Shoulder

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The shoulder is an excellent region for the use of ultrasound-guided diagnosis and intervention due to its high injury prevalence and the superficial nature of commonly injured structures [1]. The shoulder girdle, composed of the scapula, clavicle, and proximal humerus, gives rise to the glenohumeral (GH), acromioclavicular (AC), and sternoclavicular joints. The deltoid, long head of the biceps brachii, and rotator cuff muscles (the supraspinatus, infraspinatus, teres minor, and subscapularis) facilitate shoulder movement in almost every plane [2]. The biceps tendon sheath, AC and GH joints, and subacromial/subdeltoid bursa (SASDB) are common sites for injection. There are also newer promising interventions, including prolotherapy, percutaneous needle tenotomy, and platelet-rich plasma, targeting rotator cuff tendons with ultrasound guidance.

Long Head of Biceps Brachii Tendon Sheath

Inflammation of the biceps tendon or sheath (tenosynovitis) from isolated injury or overuse is a common source of shoulder pain [3]. As the tendon passes through the bicipital groove of the humerus toward its insertion onto the superior labrum, it is exposed over the anterior region of the shoulder. The long head of the biceps contributes to humeral head stability, especially during abduction and external rotation [4]. Presenting symptoms may include anterior shoulder pain and discomfort. Injections to the biceps tendon sheath are historically performed blind.

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A recent study by Hashiuchi et al. (Table 2.1) demonstrated that 86.7 % of ultrasound-guided injections achieved contrast within the tendon sheath compared to 26.7 % performed with the blind technique. Of those that were performed blind, another 33 % were completely outside the tendon sheath compared to 0 % when ultrasound was utilized [5]. Gazzillo et al. demonstrated that palpation-guided needle placement locating the long head of the biceps tendon was accurate only 5.3 % of the time without ultrasound verification [6].

Scanning Technique and Anatomy to Identify

For an optimal view of the biceps tendon, the patient's hand should be supinated with the elbow flexed, lying on the ipsilateral thigh. With the transducer placed in the axial plane over the proximal humerus, the hyperechoic tendon of the long head of the biceps brachii can be visualized within the bicipital groove. The transverse humeral ligament lies superficial to the tendon. The subscapularis tendon can be seen medially. Using Doppler imaging, the ascending branch of the circumflex humeral artery may be visualized laterally. Turn the transducer 90° to view the tendon longitudinally. Sweep medially to view the pyramid shape of the lesser tuberosity (Fig. 2.1) [7].

Injection Techniques: In-Plane Axial Approach

Patient positioning: Sit the patient with the hand supinated and elbow flexed.

Probe positioning: Place the transducer in the axial plane on the patient's proximal humerus, visualizing the greater and lesser tuberosities and the bicipital groove (Fig. 2.2a).

Markings: Identify the ascending branch of the circumflex humeral artery using power Doppler imaging. This vessel runs up the lateral side of the bicipital groove.

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Table 2.1 Accuracy of blind vs. ultrasound-guided LHBT injection

		Type 1	Type 2	Type 3
Author	Location of injectate	Within tendon sheath	Inside tendon, tendon sheath, and surrounding area	Outside tendon sheath
Hashiuchi, 2011	Ultrasound-guided	86.7 %	13.3 %	0 %
	Unguided	26.7 %	40.0 %	33.3 %

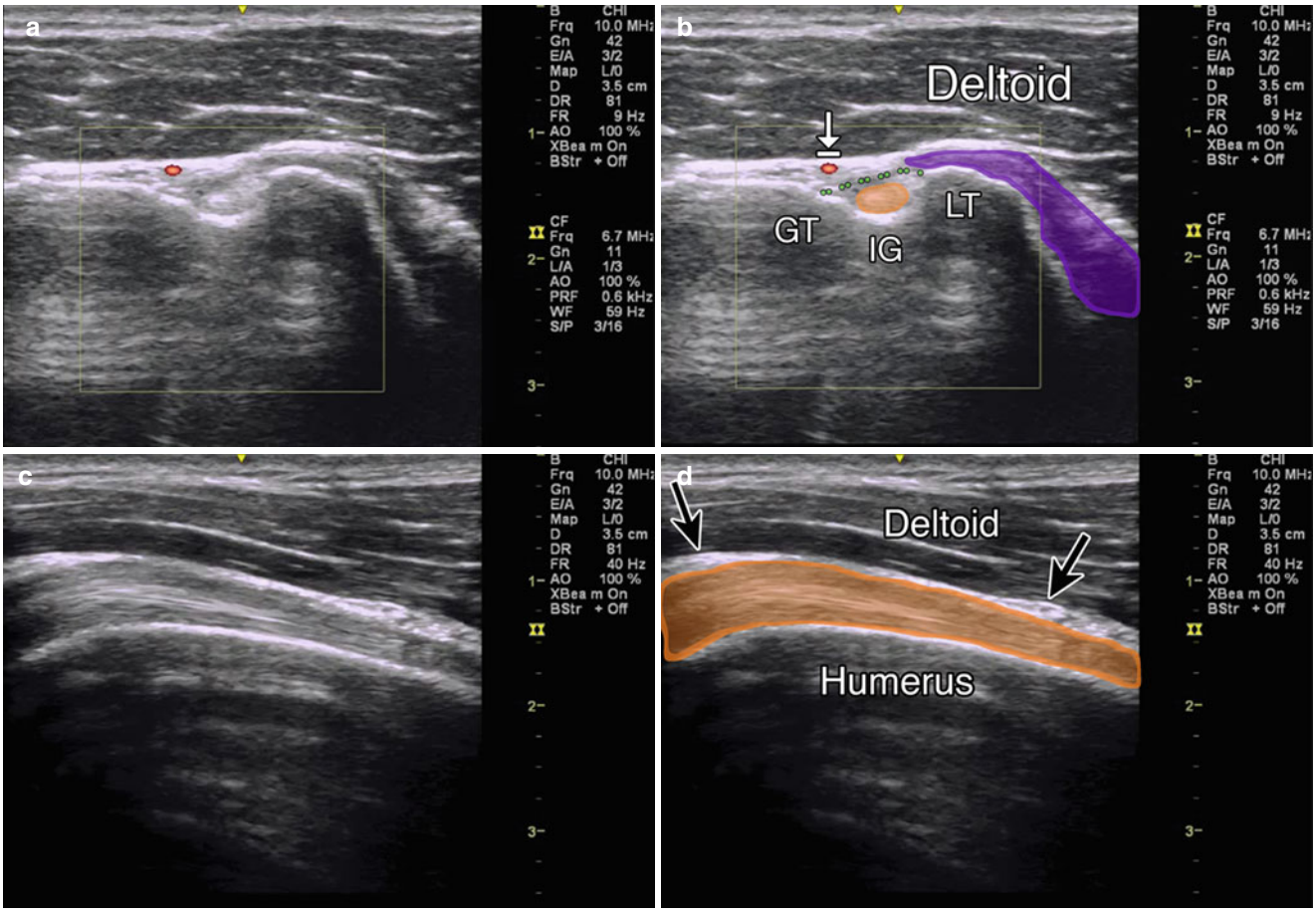

Fig. 2.1 (**a**) Short-axis view of the biceps tendon with circumflex humeral artery in *red*. (**b**) GT-greater tuberosity, *IG* intertubercular groove, *LT* lesser tuberosity, *arrow* with stop indicates circumflex humeral artery, deltoid labeled, *purple* subscapularis muscle, *orange circle* biceps tendon, *dotted green line* transverse humeral ligament. (**c**) Longitudinal view of biceps tendon. (**d**) Humerus deep to biceps tendon (*orange*) with thin bursa overlying it marked by *black arrows*, deltoid labeled

Needle position: Insert the needle from lateral to medial in-plane with the probe targeting the biceps tendon sheath situated between the biceps tendon and the transverse humeral ligament.

Safety considerations: Avoid directly injecting the tendon, as this may increase susceptibility to tendon rupture [8, 9]. Although the space between the tendon and the greater tuberosity can also be injected, the circumflex humeral artery should be properly visualized and avoided.

Pearls:

- The subacromial/subdeltoid bursa lies just superficial to the biceps tendon sheath and may be injected at the same time if so desired.
- Make sure injectate is seen flowing around the biceps tendon ("donut sign") and not in the bursa.

Injection Techniques: In-Plane Sagittal Approach

Patient positioning: Same as above

Probe positioning: Place the transducer sagittally to visualize the length of the biceps tendon within its groove and the pyramid shape of the lesser tuberosity (Fig. 2.3a).

Markings: The lesser tuberosity will appear medial to the bicipital groove. Fluid may be seen in the tendon sheath.

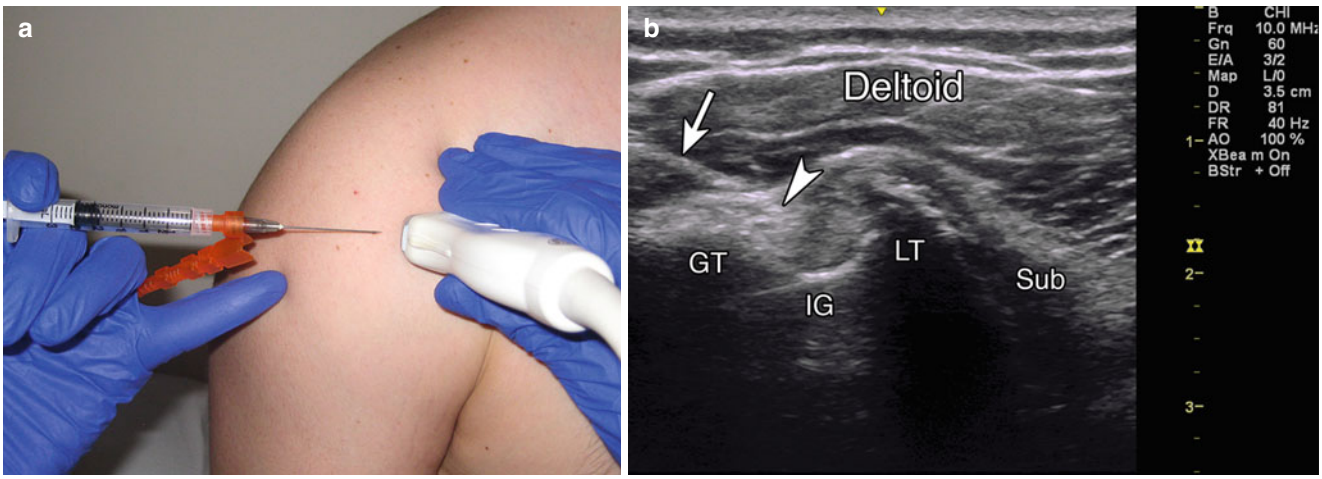

Fig. 2.2 (**a**) Example of axial probe position over biceps tendon with in-plane needle position. (**b**) Example of in-plane axial injection into the biceps tendon sheath, *GT* greater tuberosity, *IG* intertubercular groove, *LT* lesser tuberosity, *arrow* indicates needle, *arrowhead* indicates needle tip, sub-subscapularis muscle, deltoid labeled

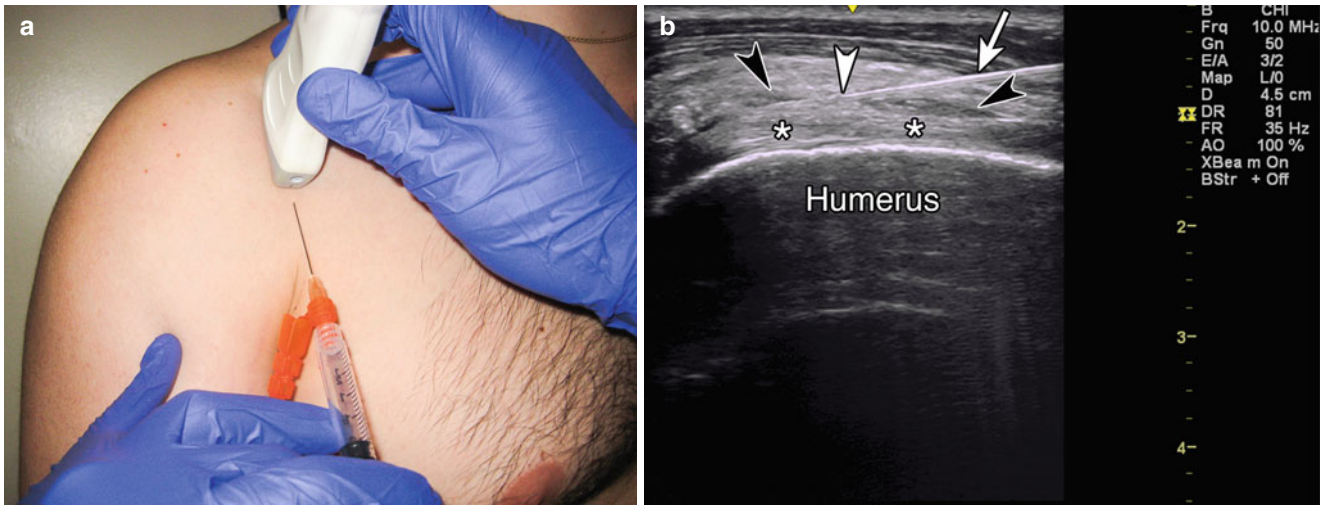

Fig. 2.3 (**a**) Example of longitudinal probe position over biceps tendon with in-plane injection technique. (**b**) Example of in-plane long axis approach, *asterisk* indicates biceps tendon, *black arrowheads* indicate tendon sheath filling with injectate, *white arrow* indicates needle, *white arrowhead* indicates needle tip

Needle position: Enter the skin from caudad to cephalad and in-plane with the probe.

Safety considerations: Same as above

Pearls:

- Supinate the hand to rotate the bicipital groove anteriorly.
- Angulate the transducer cephalad to eliminate anisotropy caused by the deep course of the biceps tendon.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 25 gauge, 1.5″ needle
- 0.5 ml of steroid preparation (typically 40 mg of triamcinolone or methylprednisolone)
- 1 ml of local anesthetic

Acromioclavicular (AC) Joint

The AC joint is formed by the articulation of the distal end of the clavicle and acromion process of the scapula, where a step-off can be palpated. Osteoarthritis of the AC joint is a frequent source of pain and occurs due to trauma or overuse from frequent rotational motion, shear stress, high compressive forces, or failure of the surrounding muscles [1, 10].

Ultrasound-guided AC joint injections can help diagnose AC joint mediated pain. Physical exam maneuvers such as the cross body arm abduction (scarf) sign and focal tenderness have low sensitivity [10]. Palpation-guided AC joint injections range in accuracy from 40 to 66 % (Table 2.2),

while image-guided injections have been shown to have a much higher degree of accuracy [11–15].

Scanning Technique and Anatomy to Identify

The patient can be positioned supine or seated upright. The medial acromion or lateral clavicle can be palpated and the ultrasound probe placed in the anatomic coronal plane over the AC joint. Alternatively the joint can be found by scanning superiorly from the bicipital groove in the transverse plane [7]. With the probe directly over the AC joint, an anechoic joint space can be visualized separating the hyperechoic cortex of the acromion and clavicle (Fig. 2.4). The hyperechoic fibrocartilaginous disk interposing the joint may be visualized in younger patients [2].

Table 2.2 Accuracy of AC joint injections

Author	Specimen	Guidance	Accuracy	Verification
Partington, 1998	Cadaver	Blind	67 %	Dissection
Peck, 2010	Cadaver	Blind/US	Blind (40 %) US (100 %)	Dissection
Pichler, 2009	Cadaver	Blind	57 %	Dissection
Bisbinas, 2006	Clinical	Blind	39.4 %	Fluoroscopy
Sabeti-Aschraf, 2011	Cadaver	Blind/US	Blind (72 %) US (95 %)	US expert

Injection Techniques: In-Plane Coronal Approach

Patient positioning: Sit the patient with the arm in a neutral position, hanging at the side. This position is optimal as the weight of the shoulder and arm maximally opens the joint space. Downward traction on the arm can further accentuate this.

Probe position: Center the probe over the AC joint in the coronal plane (Fig. 2.5a).

Markings: No significant vascular or neural structures need to be marked.

Needle position: Insert the needle in-plane from lateral to medial aiming at the lateral margin of the clavicle. A gel standoff technique can be utilized.

Safety considerations: The subacromial space is approximately 4 mm below the capsule, so the needle should be carefully placed to avoid puncturing the deep capsule and entering the subacromial space.

Pearls:

- Direct the needle parallel to the probe, as the joint lies relatively superficial.
- Immediately after successful injection, the capsule may appear elevated and the joint space wider.
- A gel standoff technique may be used to allow more room for the needle approach.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 25 gauge, 1.5″ needle

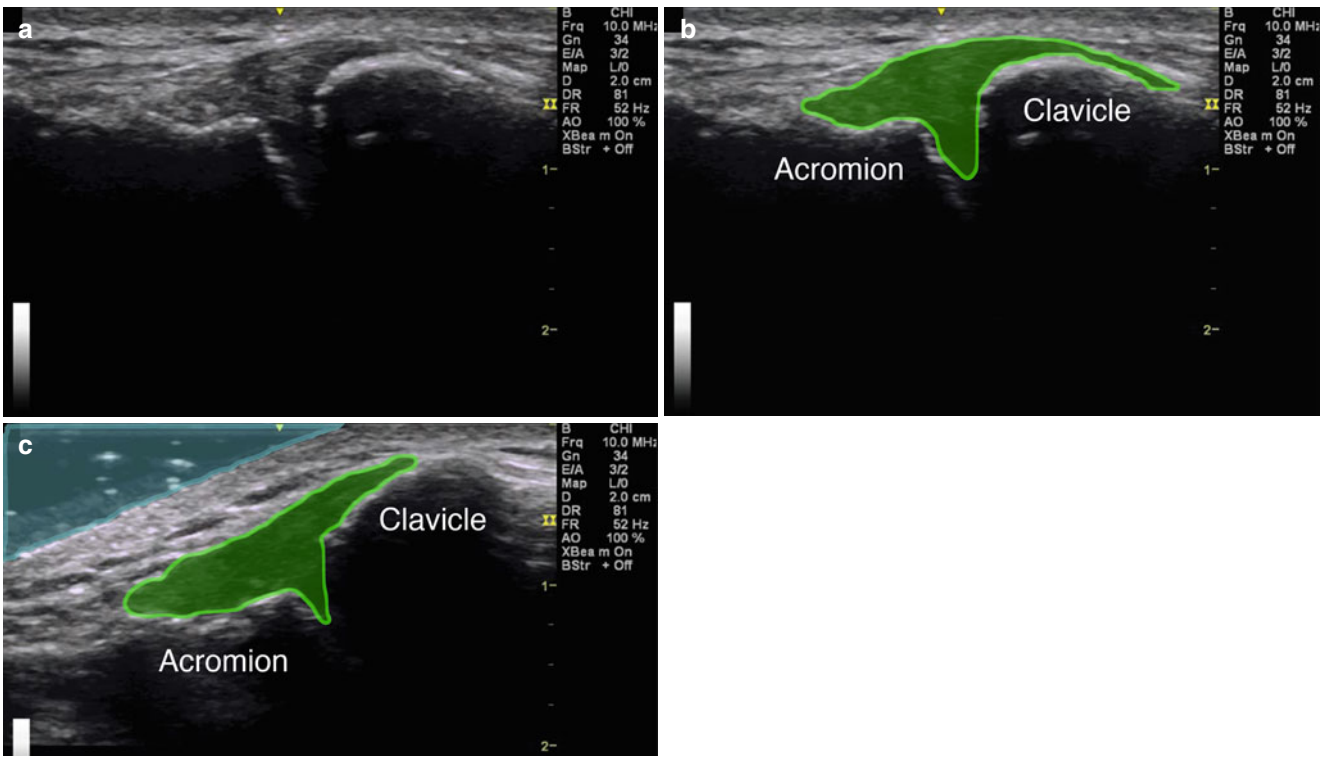

Fig. 2.4 (**a**) Coronal view of the acromioclavicular joint. (**b**) *Green* indicates AC joint fluid within the joint capsule, acromion and clavicle labeled. (**c**) Coronal view for a gel standoff approach, *light blue* indicating gel

- 0.5 ml of steroid preparation (typically 40 mg of triamcinolone or methylprednisolone)
- 1–2 ml of local anesthetic

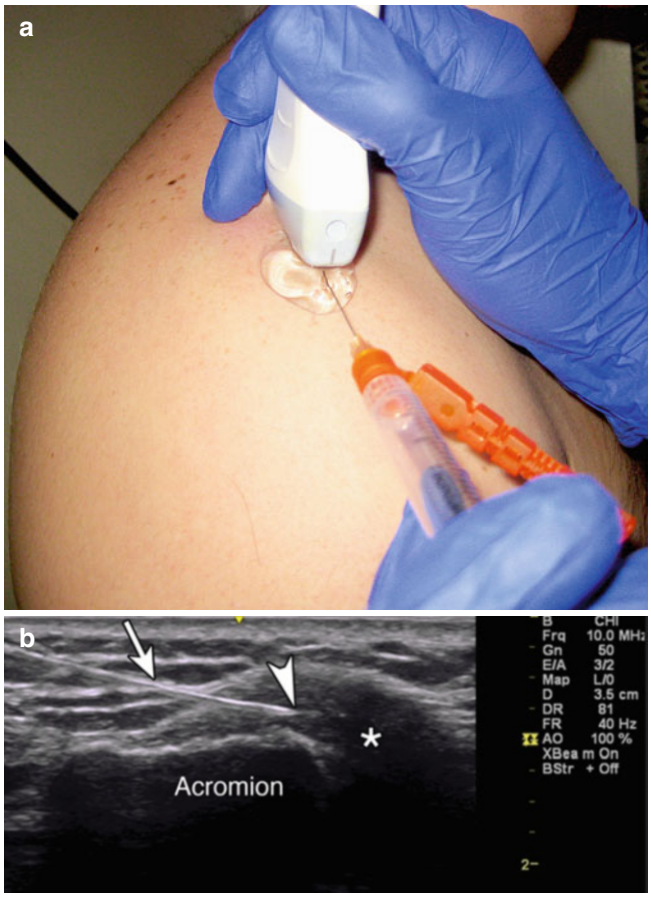

Fig. 2.5 (**a**) Example of coronal probe position over AC joint with gel standoff in-plane injection technique. (**b**) *Asterisk* indicates injectate in AC joint space, *arrow* points to needle, *arrowhead* points to needle tip, acromion labeled

Suprascapular Nerve Block

The suprascapular nerve innervates the supraspinatus and infraspinatus muscles and provides sensory branches to the posterior glenohumeral joint capsule, acromioclavicular joint, subacromial bursa, coracoclavicular, and coracoacromial ligaments [16]. A nerve block can be used to temporarily relieve pain or provide local anesthesia to any of these structures [17].

Scanning Technique and Anatomy to Identify

Place the ultrasound probe transversely over the superior medial border of the spine of the scapula, over the supraspinatus muscle. Follow the orientation of the superficial supraspinatus muscle and the deeper bony scapula; move the probe laterally along the axis of the supraspinatus muscle until the suprascapular notch appears (Fig. 2.6a) [18]. The suprascapular nerve will be visualized beneath the transverse scapular ligament in the suprascapular notch [19]. The nerve may be difficult to visualize but can be seen adjacent to the suprascapular artery, which can be identified with Doppler.

Injection Technique: In-Plane Coronal Approach

Patient positioning: Sit the patient with the arm in lap or with the hand of the side being blocked resting on the contralateral shoulder [19].

Probe positioning: The probe is placed parallel to the superior aspect of the scapular spine and then moved laterally and cephalad in a coronal plane to visualize the scapular floor and the suprascapular notch. Toggling the probe from

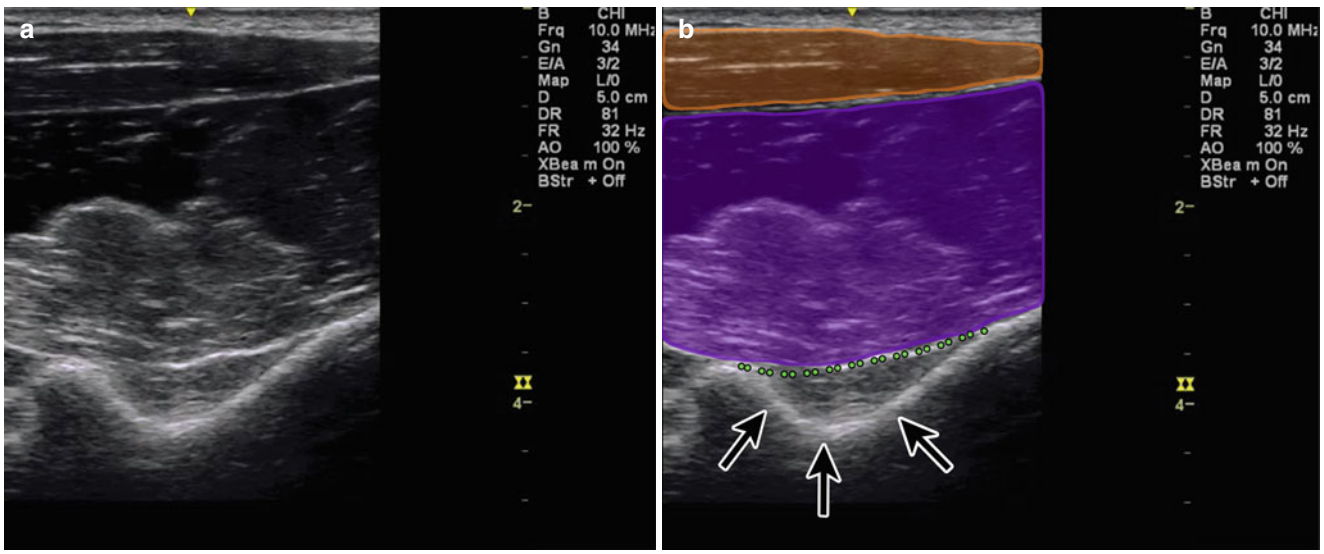

Fig. 2.6 (**a**) Coronal view of suprascapular notch. (**b**) *Orange* indicates trapezius muscle, *purple* indicates supraspinatus muscle, *black arrows* point to suprascapular notch, *green dotted line* indicates suprascapular ligament

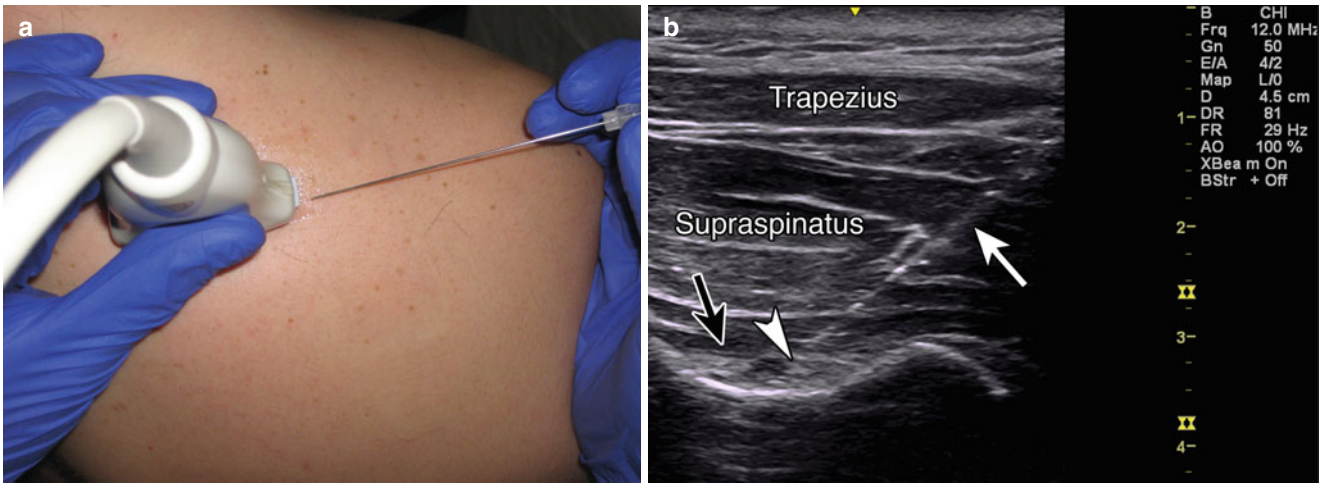

Fig. 2.7 (**a**) Example of coronal probe position over suprascapular notch. (**b**) Example of in-plane needle approach, *black arrow* point to suprascapular ligament, white arrow indicates needle, *white arrowhead* points to needle tip adjacent to suprascapular nerve, trapezius and supraspinatus muscles labeled

axial to coronal planes may help to visualize the suprascapular nerve and the transverse ligament (Fig. 2.7a).

Markings: The trapezius and supraspinatus will be clearly visualized deep to the subcutaneous tissue. The suprascapular artery can be confirmed with Doppler.

Needle position: The needle is directed from the lateral side of the probe in-plane toward the nerve sheath.

Safety considerations: The needle should be visualized at all times to avoid pneumothorax.

Pearls:

- Live ultrasound can demonstrate the spread of the injectate around the nerve and under the suprascapular ligament.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 22–25 gauge, 3″ or 3.5″ needle
- 0.5 ml of steroid preparation (typically 40 mg of triamcinolone or methylprednisolone)
- 4 ml of local anesthetic

Glenohumeral (GH) Joint

The GH joint is formed by the humeral head and glenoid cavity and is deepened and supported by the cartilaginous glenoid labrum. Its capsule is strengthened by three glenohumeral ligaments and extends down the bicipital tendon sheath in the intertubercular groove [16]. In patients with adhesive capsulitis or glenohumeral arthrosis, the shoulder can be an intense source of pain and limited mobility and function. Although primary osteoarthritis is uncommon in this region, rotator cuff failure, trauma, previous surgery, avascular necrosis, inflammatory arthropathies, osteochondritis dissecans, and iatrogenic injury can all lead to secondary osteoarthritis [1]. Adhesive capsulitis, commonly referred to as "frozen shoulder," initially presents as pain followed by progressively worsening range of motion. Although active or passive ranges of motion have been shown to improve function in adhesive capsulitis, GH joint injection expedites progress and symptom relief [20]. The accuracy of blind injections ranges from 27 to 72 % (Table 2.3) compared to ultrasound-guided injections which have been shown to be accurate 92–99 % of the time [21–29].

Scanning Technique and Anatomy to Identify

The glenohumeral joint can be visualized from either a posterior or an anterior approach. In a pathological joint, synovial hypertrophy and joint effusion can be visualized, most commonly in the posterior recess. Bone erosions of the humeral head can also be detected, often indicating a rotator cuff injury [30]. Posteriorly, the humeral head, bony glenoid, and labrum can be visualized deep to the infraspinatus and deltoid muscles (Fig. 2.8). Just medial, the spinoglenoid notch with the suprascapular neurovascular bundle can be seen [1].

Injection Techniques: In-Plane Axial Posterior Approach [1]

Patient positioning: Sit or place the patient in a semi-prone position with the hand of shoulder being injected crossing the chest (ipsilateral humerus adducted across thorax) or hanging at the side. The scapula should also remain protracted.

Probe position: Place the probe caudal and parallel to the lateral end of the scapular spine (Fig. 2.9a).

Table 2.3 Accuracy of GH joint injections

Author	Specimen	Guidance	Accuracy	Verification
Eustace, 1997	Clinical	Blind	42 %	Radiograph
Patel, 2012	Cadaver	Blind/US	72.5 %/92.5 %	Radiograph
Sethi, 2005	Cadaver	Blind	26.8 %	MR arthrography
Choudur, 2011	Clinical	US	99 %	MR arthrography
Gokalp, 2010	Clinical	US	96.7 %	MR arthrography
Koivikko, 2008	Clinical	US	Posterior 100 % Anterior 100 %	MR arthrography
Souza, 2010	Clinical	US	92 %	MR arthrography
Schaeffeler, 2010	Clinical	US/Fluoroscopy	US 100 % Fluoro 100 %	MR arthrography
Rutten, 2009	Clinical	US/Fluoroscopy	US 94 % Fluoro 72 %	MR arthrography

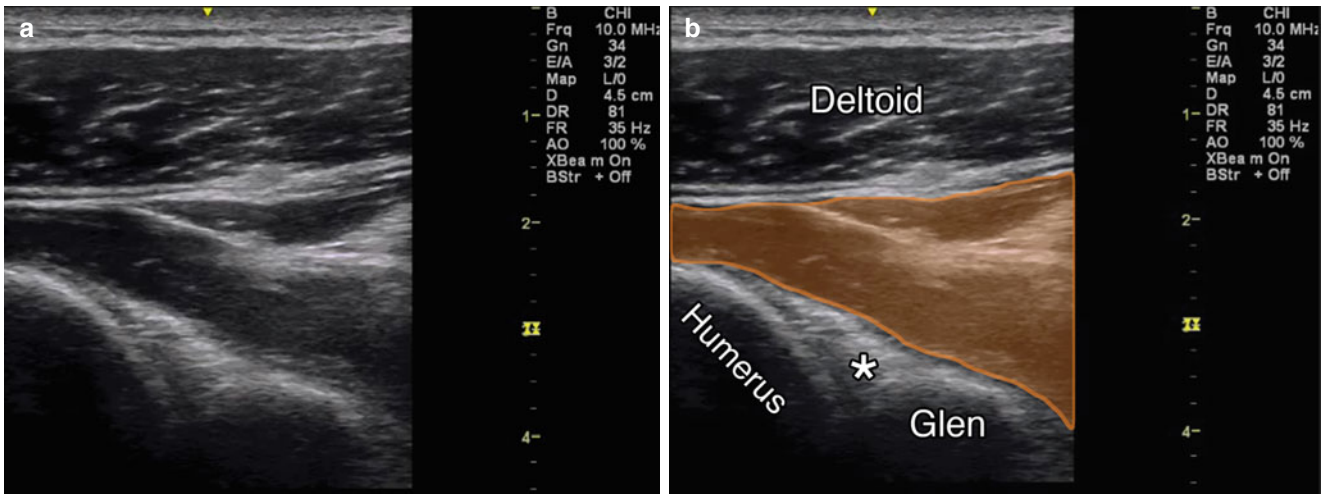

Fig. 2.8 (**a**) Posterior view of glenohumeral joint. (**b**) View of the posterior glenohumeral joint, deltoid and humerus labeled, *Glen* glenoid, *asterisk* indicates labrum, *orange* overlies infraspinatus muscle

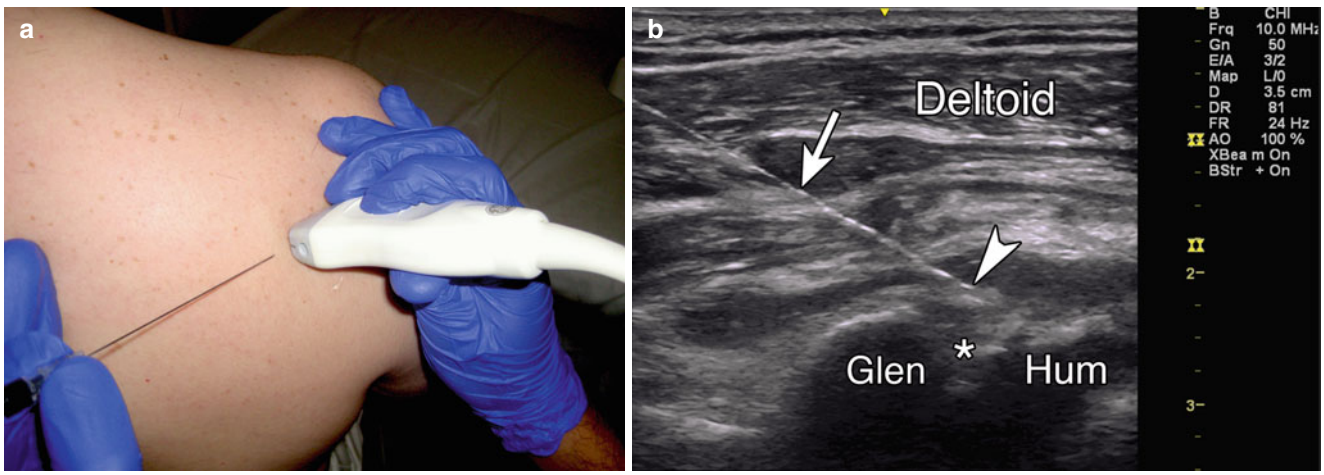

Fig. 2.9 (**a**) Example of probe position over posterior glenohumeral joint. (**b**) Example of in-plane needle approach, *white arrow* indicates needle, *white arrowhead* indicates needle tip, Hum-humerus, *Glen* glenoid, *asterisk* indicates labrum, deltoid labeled

Markings: The infraspinatus muscle, humeral head, posterior glenoid rim, and labrum can be visualized. Doppler can be checked to visualize the suprascapular artery in the spinoglenoid notch.

Needle position: The needle is directed, in-plane, from the medial or lateral side of the probe until it is subcapsular and contacts the humeral head.

Safety considerations: Avoid puncturing the glenoid labrum. Care must be taken to drive the needle directly toward the humeral head. For larger shoulders, a steeper approach may be necessary employing a walk-off technique of the needle off the posterior aspect of the humeral head.

Pearls:

- If resistance is encountered during injection, the needle may be embedded in the cartilage or capsule and may require slight manipulation to allow better flow of injectate into the joint.

Equipment needed:

- Linear array transducer (8 MHz+)
- 22–25 gauge, 3″ or 3.5″ needle
- 0.5–1.0 ml of steroid preparation (typically 40 mg of triamcinolone or methylprednisolone)
- 4 ml of local anesthetic

Subacromial/Subdeltoid Bursa (SASDB)

The SASDB is the most commonly injected shoulder structure and is helpful in diagnosing and treating impingement syndrome, rotator cuff tears, tendinosis, and other sources of bursitis. Impingement typically occurs from postural factors, rotator cuff deficits (partial tear, tendinosis, weakness), anatomic variations of the acromion or AC joint, thickening of the coracoacromial ligament, or repetitive overhead activities which then inflame the bursa. The mainstay of initial treatment is rest, nonsteroidal anti-inflammatory medication, and physical therapy, but patients with impingement may benefit from a SASDB corticosteroid injection to facilitate a more active therapy program when pain limited [1]. Blind SASDB injections are inconsistent, with studies demonstrating accuracy ranging from 60 to 100 % compared to near 100 % accuracy with ultrasound (Table 2.4) [31–37].

Scanning Technique and Anatomy to Identify

When viewing the SASDB, the acromion and deltoid muscles can be used as landmarks. The bursa will appear lateral to the acromion, below the relatively hypoechoic deltoid muscle and above the more hyperechoic supraspinatus tendon. When distended, a thin rim of hypoechoic fluid may be seen within the bursa (Fig. 2.10). When not distended, the location of the bursa can be estimated from the peribursal fat in between the deltoid muscle and supraspinatus tendon [1].

Injection Technique: In-Plane Coronal Approach

Patient position: Sit the patient with the ipsilateral arm hanging down.

Probe position: Place the probe in the coronal plane over the lateral end of the acromion perpendicular to the coracoacromial arch (Fig. 2.11a).

Marking: The acromion can be visualized on the medial most part of the ultrasound screen. The SASDB lies between the hyperechoic peribursal fat, below the hypoechoic deltoid muscle.

Needle position: Insert the needle in-plane directed toward the anechoic space between the peribursal fat, representing the SASDB [1].

Safety considerations: No significant structures are vulnerable to injury. Avoid spreading corticosteroid into the deltoid or supraspinatus tendon.

Table 2.4 Accuracy of SASDB injections

Author	Specimen	Guidance	Accuracy	Verification
Yamakado, 2002	Clinical	Blind	Anterolateral (70 %)	Radiographs
Henkus, 2006	Clinical	Blind	Posterior (76 %) Anteromedial (69 %)	MRI
Kang, 2008	Clinical	Blind	Posterior (75 %) Anterolateral (75 %) Lateral (60 %)	Radiographs
Park, 2010	Clinical	Blind	Anterolateral (49 %)	Radiographs
Rutten, 2007	Clinical	Blind/US	Posterior blind (100 %) Posterior US (100 %)	MRI
Hanchard, 2006	Cadaver	Blind	Posterior lateral (91 %)	Dissection
Mathews, 2005	Cadaver	Blind	Anterolateral (90 %) Posterior (80 %)	Dissection

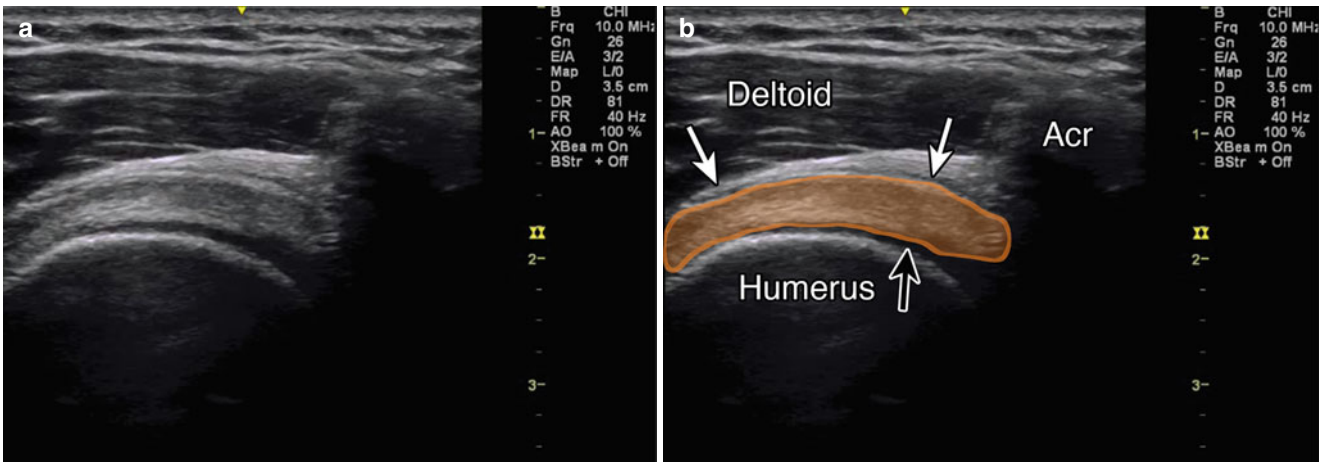

Fig. 2.10 (**a**) Coronal view of the SASDB. (**b**) Deltoid and humerus labeled, *Acr* acromion, *black arrow* indicates hyaline cartilage, *white arrows* indicate SASDB, *orange* indicates supraspinatus muscle

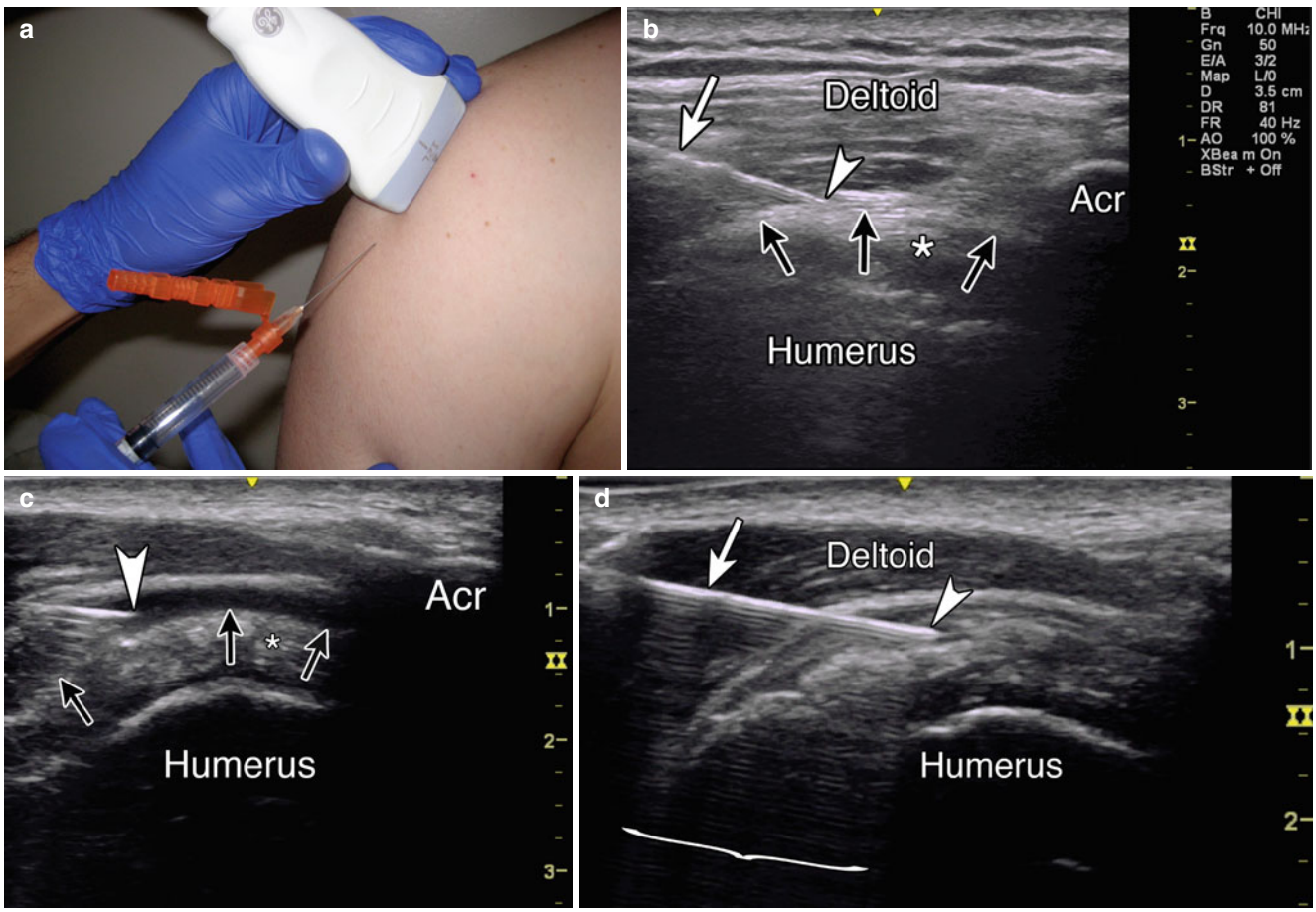

Fig. 2.11 (**a**) Example of probe position over SASDB with in-plane injection technique. (**b**) Example of in-plane needle approach, *white arrow* indicates needle, *white arrowhead* indicates needle tip, humerus and deltoid labeled, *Acr* acromion, *black arrows* indicate location of SASDB, *asterisk* indicates supraspinatus muscle with anisotropy. (**c**) *White arrowhead* indicates needle tip, *black arrows* indicate injectate filling bursa, *asterisk* indicates supraspinatus muscle with anisotropy, *Acr* acromion, humerus labeled. (**d**) Example of calcific tenotomy, *white arrow* indicates needle, *white arrowhead* indicates needle tip, *bracket* indicates needle reverberation, deltoid and humerus labeled

Pearls:

- Following injection, the separation between the supraspinatus and deltoid muscle can be seen under live ultrasound; make sure the fluid is seen diving underneath the acromion to confirm accurate placement.

Equipment needed:

- High-frequency linear transducer (10 MHz+)
- 25 gauge, 1.5″ needle
- 40 mg of triamcinolone or methylprednisolone
- 4–6 ml of local anesthetic

References

1. Peng P, Cheng P. A review of anatomy, sonoanatomy, and procedures. Part III: shoulder. Reg Anesth Pain Med. 2011;36:592–605.
2. Chiang YP, Feng CF, Lew HL. Ultrasound-guided examination and injection of the shoulder. Am J Phys Med Rehabil. 2011;90: 616–7.
3. Ahrens P, Boileau P. The long head of biceps and associated tendinopathy. J Bone Joint Surg Br. 2007;89(8):1001–9.
4. Durham B. Emedicine [Online]. 8 February 2012. [Cited: 19 June 2012.] http://emedicine.medscape.com/article/96521-overview#a0106
5. Hashiuchi T, et al. Accuracy of the biceps tendon sheath injection: ultrasound-guided or unguided injection? A randomized controlled trial. J Shoulder Elbow Surg. 2011;20:1069–73.
6. Gazzillo GP, Finnoff JT, Hall MM, Sayeed YA, Smith J. Accuracy of palpating the long head of the biceps tendon: an ultrasonographic study. PM R. 2011;3:1035–40.
7. Jacobson JA. Fundamentals of musculoskeletal ultrasound. Philadelphia: Saunders/Elsevier; 2007.
8. Haraldsson BT, Langberg H, Aagaard P, Zuurmond AM, van El B, Degroot J, Kjaer M, Magnusson SP. Corticosteroids reduce the tensile strength of isolated collagen fascicles. Am J Sports Med. 2006;34:1992–7.
9. Carpenito G, Gutierrez M, Ravagnani V, Raffeiner B, Grassi W. Complete rupture of biceps tendons after corticosteroid injection in psoriatic arthritis "Popeye sign": role of ultrasound 2. J Clin Rheumatol. 2011;17:108.
10. Renfree KJ, Wright TW. Anatomy and biomechanics of the acromioclavicular and sternoclavicular joints. Clin Sports Med. 2003;22:219–38.
11. Pichler W, Weinberg AM, Grechenig S, Tesch NP, Heidari N, Grechenig W. Intra-articular injection of the acromioclavicular joint. J Bone Joint Surg Br. 2009;91:1638–40.
12. Partington PF, Broome GH. Diagnostic injection around the shoulder: hit and miss? A cadaveric study of injection accuracy. J Shoulder Elbow Surg. 1998;7:147–50.
13. Peck E, Lai JK, Pawlina W, Smith J. Accuracy of ultrasound-guided versus palpation-guided acromioclavicular joint injections: a cadaveric study. PM R. 2010;9:817–21.
14. Bisbinas I, Belthur M, Said H, Green M. Learmonth. Accuracy of needle placement in ACJ injections. Knee Surg Sports Traumatol Arthrosc. 2006;14:762–5.
15. Sabeti-Aschraf M, Lemmerhofer B, Lang S. Ultrasound guidance improves the accuracy of the acromioclavicular joint infiltration: a prospective randomized study. Knee Surg Sports Traumatol Arthrosc. 2011;19:292–5.
16. Drake R, Wayne A, Mitchell A. Gray's anatomy for students. Philadelphia: Elsevier; 2010.
17. Sigenthaler A, et al. Ultrasound-guided suprascapular nerve block; description of a novel supraclavicular approach. Reg Anesth Pain Med. 2012;37:325–8.
18. Taskaynatan MA, Ozgul A, Aydemir K, Koroglu OO, Tan AK. Accuracy of ultrasound-guided suprascapular nerve block measured with neurostimulation. Rheumatol Int. 2012;32:2125–8.
19. Harmon D, Hearty C. Ultrasound-guided suprascapular nerve block technique. Pain Physician. 2007;10(6):743–6.
20. Marx RG, Malizia RW, Kenter K. Intra-articular corticosteroid injection for the treatment. HSS J. 2007;3(2):202–7.
21. Patel DN, Nayyar S, Hasan S, Khatib O, Sidash S, Jazrawi LM. Comparison of ultrasound-guided versus blind glenohumeral injections: a cadaveric study. J Shoulder Elbow Surg. 2012;21(12):1664–8.
22. Sethi PM, Kingston S, Elattrache N. Accuracy of anterior intra-articular injection of the glenohumeral joint. Arthroscopy. 2005;21: 77–80.
23. Eustace JA, Brophy DP, Gibney RP, Bresnihan B, FitzGerald O. Comparison of the accuracy of steroid placement with clinical outcome in patients with shoulder symptoms. Ann Rheumatol Dis. 1997;56:59–63.
24. Choudur HN, Ellins ML. Ultrasound-guided gadolinium joint injections for magnetic resonance arthrography. J Clin Ultrasound. 2011;39:6–11.
25. Gokalp G, Dusak A, Yazici Z. Efficacy of ultrasonography-guided shoulder MR arthrography using a posterior approach. Skeletal Radiol. 2010;39:575–9.
26. Koivikko MP, Mustonen AO. Shoulder magnetic resonance arthrography: a prospective randomized study of anterior and posterior ultrasonography-guided contrast injection. Acta Radiol. 2008;49:912–7.
27. Souza PM, Aguiar RO, Marchiori E, Bardoe SA. Arthrography of the shoulder: a modified ultrasound-guided technique of joint injection at the rotator interval. Eur J Radiol. 2010;74:29–32.
28. Rutten MJ, Collins JM, Maresch BJ. Glenohumeral joint injection: a comparative study of ultrasound and fluoroscopically guided techniques before MR arthrography. Eur Radiol. 2009;19:722–30.
29. Schaeffeler C, Brügel M, Waldt S, Rummeny EJ, Wörtler K. Ultrasound-guided intraarticular injection for MR arthrography of the shoulder. Rofo. 2010;182:267–73.
30. Petranova T, et al. Ultrasound of the shoulder. Med Ultrason. 2012;14(2):133–40.
31. Rutten MJ, Maresch BJ, Jager GJ, de Waal Malefijt MC. Injection of the subacromial-subdeltoid bursa: blind or ultrasound-guided? Acta Orthop. 2007;78:24–257.
32. 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: 227–82.
33. Yamakado K. The targeting accuracy of subacromial injection to the shoulder: an arthrographic evaluation. Arthroscopy. 2002; 18:887–91.
34. 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;17:61–6.
35. Park JY, Siti HT, O KS, Chung KT, Lee JY, Oh JH. Blind subacromial injection. J Shoulder Elbow Surg. 2010;19:1070–5.
36. Hanchard N, Shanahan D, Howe T, Thompson J, Goodchild L. Accuracy and dispersal of subacromial and glenohumeral injections in cadavers. J Rheumatol. 2006;33:1143–6.
37. Mathews PV, Glousman R. Accuracy of subacromial injection: anterolateral versus posterior approach. J Shoulder Elbow Surg. 2005;14:145–8.