3 Elbow

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Ultrasound can play an important role in differentiating the etiology of elbow pain since most pathology is extra-articular and superficial, including tendinosis and tears, ligamentous injury, nerve injury or entrapment, and bursitis [1–4]. Elbow arthritis, fractures, and other intra-articular pathologies can also be diagnosed indirectly by visualizing effusions which are easily seen. Due to the prevalence of tendinopathies, the elbow is a good region for some of the more emerging interventional procedures including prolotherapy, percutaneous needle tenotomy, and platelet-rich plasma injection [5].

Medial Epicondylosis (ME): Common Flexor Tendon (CFT)

The two most common pathologies involving the CFT are medial epicondylosis and tendon tear. Clinically distinguishing between these two diagnoses can be challenging [6]. However, with ultrasound guidance, diagnosis of degenerative changes versus tendon tear can be readily made. This information helps guide the early management of medial elbow pain. In addition, serial scanning with ultrasound can help assess response to intervention. Medial epicondylosis, known as "golfer's elbow," is characterized as an overuse syndrome or degenerative tendinosis caused by repetitive motion, especially during pronation and flexion of the wrist, involving the attachment at the CFT origin [3]. Medial epicondylosis is also frequently reported in baseball pitchers due to intense valgus force, and in athletes participating in tennis, bowling, racquetball, and javelin [4].

Clinically, the patient presents with localized tenderness at the medial epicondyle that is exacerbated by pronation and often associated with decreased grip strength [5]. One provocative test, called the medial epicondylitis test ("reverse Cozen's test"), reproduces medial elbow pain with resisted wrist flexion while the elbow is in full extension and the forearm is supinated [7]. Treatments vary from oral anti-inflammatory medications, rest, ice, physical therapy, and a variety of injections including ultrasound-guided corticosteroids and newer alternative minimally invasive procedures such as percutaneous needle tenotomy (PNT), autologous blood injection (ABI), and platelet-rich plasma (PRP) [5, 8]. Combined approach of PNT and autologous blood (AB) with ultrasound guidance has been shown as an effective treatment for refractory medial epicondylosis [8].

Scanning Technique and Anatomy to Identify

With the patient's hand in supination, the ultrasound probe is placed in a longitudinal orientation over the medial epicondyle [1]. In this view, the medial epicondyle is seen proximally with the trochlea and ulna. The anterior band of the ulnar collateral ligament is seen overlying the ulna and trochlea and ultimately inserts onto the epicondyle. The common flexor tendon appears fibrillar and overlies these structures inserting on the ridge of the epicondyle [2].

Ultrasound assessment usually reveals a normal hyperechoic triangular tendon interspersed with focally thickened or hypoechoic areas. As these changes may appear quite subtle it is critical to compare with the contralateral side [2]. In the presence of more progressive changes, hypoechogenicity, loss of normal fibrillar pattern, and even hyperemia from neovascularization can be visualized with color or power Doppler mode [3]. In chronic medial epicondylosis, calcifications may be observed that can lead to increased risk of partial or complete tendon rupture. Acute medial tendon

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ruptures can be diagnosed quickly and effectively by scanning in both the longitudinal and transverse plane. Typically, there is a loss or replacement of the regular hyperechoic fibrillar tendon pattern with irregular hypoechoic fluid and debris. If this is visualized, confirm clinically by palpating the identified location. One may feel a subtle step-off defect [9]. In this case, surgical intervention is often indicated (Fig. 3.1).

Injection Technique: In-Plane Coronal Approach

Patient positioning: The patient should be seated or lay supine with 90° of elbow flexion and the shoulder externally rotated. Place a towel underneath the lateral epicondyle for comfort.

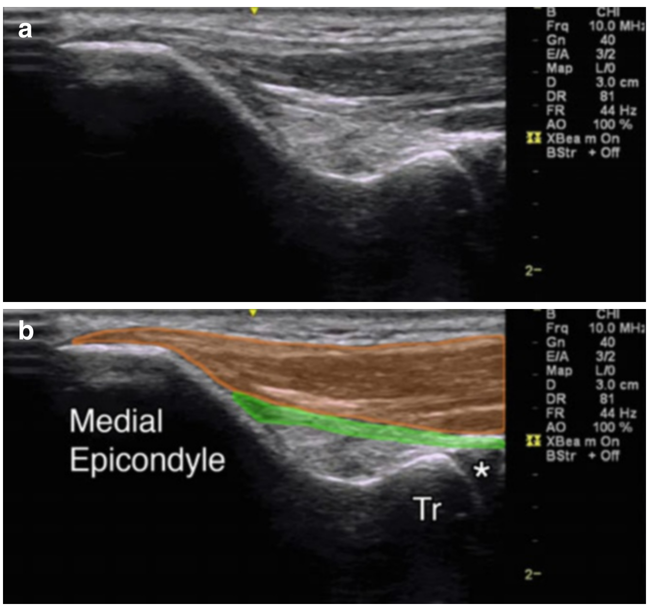

Fig. 3.1 (**a**) Coronal view of the common flexor tendons. (**b**) Tr-trochlea, *asterisk* indicates joint space, *orange* indicates common flexor tendons, and *green* indicates ulnar collateral ligament

Probe position: Place the probe longitudinally (coronal) with the proximal end of the transducer over the medial epicondyle to visualize the common flexor tendon. Scan proximally and distally until the medial epicondyle and the proximal attachments of the CFT are clearly identified (Fig. 3.2a).

Markings: Mark any obvious vessel or tendon prior to injection. Mark the medial epicondyle and the olecranon process.

Needle position: The needle should be inserted parallel to the transducer from either proximal to distal or distal to proximal. Due to the superficial nature of the tendon, a gel standoff may be helpful. For PNT, insert the needle into the tendon itself. For a peritendinous injection, keep the needle above or below the tendon.

Safety considerations: For corticosteroid injections, be careful when injecting superficial to the tendon since this can cause subcutaneous atrophy or depigmentation. PNT may cause local bleeding and post-procedure pain. Be careful to not inject too posterior, as this is where the ulnar nerve may lie.

Pearls:

- If performing PNT, intermittently switch to an out-of-plane/short-axis view in order to determine the anterior-posterior/radial-ulnar position of the needle within the region of tendinosis [4]. Repetitively fenestrate the entire region of tendinosis while injecting local anesthetic, PRP, or AB. Resistance should decrease with increased passes. Calcifications and enthesophytes should be mechanically broken up [11–13].

Equipment needed:

- High-frequency linear array transducer (10 MHz+).
- 25 gauge, 1.5″ needle.
- 0.5 mL of steroid preparation.
- 1–3 mL of local anesthetic.
- For PNT, use a larger (18–20 gauge) needle.
- May include 0.5–1 mL of steroid preparation with 1–3 mL of local anesthetic or 2–3 mL of PRP or autologous whole blood [11, 12].

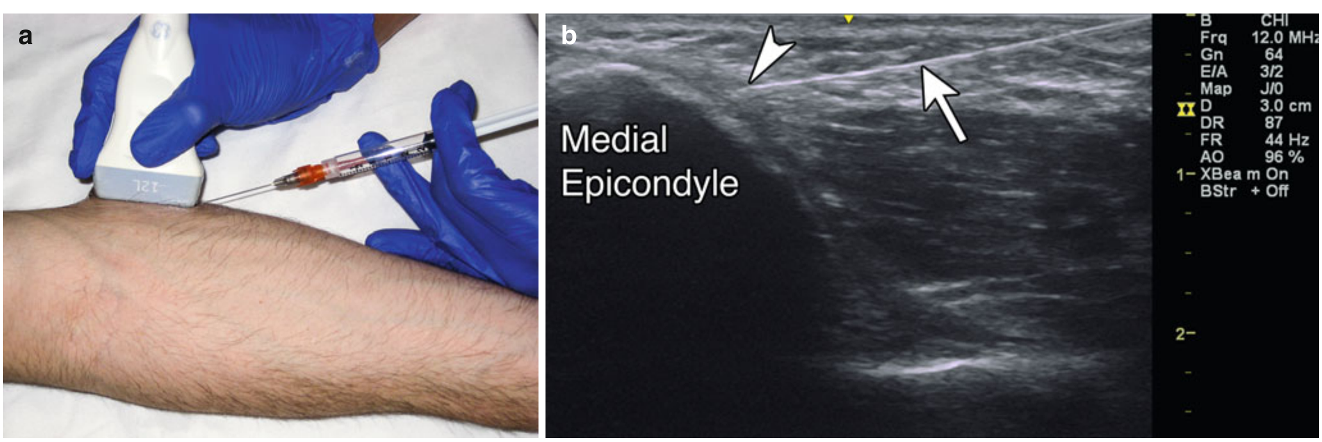

Fig. 3.2 (**a**) Example of probe position over medial epicondyle with in-plane injection technique. (**b**) Example of in-plane long-axis approach, *white arrow* indicates needle, *arrowhead* indicates needle tip, medial epicondyle labeled

Ulnar Collateral Ligament (UCL)

Ultrasound is very useful for distinguishing UCL pathology, including partial or complete tears, avulsion fractures, and chronic UCL injury and thickening. The UCL is a short and broad-based ligament divided into three components: an anterior, posterior, and transverse segment [5]. The anterior bundle provides the primary stabilization of the medial elbow, playing a critical role during valgus stress of the joint [10]. In injuries from sports requiring overhead throwing, prompt diagnosis is critical in determining appropriate management, whether it is surgical intervention for a complete tear versus conservative care for a partial tear or sprain [10]. For a professional athlete, delayed diagnosis of a torn ligament that ultimately requires surgery will have a significant adverse impact and may lead to the abrupt end of a professional sports career.

Clinically, a patient will present with medial elbow pain, tenderness to palpation along the ligament, and increased laxity with valgus stress at 30–90° [6]. Treatment with corticosteroid injection or PRP shows variable to promising improvement [5, 11]. In acute UCL injury, avoid using steroids for symptomatic relief, as there is an increased risk of ligamentous laxity and potential rupture [7]. In these cases, lidocaine injection may be used for temporary pain relief. After a corticosteroid injection, the patient should undergo a rehabilitation program focusing on proximal muscle strength, trunk rotation, core and gluteal strength, and the entire kinetic chain. A formal physical therapy program may be helpful [12].

Scanning Technique and Anatomy to Identify

The UCL is best visualized with the elbow positioned at 30° of flexion and the forearm supinated [4, 6]. Sprains include stretch injury with continuity of the ligament (Grade 1), partial tears (Grade 2), or complete rupture (Grade 3). With grade 1 sprains, the UCL may appear mildly thickened and hypoechoic [2]. Partial tears of the UCL appear as abnormal ligament thickening with internal hypoechoic disruption; the presence of hypoechoic fluid is variable [2, 9]. Complete tears or full thickness rupture appear as focal discontinuity of the ligament with surrounding hypoechoic edema or inability to visualize the ligament at all [13]. Increased gapping with valgus stress implies partial or full thickness tear. The anterior bundle extends from the anterior-inferior aspect of the medial epicondyle to the medial edge of the coronoid process [2, 3]. UCL avulsion, more commonly seen in the adolescent population, appears as a hyperechoic bony fragment adjacent to the medial epicondyle [2]. Chronic UCL injury from repetitive microtrauma causes progressive thickening, hypoechoic foci and calcifications that can lead to ligamentous instability (Fig. 3.3) [2, 5].

Injection Technique: In-Plane Coronal Approach

Patient positioning: The patient should be seated or lay supine with 30° of elbow flexion and the shoulder externally rotated. Place a towel underneath the lateral epicondyle for comfort.

Probe position: Place the probe longitudinally (coronal) with the proximal end of the transducer over the medial epicondyle to visualize the CFT. Scan proximally and distally until the medial epicondyle and the proximal attachments of the CFT are clearly identified. The UCL appears deep to the CFT (Fig. 3.4a). A normal UCL appears compact, fibrillar, and hyperechoic compared to an abnormal UCL, which appears as a thin hypoechoic band [3].

Markings: Mark the length of the anterior band of the UCL to plan the needle approach.

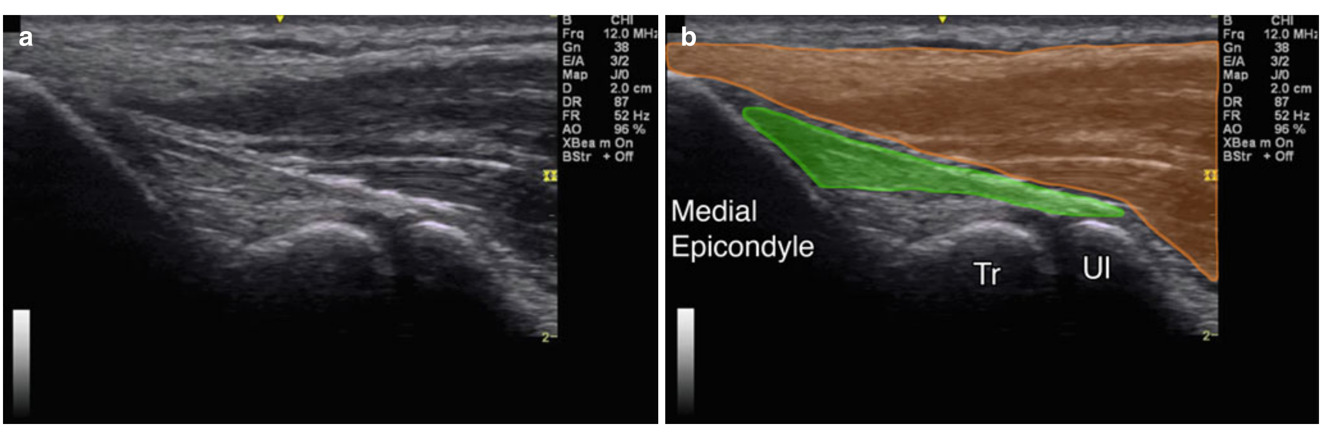

Fig. 3.3 (**a**) Coronal view of ulnar collateral ligament. (**b**) *Green* indicates ulnar collateral ligament, *orange* indicates common flexor tendons, *Tr* trochlea, *Ul* ulna, medial epicondyle labeled

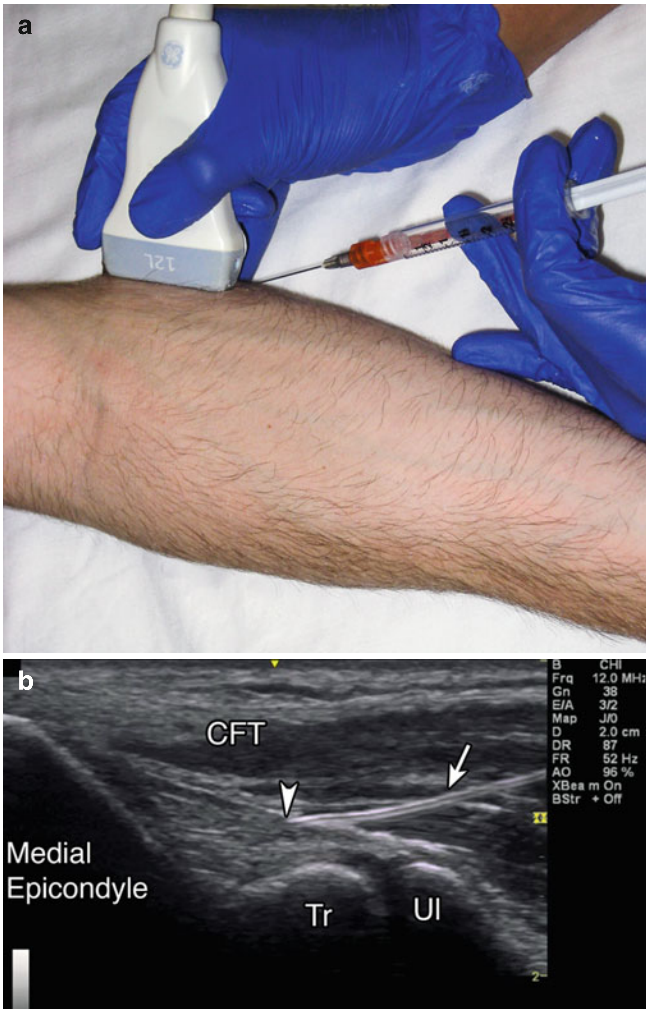

Fig. 3.4 (**a**) Example of probe position over ulnar collateral ligament. (**b**) Example of in-plane long-axis approach, white arrow indicates needle, arrowhead indicates needle tip, *Tr* trochlea, *Ul* ulnar, CFT-common flexor tendon, medial epicondyle labeled

Needle position: The needle should be inserted in-plane to the transducer. Inject into the hypoechoic region of the pathologic ligament with a single injection directed from distal to proximal [5].

Safety considerations: There is a risk of fatty atrophy and local depigmentation with corticosteroid injection. Be careful to not inject too posterior, where the ulnar nerve may lie.

Pearls:

- Valgus stress on the elbow will help to identify laxity of the UCL.
- An abnormal UCL appears hypoechoic with discontinuous fibers.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 25G 1.5″ needle
- 22G needle for PRP or autologous whole blood
- 0.5–1 mL of steroid preparation or 2–3 mL of PRP or autologous whole blood [11, 12]
- 1–3 mL local anesthetic

Ulnar Nerve at the Elbow

The ability of ultrasound to evaluate structures dynamically is particularly useful when evaluating the ulnar nerve at the elbow for ulnar subluxation or other causes of neuropathy [14]. At the level of the elbow, the ulnar nerve lies in the retroepicondylar groove and has a variable amount of slack in extension. This predisposes it to subluxation over the medial epicondyle during flexion, which can occur in roughly 20 % of individuals, although many may be asymptomatic. This movement predisposes the patient to ulnar neuritis [9]. Ulnar nerve subluxation also occurs in "snapping triceps syndrome." This can occur when the distal medial head of the triceps muscle subluxes from a lateral direction during elbow flexion, causing displacement of the ulnar nerve from its groove over the medial epicondyle [9]. As a result, ulnar nerve compression and neuropathy can occur at the retroepicondylar groove and the edge of the flexor carpi ulnaris muscle aponeurosis.

Clinically, patients commonly present with upper extremity weakness, hand pain, and numbness in the ulnar distribution [15]. It may be difficult to determine if the ulnar nerve is involved and the level of involvement. Ultrasound guided diagnostic ulnar nerve blockade is an effective and efficient method to determine ulnar nerve involvement [16]. This method is often used prior to a peripheral nerve stimulator in cases of refractory ulnar neuropathy. In addition, regional anesthesia of the ulnar nerve using ultrasound guidance is an effective technique. This is often used to potentiate distal anesthesia in incomplete brachial plexus blocks and in postoperative anesthesia of forearm and hand procedures to help minimize the need for pain medication.

Scanning Technique and Anatomy to Identify

Begin by scanning proximal to distal in the transverse plane at the level of the medial epicondyle. Proximally, the nerve appears oval or triangular in shape with internal punctate hyperechoic areas [16]. The ulnar nerve has a characteristic honeycomb pattern in the transverse plane, which is the typical appearance of a peripheral nerve [17]. This pattern describes the arrangement of the hypoechoic nerve fascicles with the hyperechoic perineurium and endoneurium. Identify the medial epicondyle and triceps muscle. Distally, the nerve becomes

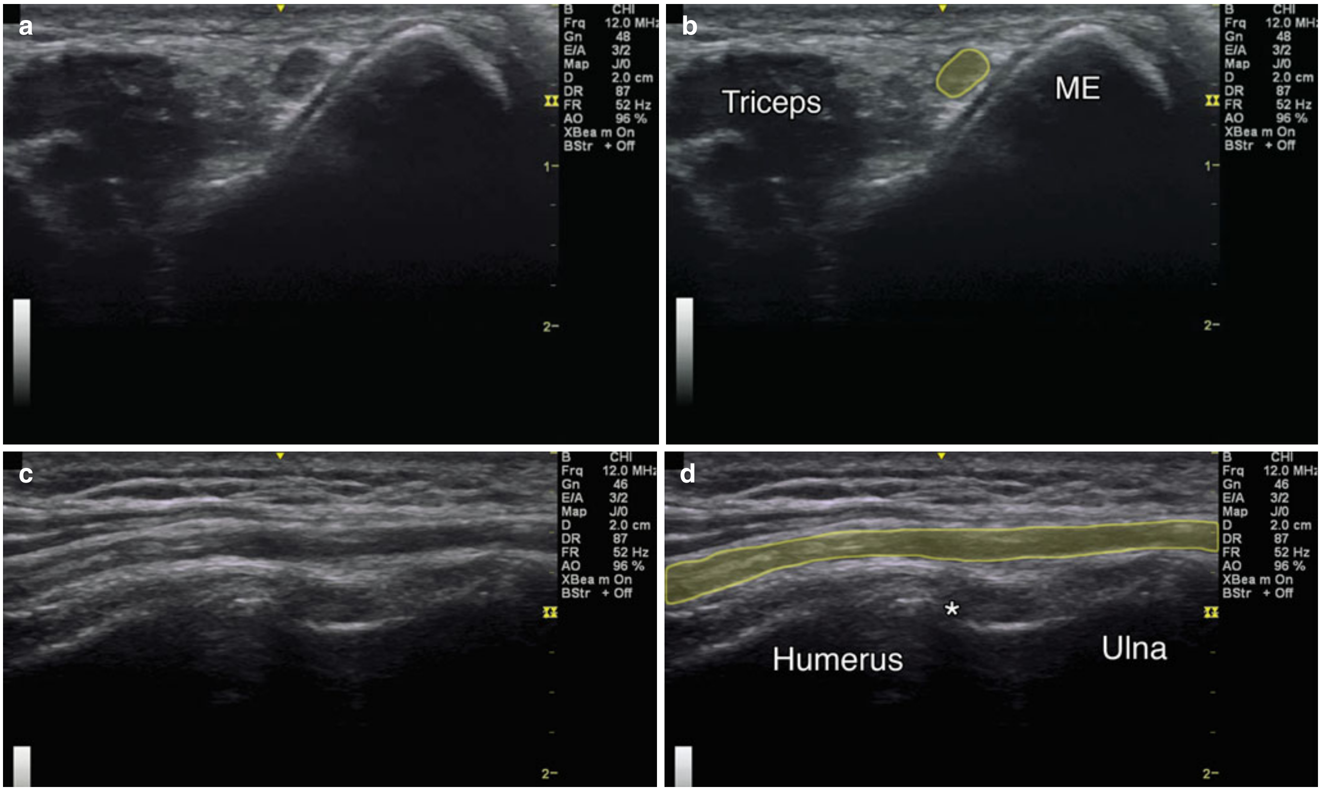

Fig. 3.5 (**a**) Transverse (axial) view of the ulnar nerve. (**b**) *Yellow* indicates ulnar nerve, *ME* medial epicondyle, triceps labeled. (**c**) Longitudinal view of the ulnar nerve. (**d**) *Yellow* indicates ulnar nerve, *asterisk* indicates joint space, humerus and ulna labeled

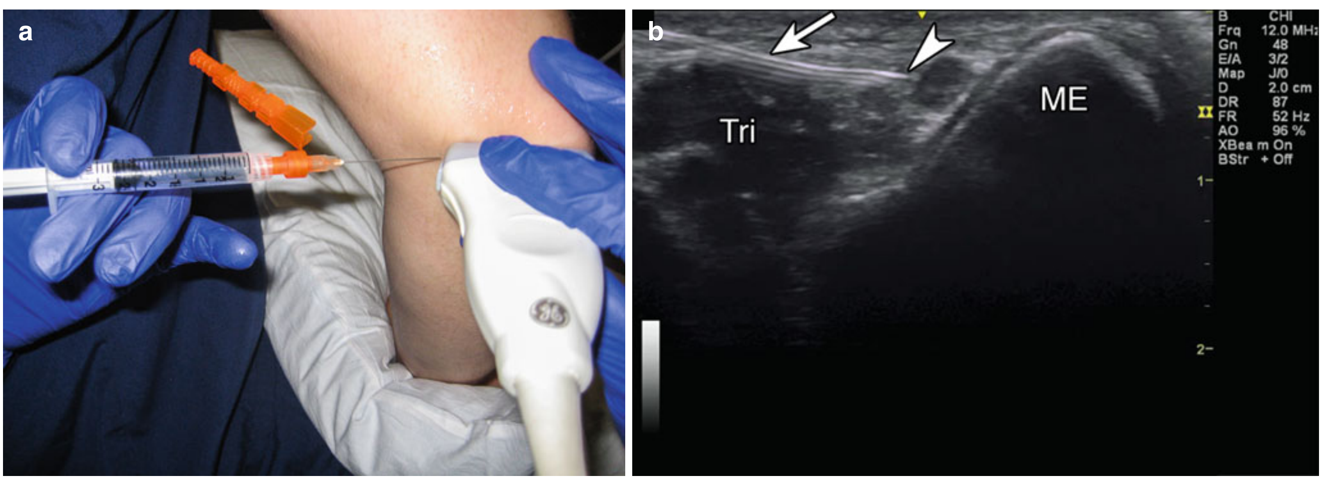

Fig. 3.6 (**a**) Example of probe position over ulnar nerve at the elbow. (**b**) Example of in-plane short-axis approach, *white arrow* indicates needle, *arrowhead* indicates needle tip, *Tri* triceps, *ME* medial epicondyle

thinner and difficult to differentiate from tendon. This is because the nerve contains smaller amounts of myelinated axons and thus can mimic the appearance of tendons. In the longitudinal plane, the ulnar nerve appears as a thin hyperechoic tubular structure. In an entrapment, the ulnar nerve becomes enlarged and edematous with an increase in hypoechoic appearance with loss of fascicular pattern (Fig. 3.5) [17].

Injection Technique: In-Plane Axial Approach

Patient positioning: The patient should lay supine, shoulder abducted 90° and elbow flexed approximately 90°, or be seated with the elbow flexed 90° with the hand on the table [15].

Probe positioning: Place the transducer transverse relative to the ulnar nerve at the elbow (Fig. 3.6a).

Markings: Mark any blood vessels prior to injection.

Needle position: Start from the ulnar (medial) aspect of the transducer. An in-plane approach is advised, as this provides continuous visualization of the needle tip. Identify the ulnar nerve and then guide the needle adjacent to the nerve and inject medication to create a "target sign." Look for spread around the circumference of the nerve and reposition as needed.

Safety considerations: Identify and avoid intravascular injection into the superior ulnar recurrent artery. Injections at this site should be limited to 3–5 mL in volume to minimize the risk of a compartment syndrome.

Pearls:

- Unlike blood vessels, nerves are not compressible structures.
- Injecting small amounts of anesthetic can help localize the needle tip.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 25G 1.5″ needle
- 3–5 mL local anesthetic

Injection Technique: In-Plane Longitudinal Approach

Patient positioning: Lay the patient supine, shoulder abducted 90° and elbow flexed approximately 90°, or with the patient sitting and the elbow flexed 90° with the hand on the table [15].

Probe positioning: Place the transducer longitudinal relative to the ulnar nerve at the elbow (Fig. 3.7a).

Markings: Mark any blood vessels prior to injection.

Needle position: Start from the ulnar (medial) aspect of the transducer. An in-plane approach is advised, as this provides continuous visualization of the needle tip. Identify the ulnar nerve and then guide the needle adjacent to the nerve. Look for spread around the superficial aspect of the nerve.

Safety considerations: Identify and avoid intravascular injection into the superior ulnar recurrent artery. Injections at this site should be limited to 3–5 mL in volume to minimize the risk of a compartment syndrome.

Pearls:

- Unlike blood vessels, nerves are not compressible structures.
- Injecting small amounts of anesthetic can help localize the needle tip.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 25G 1.5″ needle
- 3–5 mL local anesthetic

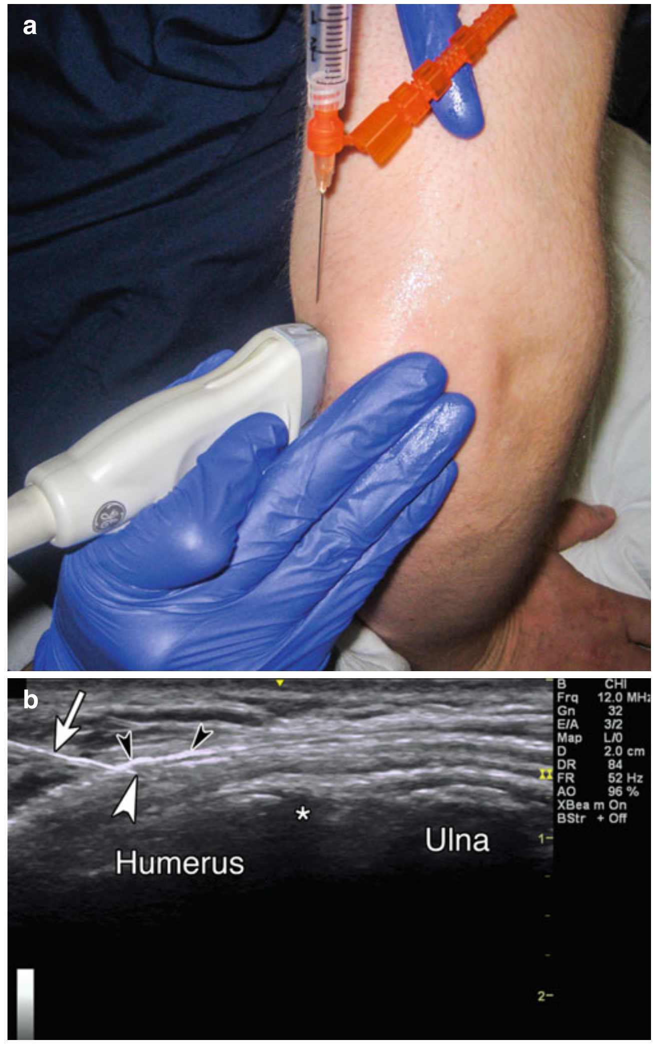

Fig. 3.7 (**a**) Example of probe position over ulnar nerve at the elbow. (**b**) Example of in-plane longitudinal approach, *white arrow* indicates needle, *white arrowhead* indicates needle tip, *black arrowheads* indicate injectate over nerve sheath, *asterisk* indicates joint space, humerus and ulna labeled

Lateral Epicondylosis (LE)

Lateral epicondylosis, also known as tennis elbow, is a common tendinopathy in the upper extremity. LE consists of pain at the proximal attachment of the common extensor tendon, usually arising from repetitive use and microtrauma. Patients often complain of pain in the region of the proximal wrist extensor attachments, especially with resisted wrist extension, twisting motions as the wrist, and grasping objects. Physical examination may reveal tenderness to palpation over the lateral epicondyle and reduced strength with resisted grip, supination, and wrist extension [18]. Provocative tests such as Cozen's and Mill's can reproduce the symptoms. Ultrasound may assist in identifying enthesophytes, tendon

Table 3.1 Outcomes of USG percutaneous needle tenotomy in the treatment of common extensor tendinosis in the elbow, *N* = 52 [11]

Excellent	Good	Fair	Poor
30 (57.7 %)	18 (34.6 %)	1 (1.9 %)	3 (5.8 %)

Excellent – very happy with the procedure and had no room for improvement
Good – happy with the procedure and had only mild room for improvement
Fair – slight dissatisfaction with the outcome of the procedure and had room for considerable improvement
Poor – dissatisfied with the outcome of the procedure and had little or no improvement

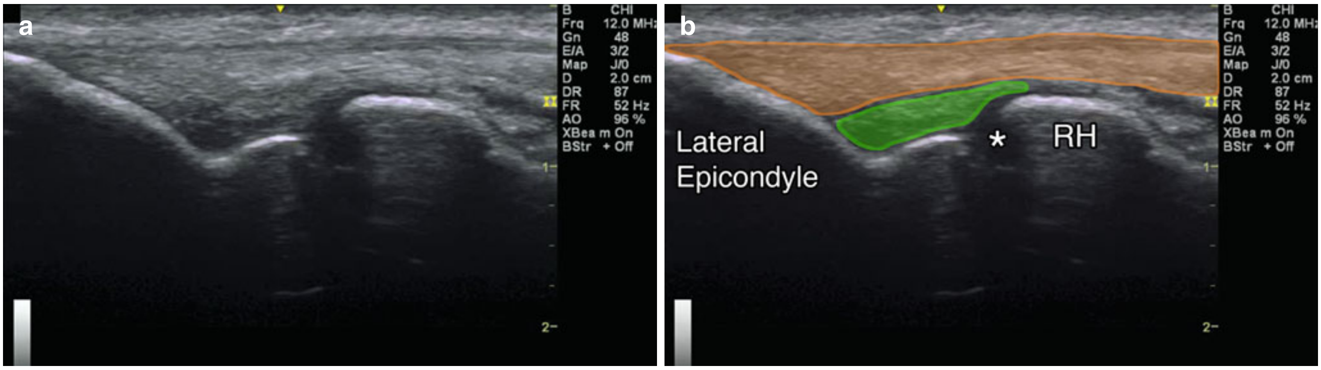

Fig. 3.8 (**a**) Coronal view of common extensor tendon. (**b**) *Green* indicates radial collateral ligament, *orange* indicates common extensor tendons, *RH* radial head, *asterisk* indicates joint space, lateral epicondyle labeled

thickening, and calcifications [17, 18]. PNT, PRP, and corticosteroid injection into or around the involved tendon have all shown varying efficacy in treating lateral epicondylosis (Table 3.1) [19–21].

Scanning Technique and Anatomy to Identify

The patient should lay supine with the forearm rested across the abdomen or be seated with the arm on a table. Place the transducer longitudinally, in line with the forearm, over the common extensor tendon (CET). This allows evaluation of the lateral epicondyle and the proximal attachments of the CET [22]. The CET can be seen here at its origin on the lateral epicondyle traversing distally over the radial head. The radial collateral ligament can be seen deep to the CET between the lateral epicondyle and the radial head. The CET may show tendon thickening at its origin, degenerative changes, and tears, which appear as linear focal or complex hypoechoic areas within the normal tendon matrix [9, 23]. Other findings may include calcification, adjacent cortical irregularity, and diffuse tendon heterogeneity [18]. The lateral collateral ligament complex (LCL) of the elbow is a Y-shaped complex composed of three components: the radial collateral ligament (RCL), the lateral ulnar collateral ligament (LUCL), and the annular ligament. The RCL extends from the lateral epicondyle to the annular ligament. The LUCL spans from the lateral epicondyle to the supinator crest of the ulna. The annular ligament courses from the ulnar anterior margin at the sigmoid notch to the supinator crest at the posterior margin of this bone, forming a ring encompassing the radial head and neck [24]. Part of the elbow joint between the radial head and the lateral epicondyle can also be appreciated deep to the CET (Fig. 3.8).

Injection Technique: In-Plane Long-Axis Approach

Patient positioning: The patient should lay supine with the arm internally rotated and elbow flexed. The patient can also be seated with the affected arm resting comfortably on a table with the elbow in 20–40° of flexion and forearm pronated. Place a towel underneath the medial epicondyle for comfort.

Probe positioning: Place the probe longitudinally (coronal) with the proximal end of the transducer over the lateral epicondyle to visualize the CET. Scan proximally and distally until the lateral epicondyle and the origin of the CET are clearly identified. The radial collateral ligament appears deep to the CET. If performing PNT, alternate changing to an out-of-plane/short-axis view to identify and confirm the position of the needle within the region of tendinosis (Fig. 3.9a).

Markings: None

Needle position: The needle should be inserted parallel to the transducer from either proximal to distal or distal to proximal. Due to the superficial nature of the tendon, a gel

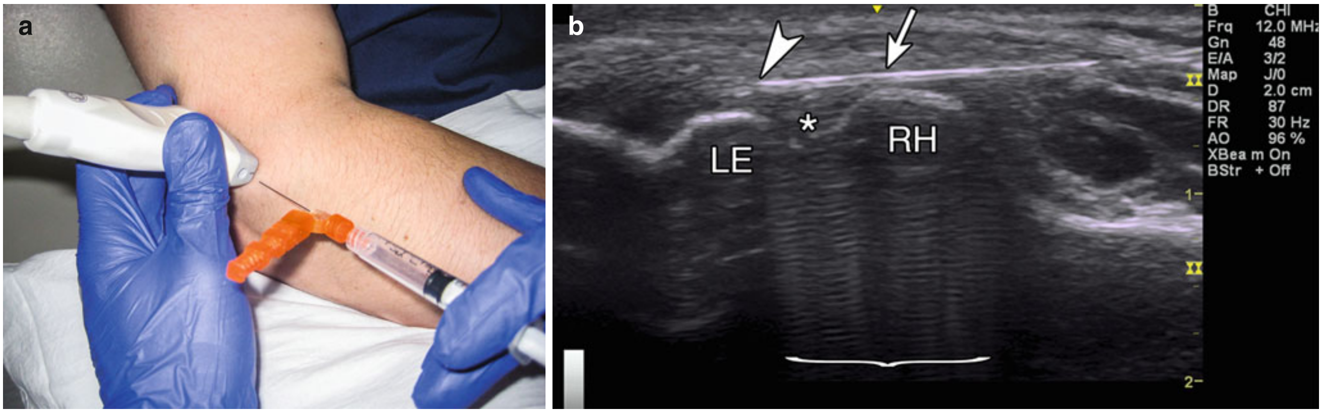

Fig. 3.9 (**a**) Example of probe position over common extensor tendon. (**b**) Example of in-plane long-axis approach, *arrow* indicates needle, *arrowhead* indicates needle tip, *asterisk* indicates joint space, *bracket* indicates needle reverberation, *LE* lateral epicondyle, *RH* radial head

standoff may be helpful. For PNT, insert the needle into the tendon itself and repetitively fenestrate the entire region of tendinosis. For a peritendinous injection, keep the needle above or below the tendon. The elbow joint can also be accessed using the same approach directed towards the space between the radial head and lateral epicondyle.

Safety considerations: For corticosteroid injections, be careful when injecting superficial to the tendon since this can cause subcutaneous atrophy or depigmentation. PNT may cause local bleeding and post-procedure pain. Avoid the lateral collateral ligament complex and the radial and posterior interosseous nerves.

Pearls:

- Doppler may help to identify hyperemia and chronic tendinosis.
- If performing PNT, intermittently switch to an out-of-plane/short-axis view in order to determine the anterior-posterior/radial-ulnar position of the needle within the region of tendinosis [4].
- For PNT, repetitively fenestrate the entire region of tendinosis while injecting local anesthetic, PRP, or AB. Resistance should decrease with increased passes. Calcifications and enthesophytes should be mechanically broken up.
- The elbow joint, between the radial head and lateral epicondyle, can be accessed using this approach by angling the needle deeper through the common extensor tendon.

Equipment needed:

- High-frequency linear array transducer (10 MHz+).
- 25 gauge, 1.5″ needle.
- 0.5 mL of steroid preparation.
- 1–3 mL of local anesthetic.
- For PNT, use a larger (18–20 gauge) needle.
- May include 0.5–1 mL of steroid preparation with 1–3 mL of local anesthetic or 2–3 mL of PRP or autologous whole blood [19–21].

Radial and Posterior Interosseous Nerve

Compression neuropathy of the posterior interosseous nerve (PIN) near or below the supinator muscle is known as supinator syndrome, posterior interosseous syndrome, or radial tunnel syndrome [25]. The PIN is the terminal motor branch of the radial nerve [26]. Entrapment may be due to hypertrophy of the supinator muscle, which acts in synergy with the biceps to supinate the forearm when the elbow is extended. Furthermore, the PIN may be bound and entrapped by fibrous bands or recurrent radial vessels at the arcade of Fröhse. Soft-tissue masses, such as periosteal lipomas and deep ganglia may also compress the nerve [27–29]. Radial head and neck fractures, including Monteggia fracture-dislocations, may displace and compress the PIN as it courses through the radial tunnel [30]. The PIN is a purely motor nerve, but patients usually complain of a dull ache and burning pain around the lateral epicondyle, very similar to lateral epicondylosis. Diagnosis is usually made clinically or with a diagnostic block. The radial nerve innervates the extensor carpi radialis longus, the extensor carpi radialis brevis, and the brachioradialis, while the PIN branch innervates the supinator, extensor digitorum communis, extensor digiti minimi, extensor carpi ulnaris, abductor polices longus, extensor polices brevis and longus, and extensor indicis proprius. Therefore, radial wrist extension should be preserved, and the patient has more of a “finger drop” than the characteristic radial “wrist drop” [30]. Provocation of the symptoms is performed by passive supination or active pronation of the forearm. There may also be a positive Tinel’s sign [26].

Scanning Technique and Anatomy to Identify

Place the transducer in an axial plane over the elbow. The radial nerve courses between the brachioradialis and the brachialis muscles then bifurcates into the superficial sensory branch and

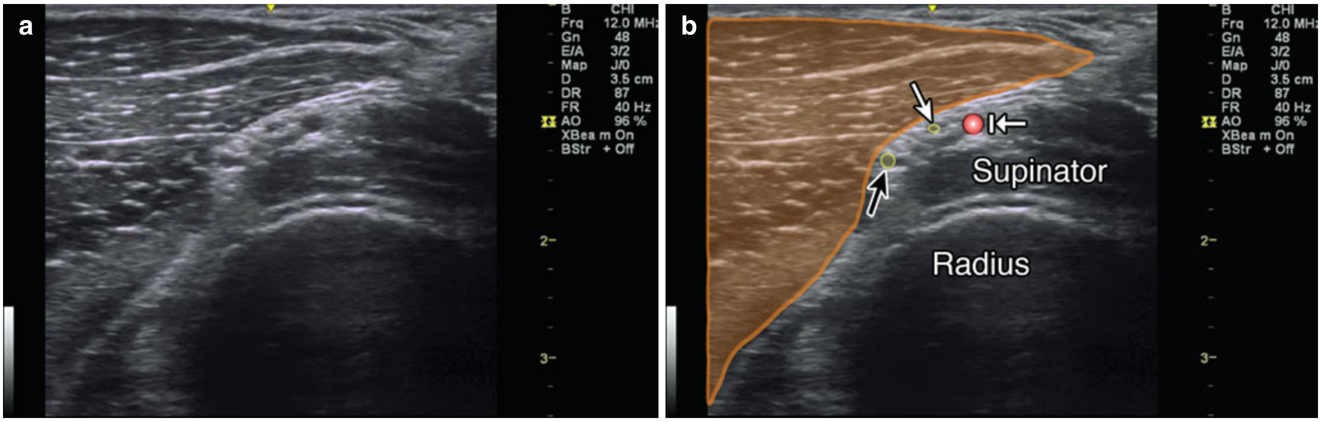

Fig. 3.10 (**a**) Transverse (axial) view of branching radial nerve. (**b**) *White arrow* indicates superficial radial nerve, *black arrow* indicates posterior interosseous nerve, *orange* indicates brachioradialis, *arrow with stop* indicates vessel, supinator and radius labeled

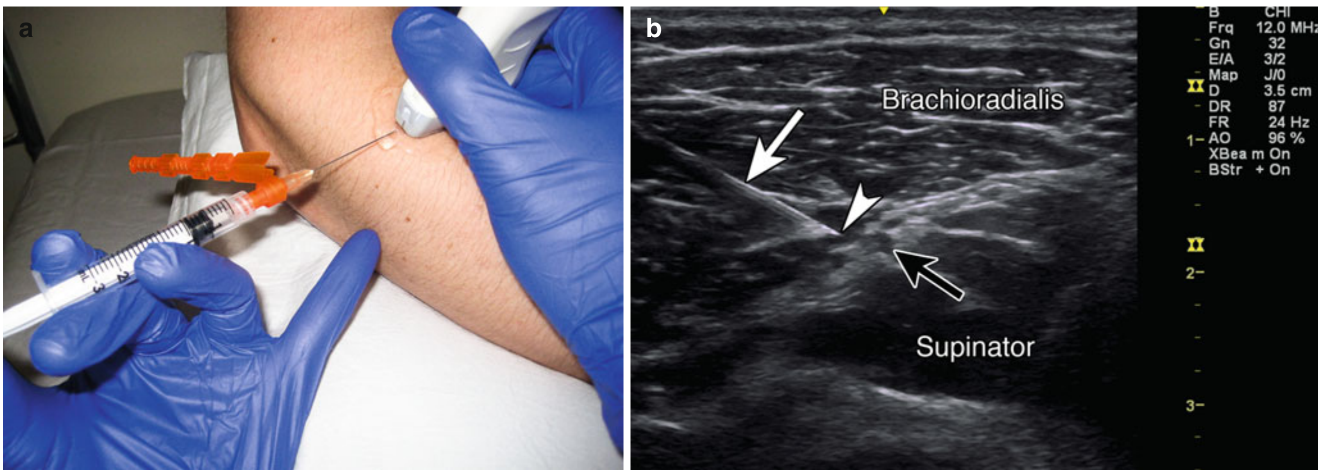

Fig. 3.11 (**a**) Example of probe position over branching radial nerve. (**b**) *White arrow* indicates needle, *arrowhead* indicates needle tip, *black arrow* indicates posterior interosseous nerve, brachioradialis and supinator labeled

the deep branch (PIN) just anterior to the lateral epicondyle. Scan these branches transversely to their termination. Almost immediately, the PIN can be seen entering the "radial tunnel," piercing between the superficial and deep parts of the supinator. The roof of this tunnel is known as the arcade of Fröhse. The PIN may also be assessed by pronating and supinating the forearm while passing the probe over the supinator in an axial plane [25, 26]. A compressed nerve typically appears enlarged and hypoechoic proximal to or inside the site of compression, in this case the supinator muscle [26]. After a radial fracture, the nerve may be surrounded by hypoechoic scar tissue (Fig. 3.10) [30].

Injection Techniques: In-Plane Short-Axis Approach

Patient positioning: The patient should be seated with the affected arm resting on the table, with elbow flexed, and forearm neutral or pronated.

Probe position: Place the transducer transverse relative to the PIN at the level of the distal humerus and locate the radial nerve laterally. Follow the nerve distally until it bifurcates into the superficial sensory branch and PIN (Fig. 3.11a).

Markings: Mark any obvious vessels prior to injection.

Needle position: Insert the needle in-plane from the ulnar (lateral) to radial (medial) aspect of the transducer, transverse to the PIN. Identify the PIN as it enters the arcade of Fröhse by following it distally from the radial bifurcation. Guide the needle tip adjacent to the nerve and then inject medication to produce a "target sign."

Safety considerations: Identify the superficial radial nerve and the recurrent radial artery and avoid intravascular injection.

Pearls:

- Injecting small amounts of anesthetic can help localize the needle tip.
- Adjust the forearm pronation/supination for optimal imaging of the PIN.

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 22–25G 1.5″ needle
- 1–3 mL local anesthetic [31]

Olecranon Bursitis

Olecranon bursitis is the most common superficial bursitis [32]. Causes include inflammation from repetitive mechanical stress, trauma, infection, or systemic inflammatory diseases such as gout, pseudogout, and rheumatoid arthritis [33]. Ultrasound assesses olecranon bursa location, depth, and size while providing guidance for aspiration and therapeutic injection [5]. Olecranon bursitis typically presents as unilateral swelling over the posterior elbow, with or without pain. Aseptic bursitis is commonly painless; septic bursitis is more often painful with associated cellulitic changes [5, 33].

Scanning Technique and Anatomy to Identify

The olecranon bursa is an anatomical potential space, located between the proximal aspect of the olecranon process and the subcutaneous tissue on the extensor surface. Normally, the bursa appears as a thin hypoechoic area surrounded by a hyperechoic synovial lining. Fluid collection in this potential space displaces the posterior fat pad and creates a distended fluid-filled collection that appears anechoic or hypoechoic [34]. In the transverse view, fluid in the joint is evidenced by fat pad displacement, and frequently epicondylar injury can be detected [35]. Hypoechoic fluid can be distinguished from hypoechoic cartilage by its compressibility and altered fluid distribution with dynamic movement [34].The olecranon recess is accessible with the elbow flexed at 90°, either medial or lateral to the triceps tendon. Diagnostic sonography is more sensitive with the elbow in the flexed position; 1–3 mL of joint fluid can be identified on ultrasound, compared with the 5–10 mL

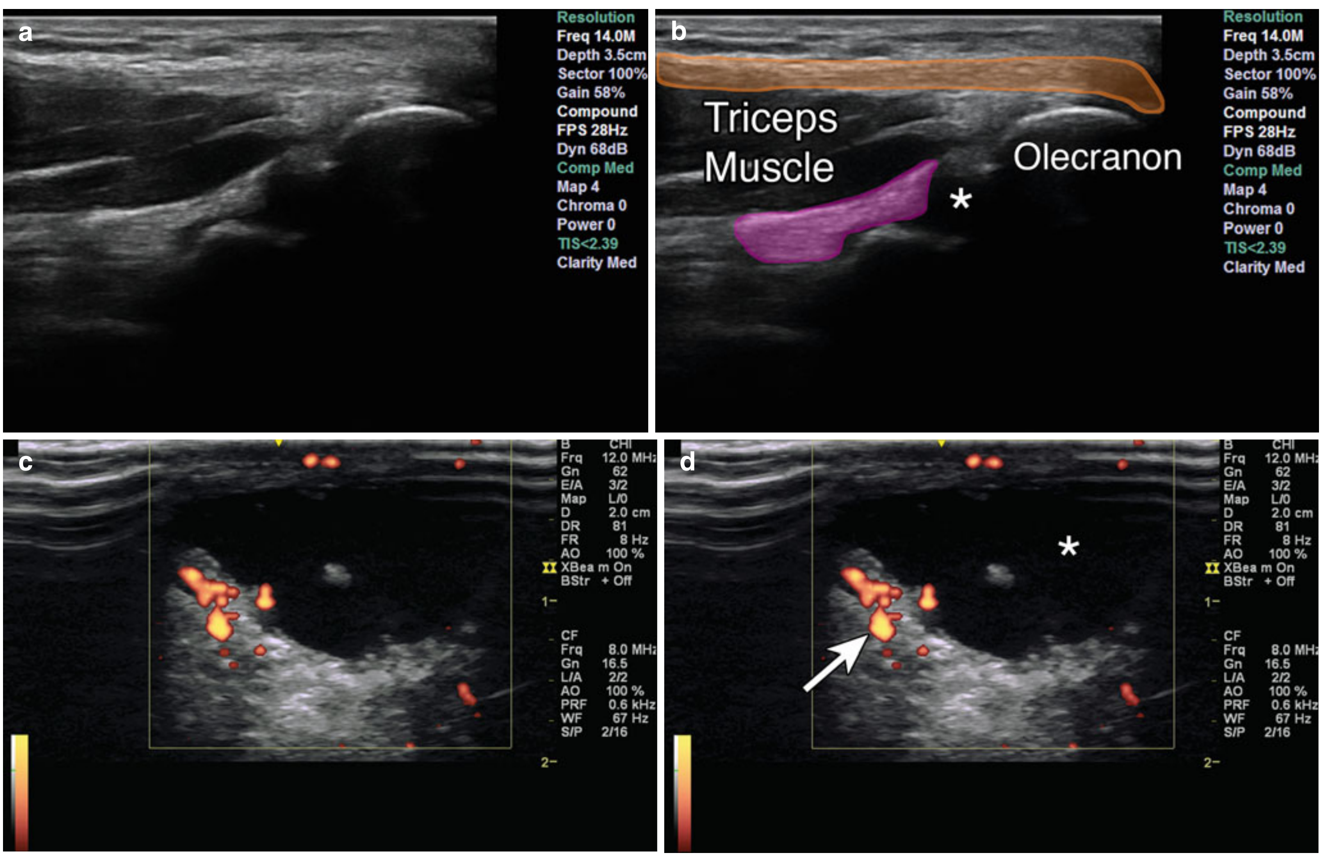

Fig. 3.12 (**a**) Example of sagittal view over posterior elbow. (**b**) Triceps muscle labeled, *orange* indicates tendinous portion of triceps muscle, *asterisk* indicates joint space between olecranon and trochlea, *magenta* indicates fat pad, olecranon labeled. (**c**) Example of transverse (axial) view over olecranon bursitis. (**d**) *White arrow* indicates hyperemia, *asterisk* indicates hypoechoic fluid-filled bursa

required for identification of a posterior fat pad on plain films [34]. Aspiration is used to decompress the bursa especially when it is painful, interferes with daily activity or causes a cosmetic concern, and it provides diagnostic analysis when infectious or crystal arthropathies are suspected [33].

Start by placing the transducer parallel to the triceps muscle and tendon and identify the olecranon joint recess, olecranon fossa, and posterior fat pad. Move the transducer inferiorly and the olecranon bursa will come into view. Rotate the transducer to the axial plane and identify the ulnar nerve in the retroepicondylar groove. Doppler may identify active inflammation in the bursa with local hypervascularity [3, 36]. Olecranon bursitis will have local hypervascularity along with bursal wall distention [37]. In chronic bursitis, the synovial wall of the bursae becomes thickened and appears hyperechoic (Fig. 3.12).

Injection Techniques: In-Plane Axial Approach

Patient positioning: Place the affected arm on a table with the elbow flexed to 90°.

Probe positioning: Place the probe transversely over the bursa (Fig. 3.13a).

Markings: It may be helpful to identify the cubital tunnel and ulnar nerve. Mark the border of the triceps tendon.

Needle position: The needle should be inserted in-plane from radial to ulnar, distal to proximal, or proximal to distal. A posterior intra-articular elbow injection can be performed in this position as well targeting the space between the olecranon and trochlea [38].

Safety considerations: There is a risk of reoccurrence of swelling or fistula formation from aspirating the olecranon bursa through the extensor compartment [39, 40]. If septic or infection suspected, steroid injections should not be used, until diagnostic confirmation.

Pearls:

- Aspirate from a lateral approach; needle is inserted at an angle into the bursa; use the "zigzag" needle method to prevent the formation of fistula or direct sinus with the skin or subcutaneous tissue.
- Posterolateral approach is used to help avoid the ulnar nerve.
- Doppler mode may help identify hyperemia.
- Compression with the ultrasound probe will compress the olecranon bursa.
- Avoid intratendinous injection and neurovascular structures.
- Hyperechoic particles within the fluid suggest a hemorrhagic, an inflammatory, or septic etiology [41].

Equipment needed:

- High-frequency linear array transducer (10 MHz+)
- 18 or 20 gauge needle 1.5″ needle
- 0.5 mL of steroid preparation
- 3–5 mL local anesthetic

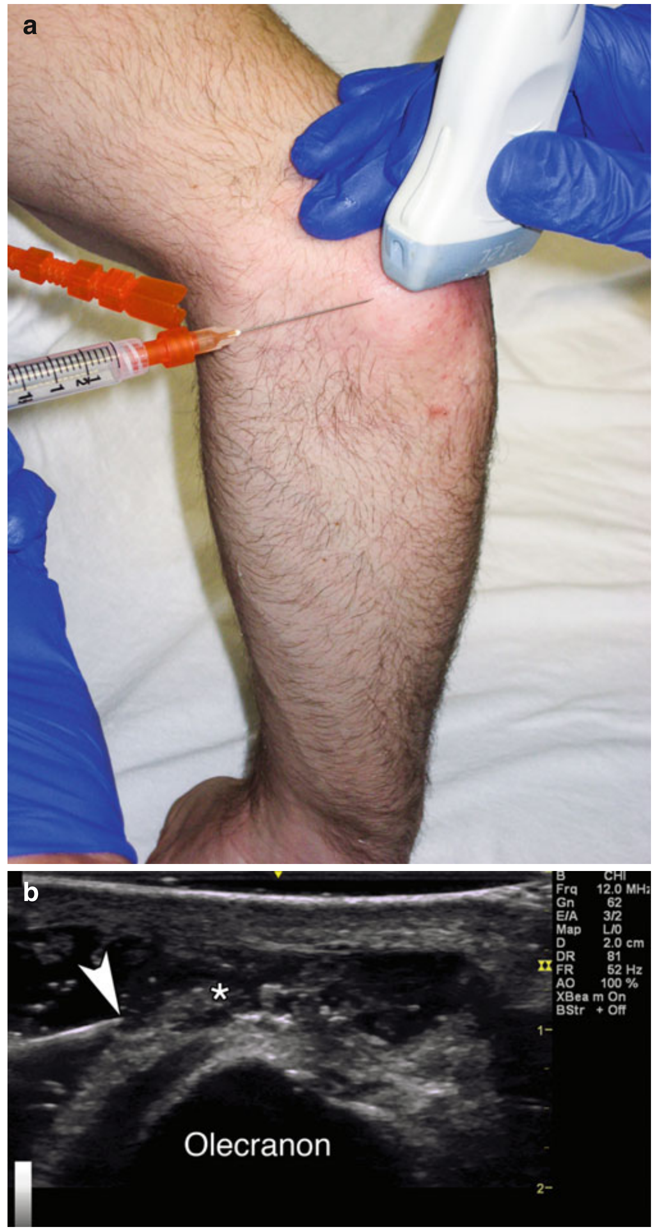

Fig. 3.13 (**a**) Example of probe position over olecranon with in-plane injection technique. (**b**) Example of in-plane axial approach, *arrowhead* indicates needle tip, *asterisk* indicates fluid-filled bursa, olecranon labeled

References

1. AIUM practice guideline for the performance of a musculoskeletal ultrasound examination. Journal of ultrasound in medicine. 2012;31(9):1473–88.
2. Tran N, Chow K. Ultrasonography of the elbow. Semin Musculoskelet Radiol. 2007;11(2):105–16.

3. Martinoli C, Bianchi S, Giovagnorio F, Pugliese F. Ultrasound of the elbow. Skeletal Radiol. 2001;30(11):605–14.
4. Lee KS, Rosas HG, Craig JG. Musculoskeletal ultrasound: elbow imaging and procedures. Semin Musculoskelet Radiol. 2010;14(4): 449–60.
5. Banffy MB, ElAttrache NS. Injection therapy in the management of musculoskeletal injuries: the elbow. Oper Tech Sports Med. 2012;20(2):124–31.
6. Ciccotti MC, Schwartz MA, Ciccotti MG. Diagnosis and treatment of medial epicondylitis of the elbow. Clin Sports Med. 2004;23(4): 693–705.
7. Piligian G, Herbert R, Hearns M, Dropkin J, Landsbergis P, Cherniack M. Evaluation and management of chronic work-related musculoskeletal disorders of the distal upper extremity. Am J Ind Med. 2000;37(1):75–93.
8. Suresh SP, Ali KE, Jones H, Connell DA. Medial epicondylitis: is ultrasound guided autologous blood injection an effective treatment? Br J Sports Med. N2006;40(11):935–9.
9. Bodor M, Fullerton B. Ultrasonography of the hand, wrist, and elbow. Phys Med Rehabil Clin N Am. 2010;21(3):509–31.
10. Callaway GH, Field LD, Deng XH, et al. Biomechanical evaluation of the medial collateral ligament of the elbow. J Bone Joint Surg Am. 1997;79(8):1223–31.
11. Podesta L, Crow SA, Volkmer D, et al. Treatment of partial ulnar collateral ligament tears in the elbow with platelet-rich plasma. Am J Sports Med. 2013;41(7):1689–94 [Epub ahead of print].
12. Van Hofwegen C, Baker 3rd CL, Baker Jr CL. Epicondylitis in the athlete's elbow. Clin Sports Med. 2010;29(4):577–97.
13. Jacobson JA, Propeck T, Jamadar DA, Jebson PJ, Hayes CW. US of the anterior bundle of the ulnar collateral ligament: findings in five cadaver elbows with MR arthrographic and anatomic comparison–initial observations. Radiology. 2003;227(2):561–6.
14. Beekman R, Schoemaker MC, Van Der Plas JP, et al. Diagnostic value of high-resolution sonography in ulnar neuropathy at the elbow. Neurology. 2004;62(5):767–73.
15. Beekman R, Visser LH, Verhagen WI. Ultrasonography in ulnar neuropathy at the elbow: a critical review. Muscle Nerve. 2011;43(5):627–35.
16. Gray AT. Ultrasound-guided regional anesthesia: current state of the art. Anesthesiology. 2006;104(2):368–73.
17. Smith J, Finnoff JT. Diagnostic and interventional musculoskeletal ultrasound: part 2. Clinical applications. PM R. 2009;1(2):162–77.
18. Levin D, Nazarian LN, Miller TT, et al. Lateral epicondylitis of the elbow: US findings. Radiology. 2005;237(1):230–4.
19. McShane JM, Shah VN, Nazarian LN. Sonographically guided percutaneous needle tenotomy for treatment of common extensor tendinosis in the elbow. J Ultrasound Med. 2008;27(8):1137–44.
20. McShane JM, Nazarian LN, Harwood MI. Sonographically guided percutaneous needle tenotomy for treatment of common extensor tendinosis in the elbow. J Ultrasound Med. 2006;25(10):1281–9.
21. Mishra A, Pavelko T. Treatment of chronic elbow tendinosis with buffered platelet-rich plasma. Am J Sports Med. 2006;34(11):1774–8.
22. AIUM practice guideline for the performance of the musculoskeletal ultrasound examination. Laurel: American Institute of Ultrasound in Medicine. http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/us/us_msculoskeleta.aspx. Accessed 20 Feb 2012. (In other publications this is cited as originally cited: AIUM practice guideline for the performance of the musculoskeletal ultrasound examination. October 1, 2007. Laurel: American Institute of Ultrasound in Medicine.)
23. van Holsbeeck MT, Introcaso JH. Musculoskeletal ultrasound. 2nd ed. St. Louis: Mosby; 2001.
24. Augusto P, Teixeira G, et al. Ultrasound assessment of the lateral collateral ligamentous complex of the elbow: imaging aspects in cadavers and normal volunteers. Eur Radiol. 2011;21(7):1492–8.
25. Beggs I, Bianchi S, Bueno A and M Cohen. Elbow. In: ESSR Ultrasound Group Protocols. Musculoskeletal ultrasound technical guidelines. European Society of Musculoskeletal Radiology, Vienna, Austria. p. 1–6. http://www.essr.org/html/img/pool/elbow.pdf. Accessed Feb 20, 2012.
26. Bodner G, Harpf C, Meirer R, Gardetto A, Kovacs P, Gruber H. Ultrasonographic appearance of supinator syndrome. J Ultrasound Med. 2002;21(11):1289–93.
27. Dang AC, Rodner CM. Unusual compression neuropathies of the forearm. Part I: radial nerve. J Hand Surg Am. 2009;34(10): 1906–14.
28. Hamdi MF, Aloui I, Allagui M, Abid A. Letter to Editor: Paralysis of posterior interosseous nerve caused by parosteal lipoma. Neurol India. 2010;58(2):319–20.
29. Lubahn J, Cermak M. Uncommon nerve compression syndromes of the upper extremity. J Am Acad Orthop Surg. 1998;6: 378–86.
30. Bianchi S, Martinoli C. Elbow. In: Bianchi S, Martinoli C, editors. Ultrasound of the musculoskeletal system, Medical radiology. Berlin/Heidelberg: Springer; 2007. p. 349–407.
31. Frenkel O, Herring AA, Fischer J, Carnell J, Nagdev A. Supracondylar radial nerve block for treatment of distal radius fractures in the emergency department. J Emerg Med. 2011;41(4): 386–8.
32. Pien FD, Ching D, Kim E. Septic bursitis: experience in a community practice. Orthopedics. 1991;14(9):981–4.
33. Aaron DL, Patel A, Kayiaros S, Calfee R. Four common types of bursitis: diagnosis and management. J Am Acad Orthop Surg. 2011;19(6):359–67.
34. De Maeseneer M, Jacobson JA, Jaovisidha S, et al. Elbow effusions: distribution of joint fluid with flexion and extension and imaging implications. Invest Radiol. 1998;33(2):117–25.
35. Barr LL, Babcock DS. Sonography of the normal elbow. AJR Am J Roentgenol. 1991;157(4):793–8.
36. Koski JM. Ultrasonography of the elbow joint. Rheumatol Int. 1990;10(3):91–4.
37. Radunovic G, Vlad V, Micu MC, et al. Ultrasound assessment of the elbow. Med Ultrason. 2012;14(2):141–6.
38. Louis LJ. Musculoskeletal ultrasound intervention: principles and advances. Radiol Clin North Am. 2008;46(3):515–33.
39. Del Buono A, Franceschi F, Palumbo A, Denaro V, Maffulli N. Diagnosis and management of olecranon bursitis. Surgeon. 2012;10(5):297–300.
40. Stell IM. Septic and non-septic olecranon bursitis in the accident and emergency department – an approach to management. J Accid Emerg Med. 1996;13(5):351–3.
41. Finlay K, Ferri M, Friedman L. Ultrasound of the elbow. Skeletal Radiol. 2004;33(2):63–79.