**Ultrasound of the elbow, what the radiologist should know.**

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<th>Poster No.:</th>
<th>C-1679</th>
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<tr>
<td>Congress:</td>
<td>ECR 2012</td>
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<tr>
<td>Type:</td>
<td>Educational Exhibit</td>
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<tr>
<td>Keywords:</td>
<td>Trauma, Pathology, Artifacts, Technical aspects, Education, Diagnostic procedure, Ultrasound-Colour Doppler, Ultrasound, Musculoskeletal system, Musculoskeletal soft tissue, Musculoskeletal joint</td>
</tr>
<tr>
<td>DOI:</td>
<td>10.1594/ecr2012/C-1679</td>
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**Learning objectives**

- To review the normal anatomy of the elbow.
- To show standard anatomical cuts that allow an optimal study of the joint and correlate with common clinical presentations.
- To describe the sonographic findings of the pathologies that occur in the elbow.
- To present the most representative cases.

**Background**

Elbow ultrasound is a very useful tool for the diagnosis of a large number of pathologies.

The advantages of elbow ultrasound are as follows: it is a dynamic study with good correlation with the location of the pain, it allows comparison with the contralateral elbow, it helps guiding interventional procedures and it is an inexpensive and fairly available imaging modality.

The main indications of ultrasound are: to evaluate refractory epicondylitis with potential ultrasound-guided intervention; to assess for tendinopathy, tendon rupture or the extent of shrinkage; to assess for joint effusion and bursitis with option of intervention; to rule out occult fractures in the paediatric population; to evaluate if there is ulnar nerve dislocation during flexion and finally it can be a good alternative for patients with claustrophobia or with MRI contraindications.

We perform standard views that allow thorough evaluation of: tendons (common extensor, common flexor, triceps and biceps), ligaments (ulnar collateral mainly), nerves (ulnar, radial, posterior interosseous and median) and the joint.

Colour and Power-Doppler provide information of certain pathologies. Dynamic sonography allows the evaluation of some entities such as ulnar nerve dislocation.

**Imaging findings OR Procedure details**

**TECHNIQUE AND NORMAL ANATOMY**
We use high-frequency lineal transducers (10-12 MHz). The patient should be seated in front of the examiner, with the arm on the table.

We describe the patient positioning for the evaluation of the different compartments (anterior, lateral, medial and posterior). We describe and illustrate systematic standardized views (on transverse and sagittal planes) of the normal anatomy in the different compartments. The different compartments correlate well with different elbow pathologies.

In the anterior elbow we evaluate the distal biceps tendon (which lies on the brachialis muscle), the anterior joint recess, and the nerves (median, radial and posterior interosseous nerves), (Fig. 1 on page 6, Fig. 2 on page 7, Fig. 3 on page 8, Fig. 4 on page 9).

In the lateral elbow we evaluate the common extensor tendon, the lateral synovial fringe of radiocapitellar joint and the appearance of radial head (Fig. 5 on page 10, Fig. 6 on page 11).

In the medial elbow we check the common flexor tendon and medial collateral ligament (Fig. 7 on page 12, Fig. 8 on page 13, Fig. 9 on page 14).

In the posterior elbow we primarily evaluate the triceps tendon and muscle, the olecranon fossa and its recess, and the ulnar nerve (Fig. 10 on page 15, Fig. 11 on page 16).

Dynamic ultrasound is useful to rule out ulnar nerve instability. We show ulnar nerve appearance during extension and flexion in normal conditions (Fig. 12 on page 17).

ELBOW PATHOLOGIES ATTENDING TO THE DIFFERENT COMPARTMENTS

We describe and illustrate the ultrasound findings of a wide spectrum of pathologies based on their localization in the different compartments of the elbow.

ANTERIOR ELBOW PATHOLOGY

In the anterior elbow, the most common diseases are joint effusion, intraarticular loose bodies, biceps distal tendon rupture, bicito-radial bursitis, and median nerve pathology.

Ultrasound is very sensitive for detecting joint effusions. It is best depicted by examining the olecranon fossa in the sagittal plane. In normal conditions, a small amount of fluid
may be seen between the fat pad and the humerus, with an anechoic appearance. If the effusion is echogenic or contains debris, it may indicate bleeding or infection. We also have to rule out synovial thickening or the presence of loose bodies. Synovial thickening is echogenic, incompressible being a typical finding in rheumatoid arthritis (Fig. 13 on page 18).

**Rupture of the distal biceps tendon** is uncommon and it is usually due to attempting to lift a heavy weight. Complete ruptures usually cause pain and a clinically palpable defect so it is not difficult to diagnose. In complete tears without muscle retraction, when there is an important soft-tissue swelling with difficult clinical examination or in partial ruptures, imaging may be required. The complete rupture of the tendon (Fig. 14 on page 19) produces a defect at the expected location of the tendon. The gap is filled with haematoma, and the retracted tendon edge may be visible. Anomalies of the median nerve can also be demonstrated. We show a case of iatrogenic neuropathy after venopuncture (Fig. 15 on page 20).

**LATERAL ELBOW PATHOLOGY**

In the lateral elbow the most common diseases are lateral epicondylitis and radiohumeral osteoarthritis.

**Lateral epicondylitis**, also known as “tennis elbow” is an overuse syndrome of the common extensor tendon. It is thought to be due to repetitive microtrauma during supination of the forearm and dorsiflexion of the wrist, that results in the breakdown of fibers with tissue necrosis and fibrosis. Typically occurs in the 4th and 5th decades, with equal prevalence in women and men. Patients complain of poorly defined pain located over the lateral elbow that is exacerbated with activities requiring wrist extension. Imaging is reserved for cases which are refractory to conservative treatment, to exclude other abnormalities and to assess the amount of damaged tendon before surgery. US findings are: tendon thickening, diffuse heterogeneity of the tendon with loss of the normal fibrillar architecture, focal hypoechoic regions, intratendinous calcifications, adjacent bone irregularity, enthesophytes at the tendon insertion site, linear intrasubstance tears, peritendinous fluid and thickening of peritendinous tissues and neovascularity in Colour Doppler (Fig. 16 on page 24, Fig. 17 on page 25, Fig. 18 on page 26).

Epicondylitis refractory to physiotherapy and blind injection treatment, is an indication for injecting the common extensor tendon. We perform a coronal approach. The needle should reach the deeper portion of the tendon (Fig. 19 on page 23). Corticosteroid injection, percutaneous needle tenotomy (“dry injections”) and autologous blood injection, are the most used techniques.
INTERNAL ELBOW PATHOLOGY

In the medial elbow the most common pathologies are medial epicondylitis, ulnar collateral degeneration or tear and epitrochlear adenopathy.

**Medial epicondylitis** also known as "golfer elbow" is an overuse syndrome of the common flexor tendon. It is thought to be due to repetitive microtrauma and results in fibrosis. The ultrasound findings are comparable with those of lateral epicondylitis (Fig. 20 on page 22, Fig. 21 on page 21).

The **medial collateral ligament** is injured in cases of repeated valgus stress. It can be injured without damage of the overlying common flexor tendon. Ultrasound may demonstrate hypoechoic areas with fibrillar pattern disruption, thickening or calcification of the ligament.

In the proximal elbow and adjacent to the epitrochlea, the small lymph nodes can increase because of inflammation or infection (Fig. 22 on page 27). **Epitrochlear adenophathy** can be caused by cat scratch disease.

POSTERIOR ELBOW PATHOLOGY

Olecranon bursitis, triceps tendon rupture, ulnar nerve dislocation and entrapment of the ulnar nerve are the most frequent pathologies that occur in the posterior elbow.

**Olecranon bursitis** is due to repetitive trauma although it also can be associated with calcifying enthesopathy of the distal triceps tendon and in patients with systemic diseases (gout, rheumatoid arthritis). It produces a subcutaneous fluid-filled mass superficial to olecranon process (Fig. 23 on page 28, Fig. 24 on page 29, Fig. 25 on page 30). Colour Doppler may show peripheral hyperaemia. Care should be taken not to apply excessive pressure with the probe, because small effusions may be squeezed away. Echogenic fluid may be due to infection, inflammation, haematoma or in hydroxyapatite deposition disease.

The **rupture of the triceps tendon** usually results from a fall with an outstretched hand. A bone fragment may remain attached to the tendon (avulsion). Ultrasound shows a retracted tendon surrounded by fluid. Partial ruptures produce a small fluid-filled or an hypoechoic area in the tendon (Fig. 26 on page 31).
Dynamic sonography of the elbow is very useful in diagnosing ulnar nerve dislocation and snapping of the medial triceps muscle, confirming either medial dislocation of the nerve or the medial triceps muscle over the medial epicondyle, or even both of them.

OTHER PATHOLOGIES

Many tumours can occur around the elbow. Lipomatous tumours as lipoma (Fig. 27 on page 32) or liposarcoma, are usually found in the subcutaneous tissue or inside a muscle. Neural tumours: benign and malignant nerve sheath tumours (Fig. 28 on page 33), muscular tumours, fibrous tumours, vascular tumours, and many others can appear in the elbow. We show a case of a satellite implant of melanoma (Fig. 29 on page 34).

Synovial osteochondromatosis (Fig. 30 on page 35) is characterized by the formation of cartilage by a process of metaplasia of the synovium. Knee, hip and elbow are the most frequently joints affected. This lesion is more common in males and it occurs between 3-5th decades. It is characterized by the presence of a periarticular soft tissue mass with formation of intraarticular loose bodies which can be calcified. Secondary osteoarthritis is frequent.

Images for this section:
ANTERIOR ELBOW. TECHNIQUE

- The patient is seated facing the examiner with elbow extension and supination of the forearm.
- Transverse study from 5 cm proximal to 5 cm below the trochlea-ulna joint.
- We evaluate the distal biceps tendon, which lies on the brachialis muscle. Medial to the biceps tendon we examine the brachial artery and median nerve (which lies medially to the artery).
- We must check the anterior joint recess in the transverse plane.

Fig. 1: Normal anatomy of anterior elbow.
ANTERIOR ELBOW. ANTERIOR JOINT RECESS

- We should check the anterior joint recess in sagittal and transverse planes.
- In medial sagittal plane, the coronoid fossa appears as a concavity of the anterior surface of the humerus, filled with the anterior fat pad.
- Under normal conditions a small amount of fluid may be seen.
- Joint effusion, synovial thickening and the presence of loose bodies should be ruled out.

Fig. 2: Normal anatomy of anterior elbow. Anterior joint recess.
ANTERIOR ELBOW. DISTAL BICEPS TENDON

- Patient’s forearm in maximal supination to evaluate the tendon insertion on the medial aspect of the radial tuberosity. It is best examined on its long axis.

- Because of an oblique course of the tendon from surface to depth we must maintain the probe parallel to the tendon to avoid anisotropy. Move the distal half of the probe laterally and push gently against the patient.

- The distal biceps tendon has a length of 7 cm.

Sagittal image of distal biceps tendon insertion (arrows), radial head (RH), humeral capitellum (HC), supinator muscle (S).

**Fig. 3:** Normal anatomy of anterior elbow. Distal biceps tendon.
ANTERIOR ELBOW. RADIAL AND POSTERIOR INTEROSSEOUS NERVES

- We evaluate the main trunk of the radial nerve on a transverse plane in the anterolateral elbow. We must follow the main trunk distally to its bifurcation into the superficial sensory branch and the posterior interosseous nerve.
- We follow the posterior interosseous nerve using short-axis planes as it passes between the superficial and deep parts of the supinator muscle.

Fig. 4: Normal anatomy of anterior elbow. Radial and posterior interosseous nerves.
LATERAL ELBOW. TECHNIQUE.

- It is examined with the elbow in flexion (“prayer position”).
- The common extensor tendon is examined on its long-axis using coronal planes with the cranial edge of the probe placed on the lateral epicondyle.
- Short-axis planes should also be obtained over the tendon insertion.
- In normal conditions, the lateral collateral ligament cannot be separated from the extensor tendon because they have similar echogenicity.

**Fig. 5:** Normal anatomy of lateral elbow.
LATERAL ELBOW. RADIOCAPITELLAR JOINT

- It is best examined with longitudinal views.
- We should check the lateral synovial fringe and evaluate if there is irregularity or thickening. In normal conditions the lateral synovial fringe appears as a small echogenic triangle.
- Dynamic scanning during pronation and supination can help to evaluate the morphology of the radial head and rule out fractures. The annular ligament can also be demonstrated. On sagital planes, the radial head exhibits a square appearance.

![Image of radiocapitellar joint]

**Fig. 6:** Normal anatomy of lateral elbow. Radiocapitellar joint.
MEDIAL ELBOW. TECHNIQUE

- The patient is asked to keep the arm in forced extension and supination of the forearm. As an alternative, the patient in supine position with abduction and external rotation of the shoulder and the elbow in 90 degree of flexion.

- For examination of the common flexor tendon we use coronal planes with the cranial edge of the probe placed on the medial epicondyle (epitrochlea).

- Deep to the common flexor tendon we should check the anterior bundle of the medial collateral ligament. Dynamic study in valgus stress may be useful to assess the lateral collateral ligament.

Fig. 7: Normal anatomy of medial elbow.
The common flexor tendon has the same features that the common extensor tendon except it is shorter and thicker.

Longitudinal image of normal medial elbow. Common flexor tendon origin (arrows), medial collateral ligament (asterisk), medial epicondyle (ME).

**Fig. 8:** Normal anatomy of medial elbow. Common flexor tendon.
MEDIAL ELBOW. MEDIAL COLLATERAL LIGAMENT

- Deep to the common flexor tendon we evaluate the medial collateral ligament.
- It provides greater resistance to valgus stress.
- Medial collateral ligament originates from the medial epicondyle (ME) and inserts on the ulna.
- It has three bundles (anterior, posterior and transversal) of which the former is the largest, the most important and the one we evaluate.

Longitudinal image of normal medial elbow. Medial collateral ligament (yellow arrows) originates from medial epicondyle (ME) and inserts on the ulna (U).

**Fig. 9:** Normal anatomy of medial elbow. Medial collateral ligament.
POSTERIOR ELBOW. TECHNIQUE

For evaluation of posterior elbow, the patient’s elbow should be placed in 90° flexion, maximum pronation, with the palm of the hand resting on the table ("crab position"). The triceps muscle and tendon must be evaluated on its long-axis and short-axis.

- Deep to the triceps, we evaluate the olecranon fossa and posterior olecranon recess filled with the echogenic fat pad.
- We can identify small effusions in the olecranon recess (between the ulna and the fat pad).
- It is usefull to rule out loose intraarticular bodies.

Fig. 10: Normal anatomy of posterior elbow.
POSTERIOR ELBOW. CUBITAL TUNNEL AND ULNAR NERVE

- The patient’s elbow should be placed in forceful internal rotation, extended, and with the olecranon facing the examiner.
- Use plenty of gel.
- The ulnar nerve is examined on its short-axis from the distal arm through the distal forearm.
- The nerve has a fascicular appearance: hypoechoic neuronal fascicles separated by hyperechoic stroma.
- In normal conditions, the ulnar nerve is placed posterior to the medial epicondyte.

Transversal image of ulnar nerve (arrow) which is placed posterior to the medial epicondyte (ME) apex (arrowhead). Olecranon (O), common flexor tendon (asterisk).

Fig. 11: Normal anatomy of posterior elbow. Cubital tunnel and ulnar nerve.
Fig. 1. Transverse image of the ulnar nerve with the elbow in extension, with the probe between the medial epicondyle and olecranon. The nerve (red arrow) is posterior to the medial epicondyle apex (medial epicondyle: ME, apex: arrowhead). The identification of the medial epicondyle apex is aided by finding the common flexor tendon origin which is located immediately anterior (yellow arrow) to the apex.

Fig. 2. Transverse image of the ulnar nerve with the elbow in flexion. The probe remains stabilized to the medial epicondyle. In normal conditions, the nerve (red arrow) and medial belly of the triceps muscle (TM) are placed posterior to the medial epicondyle apex (medial epicondyle: ME, apex: arrowhead). Common flexor tendon origin (yellow arrow).

Fig. 12: Normal anatomy of posterior elbow. Dynamic ultrasound of the ulnar nerve.
JOINT EFFUSIONS

- Ultrasound is very sensitive for diagnosing effusions.
- Effusions are best detected by examining the olecranon fossa in the sagittal plane.
- In normal conditions a small amount of fluid may be seen between the fat pad and the humerus.
- The fluid is anechoic in not complicated effusions. If the effusion is echogenic it may indicate bleeding or infection.
- We have to rule out synovial thickening or the presence of loose bodies.

**Fig. 13:** Anterior elbow pathology. Joint effusion and synovial thickening in rheumatoid arthritis.
**Fig. 14:** Anterior elbow pathology. Complete rupture of distal biceps tendon.
Fig. 15: Anterior elbow pathology. Iatrogenic median nerve neuropathy after puncture.

Fig. 1. Longitudinal image of median nerve showing focal swelling, hypoechogenicity and poor definition of the nerve, at the level of elbow flexure.

Fig. 2. Transversal image of the affected median nerve (Fig. 2A) and the normal contralateral elbow (2B). The injury was confirmed by electromyogram (subacute incomplete axonotmesis) after traumatic venous blood extraction. The patient recovered completely.
**Fig. 21:** Medial elbow pathology. Medial epicondylitis.

Transverse (Fig. 1) and longitudinal images (Fig. 2 y 3) of common flexor tendon in three patients with epicondylitis.

Fig. 1 and Fig. 2. Anechoic areas consistent with intrasubstance tears (arrow).

Fig. 3. Power Doppler shows increased blood flow due to neo-vascularity.
Fig. 20: Medial elbow pathology. Medial epicondylitis.
LATERAL EPICONDYLITIS
INTERVENTIONAL ULTRASOUND

- The more used techniques of injection in the common extensor tendon are:
  - Corticosteroid injection.
  - Percutaneous needle tenotomy ("dry injections")
  - Autologous blood injection
- The main indication for injecting the common extensor elbow is epicondylitis refractory to physiotherapy and blind injection treatment.

Fig. 19: Lateral elbow pathology. Injection of the common extensor tendon.
**Fig. 16**: Lateral elbow pathology. Epicondylitis.

Longitudinal images of common extensor tendon with findings of epicondylitis in four patients. Fig.1. Tendon thickening and diffuse hypoechoogenicity of the tendon. Fig.2. Pathologic elbow (yellow asterisk) compared with the normal contralateral elbow (red asterisk). Fig.3. Enthesophytes. Fig.4. Intratendinous calcifications.
Fig. 17: Lateral elbow pathology. Epicondylitis.

Longitudinal images of common extensor tendon with findings of epicondylitis in four patients: Fig. 1 & 2. Anechoic or hypoechoic foci consistent with intrasubstance tears. Fig. 3. Peritendinous fluid (arrows) and hypoechoic focus consistent with intrasubstance tear. Fig. 4. Marked epicondyle irregularity (arrows).
Longitudinal Colour Doppler images of epicondylitis in two different patients. There is an increase in vascularity because of neovascularity (Fig. 1 y 2). In Fig. 2 we compare pathological elbow with the normal one.

**Fig. 18:** Lateral elbow pathology. Epicondylitis.
Young woman with a painful palpable mass in the medial elbow. Longitudinal image demonstrates an hypoechoic mass with an hyperechoic center that suggests a lymph node (yellow arrows). The fat surrounding the lesion is hyperechoic (asterisk) due to inflammation.

**Fig. 22:** Medial elbow pathology. Epitrochlear adenopathy.
Fig. 23: Posterior elbow pathology. Olecranon bursitis.
Fig. 24: Posterior elbow pathology. Olecranon bursitis.
Fig. 25: Posterior elbow pathology. Calcifying tendinopathy of triceps tendon.
Fig. 26: Posterior elbow pathology. Triceps tendon rupture.
Fig. 27: Tumours. Intramuscular lipoma.

Intramuscular lipoma. Fig.1. Longitudinal image of lateral anterior forearm. Well-defined hyperechoic intramuscular mass with not detectable Doppler signal (asterisk), suggesting a benign lipomatous tumour. Pathologists confirmed it was a lipoma after resection. Fig.2. Axial FSE DP FAT SAT MR image of the elbow. Intramuscular mass (asterisk) in carpi radialis muscle with fat signal intensity in all sequences.
Man with type 1 neurofibromatosis with a palpable mass in the medial aspect of the distal arm proximal to elbow’s flexure.

Fig.1. Marked thickening of the ulnar nerve (arrows) from the proximal arm to the elbow, suggesting multiple plexiform neurofibromas, with a palpable 4 cm mass (asterisk) of heterogeneous echogenicity. The pathologists confirmed a malignant low-grade nerve sheath tumour developed on a plexiform neurofibroma.

Fig.2. Transverse image of ulnar nerve in the cubital tunnel shows a normal appearance at this level (arrows). The ulnar nerve in the forearm showed no abnormalities.

**Fig. 28:** Tumours. Malignant nerve sheath tumour developed on a plexiform neurofibroma.
Patient with melanoma in a finger of the hand, with a satellite implant in the elbow. The cytology after fine needle aspiration and the pathology after resection confirmed the diagnosis.

Transverse view of anterior elbow. The lesion is placed medially to the braquial artery, and in contact with it.

Braquial artery (BA), implant of melanoma (yellow arrows) and median nerve (red arrow).

**Fig. 29:** Tumours. Melanoma.
SYNOVIAL OSTEOCHONDROMATOSIS

- It is characterized by the formation of cartilage by a process of metaplasia of the synovial membrane.
- Knee, hip and elbow are the most frequently joints affected. It affects all compartments.
- It is more common in males and it occurs between 3-5th decades.
- It is characterized by the presence of periarticular soft tissue mass with formation of intraarticular loose bodies which can be calcified.
- Secondary osteoarthritis is frequent.

Fig. 1. Lateral X-Ray of the elbow shows multiple periarticular calcifications. Longitudinal US images of posterior (Fig. 2) and lateral (Fig. 3) compartments of the elbow show a soft tissue mass (asterisks), joint effusion (e) and calcified loose bodies (arrows). Radius head (RH), lateral epicondyle (LE) and olecranon (O).

Fig. 30: Synovial osteochondromatosis.
Conclusion

Elbow ultrasound is a diagnostic technique that in expert hands allows the diagnosis of many diseases and can avoid performing other less available techniques. Ultrasound allows us to guide therapeutic procedures.

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References


