderate BMI, moderate OA, intact cuff — reasonable landmark accessibility, though moderate OA slightly reduces joint space access.
2. Third: Elevated BMI + severe OA + prior surgery — triple compounding factors. Any one of these alone reduces accuracy; all three together make ultrasound guidance highly advisable.
4. Least accurate: Total knee replacement — the normal joint anatomy no longer exists. Landmark-guided injection post-arthroplasty is unreliable and ultrasound or fluoroscopic guidance is standard.

Narration

[No narration during question — learner-directed activity]

Student Actions

Ranking/sequencing interaction: Learner drags scenarios from most to least likely accurate.

Student must answer correctly to move on.

Developer Notes: Assessment type: Formative. References: 2, 3, 5.

Slide 27: Tissue Layers and Needle Pathway: Shoulder

Objective: Learners will correctly sequence the tissue layers encountered during a lateral subacromial injection from skin to target space in correct anatomical order.

Visual / Background

[Case Study] You perform a second shoulder injection the following week — this time on a patient with adhesive capsulitis requiring a glenohumeral injection. As you prepare, you mentally walk through each tissue layer your needle will encounter from skin to target.

[Visual Description] Sagittal cross-section of the lateral shoulder showing the posterior midline needle path for lateral subacromial approach with the following labels available:

1. Skin
2. Subcutaneous tissue
3. Deltoid muscle
4. Deltoid fascia / subdeltoid fat
5. Subacromial-subdeltoid bursa
6. Supraspinatus tendon

Possible Image Labeled: Image 27, Image credit: AI-generated

Actions

Interactive image: Learner arranges anatomical layers in correct order from superficial to deep before being able to move on.

Narration

Let's put together the layer-by-layer anatomy for the lateral subacromial approach.

The first layer encountered is the skin, which varies in thickness by patient and body region. Deep to the skin is the subcutaneous adipose tissue, which in obese patients may occupy several centimeters before reaching the deltoid fascia.

Next is the deltoid muscle. The deltoid is a large, thick muscle overlying the shoulder. In the lateral subacromial approach, the needle enters the anterior or posterolateral deltoid and must pass through it to reach deeper structures. The deltoid is typically 1 to 3 cm thick at the injection site.

Deep to the deltoid, a thin layer of deltoid fascia separates the muscle from the subdeltoid fat and bursal space. The subacromial-subdeltoid bursa lies immediately deep to this fascia. In inflamed bursitis, this is where you will encounter fluid and reduced resistance.

The supraspinatus tendon is the next structure deep to the bursa. This is the structure you want to avoid injecting into. If resistance increases

Student Actions

as the needle advances past the bursal space, the tip is likely entering the rotator cuff tendon. Withdraw and redirect superiorly.

Learner reads case study. Clicks Continue to begin narration.

Learner arranges anatomical layers in correct order from superficial to deep before being able to move on.

Developer Notes: References: 1, 2, 4. Mirrors the needle pathway sequencing format of the original OB module.

Slide 28: Knowledge Check 9 — Shoulder Layer Sequence

Objective: Learners will correctly sequence the tissue layers encountered during a lateral subacromial injection from skin to target space in correct anatomical order.

Visual / Background

During a lateral subacromial injection, arrange the following structures in correct order from most superficial to deepest as the needle advances from skin to the subacromial bursa.

Actions

Sequencing interaction. Learner arranges these five items in correct order from superficial to deep:

Correct order:

1. Skin
2. Subcutaneous tissue
3. Deltoid muscle
4. Deltoid fascia
5. Subacromial-subdeltoid bursa

Feedback:

Skin is the first layer encountered. Subcutaneous tissue lies immediately beneath the dermis. The deltoid muscle is the dominant soft tissue layer and is 1–3 cm thick at the injection site. The deltoid fascia is a thin fibrous layer deep to the deltoid that separates the muscle from the bursal space. The subacromial-subdeltoid bursa is the target space, lying between the deltoid fascia and the supraspinatus tendon.

Narration

[No narration during question — learner-directed activity]

Student Actions

Sequencing interaction: Learner arranges five items in correct order from superficial to deep.

Student must answer correctly to move on.

Developer Notes: Assessment type: Formative. References: 1, 2, 4. Directly tests the core objective: sequencing the needle pathway.

Slide 29: Tissue Layers and Needle Pathway: Knee and Hip

Objective: Learners will correctly sequence the tissue layers encountered during medial midpatellar knee injection and anterior hip injection from skin to target space.

Visual / Background

[Case Study] Having reviewed the shoulder layers, you compare the knee and hip pathways — each has a distinct layer-by-layer anatomy, different depths, and different resistance signatures that guide technique.

[Visual Description] Two side-by-side cross-sectional diagrams:
Left — Axial cross-section of the knee at the patellar level showing medial midpatellar approach layers: skin, subcutaneous tissue, medial retinaculum, joint capsule, intra-articular space
Right — Coronal/sagittal cross-section of the anterior hip showing: skin, subcutaneous tissue, iliopsoas muscle/tendon, joint capsule, anterior synovial recess

Possible Image Labeled: Image 29, Image credit: AI-generated

Actions

Interactive comparison: Two drag-and-drop sequencing panels — one for knee, one for hip — displayed side by side.

Learner must sequence both pathways correctly to advance.

Narration

Let's compare the needle pathway layer sequences for the knee and hip.

For the medial midpatellar knee injection, the layers from superficial to deep are: skin, subcutaneous tissue, medial retinaculum, joint capsule, and intra-articular space. The medial retinaculum is a fibrous condensation of the joint capsule medially — it is thinner than the ligamentum flavum but provides a slight resistance change before entering the joint. Correct intra-articular placement typically produces smooth, low-resistance injection as the joint cavity accepts the volume.

For the anterior hip injection, the layers are: skin, subcutaneous adipose tissue, iliopsoas muscle and tendon, joint capsule, and anterior synovial recess. The iliopsoas is the dominant soft tissue layer — it is a large, bulky muscle-tendon complex that must be traversed to reach the hip joint. The joint capsule is thicker than in the knee, and passing through it may produce a tactile pop. The anterior synovial recess is the target — a potential space that expands with injection.

In summary: the knee has a relatively short, predictable pathway with a modest retinaculum layer; the hip has a longer pathway through the iliopsoas before reaching the capsule and recess. Both require low-resistance injection as confirmation of correct placement.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Learner must correctly sequence both the knee and hip pathways to advance.

Developer Notes: References: 1, 2, 3, 5.

Slide 30: Peripheral Nerve Anatomy Relevant to Joint Injection

Objective: Learners will identify the peripheral nerves adjacent to the shoulder, knee, and hip injection sites and describe how inadvertent nerve contact or injection manifests clinically.

Visual / Background

[Case Study] During a hip injection training session, a junior resident reports that a patient experienced a sharp shooting pain down the anterior thigh during needle insertion. You recognize this as a sign of femoral nerve contact and use it as a teaching moment on the peripheral nerve anatomy at injection sites.

[Visual Description] Three annotated diagrams showing peripheral nerve positions at each joint:

1. Shoulder: axillary nerve (posterior), musculocutaneous nerve (anterior), brachial plexus cords (medial)
2. Knee: common peroneal nerve (posterior lateral), saphenous nerve (medial), popliteal neurovascular bundle (posterior)
3. Hip: femoral nerve (lateral to artery), lateral femoral cutaneous nerve (medial to ASIS), sciatic nerve (posterior)

Possible Image Labeled: Image 30, Image credit: AI-generated

Actions

Learner clicks each joint tab to view the nerve anatomy diagram and read the clinical description.

Must view all three joints before advancing.

Narration

Understanding the peripheral nerve anatomy adjacent to injection sites is essential for avoiding neurological complications.

At the shoulder, the axillary nerve is the most clinically significant. It exits the posterior cord of the brachial plexus and wraps around the posterior surgical neck of the humerus, traveling through the quadrilateral space. The posterior glenohumeral approach needle must be directed medially to avoid contacting the axillary nerve laterally at the humeral neck. The musculocutaneous nerve enters the coracobrachialis medially and must be respected during anterior approaches that stray medially of the coracoid.

At the knee, the common peroneal nerve wraps around the fibular neck laterally and is vulnerable during lateral knee procedures. The saphenous nerve — the terminal sensory branch of the femoral nerve — runs along the medial aspect of the knee. Posterior knee approaches are rarely performed for injection, but the popliteal neurovascular bundle defines the posterior danger zone.

At the hip, the femoral nerve lies lateral to the femoral artery in the femoral triangle. As mentioned, staying lateral to the artery does not guarantee nerve safety — the nerve is also lateral to the artery. The

Student Actions

landmark to remember is that both the nerve and artery lie lateral to the vein; the nerve is the most lateral structure. The lateral femoral cutaneous nerve exits medial to the ASIS and can be compressed or injured by overly medial needle placement. The sciatic nerve is posterior and is not at risk in anterior hip approaches.

Learner reads case study. Clicks Continue to begin narration.
Learner must click all three joint tabs and view nerve diagrams before advancing.

Developer Notes: References: 1, 2, 5. Key teaching point: nerve contact produces sharp radiating paresthesia — withdraw immediately and redirect.

Slide 31: Vascular Anatomy and Avoidance at Injection Sites

Objective: Learners will identify the major vascular structures adjacent to shoulder, knee, and hip injection sites and describe how inadvertent vascular injection manifests and is prevented.

Visual / Background

[Case Study] During a subacromial injection, you notice that the syringe shows blood flashback when you pull back slightly on the plunger before injecting. You recognize this immediately and redirect the needle. This brief aspiration test — though its reliability is debated — remains part of your standard technique.

[Visual Description] Three diagrams showing vascular structures at each injection site:

1. Shoulder: anterior circumflex humeral artery (anterior glenohumeral approach), posterior circumflex humeral artery (posterior approach), thoracoacromial artery (lateral subacromial)
2. Knee: geniculate arteries (medial and lateral, ring around joint), popliteal artery (posterior)
3. Hip: femoral artery and vein (anterior), medial and lateral circumflex femoral arteries

Possible Image Labeled: Image 31, Image credit: AI-generated

Actions

Learner clicks each vascular structure in an interactive diagram to view a tooltip with its location and clinical relevance.

Must interact with all structures before advancing.

Narration

Let's review the vascular anatomy at each injection site.

At the shoulder, the anterior circumflex humeral artery wraps around the surgical neck of the humerus and is in proximity to the anterior glenohumeral approach. The posterior circumflex humeral artery accompanies the axillary nerve through the quadrilateral space and is at risk with posterior approaches that are too inferolateral. The thoracoacromial artery's acromial branch passes through the coracoacromial ligament region and can be encountered during subacromial approaches.

At the knee, the geniculate arteries form a rich anastomotic ring around the joint. The superior medial, superior lateral, inferior medial, and inferior lateral geniculate arteries contribute to this network. Hemarthrosis after injection, while rare, typically reflects puncture of one of these vessels. The popliteal artery is posterior and not at risk from anterior or lateral approaches.

At the hip, the femoral artery and vein are the primary concern for the anterior approach, as previously discussed. The medial circumflex

femoral artery passes posteriorly around the femoral neck and provides most of the blood supply to the femoral head — it is not at risk from anterior approaches but is clinically important in the context of femoral neck fractures and avascular necrosis.

Aspiration before injection can detect vascular entry, but negative aspiration does not guarantee extravascular placement. Ultrasound guidance with Doppler can identify vascular structures in real time, which is the most reliable way to avoid them.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Learner must interact with all vascular structure tooltips before advancing.

Developer Notes: References: 1, 2, 5. Key teaching point: negative aspiration is reassuring but not definitive — US Doppler provides real-time vascular avoidance.

Slide 32: Knowledge Check 10 — Nerves, Vessels, and Complications

Objective: Learners will identify the peripheral nerves and vascular structures adjacent to injection sites and describe how complications manifest clinically.

Visual / Background

No background image needed.

Actions

A provider is performing a landmark-guided anterior hip injection. The needle is inserted 2 cm lateral to the femoral pulse. After advancing to 5 cm depth, the patient reports sharp, shooting pain radiating down the anterior thigh to the knee, followed by paresthesia in the medial leg. Which of the following best explains this finding?

- A. The needle has entered the hip joint space — the pain is from capsule distension, which is expected.
- B. The needle has contacted the femoral nerve, which lies lateral to the femoral artery — withdraw immediately and redirect.
- C. The needle has entered the femoral vein — aspirate to confirm and withdraw.
- D. The pain is referred from hip OA — this is a normal response and the injection can proceed.

Correct answer: B.

Feedback:

- A. Incorrect. Intra-articular needle placement produces a dull pressure sensation with distension, not sharp radiating pain with paresthesia. Sharp shooting pain with distal radiation is a nerve symptom, not a joint distension symptom.
- B. Correct. Sharp pain radiating down the anterior thigh (femoral nerve distribution) with medial leg paresthesia (saphenous nerve, the terminal sensory branch of the femoral nerve) indicates femoral nerve contact. The femoral nerve lies lateral to the femoral artery in the femoral triangle. Inserting 2 cm lateral to the artery does not guarantee nerve clearance. Withdraw immediately and redirect slightly more medially.
- C. Incorrect. Femoral vein entry produces no pain symptoms — the vein is medial to the artery, and this needle was placed lateral to the artery. Vascular entry is detected by blood flashback on aspiration, not by pain.
- D. Incorrect. Radiating paresthesia is never a normal response to joint injection. This finding requires immediate withdrawal and reassessment.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: *Formative*. References: 1, 2, 5.

Slide 33: Injectate Selection and Anatomical Considerations

Objective: Learners will explain how the choice of injectate (corticosteroid, hyaluronic acid, platelet-rich plasma) relates to target anatomy and how injectate volume affects injection planning.

Visual / Background

[Case Study] You prepare to inject 40 mg triamcinolone acetonide combined with 3 mL of 1% lidocaine for Diana's knee. You consider the volume — 4 mL total — and confirm this is appropriate for the knee joint cavity, which typically accommodates 4 to 8 mL comfortably.

[Visual Description] Table/diagram comparing three injectates across three joints — showing recommended volumes, anatomical rationale, and key clinical considerations for each combination.

Possible Image Labeled: Image 33, Image credit: AI-generated (interactive table)

Actions

Interactive table: Learner clicks each cell (injectate × joint) to expand clinical details and volume guidance.

Can only advance after viewing all cells.

Narration

The choice and volume of injectate must be tailored to the target anatomy.

Corticosteroids are the most commonly used injectates for inflammation-driven pathology. They reduce synovial inflammation, reduce bursal fluid production, and decrease pain. Volume considerations matter: for the subacromial bursa, 3 to 5 mL is typical; for the glenohumeral joint, 5 to 10 mL; for the knee, 4 to 8 mL; for the hip, 4 to 6 mL. Exceeding these volumes may increase intracapsular pressure uncomfortably and is not clinically beneficial.

Particulate corticosteroids — triamcinolone acetonide and methylprednisolone — have a longer duration of action but carry a higher risk of harm if inadvertently injected into a tendon. Soluble corticosteroids — dexamethasone — have a shorter duration of action but are considered safer for peritendinous use.

Hyaluronic acid viscosupplementation is used specifically for intra-articular knee and hip injection and requires correct intra-articular placement to be effective. It is not appropriate for bursae or tendon sheaths.

Platelet-rich plasma is increasingly used for tendons and joints. It requires precise delivery to the target tissue — intratendinous placement for tendon pathology, intra-articular for joint disease. Volume is typically 3 to 5 mL for large joints.

Student Actions

In all cases, confirming correct placement before injecting the full volume — with aspiration or a small saline test — reduces the risk of injectate being wasted in the wrong tissue layer.

Learner reads case study. Clicks Continue to begin narration.

Learner must view all table cells before advancing.

Developer Notes: References: 2, 3, 5, 8. Key teaching point: injectate choice and volume must be matched to the target space anatomy.

Slide 34: Confirming Correct Placement: Anatomical and Imaging Criteria

Objective: Learners will describe the anatomical and imaging-based criteria used to confirm correct intra-articular or intrabursal needle placement before injection.

Visual / Background

[Case Study] After advancing the needle into Diana's knee and before injecting, you aspirate 4 mL of straw-colored synovial fluid, confirming intra-articular placement. This step — confirmation before injection — is part of your standard protocol for every procedure.

[Visual Description] Comparison diagram showing three confirmation methods:

1. Landmark-guided: Smooth, low-resistance injection; negative aspiration
2. Ultrasound: Real-time visualization of needle tip in target space; saline test showing space distension
3. Fluoroscopy: Contrast injection confirming intra-articular distribution pattern

Possible Image Labeled: Image 34, Image credit: AI-generated

Actions

Learner clicks each confirmation method to expand a detailed description with pros and cons.

Must view all three before advancing.

Narration

Confirming correct needle placement before injecting therapeutic agents is a foundational safety principle.

For landmark-guided injections, the primary anatomical confirmation is tactile: smooth, low-resistance injection indicates the needle is in a fluid-capable space. Resistance suggests the needle is within a tendon, ligament, or pressed against cartilage. Aspiration prior to injection checks for blood, which would indicate vascular entry. However, negative aspiration and smooth injection are imperfect — they do not guarantee correct anatomical placement, particularly for deep joints like the hip.

Ultrasound confirmation uses real-time imaging. The needle tip should be visible within the target space. A test injection of 0.5 to 1 mL of normal saline should expand the target space — saline in the subacromial bursa distends the bursal stripe; saline in the knee expands the suprapatellar pouch; saline in the hip distends the anterior synovial recess. If the saline instead forms a soft tissue bleb or spreads diffusely, the needle is extracapsular or extrabursal.

Fluoroscopic confirmation uses a small volume of radiopaque contrast to map the distribution of injectate in real time. Correct intra-articular placement shows contrast outlining the joint contours. This method is

the gold standard for deep joints and joints with significant prior surgery, as it is not dependent on tissue echotexture or visualization through soft tissue.

All three methods have a role. The principle common to all is: confirm before you inject the full volume.

Student Actions

Learner reads case study. Clicks Continue to begin narration.

Learner must click and expand all three confirmation method panels before advancing.

Developer Notes: References: 2, 3, 5, 6. Key teaching point: all three confirmation methods share the same principle — confirm placement before full-volume injection.

Slide 35: Clinical Complications: Anatomy-Driven Risk Reduction

Objective: Learners will identify four injection-related complications — tendon damage, vascular entry, nerve injury, and infection — and describe how anatomical knowledge reduces the risk of each.

Visual / Background

[Case Study] At your department's quality review meeting, four injection-related adverse events are discussed from the past year: one case of patellar tendon rupture after inadvertent intratendinous injection, one episode of hemarthrosis after knee injection, one case of femoral nerve neuropraxia after hip injection, and one case of septic arthritis after shoulder injection. You reflect on how each could have been prevented.

[Visual Description] Four-panel infographic showing each complication:

1. Tendon damage: Cross-section showing needle within tendon vs. in adjacent space
2. Vascular entry: Diagram showing blood flashback on aspiration
3. Nerve injury: Diagram showing paresthesia distribution after nerve contact
4. Infection/septic arthritis: Image of infected joint with aseptic technique reminders

Possible Image Labeled: Image 35, Image credit: AI-generated

Actions

Learner clicks each complication panel to expand the full anatomy-based risk reduction description.

Must view all four panels before advancing.

Narration

Each major injection complication has an anatomical explanation and an anatomy-informed prevention strategy.

Tendon damage, including tendon rupture, results from direct intratendinous injection of corticosteroid. The mechanism is corticosteroid-induced collagen disruption. Prevention requires knowing exactly where the tendon is and maintaining needle tip position in the adjacent bursa or joint space — not within the fibrillar tendon substance. Resistance during injection is the key warning sign: stop, withdraw, and redirect before injecting any volume.

Vascular entry is prevented by understanding the neurovascular anatomy at each site and using aspiration before injection. For the shoulder, the thoracoacromial and circumflex humeral arteries are the primary risks. For the knee, the geniculate network. For the hip, the femoral artery and vein. Ultrasound with Doppler can identify vascular structures in real time.

Nerve injury results from direct needle trauma or intraneural injection. The warning sign is sharp, shooting pain or paresthesia during needle advancement — stop and withdraw immediately. Gentle needle placement with a small test advance before proceeding reduces this risk.

Septic arthritis after injection is uncommon but catastrophic. It is entirely preventable with strict aseptic technique: sterile gloves, betadine or chlorhexidine skin preparation, sterile needle and syringe, and avoidance of injecting through infected or inflamed skin. The anatomy of the joint capsule as a barrier to the sterile synovial space makes intact aseptic technique the only reliable prevention.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Learner must click and view all four complication panels before advancing.

Developer Notes: References: 2, 3, 5, 8. Key teaching point: every injection complication has an anatomy-informed prevention strategy.

Slide 36: Knowledge Check 11 — Complications and Anatomy

Objective: Learners will identify four injection-related complications and describe how anatomical knowledge reduces the risk of each.

Visual / Background

No background image needed.

Actions

A provider performs a subacromial injection and encounters significant resistance at 3 cm depth but proceeds with injection of the full 5 mL volume. Two weeks later, the patient presents with complete rupture of the supraspinatus tendon. Which anatomical error best explains this outcome?

- A. The needle entered the glenohumeral joint, causing steroid-induced cartilage damage and indirect tendon weakening.
- B. The needle tip was within the supraspinatus tendon at the time of injection, and intratendinous corticosteroid caused collagen disruption leading to rupture.
- C. The needle was placed in the subdeltoid fat pad, and the corticosteroid diffused into the tendon from there.
- D. The injection volume was too large, causing mechanical distension that tore the tendon.

Correct answer: B.

Feedback:

A. Incorrect. Glenohumeral intra-articular injection carries some risk of cartilage effects with repeated dosing, but does not explain acute tendon rupture at this timeframe. Additionally, the subacromial approach does not typically enter the glenohumeral joint in an intact rotator cuff.

B. Correct. Resistance during injection in a subacromial approach most commonly indicates the needle tip is within the supraspinatus tendon. Proceeding with injection despite resistance delivers corticosteroid directly into tendon collagen — a well-documented risk factor for tendon degeneration and rupture. The key anatomical lesson: resistance = intratendinous — stop, withdraw, redirect.

C. Incorrect. Diffusion from the subdeltoid fat pad does not deliver pharmacologically significant concentrations to the tendon in a way that causes rupture.

D. Incorrect. Mechanical distension from injection volume alone does not rupture a tendon. The mechanism is direct corticosteroid toxicity to collagen.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: Assessment type: *Formative*. References: 2, 5, 8.

Slide 37: Integrating Anatomy: Approach Selection Decision Framework

Objective: Learners will apply anatomical knowledge to select the most appropriate injection approach and guidance modality for a patient given their specific anatomy, pathology, and clinical context.

Visual / Background

[Case Study] You are now the supervising provider in a busy outpatient procedure suite. You have four patients scheduled: (1) a 40-year-old athlete with glenohumeral OA; (2) a 65-year-old with grade III knee OA and BMI of 39; (3) a 55-year-old with subacromial impingement and BMI of 22; (4) a 78-year-old with hip OA, prior hip arthroscopy, and BMI of 34. You must select the most appropriate approach and guidance method for each.

[Visual Description] Interactive case selection screen: Four patient cards, each with key clinical data. Learner selects approach and guidance method for each patient.

Possible Image Labeled: Image 37, Image credit: AI-generated

Actions

Interactive case selection: Learner reviews each patient card and selects (1) injection target, (2) approach, and (3) guidance method. For each case, correct and incorrect selections are highlighted with anatomy-based rationale.

All four cases must be completed before advancing.

Narration

Approach selection for joint injection is not algorithmic — it requires integrating anatomical knowledge with patient-specific factors.

For the 40-year-old athlete with glenohumeral OA: the target is the glenohumeral joint space. The posterior approach is favored because it is more accurate for joint entry than the anterior approach in most studies and avoids the anterior neurovascular structures. At a BMI of 22 with no complicating factors, landmark guidance is reasonable, though ultrasound can be used to confirm placement.

For the 65-year-old with grade III knee OA and high BMI: the target is the intra-articular space, but landmark accuracy will be reduced by the elevated BMI and the narrowed medial compartment. The suprapatellar approach, with ultrasound guidance, is preferred — it targets the suprapatellar pouch where compartment narrowing has less impact on access.

For the 55-year-old with subacromial impingement: target is the subacromial bursa. Normal BMI and no complicating factors make the lateral subacromial approach with landmark guidance straightforward.

For the 78-year-old with hip OA, prior arthroscopy, and moderate BMI: the combination of depth, prior surgery altering tissue planes, and moderate BMI all favor ultrasound or fluoroscopic guidance. Landmark-guided hip injection in this patient is not reliable.

Student Actions

Learner reads case study. Clicks Continue to begin narration.
Learner must complete all four case selections before advancing.

Developer Notes: References: 2, 3, 5, 6. Core integration slide — requires applying all module content to clinical decision-making.

Slide 38: Knowledge Check 12 — Final Integration Case

Objective: Learners will apply anatomical knowledge to select the most appropriate injection approach and guidance modality for a patient given their specific anatomy, pathology, and clinical context.

Visual / Background

No background image needed.

Actions

A 70-year-old male with a BMI of 44, severe right hip OA, and a history of prior right hip arthroscopy presents for an intra-articular hip injection. On physical exam, the femoral pulse is difficult to palpate. Which of the following approaches is most appropriate?

- A. Landmark-guided anterior approach — standard positioning is adequate for all hip injections.
- B. Ultrasound-guided or fluoroscopically guided anterior hip injection — obesity, prior surgery, and difficult landmark palpation all indicate imaging guidance.
- C. Lateral hip approach without imaging — this avoids the femoral neurovascular bundle entirely.
- D. Medial hip approach targeting the inguinal crease — easier in obese patients.

Correct answer: B.

Feedback:

A. Incorrect. Landmark-guided anterior hip injection in a patient with BMI of 44, prior surgery altering tissue planes, and impalpable femoral pulse is not reliable. This combination of factors is a clear indication for imaging guidance.

B. Correct. This patient has three major modifiers that reduce landmark-guided accuracy: severe obesity (BMI 44) increasing skin-to-joint depth to potentially 10+ cm, prior arthroscopy altering normal tissue planes, and impalpable femoral pulse eliminating the key safety landmark. Ultrasound or fluoroscopic guidance is the appropriate standard of care.

C. Incorrect. There is no standard landmark-guided lateral hip injection approach for intra-articular access — the joint is not directly accessible from the lateral approach without imaging. A lateral approach is used for greater trochanteric bursa injection, which is a different target.

D. Incorrect. There is no standard medial hip injection approach. The medial approach would place the needle in proximity to the femoral neurovascular bundle and adductor musculature, not the joint space.

Narration

[No narration during question — learner-directed activity]

Student Actions

Multiple choice question. Student must answer correctly to move on.

Developer Notes: *Assessment type: Formative. Final knowledge check of the module. Integrates all clinical and anatomical decision factors. References: 2, 3, 5, 6.*

Slide 39: Module Summary and Key Clinical Takeaways

Objective: Learners will consolidate module learning by reviewing the key anatomical and clinical principles that guide safe, accurate joint injection practice.

Visual / Background

[Case Study] The procedure suite day is complete. Marcus is comfortable and has improved range of motion. Diana reports reduced pain and is walking with less difficulty. Patricia is scheduled for a follow-up in six weeks. As you review the day's cases, you consolidate the anatomical principles that made each procedure safe and effective.

[Visual Description] Structured summary graphic organized by joint — shoulder, knee, hip — with icon-based callouts for: key surface landmarks, primary injection target, approach, key danger structures, and guidance recommendation. Optional learner-paced click-through to reveal each joint section.

Possible Image Labeled: Image 39, Image credit: AI-generated

Actions

Learner clicks each joint section to reveal the summary content. Must view all three joints before the Continue button appears.

Narration

Let's consolidate the key anatomical and clinical takeaways from this module.

For the shoulder: The subacromial-subdeltoid bursa is the primary injection target for impingement and rotator cuff tendinopathy. The lateral subacromial approach — needle directed medially under the acromion — is the most common technique. The posterior approach accesses the glenohumeral joint. Resistance during injection means the needle is in the rotator cuff — stop and redirect. The axillary nerve is the primary neurological danger at the posterior approach.

For the knee: The suprapatellar pouch and the midpatellar joint line are the primary intra-articular targets. Medial and lateral midpatellar approaches provide consistent access in normal anatomy. Grade III–IV OA with medial compartment narrowing favors a suprapatellar or ultrasound-guided approach. The pes anserine bursa is 2–3 cm below the medial joint line — a distinct structure that mimics intra-articular pathology.

For the hip: The anterior joint space is the target for intra-articular injection. The femoral neurovascular bundle is the primary safety landmark and danger boundary. Landmark-guided accuracy is lowest at the hip and drops further with obesity, prior surgery, and landmark obscurity. Imaging guidance is strongly recommended for the hip in most patients.

Student Actions

Throughout all three joints, the principles remain the same: know your layers, identify your danger zones, confirm placement before injecting, and match your technique to your patient.

Learner reads case study. Clicks Continue to begin narration.

Learner must click all three joint summary sections before advancing.

Developer Notes: *Final content slide before references. Consolidates all module learning with joint-by-joint summaries.*

Slide 40: References

Objective: N/A

Visual / Background

References slide — no visual content beyond text

Actions

1. Netter FH. Atlas of Human Anatomy. 8th ed. Elsevier; 2023.
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5. Drake RL, et al. Gray's Anatomy for Students. 4th ed. Elsevier; 2019.
6. Naredo E, et al. Ultrasound-guided versus landmark-guided joint and periarticular injections: a systematic review. Semin Arthritis Rheum. 2016;45(5):601-616.
7. Lequesne M, et al. Gluteal tendinopathy in refractory greater trochanter pain syndrome. Arthritis Rheum. 2008;59(3):327-334.
8. Kompel AJ, et al. Intra-articular corticosteroid injections in the hip and knee: perhaps not as safe as we thought. Radiology. 2019;293(3):656-663.

Narration

[No narration on references screen]

Student Actions

End of module. Option to return to beginning or exit.

Developer Notes: Format references according to institutional style guidelines.