Ultrasound-guided shoulder joint and bursa injections

Philips tutorial

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Contents

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1 Introduction

Shoulder pain disorders are very common. Shoulder pain is second only to low back pain in patients presenting to primary care physicians with musculoskeletal (MSK) pain. It is responsible for approximately 16% of all musculoskeletal complaints and an estimated 20% of the population will suffer shoulder pain during their lifetime.

The use of ultrasound (US) for MSK examination and injection is increasingly popular. Ultrasound is an excellent tool to image soft tissue structures and, hence, offers many advantages over either the blind approach or the fluoroscopy-guided approach. Ultrasound-guided shoulder injections are well established in the literature.[1-3]

2 Clinical anatomy

Anatomy of the shoulder girdle

The shoulder girdle is composed of the scapula, the clavicle, and the proximal humerus, together acting as a single biomechanical unit. The shoulder girdle complex has three joints (glenohumeral, acromioclavicular, and sternoclavicular joints) and two gliding planes (subacromial/subdeltoid and scapulothoracic). This allows for the wide range of movements compared to any other joints. [4,5]

Glenohumeral joint

The shoulder joint, otherwise known as the glenohumeral joint (GHJ), is a synovial "ball-and-socket" articulation. It is composed of a round humeral head and a relatively small, shallow glenoid fossa. The glenoid fossa is deepened and stabilized by the circular glenoid labrum, a fibrocartilaginous gasket-shaped structure.

The glenoid fossa accommodates only one-third of the humeral head; this shallow articulation explains the wide range of movements that the shoulder joint exhibits. However, this shallow articulation also predisposes the shoulder joint to injury, subluxation, and dislocation.

Innervations and blood supply

- The GHJ is innervated by the suprascapular, lateral pectoral, and axillary nerves.
- The blood supply of the shoulder is provided by the anterior and posterior circumflex humeral arteries and the suprascapular artery.

GHJ stabilizers

The stability of the glenohumeral joint is maintained by the ligaments, the rotator cuff, and the deltoid muscle.

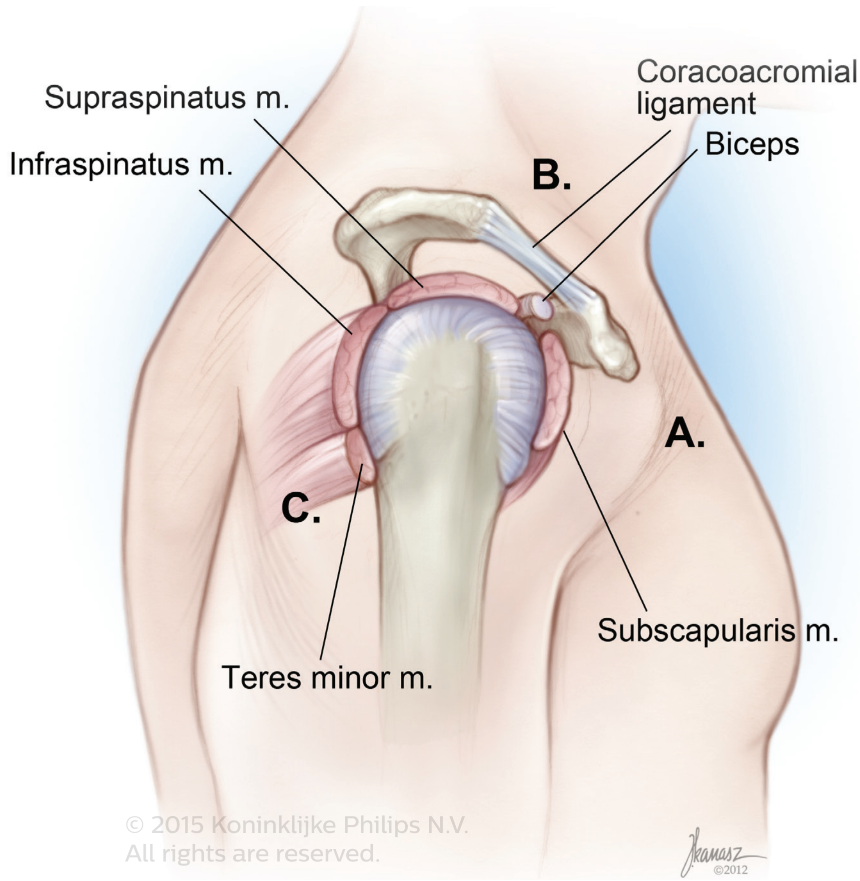
Ligaments

- The glenohumeral ligaments (GHL) are three weak bands of fibrous tissue: superior, middle, and inferior.
- The coracohumeral ligament (CHL) is a strong, fibrous tissue band originating from the coracoid process and inserting onto the lesser and greater tuberosities of the humerus.

Rotator cuff

The rotator cuff is a tight layer of tendons around the GHJ. There are four rotator cuff muscles:

- Subscapularis muscle (SSC) anteriorly.
- Supraspinatus muscle (SS) superiorly.
- Infraspinatus (IS) and teres minor (TMi) muscles posteriorly.



[Figure 1] **Illustration demonstrating the rotator cuff muscles and biceps tendon (Biceps).**

Bursae

The subacromial and subdeltoid bursa (SASDB)

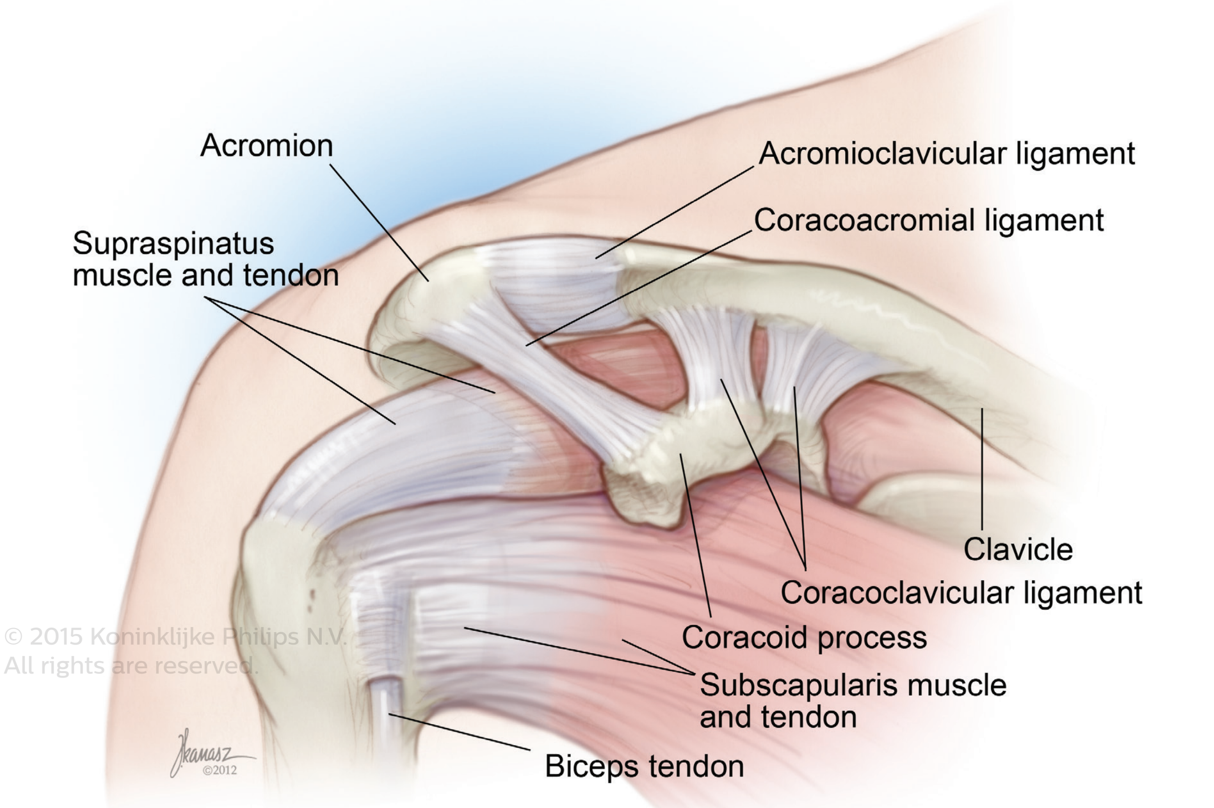
- The SASDB lies between the deltoid muscle superiorly and the supraspinatus tendon and the capsule of the GHJ inferiorly. A fluid-filled bursa provides a low friction environment for these structures to slide effortlessly past one another. The SASDB bursa does not communicate with the GHJ. The bursa functions to protect the supraspinatus as it passes beneath the overlying structures, most notably the acromion process.

The subscapular bursa

- In contrast to the SASDB, the subscapular bursa communicates with the joint through an opening in its fibrous capsule. Thus, the subscapular bursa and GHJ may be considered a single functional unit.

Rotator cuff interval

The rotator cuff interval (RCI) is a right-angled triangle over the superomedial aspect of the humeral head. It is bounded by the coracoid process medially and lies between the inferior border of the supraspinatus and superior border of subscapularis tendons. It is roofed by the CHL which constitutes the rotator interval capsule **[Figures 2 and 3]**.



[Figure 2] Illustration demonstrating shoulder anatomy of the RCI.

The RCI contains the tendon of the long head of the biceps (LHB) and the superior glenohumeral ligament (SGHL). The CHL and SGHL help to stabilize the LHB in the bicipital groove and prevent the tendon from anterior subluxation during arm movements.

Through the RCI, the GHJ synovial lining extends around the biceps tendon to the bicipital groove. Thus, it is a safe entry site to access the GHJ without encountering the rotator cuff tendons or articular structures.[6]

Long head of the biceps (LHB) tendon

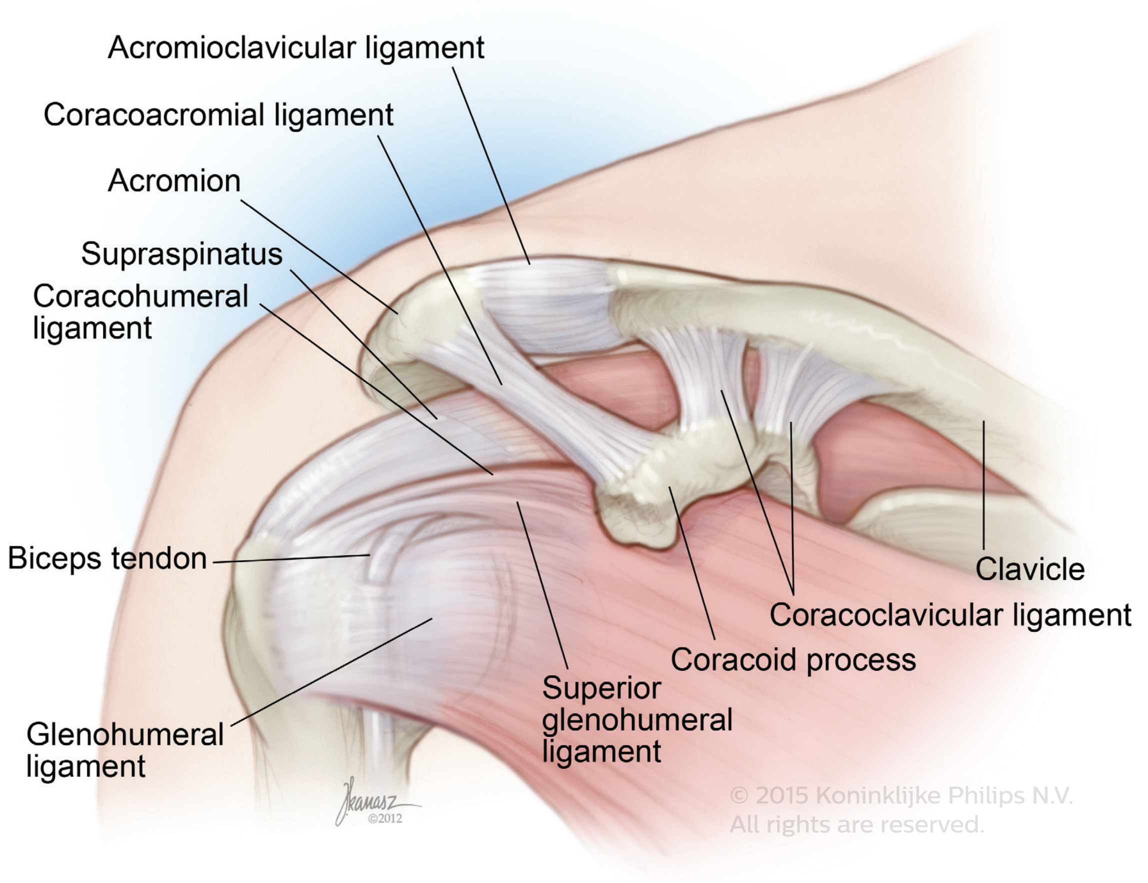
The proximal part of the LHB tendon is intra-articular but extra-synovial. It arises from the supraglenoid tubercle and the superior labrum, then travels obliquely over the anterosuperior aspect of the humeral head through the RCI, and exits within the bicipital groove formed by the lesser (medially) and greater (laterally) tuberosities. Here in the bicipital groove, the tendon is accompanied by the ascending branch of the anterior circumflex artery, usually on the lateral side. The synovial lining of the GHJ extends distally to invest the LHB tendon in the bicipital groove. Thus, fluid distension within the LHB tendon sheath usually reflects an underlying GHJ disease and effusion rather than tendon pathology.

Acromioclavicular joint anatomy

The acromioclavicular joint (ACJ) is a small gliding synovial joint with limited range of motion. The ACJ is located between the concave medial end of the acromion (laterally) and the convex lateral end of the clavicle (medially).

The articular surfaces are made up of hyaline cartilage and are separated by a wedge-shaped fibrocartilaginous disc. The superior, inferior, anterior, and posterior acromioclavicular ligaments reinforce the capsule of the ACJ.

The inferior surface of the joint is in direct contact with the subacromial portion of the SASDB and the supraspinatus (SS) muscle **[Figure 3]**. Thus, it may play a role in the development of rotator cuff impingement syndrome.



[Figure 3] **Illustration demonstrating acromioclavicular joint anatomy.**

3 Glenohumeral joint (GHJ) injections

Indications

- Glenohumeral arthritis (e.g., osteoarthritis, traumatic, inflammatory)
- Adhesive capsulitis

Efficacy

Intra-articular steroid injection has been shown to produce significant reduction in pain and improved function when combined with an exercise program.[7]

The need for ultrasound (US)

- The accuracy of blind injections is very questionable with a widely variable success rate.[8]
- One study of experienced orthopedic surgeons showed accurate needle placement in <30% of cases.[9]
- Compared to fluoroscopic-guided methods, ultrasound-guided techniques have a higher first attempt success rate (US 94% vs. fluoroscopy 72%) and >50% decrease in time.[8]

Advantages of different approaches

Posterior approach

The posterior approach is considered the preferred approach by most clinicians because of the absence of important articular structures, the presence of fewer stabilizers, and less extravasation.[10]

Rotator cuff interval (RCI) approach

This RCI approach has been recently described and this approach gradually replaced the traditional anterior approach as it avoids the anterior stabilizers and articular structures.[6]

Furthermore, when performing the traditional anterior approach, the cephalic vein, brachial plexus, and axillary artery are at risk of injury if the needle is advanced medial to the coracoid.[11]

Sonoanatomy and GHJ injection techniques

Posterior approach

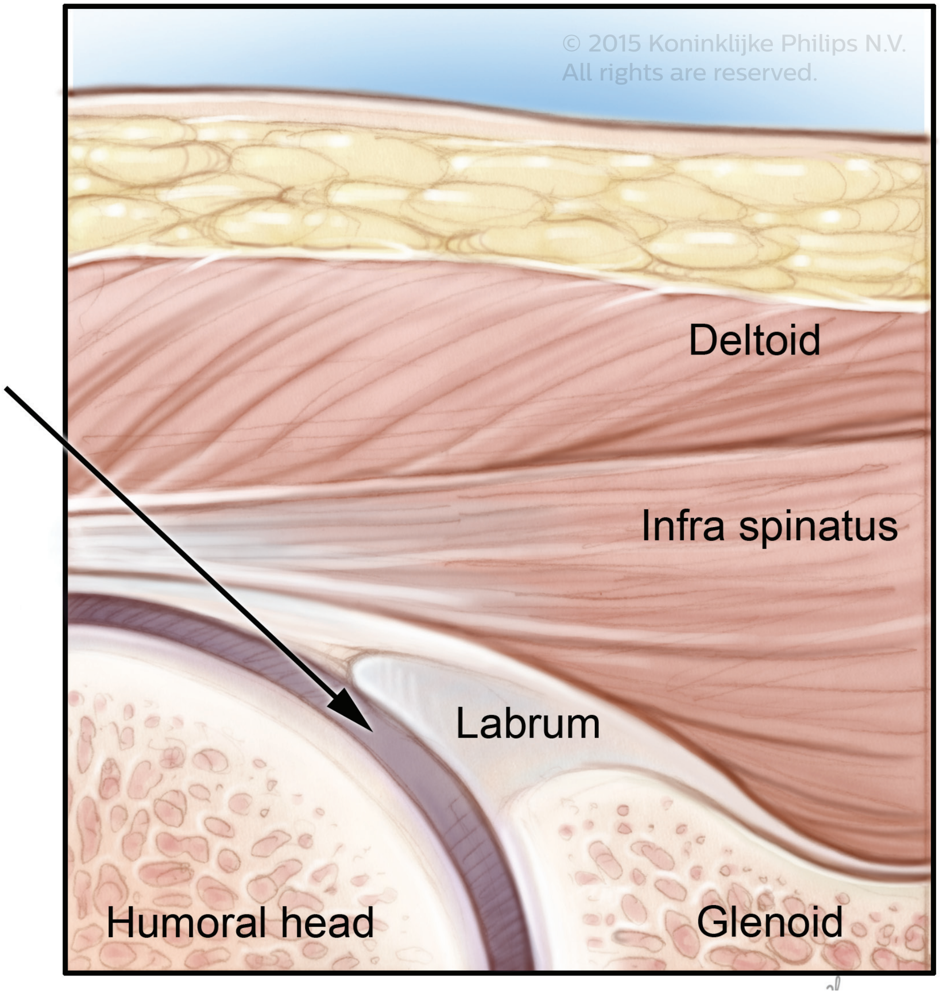
The patient is placed in the sitting or lateral position with the ipsilateral hand crossing the chest and touching the contralateral elbow, thereby internally rotating the humerus **[Figure 4a]**. A high-frequency linear transducer is usually sufficient for most patients. However, a low-frequency curved transducer should be used in muscular or obese patients.

The scapular spine is palpated and the ultrasound transducer is placed parallel and just caudal to the lateral end of the spine. In this position the transducer is overlying the long axis of the myotendinous junction of the IS muscle. The humeral head, posterior glenoid rim, and labrum can be easily visualized in this view.

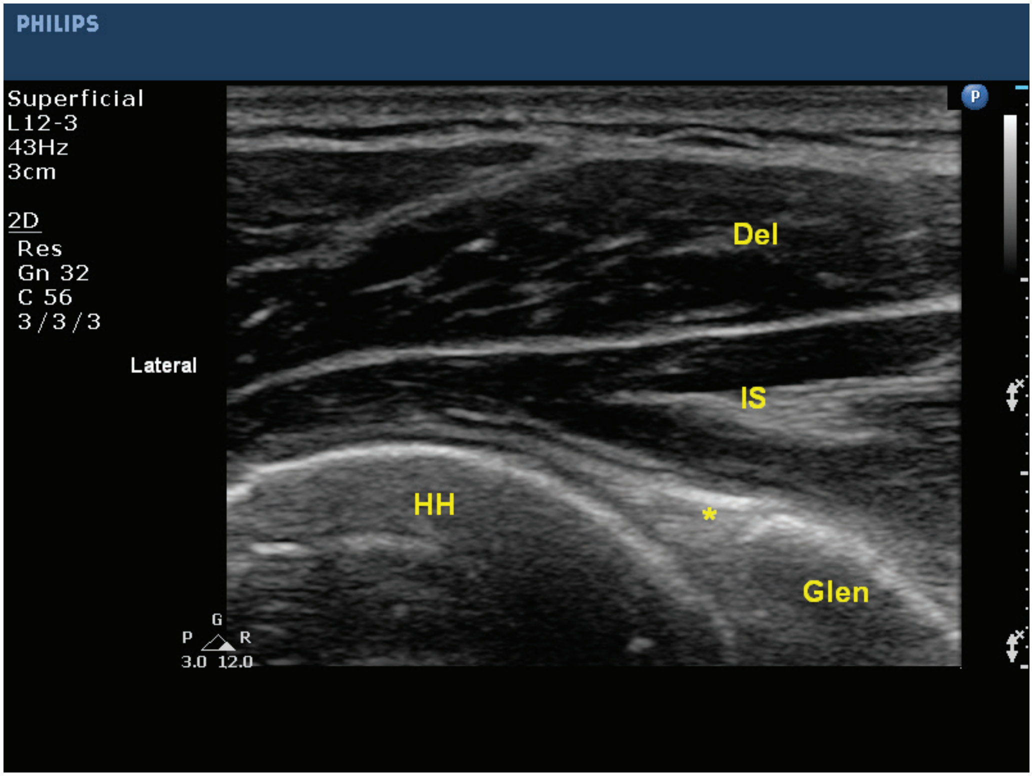
Using sterile technique a 22-gauge needle is inserted, using an in-plane needle technique, from the lateral side of the transducer and directed towards the gap between the hyperechoic medial triangular-shaped labrum and the hypoechoic articular cartilage of the humeral head **[Figures 4b and 4c and Video 1]**.

[Figure 4a] **Transducer and needle orientation for GHJ injection using an in-plane needle technique. The patient is in the lateral position.**

Resistance to injection suggests the needle is in contact with the cartilage and the needle should be repositioned. For patients with a large shoulder, the steep entry angle may make visualization of the needle tip with the linear transducer challenging and a curved transducer may be more appropriate.



[Figure 4b] **Illustration demonstrating the posterior approach to the GHJ.**



[Figure 4c] **Ultrasound image showing the posterior approach to the GHJ. Deltoid muscle (Del), infraspinatus muscle (IS), glenoid (Glen), humeral head (HH). The posterior labrum is marked by * .**

[Video 1]

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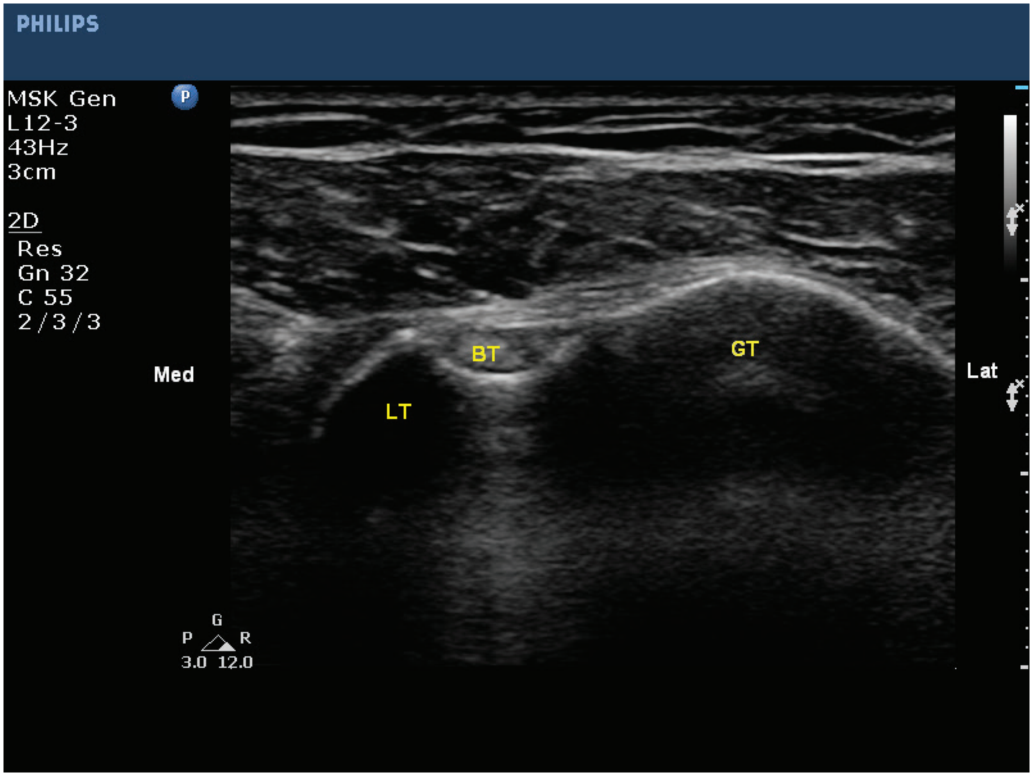
Video demonstrating a GHJ injection using the posterior approach.

Rotator cuff interval approach

The patient is placed in the supine or sitting position with the arm in a neutral position. A high-frequency linear transducer is placed over the bicipital groove between the lesser (medially) and greater (laterally) tuberosities to show the transverse view of the LHB tendon **[Figure 5a]**.

[Figure 5a] Demonstration of patient position and transducer position to obtain a short-axis view of the biceps tendon.

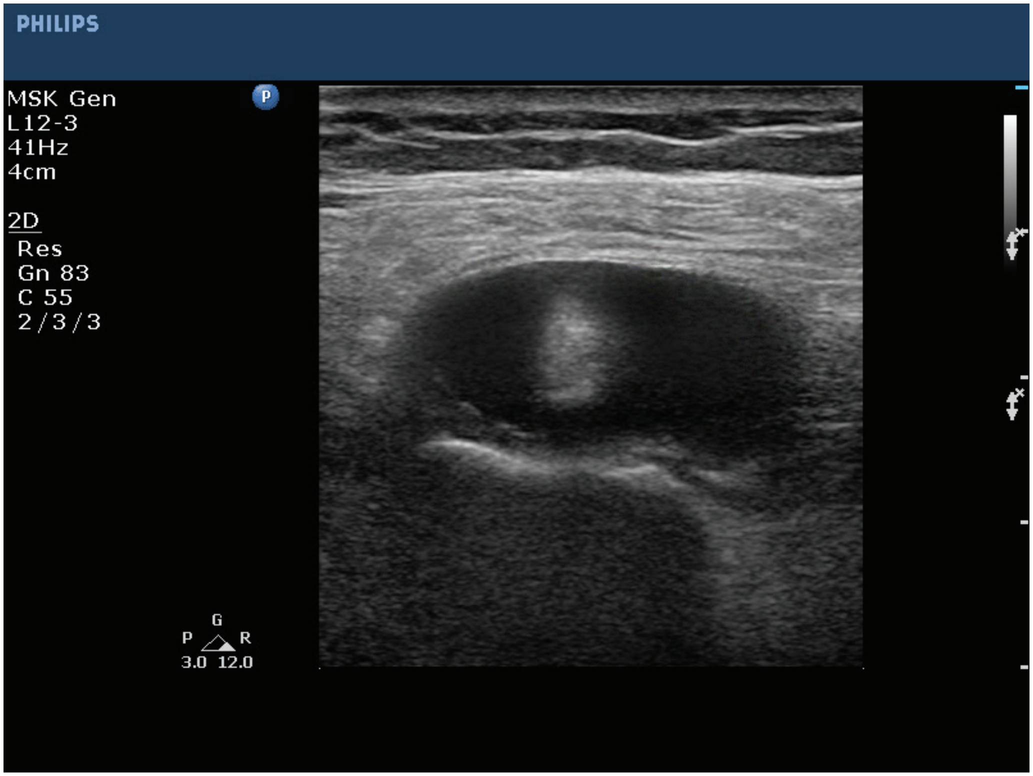
On the ultrasound image note that the lesser tuberosity has a pointed shape, whereas the greater tuberosity has a more rounded shape **[Figure 5b]**.



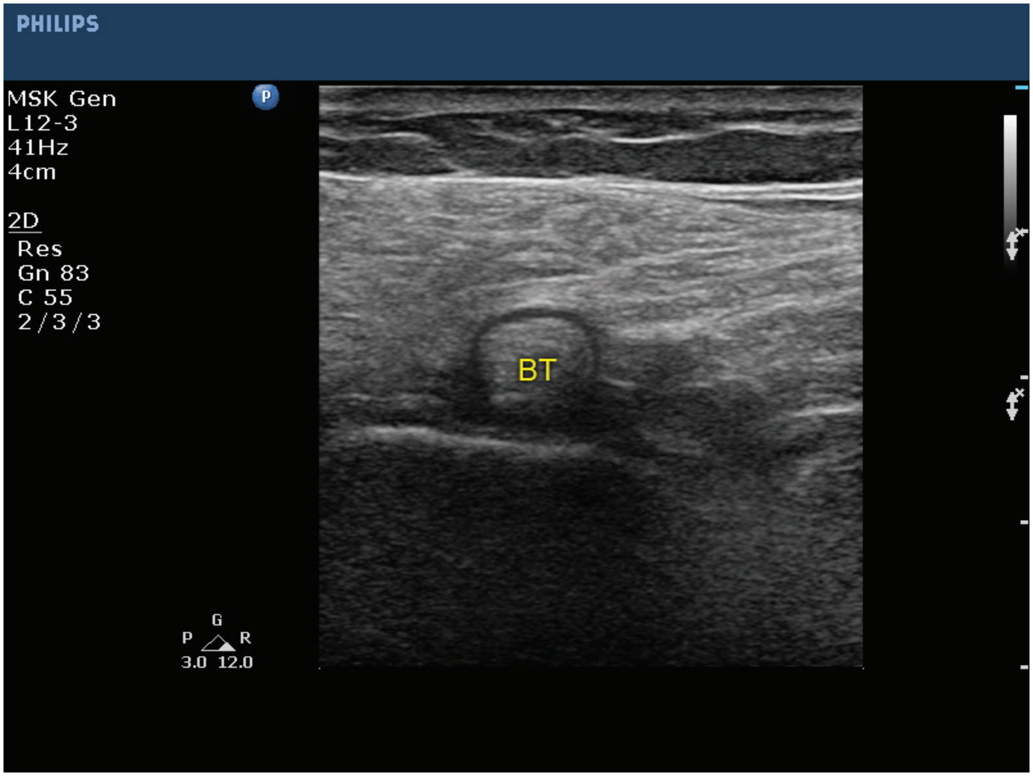
[Figure 5b] **Ultrasound image of a short-axis view of the long head biceps tendon (BT) in the bicipital groove between the lesser tuberosity (LT) medially and the greater tuberosity laterally (GT).**

In the bicipital groove, the tendon is invested by its synovial sheath and a GHJ effusion can be detected here **[Figures 6a, 6b and 6c, and Video 2]**.

[Figure 6a] Demonstration of the patient position, transducer orientation, and needle approach for drainage of GHJ effusion under ultrasound guidance.



[Figure 6b] **Ultrasound image demonstrating an effusion in the GHJ. Note the synovial sheath of the long head of biceps tendon (BT) is distended by the effusion.**



[Figure 6c] Ultrasound image of GHJ post-drainage.

[Video 2]

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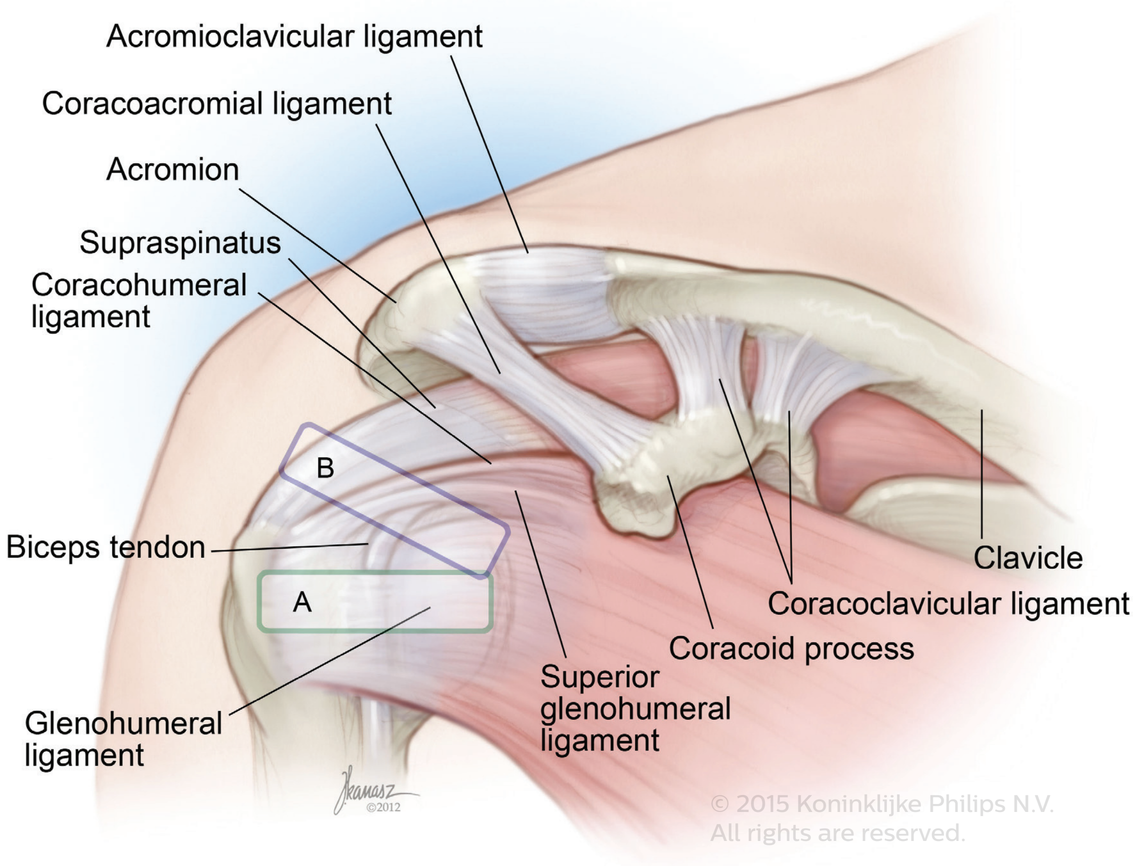
Ultrasound of needle entering shoulder effusion.

The LHB tendon runs a superomedial course from the bicipital groove through the RCI to enter the GHJ. Thus, to identify the RCI, one needs to follow the intra-articular course of the LHB tendon cranially in short axis. The orientation of the transducer will need to be adjusted accordingly **[Figures 7a and 7b]**. While sliding the transducer cranially in the short axis to follow the LHB tendon, the lateral end of the transducer should be tilted more cephalad in order to maintain the short-axis view of the LHB tendon within the RCI (Video 3). In this interval, the SS and SSC tendons are on the lateral and medial side respectively **[Figure 8]**. The CHL appears as a thick hyperechoic band over the LHB tendon and forms the roof of the RCI.

To optimize scanning of the RCI, the arm may be extended posteriorly. This also stretches the LHB tendon against the humeral head and tightens the CHL. The needle can be advanced using the out-of-plane technique to direct the needle tip into the GHJ through the RCI on either side of LHB tendon, preferably between the biceps tendon and the subscapularis tendon (medially), to avoid the ascending branch of the anterior circumflex artery on the lateral side of the LHB tendon.

[Figure 7a] **Transducer and needle orientation for biceps tendon sheath injection.**

[Figure 7b] Transducer and needle orientation for RCI injection. Please note the cephalad tilt of the lateral end of the transducer.



[Figure 7c] **Illustration demonstrating transducer position for BT sheath injection (A) and RCI injection (B).**

[Video 3]

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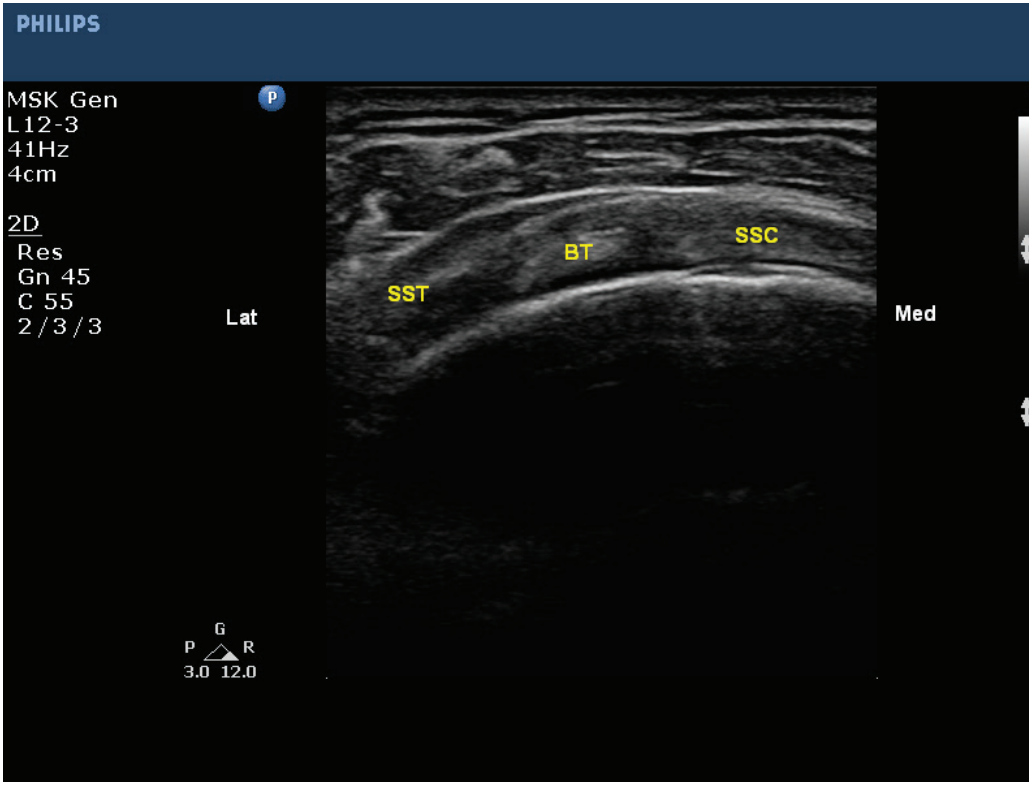
Ultrasound scan following the BT from the bicipital groove cephalad to the rotator cuff interval. The video will play twice. The subscapularis tendon (SSC), biceps tendon (BT), and supraspinatus tendon (SST) are labeled on the first loop.



[Figure 8] **Ultrasound image of the rotator cuff interval. Subscapularis tendon (SSC), biceps tendon (BT), and supraspinatus tendon (SST).**

4 Subacromial and subdeltoid bursa (SASDB) injections

Subacromial impingement syndrome accounts for the most common diagnosis of shoulder pain.

Indications

- SASDB impingement syndrome
- Subacromial bursitis
- Rotator cuff tear
- Rotator cuff tendinopathy
- SASDB injection of lidocaine is often used to diagnose impingement, and offers rationale for subacromial decompression surgery.

Efficacy

- A few random control trials (RCTs) demonstrated short-term efficacy of SASDB steroid injection for improving pain, inflammation, and function.[12–14]
- A recent large pragmatic randomized controlled trial showed that the SASDB steroid injection improved pain and functional outcome at one and six weeks. However, injection plus exercise and exercise only were similarly effective at 12 weeks.[15]

The need for ultrasound (US) guidance

- The accuracy of blind injections has been reported to be as low as 29%.[16]
- When using the blind approach for injection, the injectate was found inside other structures such as the SS, SSC, and deltoid muscles, as well as in the GHJ.[17,18]
- Precise steroid placement in the SASDB correlated with better clinical outcomes.[18,19]
- Fluoroscopy is not very reliable in confirming the spread of injectate in the subacromial space.[20]
- US-guided injection showed 100% accuracy when validated with MRI.[21]
- US-guided injection resulted in better immediate pain relief compared to blind injections.[22]
- US-guided injection resulted in superior pain and functional outcome at six weeks compared to blind injections.[23]
- US-guided injection resulted in a significant improvement in abduction range of motion compared to the blind injections.[24]
- However, one study failed to show a significant difference.[25]

Supraspinatus tendon sonoanatomy and subacromial impingement test

The intra-articular portion of the LHB tendon runs parallel to the SS tendon and can be used a reference. With the arm in neutral position, a high-frequency linear transducer is placed in the coronal plane between the acromion and greater tuberosity along the long axis of the supraspinatus tendon. The supraspinatus tendon should be visualized emerging from beneath the acromion and running over the humerus to attach to the greater tuberosity. The distal portion of the SS tendon looks like a convex, beak-like structure attached to the greater tuberosity.

Subacromial impingement can be assessed dynamically with the patient abducting the arm while in internal rotation. With this maneuver, the SS tendon can be seen sliding smoothly deep to the acromion and coracoacromial arch. With gentle active or passive abduction, a "catch" or "snap" may be appreciated in the presence of mechanical impingement **[Video 4]**.

Calcific densities or clefts within the tendon, which may indicate tendinopathy or tears, can be appreciated. Aspiration and lavage of these calcifications under ultrasound guidance has been reported.[26]

[Video 4]

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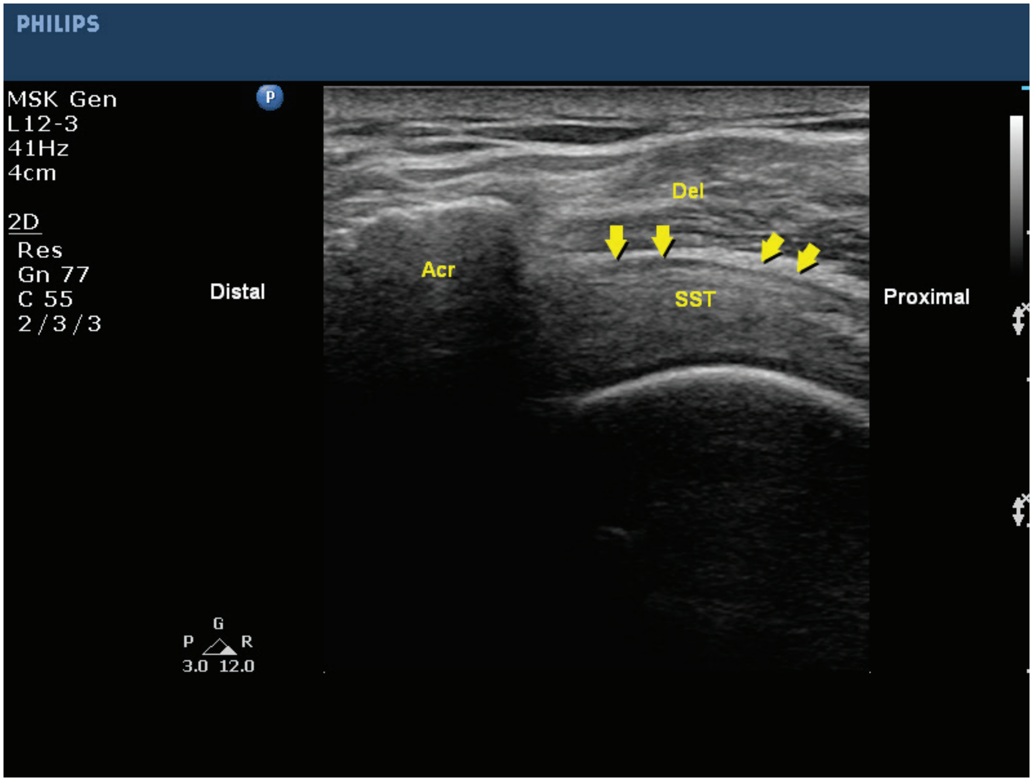
Subacromial impingement test. Note the thin layer of fluid in the SASDB.

Sonoanatomy and SASDB injection technique

To better visualize the SASDB and the supraspinatus tendon, the patient is placed in sitting position with the ipsilateral arm in the modified Crass position with elbow flexed 90°, arm supinated, and the palm of the hand placed over the ipsilateral hip (hand in back pocket of pants) **[Figure 10a]**. A high-frequency linear transducer is placed along the long axis of the SS tendon, which is parallel to the intra-articular portion of the LHB tendon.[27] In this view the deltoid muscle, SS tendon, and acromion can be seen as well. The bursa is usually seen as a thin anechoic fluid layer immediately above the tendon **[Figure 9]** or can be estimated from the peribursal fat in between the deltoid muscle and SS tendon by using dynamic scanning.[28]

Using a sterile technique, a 22-25 gauge needle is advanced to the bursa from a lateral to medial direction using an in-plane technique. The needle insertion site is approximately 1 cm lateral to the end of the transducer **[Figure 10b]**. The needle angle should be adjusted to allow bursal entry just lateral to the acromion. In very large shoulders a spinal needle may be necessary, although a 1.5 inch needle is usually sufficient. In some patients, to better visualize the bursa, the transducer is rotated 90° to be perpendicular to the SST. The SASDB can be seen between the deltoid and the short axis view of the SST **[Figure 10c]**.

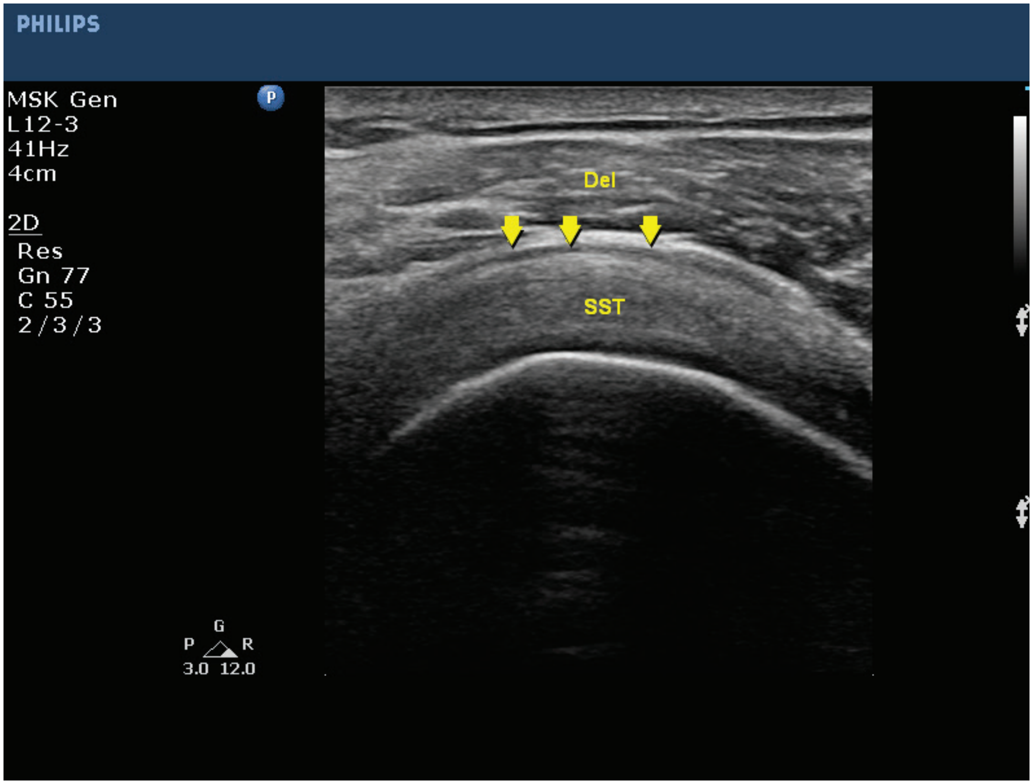
The diagnosis of impingement or the so-called “impingement test” is confirmed when the patient is reassessed approximately 15 minutes following the injection and on examination shows reduction in pain with the impingement maneuvers.[29]



[Figure 9] **Sonogram of the long-axis view of the supraspinatus tendon (SST), deltoid muscle (Del) and acromion (Acr). Note the arrows are pointing at the SASDB.**

[Figure 10a] Patient in the Crass position.

[Figure 10b] Transducer and needle orientation for SASDB injection.



[Figure 10c] Ultrasound image of the SASDB (arrows) between the deltoid muscle (Del) and the supraspinatus tendon (SST).

5 Acromioclavicular joint (ACJ) injections

The acromioclavicular joint (ACJ) is a common source of shoulder pain that is often overlooked because of the higher prevalence of rotator cuff syndromes.

Indications

Osteoarthritis, both diagnostic and therapeutic.[30]

Efficacy

- Diagnostic – the diagnostic role of ACJ injection is widely accepted.
- Therapeutic – steroid injection offers short-term pain relief.[31]

The need for ultrasound (US) guidance

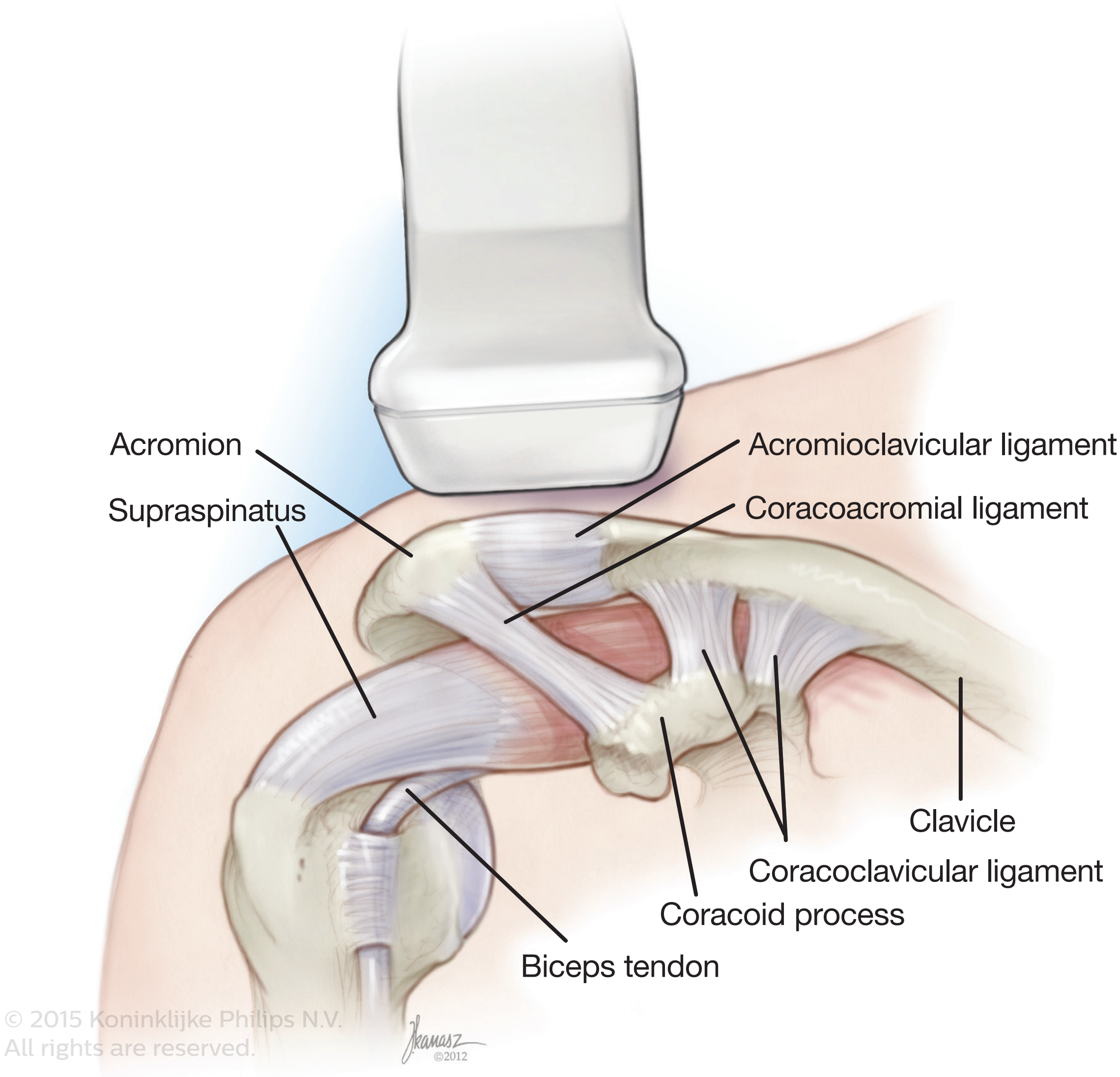
- Blind landmark-based technique was reported to be accurate in <50% of cases as confirmed by fluoroscopy.[32,33]
- US-guided technique was accurate in 95%-100% of cases in cadaver studies.[34]

Sonoanatomy and ACJ injection technique

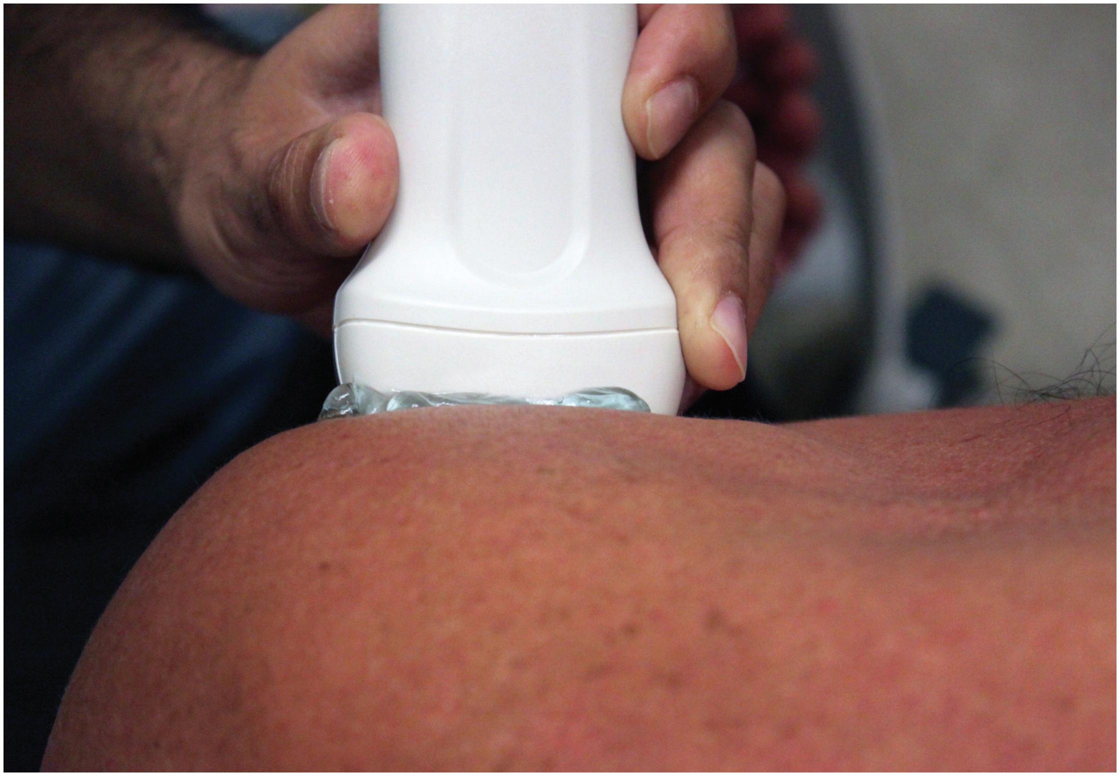
The joint can be easily seen by placing a high-frequency linear transducer over the joint in the coronal plane. The hypoechoic joint space is seen between the hyperechoic ends of the acromion and the distal clavicle. A fibrocartilaginous disc can be seen as a slightly hyperechoic wedge-shaped structure attached to the superior joint capsule in young patients with a healthy joint.

The patient is placed either in a sitting or supine position with the arm in neutral position. A high-frequency linear transducer is used because of the superficial nature of the ACJ **[Figures 11a and 11b]**. The transducer is placed over the medial side of the acromion in line with the distal clavicle in the coronal plane. The ACJ is easily visualized as a hypoechoic space between the hyperechoic ends of the acromion laterally and the distal clavicle medially **[Figure 12]**. In young patients with healthy joints, the fibrocartilage can be seen within the ACJ.

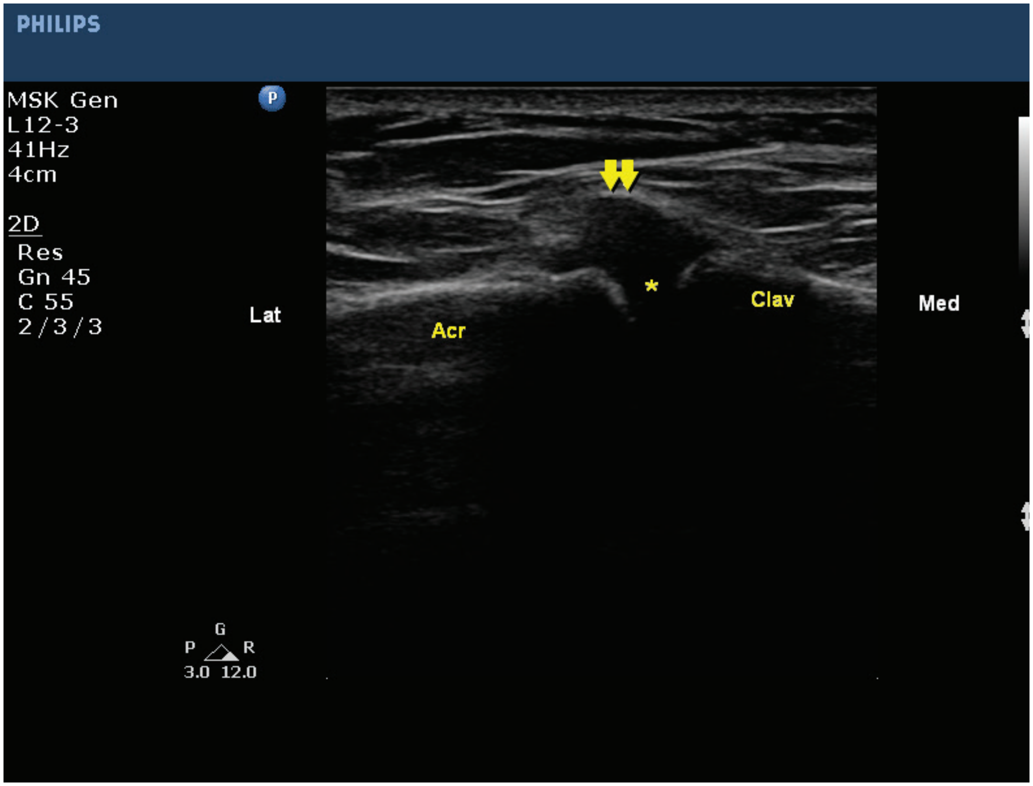
Either out-of-plane or in-plane needle technique can be used. The needle should be advanced carefully inside the ACJ as overzealous insertion of the needle can result in puncturing the deep capsule and entering the subacromial space or the SS muscle. The spread of the injectate should be monitored under real-time sonography to confirm elevation of the capsule and widening of the joint space.



[Figure 11a] **Illustration demonstrating the ACJ and the orientation of the ultrasound transducer.**



[Figure 11b] Transducer orientation for ACJ injection.



[Figure 12] **Sonogram showing the ACJ (*) as a hypoechoic space between the clavicle (medially) and the acromion (laterally). Note the arrows are pointing at the ACJ capsule which is distended after the injection.**

6 References

1. Burbank KM, Stevenson JH, Czarnecki GR, Dorfman J. Chronic shoulder pain: Part I. Evaluation and diagnosis. Am Fam Physician. 2008;77:453-60.
2. Urwin M, Symmons D, Alison T, et al. Estimating the burden of musculoskeletal disorders in the community: The comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. Ann Rheum Dis. 1998;57:649-655.
3. Van der Windt DA, Koes BW, de Jong BA, Bouter LM. Shoulder disorders in general practice: Incidence, patient characteristics, and management. Ann Rheum Dis. 1995;54:959-964.
4. Iannotti JP, Gabriel JP, Schneck SL, Evans BG, Misra S. The normal glenohumeral relationships: An anatomical study of one hundred and forty shoulders. J Bone Joint Surg Am. 1992;74:491-500.
5. Totterman SM, Miller RJ, Meyers SP. Basic anatomy of the shoulder by magnetic resonance imaging. Top Magn Reson Imaging. 1994;6:86-93.
6. Lim JB, Kim YK, Kim SW, Sung KW, Jung I, Lee C. Ultrasound guided shoulder joint injection through rotator cuff interval. Korean J Pain. 2008;21:57-61.
7. Carette S, Moffet H, Tardif J, et al. Intra-articular corticosteroids, supervised physiotherapy, or a combination of the two in the treatment of adhesive capsulitis of the shoulder: A placebo controlled trial. Arthritis & Rheumatism. 2003;48:829-838.
8. Rutten MJ, Collins JM, Maresch BJ, et al. Glenohumeral joint injection: A comparative study of ultrasound and fluoroscopically guided techniques before MR arthrography. Eur Radiol. 2009;19:722-730.
9. Sethi PM, Kingston S, Elattrache N. Accuracy of anterior intra-articular injection of the glenohumeral joint. Arthroscopy. 2005;21:77-80.
10. Gokalp G, Dusak A, Yazici Z. Efficacy of ultrasonography-guided shoulder MR arthrography using a posterior approach. Skeletal Radiol. 2010;39:575-579.
11. Zwar RB, Read JW, Noakes JB. Sonographically guided glenohumeral joint injection. AJR. 2004;183:48-50.
12. Blair B, Roit AS, Cuomo F, et al. Efficacy of injections of corticosteroids for subacromial impingement syndrome. J Bone Joint Surg Am. 1996;78:1685-1689.
13. Akgun K, Birtane M, Akarirmak U. Is local subacromial corticosteroid injection beneficial in subacromial impingement syndrome? Clin Rheumatol. 2004;23:496-500.
14. Plafki C, Steffen R, Willburger, RE, et al. Local anaesthetic injection with and without corticosteroids for subacromial impingement syndrome. International Orthopedics. 2000;24:40-42.
15. Crawshaw DP, Helliwell PS, Hensor EMA, Hay EM, Aldous SJ, Conaghan PG. Exercise therapy after corticosteroid injection for moderate to severe shoulder pain: Large pragmatic randomised trial. BMJ. 2010;340:c3037.
16. Eustace JA, Brophy RP, Gibney RP, et al. Comparison of the accuracy of steroid placement with clinical outcome in patients with shoulder symptoms. Ann Rheum Dis. 1997;56:59-63.
17. Henkus HE, Cobben LP, Coerkamp EG, Nelissen RG, van Arkel ER. The accuracy of subacromial injections: A prospective randomized magnetic resonance imaging study. Arthroscopy. 2006;22:277-282.

18. Naredo E, Cabero F, Beneyto P, et al. A randomized comparative study of short term response to blind injection versus sonographic-guided injection of local corticosteroids in patients with painful shoulder. J Rheumatol. 2004;31:308-314.

19. Kang MN, Rizio L, Prybicien M, Middlemas DA, Blacksin MF. The accuracy of subacromial corticosteroid injections: A comparison of multiple methods. J Shoulder Elbow Surg. 2008;17:61S-66S.

20. Mathews PV, Glousman RE. Accuracy of subacromial injection: Anterolateral versus posterior approach. J Shoulder Elbow Surg. 2005;14:145-148.

21. Rutten MCJM, Maresch BJ, Jager GJ, Blickman JG, van Holsbeeck MT. Ultrasound of the rotator cuff with MRI and anatomic correlation. Eur J Rad. 2007;82:427-436.

22. Hashiuchi T, Sakurai G, Sakamoto Y, Takakura Y, Tanaka Y. Comparative survey of pain-alleviating effects between ultrasound-guided injection and blind injection of lidocaine alone in patients with painful shoulder. Arch Orthop Trauma Surg. 2010;130:847-852.

23. Ucuncu F, Capkin E, Karkucak M, et al. A comparison of the effectiveness of landmark-guided injections and ultrasonography guided injections for shoulder pain. Clin J Pain. 2009;25:786-789.

24. Chen MJL, Lew HL, Hsu TC, et al. Ultrasound-guided shoulder injections in the treatment of subacromial bursitis. Am J Phys Med Rehabil. 2006;85:31-35.

25. Rutten MJ, Maresch BJ, Jager GJ, et al. Injection of the subacromial-subdeltoid bursa: Blind or ultrasound-guided? Acta Orthop. 2007;78:254-257.

26. Farin PU, Rasanen H, Heikki J, Arvi H. Rotator cuff calcifications: Treatment with ultrasound-guided percutaneus needle aspiration and lavage. Skeletal Radiology. 1996;25:551-554.

27. Cheng PH, Modir JG, Kim HJ, Narouze S. Ultrasound-guided shoulder joint injections. Tech Reg Anesth Pain Manag. 2009;13:184-190.

28. Peng PW, Cheng P. Ultrasound-guided interventional procedures in pain medicine: a review of anatomy, sonoanatomy, and procedures. Part III: Shoulder. Reg Anesth Pain Med. 2011;36:592-605.

29. Schaefer MP, Fox K. Ultrasound guided shoulder joint and bursa injections. Narouze S (ed.) Atlas of ultrasound guided procedures in interventional pain management. Springer. 2011;293-306.

30. Buttaci CJ, Stitik TP, Yonclas PP, Foye PM. Osteoarthritis of the acromioclavicular joint: A review of anatomy, biomechanics, diagnosis, and treatment. Am J Phys Med Rehabil. 2004;83:791-797.

31. Shaffer BS. Painful conditions of the acromioclavicular joint. J Am Acad Orthop Surg. 1999;7:176-188.

32. Bain GI, van Riet RP, Gooi C, Ashwood N. The long-term efficacy of corticosteroid injection into the acromioclavicular joint using a dynamic fluoroscopic method. Int J Shoulder Surg. 2007;1:104-7.

33. Bisbinas I, Belthur M, Said H, Green M, Learmonth DJ. Accuracy of needle placement in ACJ injections. Knee Surg Sports Traumatol Arthrosc. 2006;14:762-765.

34. Sabeti-Aschraf M, Lemmerhofer B, Lang S, et al. Ultrasound guidance improves the accuracy of the acromioclavicular joint infiltration: A prospective randomized study. Knee Surg Sports Traumatol Arthrosc. 2011;19:292-295.

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