Tendon pathologies at the elbow

Award: Poster Prize 2015

Poster No.: P-0072

Congress: ESSR 2015

Type: Educational Poster

Authors: M. Vansevenant[1], F. M. H. M. Vanhoenacker[2], J. De Roeck[3]; [1]Gent/BE, [2]Antwerp, Ghent, Mechelen/BE, [3]Herentals/BE

Keywords: Trauma, Calcifications / Calculi, Diagnostic procedure, Ultrasound, Plain radiographic studies, MR, Musculoskeletal system, Musculoskeletal soft tissue, Extremities

DOI: 10.1594/essr2015/P-0072

Learning objectives

The learning objectives in this pictorial essay are threefold:

1. To review the pathogenesis and imaging features of tendon diseases of the elbow.

2. To describe the imaging anatomy and the merit of each imaging technique in the diagnosis of tendon disease of the elbow.

3. To discuss the differential diagnosis.

Background

Elbow tendinosis is very frequent in daily practice and is often attributed to overuse or intensive sports activities. Microtearing occurs during stress on a tendon. If the stress is repetitive, there will be no fully repair because of the hypovascular nature of a tendon and the repetitiveness of the stress with new microtearing. This results in tendinosis and eventually macrotears. As a reaction to the (micro)tearing of the tendon, an angiofibroblastic reaction occurs with the formation of scar tissue, being very vulnerable to repetitive trauma resulting in new and further tearing.

Direct *trauma* is another cause of tendon injury and the mechanism of trauma differs along with the involved compartment. The therapeutical strategy depends on the involved compartment and the mechanism of injury.

Clinical examination and history is a prerequisite for correct diagnosis. In most scenarios, there is no need for additional imaging. In therapy resistant or severe cases or in the presence of confounding symptoms, imaging becomes mandatory. Serious tendon pathology or associated abnormalities must not be overlooked. Imaging is also useful to aid in the preoperative planning.

The elbow joint can be divided in *4 compartments*: the lateral, medial, anterior and posterior compartment. Each compartment is reviewed to its anatomy and tendon pathology with their respective differential diagnosis.

A) The lateral compartment

The lateral compartment is the most affected compartment of the elbow. The extensor muscles of the elbow attach at the lateral epicondyle: the extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis and extensor carpi ulnaris tendon (from ventral to dorsal). The last three tendons form the strong *common extensor tendon*, attached to the anterior aspect of the lateral epicondyle (Fig. 1 on page 13).

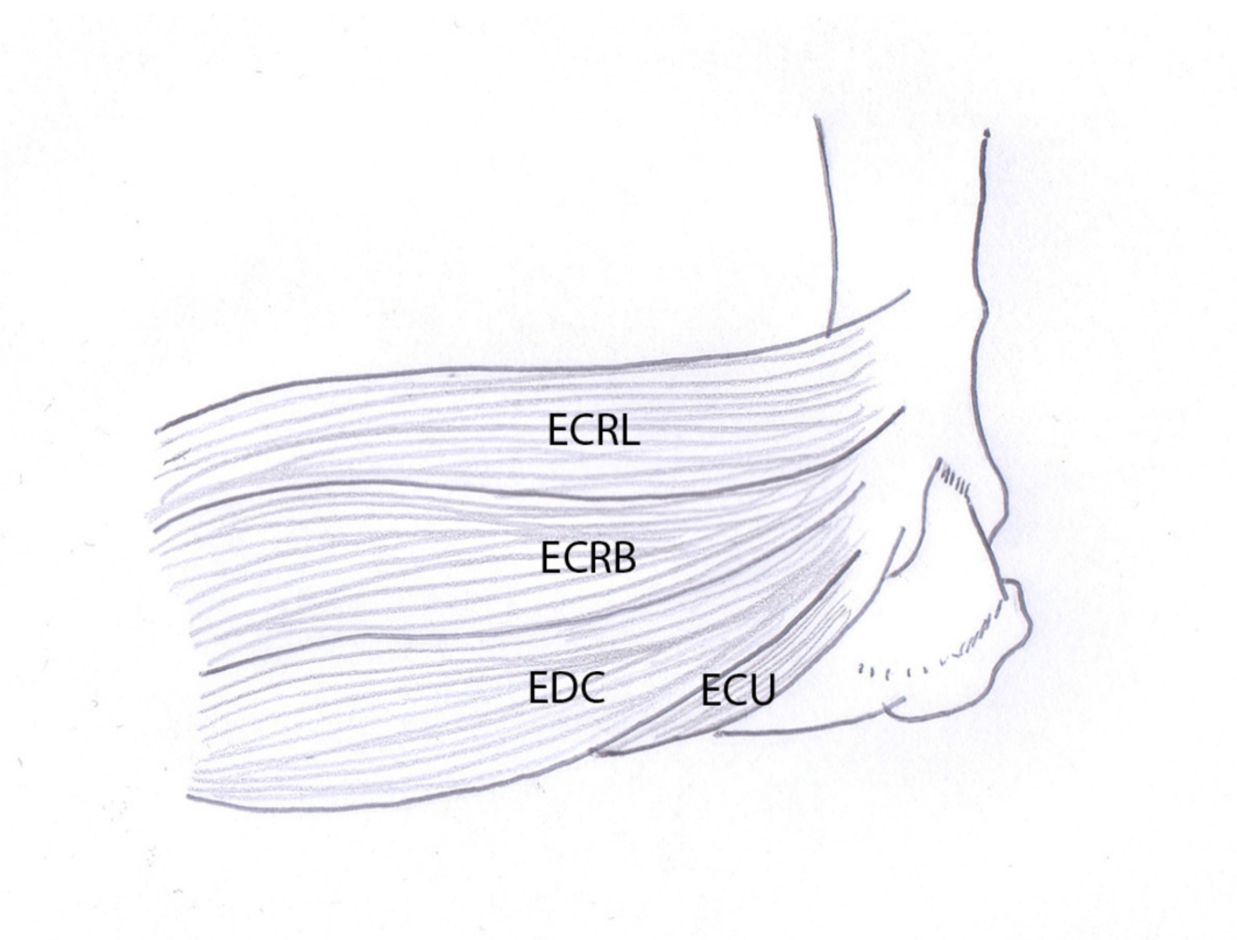

Fig. 1: Drawing of a lateral view of the elbow showing the insertion of the common extensor tendon (the extensor carpi radialis brevis (ECRB), the extensor digitorum communis (EDC) and the extensor carpi ulnaris (ECU)) and the extensor carpi radialis longus tendon (ECRL). The extensor carpi radialis brevis tendon is most frequently injured in lateral epicondylitis. The second most affected tendon is the extensor digitorum communis tendon.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

The *lateral collateral ligament* consists of the lateral ulnar collateral ligament, accessory lateral collateral ligament (inconsistently present), annular ligament and radial collateral ligament (Fig. 2 on page 14). All of them are attached to the lateral epicondyle except the annular ligament being attached to the anterior and posterior radial notch on the ulna. The annular ligament encircles the proximal radius to hold it against the ulna. The radial collateral ligament joins anteriorly with the fibers of the annular ligament and joins with the fascia of the supinator muscle. The lateral ulnar collateral ligament inserts on the supinator crest of the ulna and gives primarily resistance to varus stress. There is no attachment of the lateral collateral ligament to the radius to allow pronation and supination.

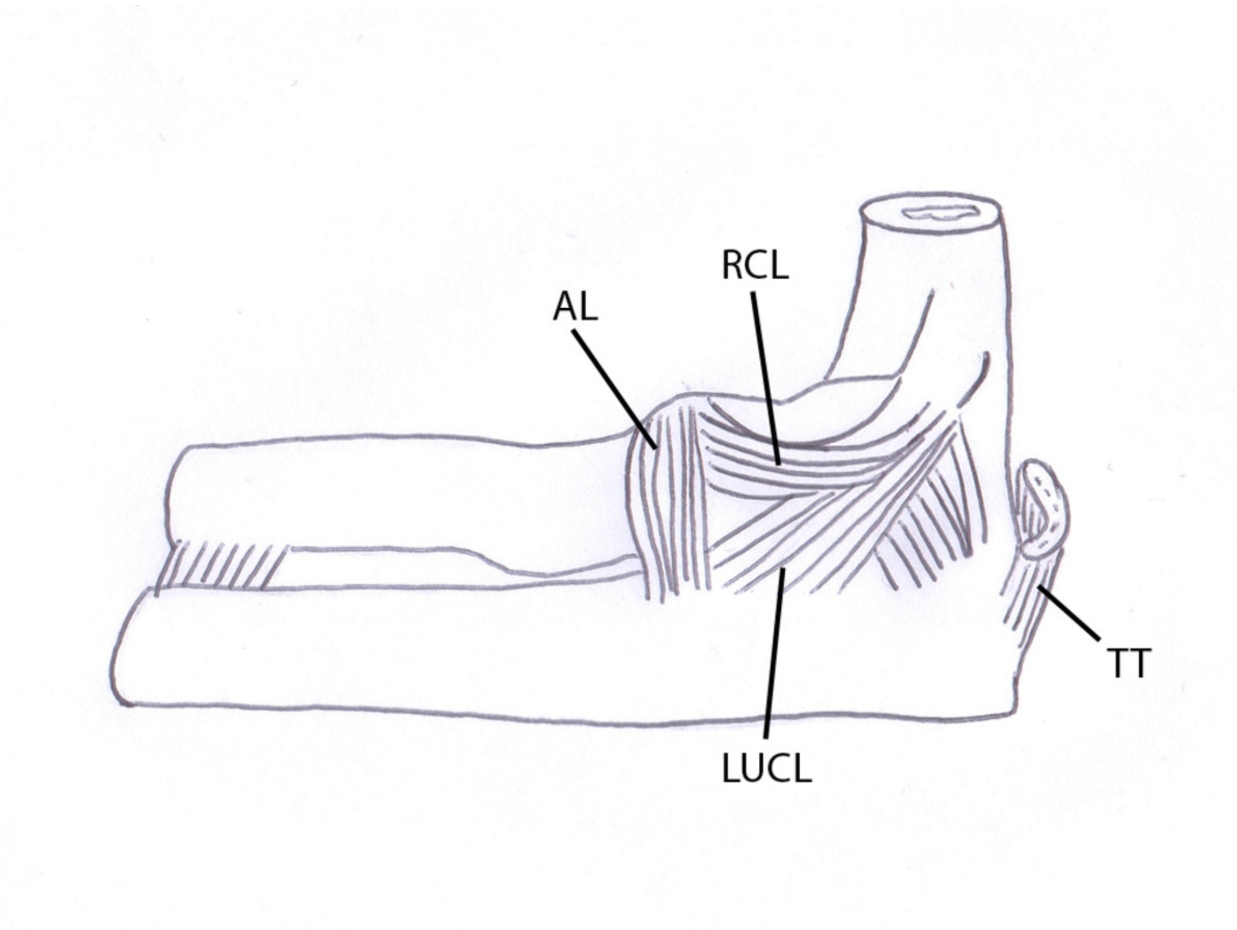

Fig. 2: Drawing of a lateral view of the elbow showing the lateral collateral ligament: the annular ligament (AL), the lateral ulnar collateral ligament (LUCL) and the radial collateral ligament (RCL). The distal triceps tendon is attached at the posterior side of the olecranon.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Lateral epicondylitis or tendinosis is caused by repetitive contraction of the extensor muscles. The **extensor carpi radialis brevis** is most frequently injured in lateral epicondylitis. The undersurface of this tendon slides over the capitellum during flexion and extension of the elbow. The second most affected tendon in lateral epicondylitis is the extensor digitorum communis tendon. In severe cases of lateral epicondylitis or post-traumatic, the lateral ulnar collateral ligament and radial collateral ligament can be injured.

The *clinical features* of lateral epicondylitis are lateral elbow pain, provoked by wrist extension and with grasping of objects. Occupations requiring wrench movements are very prone to lateral epicondylitis. It is also seen in racket sporters with backhand swings. Palpation of the tendon insertion at the lateral epicondyle is painful. History and clinical examination is usually sufficient to make the right diagnosis. In most scenario's, imaging is not required.

Lateral epicondylitis is sometimes accompanied by a lesion of the lateral collateral ligament, resulting in a *posterolateral rotatory instability* during varus stress.

There are various other (less frequent) *differential diagnoses* of pain at the lateral compartment of the elbow (Table 1 on page 15). Another cause of tear of the extensor tendons and/or lateral collateral ligament is *trauma*. The mechanism of trauma is varus stress on the elbow. In children, avulsion of the epicondyle is more frequent than tear of the tendons.

Table 1: Differential diagnosis of lateral epicondylitis
- Occult fracture or stress fracture of the elbow
- Osteochodritis dissecans of the capitellum/Panner's disease
- Osteoarthritis
- Lateral Plica syndrome
- Posterolateral rotatory instability, LUCL lesion
- Radial tunnel syndrome

Table 1: Differential diagnosis of lateral epicondylitis
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

A radial tunnel syndrome has been reported in up to 5% of the patients with an initial clinical diagnosis of epicondylitis lateralis. It is caused by an entrapment of the posterior interosseus nerve in the radial tunnel. It is associated with repetitive pronation and supination.

Osteochondritis dissecans (osteochondral lesion) is a possible differential diagnosis of lateral elbow pain, typically seen in throwing sporters between the ages of 12-15 years old. It is caused by repetitive stress at the lateral elbow resulting in a lesion of the cartilage and subchondral bone. In Panner's disease on the other hand, the growth plate is also affected. Panner's disease is seen at a younger age (7-12 years old).

The *treatment* of lateral epicondylitis is primarily conservative with relative rest, immobilization, ice application and nonsteroidal anti-inflammatory drugs (NSAID) or corticosteroid injections. If conservative treatment fails after 3-6 months, surgery can be performed with release and debridement of the degenerated tendon.

B) The medial compartment

The medial compartment is the second most affected compartment. The medial epicondyle serves as attachment of the flexor muscles of the elbow. The **flexor-pronator mass** (pronator teres and flexor carpi radialis) is most frequently injured. The other flexor tendons are the palmaris longus, flexor carpi ulnaris, flexor digitorum and flexor digitorum superficialis. The attachment of the flexor-pronator mass and the flexor carpi ulnaris is at the anterior aspect of the medial condyle (Fig. 3 on page 15).

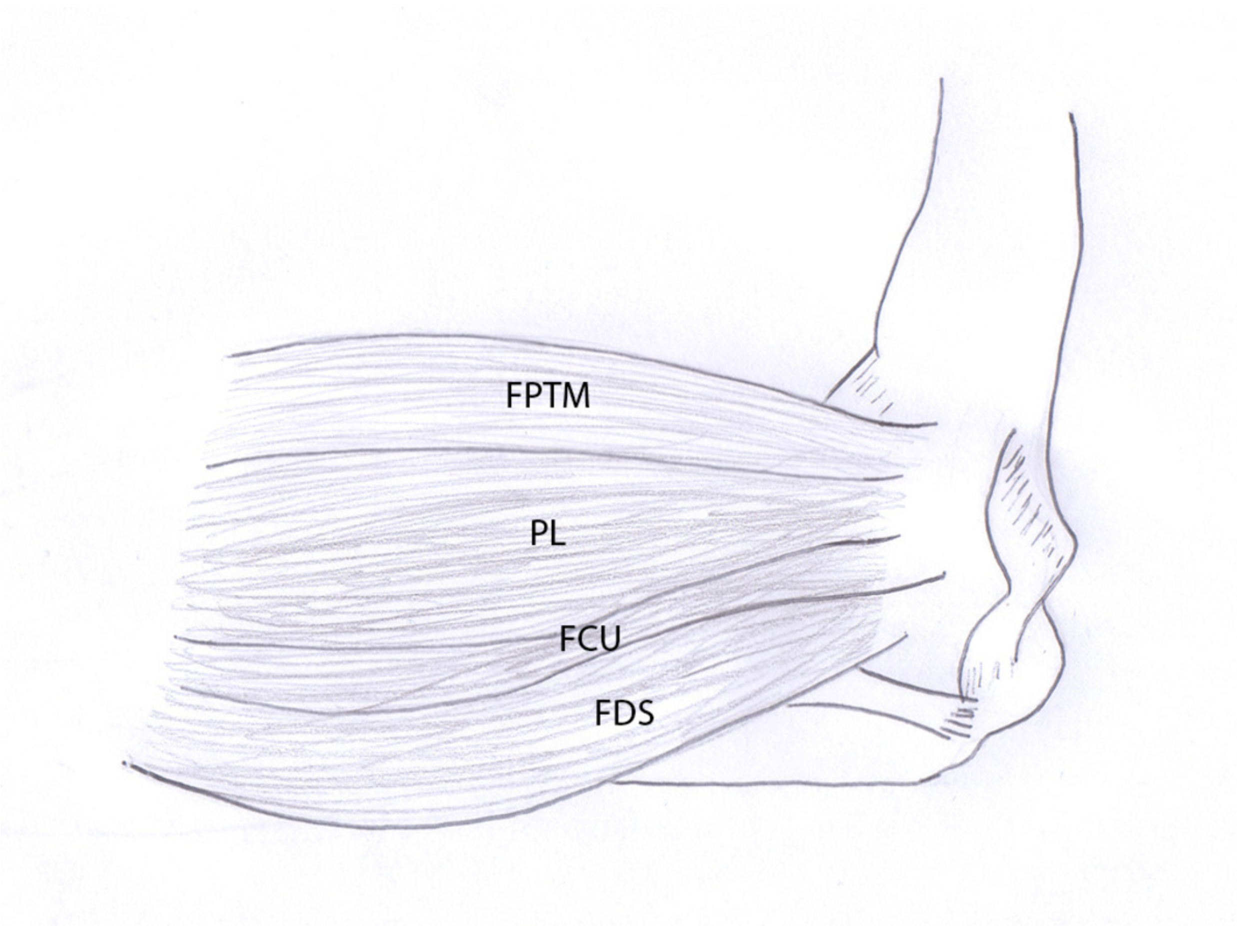

Fig. 3: Drawing of a medial view of the elbow showing the insertion of the flexor-pronator teres mass (FPTM) (pronator teres and flexor carpi radialis tendon), palmaris longus (PL), flexor carpi ulnaris (FCU) and flexor digitorum superficialis. The flexor-pronator mass is most frequently injured in lateral epicondylitis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

The *medial collateral ligament* (ulnar collateral ligament) is composed of three bundles (an anterior, posterior and oblique band), forming a triangular shaped ligament with the apex oriented to the medial epicondyle. The base is oriented on the ulna. The anterior band gives the most constraint to valgus stress. The posterior and oblique band forms the floor of the cubital tunnel, containing the ulnar nerve (Fig. 4 on page 16).

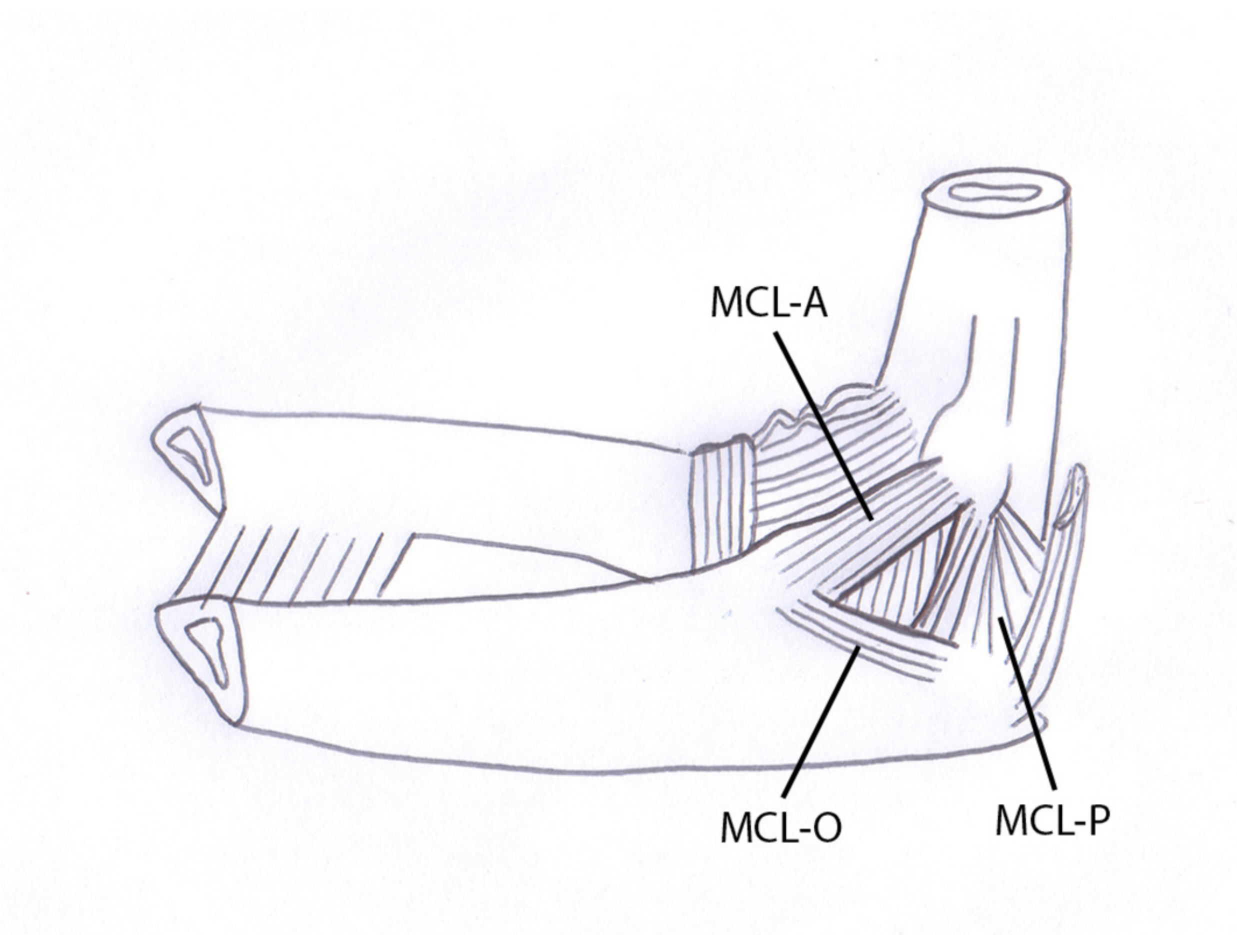

Fig. 4: Drawing of a medial view of the elbow showing the medial collateral ligament. It is composed of an anterior (MCL-A), posterior (MCL-P) and an oblique bundle (MCL-O). The posterior and oblique bundle form the floor of the cubital tunnel containing the ulnar nerve.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Medial epicondylitis is caused by repetitive contraction of the flexor muscles of the elbow and valgus stress. This is typically seen in golfers and in sports with overhand throwing. The flexor-pronator mass is most prone to injury, followed by the palmaris longus. In severe cases, the medial collateral ligament and ulnar nerve can also be injured.

The *clinical features* of medial epicondylitis are medial elbow pain, provoked by flexion of the wrist. Golfers, overhead throwing sporters and racket sporters with forehand stroke are very prone to medial epicondylitis. Symptoms of ulnar neuritis can also be present in patients with associated injury to the ulnar nerve. Palpation of the tendons at the medial epicondyle is very painful. As in lateral epicondylitis, clinical examination with history is usually sufficient to make the right diagnosis.

As in lateral epicondylitis, medial epicondylitis can be accompanied by a lesion of the ulnar collateral ligament.

Trauma will rather cause avulsion of the medial epicondyle than tear of the flexor tendons. The mechanism is a trauma with valgus stress on the elbow. There are various other (less frequent) *differential diagnoses* of pain at the medial compartment of the elbow (Table 2 on page 17).

Table 2: Differential diagnosis of medial ecpicondylitis
- Occult fracture or stress fracture of the elbow
- Osteochondritis dissecans
- Osteoarthritis
- Ulnar collateral ligament lesion
- Little league elbow
- Flexor-pronator syndrome
- Ulnar neuropathy

Table 2: Differential diagnosis of medial epicondylitis
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

The ulnar nerve is frequently injured (cubital tunnel syndrome) in medial epicondylitis and should always be evaluated in patients suspected with medial epicondylitis.

The flexor-pronator syndrome is an entrapment syndrome of the median nerve at its course between the two heads of the pronator teres muscle. It is much less frequent than the radial tunnel syndrome.

A little league elbow is an avulsion of the medial epiphyseal growth plate caused by repetetive valgus stress on the elbow. It is seen in baseball pitchers under the age of 16 years old.

Treatment of medial epicondylitis is primarily conservative consisting of relative rest, immobilization, ice application and nonsteroidal anti-inflammatory drugs (NSAID) or corticosteroid injections. If conservative treatment fails after 3-6 months, surgery can be performed with release and debridement of the degenerated tendon. Surgery is sometimes performed earlier in professional sportsmen.

C) The anterior compartment

The tendon pathology of the anterior compartment is limited to the **distal biceps brachii tendon**. The distal biceps tendon is inserted at the ulnar tuberosity (Fig. 5 on page 17 , Fig. 6 on page 19). As a supinator of the forearm, the tendon is turned around the ulnar aspect of the proximal radius in pronation. The tendon unwinds during contraction of the biceps muscle with supination of the forearm as a result (Fig. 6 on page 19). The lacertus fibrosis (bicipital aponeurosis) also arises from the distal musculotendinous junction of the biceps, inserting eventually onto the proximal ulna after enforcing the fascia of the ventral forearm (Fig. 5 on page 17).

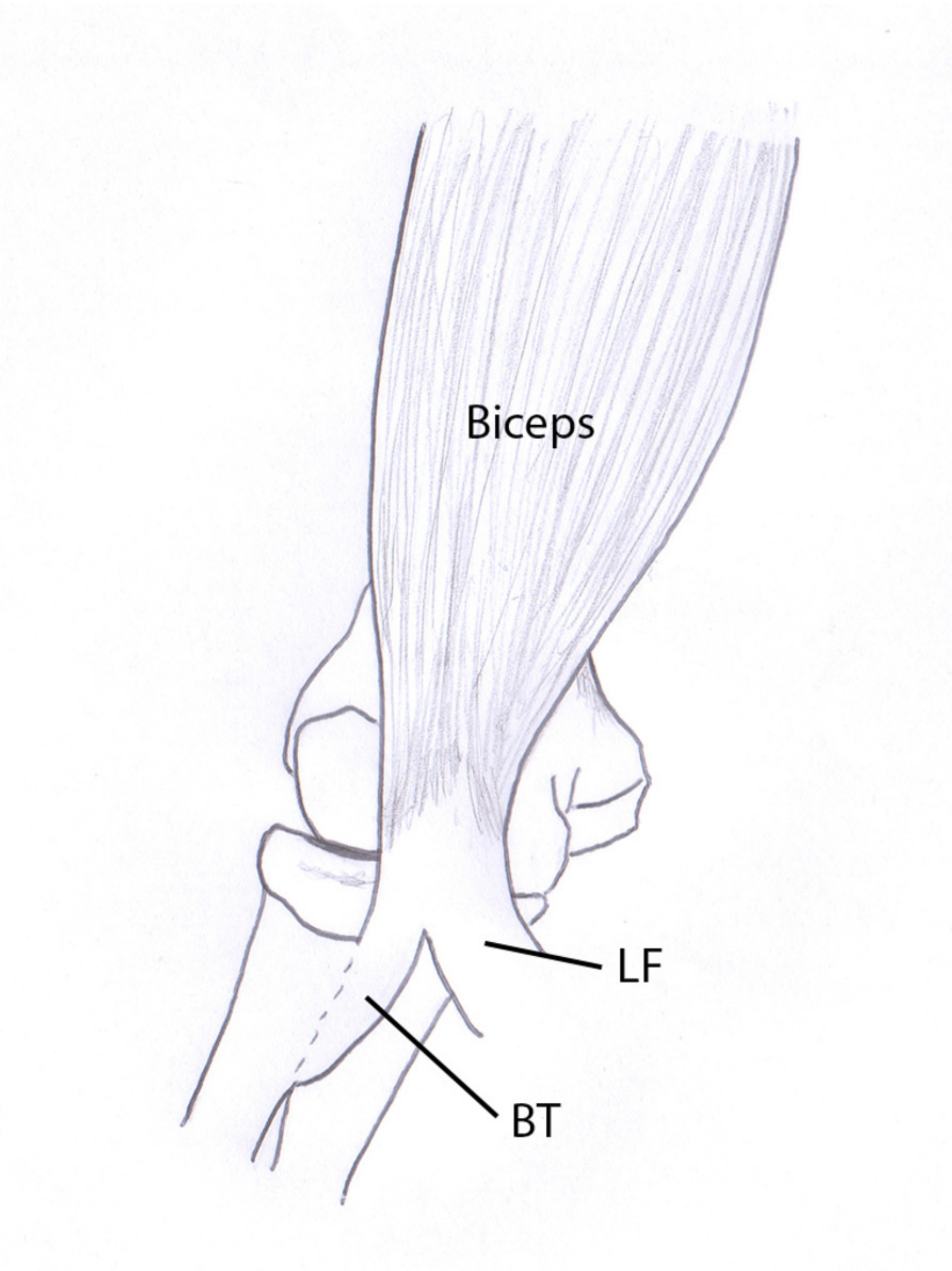

Fig. 5: Drawing of an anterior view of the elbow. The distal biceps brachii muscle tendon (BT) inserts on the radial tuberosity, situated more posteriorly in pronation than

in supination. The lacertus fibrosis (LF) or bicipital aponeurosis inserts on the fascia of the forearm and the ventral aspect of the ulna.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

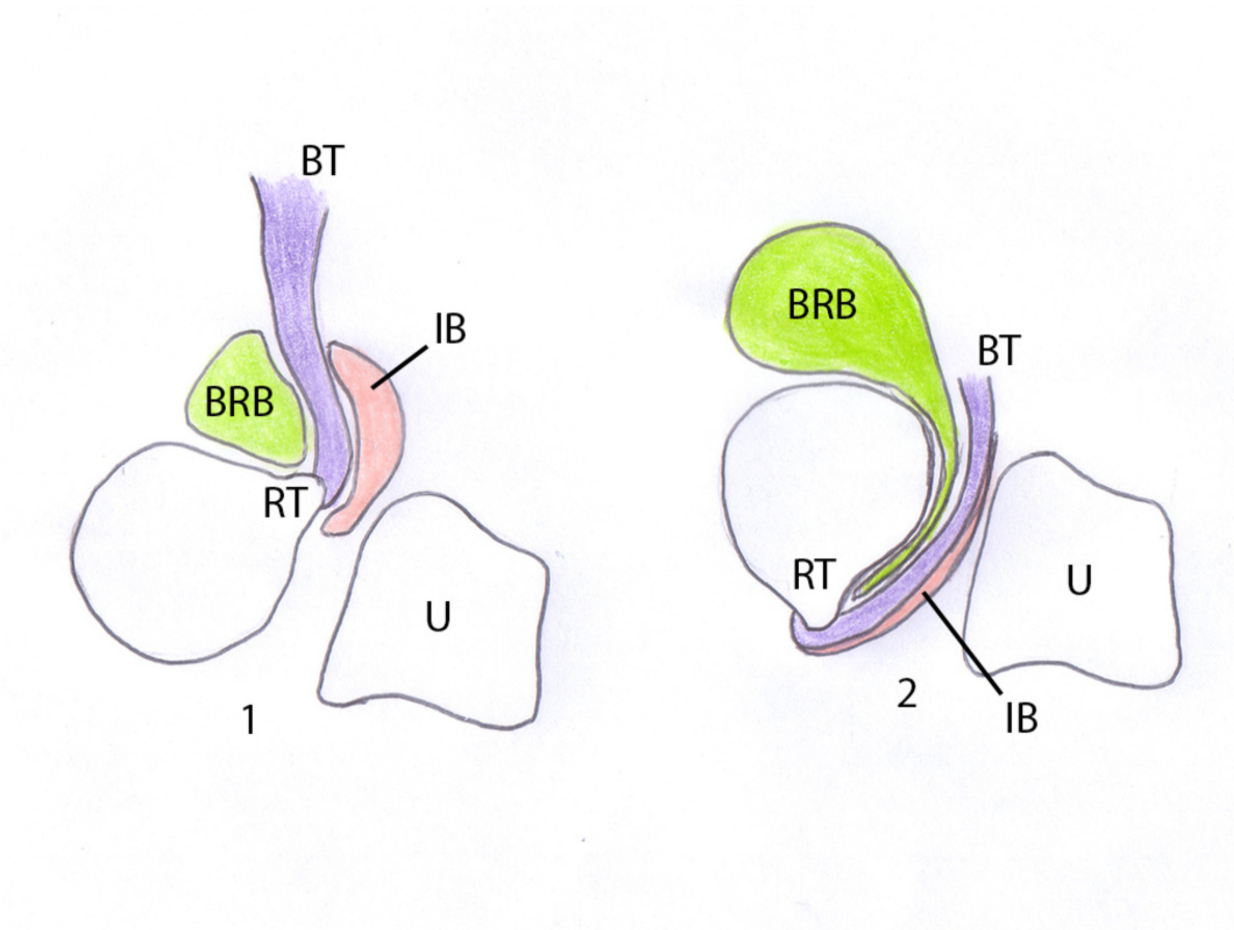

Fig. 6: Drawing of a transversal plane of the radius and ulna showing the distal biceps tendon (BT) being wound around the radius in pronation (2) and rotating the radius by pulling the radial tuberosity to a ventral position to acquire supination (1). A bicipitoradial bursa (BRB) and an interosseous bursa (IB) facilitate the movement between the radius, biceps tendon and ulna (U).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

A full thickness *tear* of the biceps tendon with rupture of the lacertus fibrosis is in most cases clinically clear without imaging. There is a history of a severe trauma with a large force against a flexed elbow. A sudden "snap" can be felt sometimes, associated with sudden severe pain.

Complete tears without rupture of the lacertus fibrosis and partial tears of the distal biceps tendon are less clear clinically. Partial tears are associated with a minor trauma or even no trauma at all, suggesting a preexisting *tendinosis*. Most tears occur at about 1 to 2 cm from the insertion on the radial tuberosity because of a relative hypovascularity in this region. Mechanical impingement is a risk factor for tearing of the distal biceps tendon. This impingement can be caused by osteophytes and enthesophytes near the radial tuberosity or by pronation.

The bicipitoradial or interosseous bursa around the distal biceps tendon (Fig. 6 on page 19) can get irritated resulting in *cubital bursitis*. A lump can be felt in the cubital fossa. Secondary compression syndromes of the median or posterior interosseous nerves occurs in rare cases. The most frequent cause of bursitis in this region is repeated mechanical trauma and is often associated to partial tearing of the distal biceps tendon.

Treatment of a complete tear of the distal biceps tendon is early surgical repair. Partial tears are most frequently treated by relative rest, immobilization, ice application and nonsteroidal anti-inflammatory drugs (NSAID) or corticosteroid injections. At failure of conservative treatment, surgical debridement of remaining fibers with tendon reattachment can be necessary.

D) The posterior compartment

The posterior tendon compartment is only rarely injured and is limited to pathology of the **distal triceps brachii tendon**. The distal triceps tendon attaches at the posterior aspect of the olecranon (Fig. 2 on page 14). There is also an extension to the forearm situated superficially of the anconeus muscle.

As in the other compartments, repetitive stress on the distal triceps tendon causes *tendinosis*. It is seen in sporters performing a lot of pushing activities (e.g. pushups, dips or boxing). *Clinical examination* reveals pain during stretching of the triceps muscle and palpatory pain at the distal insertion of the triceps tendon.

*Tear*ing of the distal triceps tendon can be partial or complete. A possible mechanism of rupture is a fall on an outstretched hand.

Olecranon bursitis is the most frequent *differential diagnosis* of tendon pathology of the posterior compartment. Other differential diagnoses are less frequent (Table 3 on page 19).

Table 3: Differential diagnosis of tendon pathology of the posterior compartment
- Olecranon bursitis
- Occult fracture or stress fracture of the olecranon
- Valgus extension overload syndrome with posterior impingement
- Posterolateral rotatory instability

Table 3: Differential diagnosis of tendon pathology of the posterior compartment
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

A frequent cause of pain at the posterior elbow is an olecranon bursitis. It is associated with a soft tissue swelling.

Posterolateral rotatory instability is also a differential diagnosis in the posterior compartment, just as in the lateral compartment.

Valgus extension overload syndrome is caused by osteophytes, loose bodies or chondromalacia at the olecranon and posteromedial fossa. It is typically seen in baseball pitchers. A cubital tunnel syndrome is frequently associated with this condition.

The same *treatment* options as in the other compartments are available for the posterior compartment. The threshold to proceed to surgical repair of a tear is lower as in the anterior compartment because the triceps muscle is an important muscle for extension of the elbow whereas in the anterior compartment, flexion can be partially taken over by the brachialis muscle.

Images for this section:

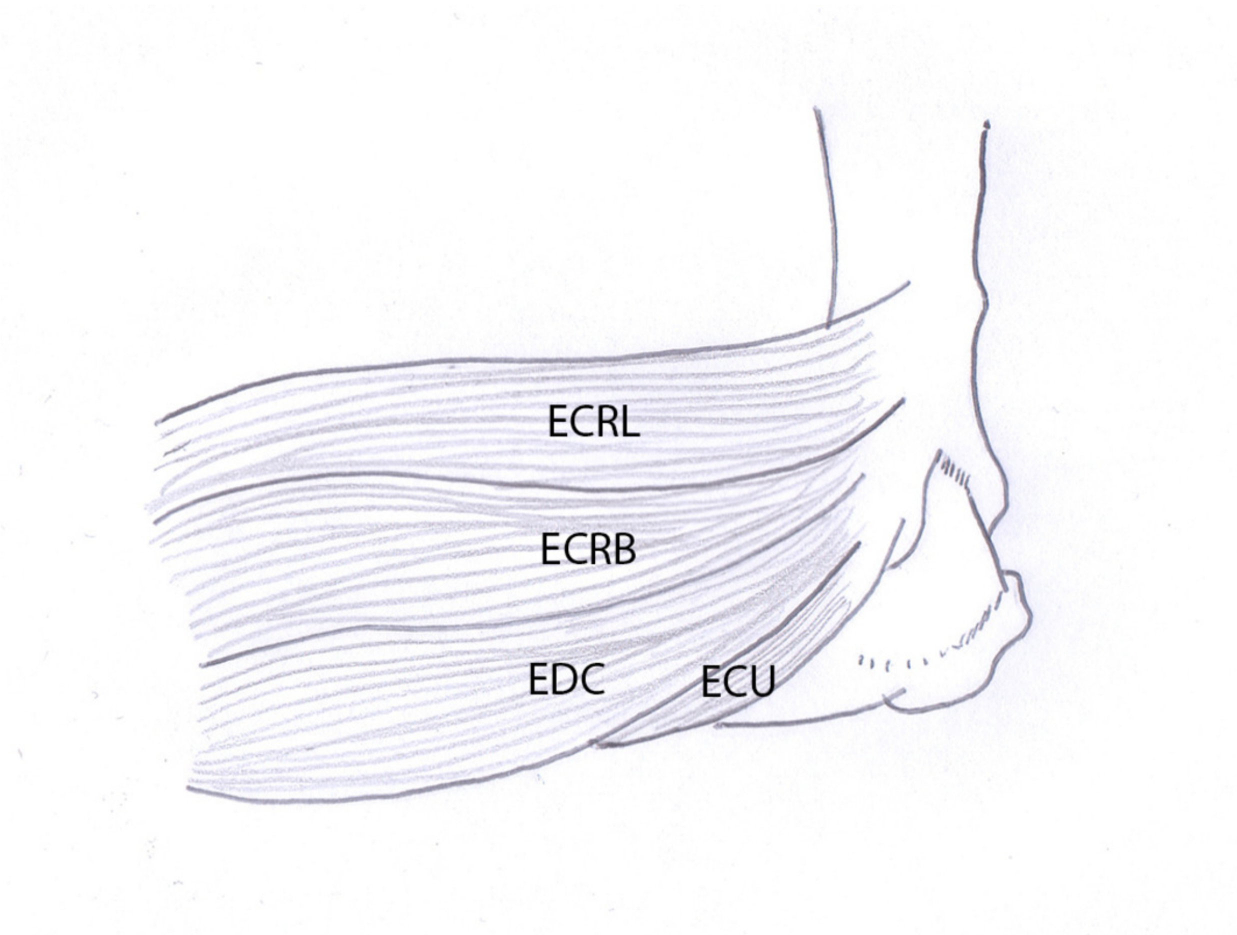

Fig. 1: Drawing of a lateral view of the elbow showing the insertion of the common extensor tendon (the extensor carpi radialis brevis (ECRB), the extensor digitorum communis (EDC) and the extensor carpi ulnaris (ECU)) and the extensor carpi radialis longus tendon (ECRL). The extensor carpi radialis brevis tendon is most frequently injured in lateral epicondylitis. The second most affected tendon is the extensor digitorum communis tendon.

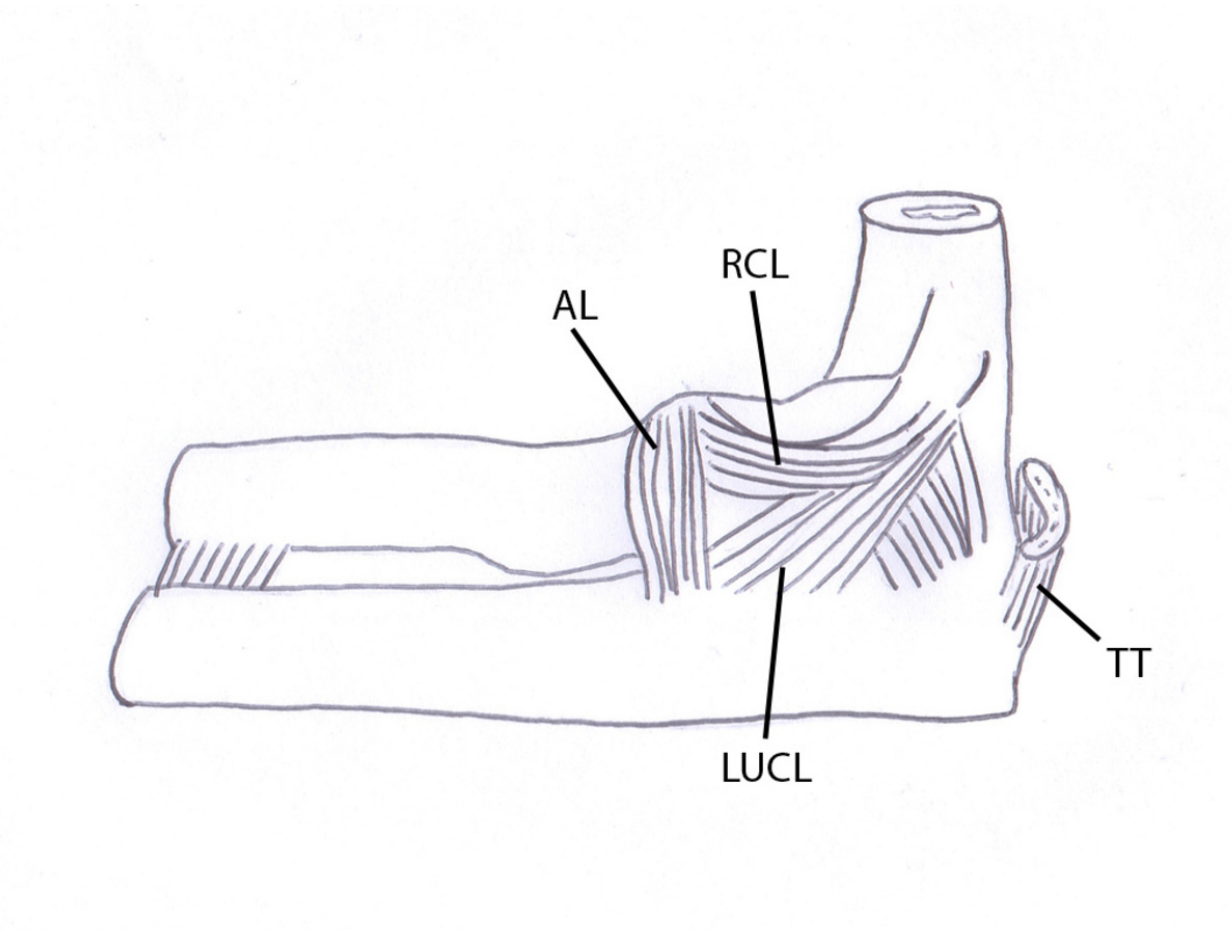

Fig. 2: Drawing of a lateral view of the elbow showing the lateral collateral ligament: the annular ligament (AL), the lateral ulnar collateral ligament (LUCL) and the radial collateral ligament (RCL). The distal triceps tendon is attached at the posterior side of the olecranon.

Table 1: Differential diagnosis of lateral epicondylitis
- Occult fracture or stress fracture of the elbow
- Osteochodritis dissecans of the capitellum/Panner's disease
- Osteoarthritis
- Lateral Plica syndrome
- Posterolateral rotatory instability, LUCL lesion
- Radial tunnel syndrome

Table 1: Differential diagnosis of lateral epicondylitis

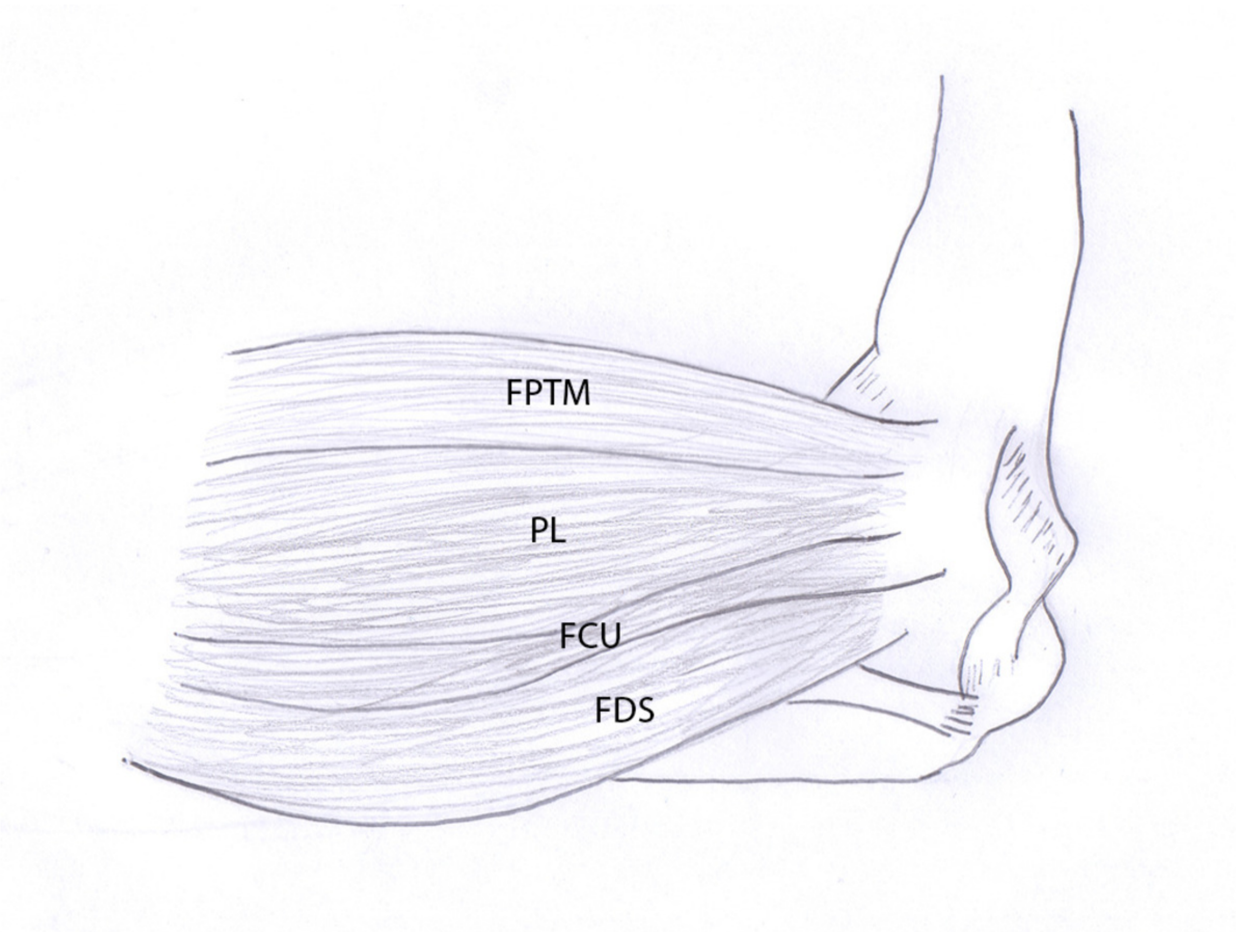

Fig. 3: Drawing of a medial view of the elbow showing the insertion of the flexor-pronator teres mass (FPTM) (pronator teres and flexor carpi radialis tendon), palmaris longus (PL), flexor carpi ulnaris (FCU) and flexor digitorum superficialis. The flexor-pronator mass is most frequently injured in lateral epicondylitis.

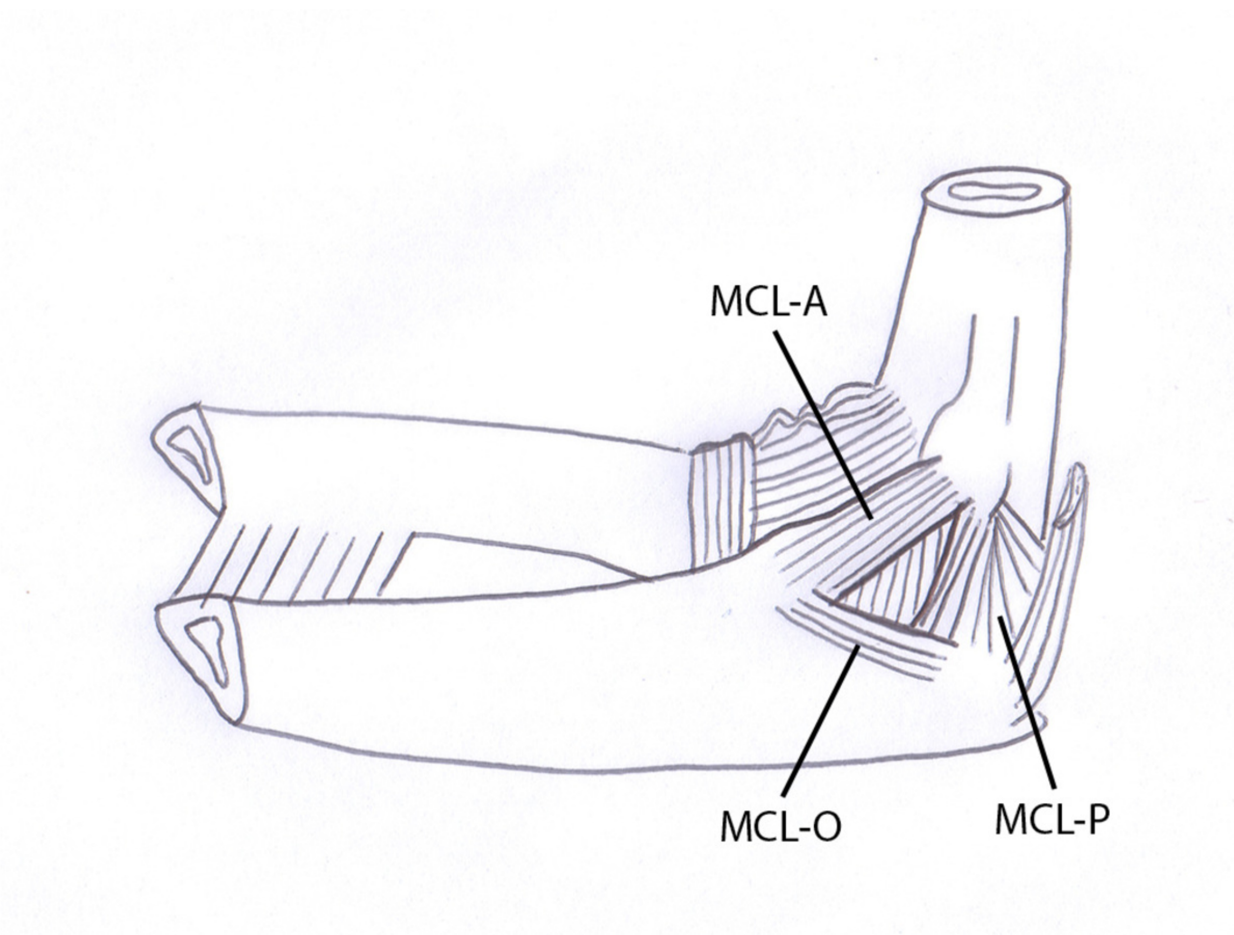

Fig. 4: Drawing of a medial view of the elbow showing the medial collateral ligament. It is composed of an anterior (MCL-A), posterior (MCL-P) and an oblique bundle (MCL-O). The posterior and oblique bundle form the floor of the cubital tunnel containing the ulnar nerve.

Table 2: Differential diagnosis of medial ecpicondylitis
- Occult fracture or stress fracture of the elbow
- Osteochondritis dissecans
- Osteoarthritis
- Ulnar collateral ligament lesion
- Little league elbow
- Flexor-pronator syndrome
- Ulnar neuropathy

Table 2: Differential diagnosis of medial epicondylitis

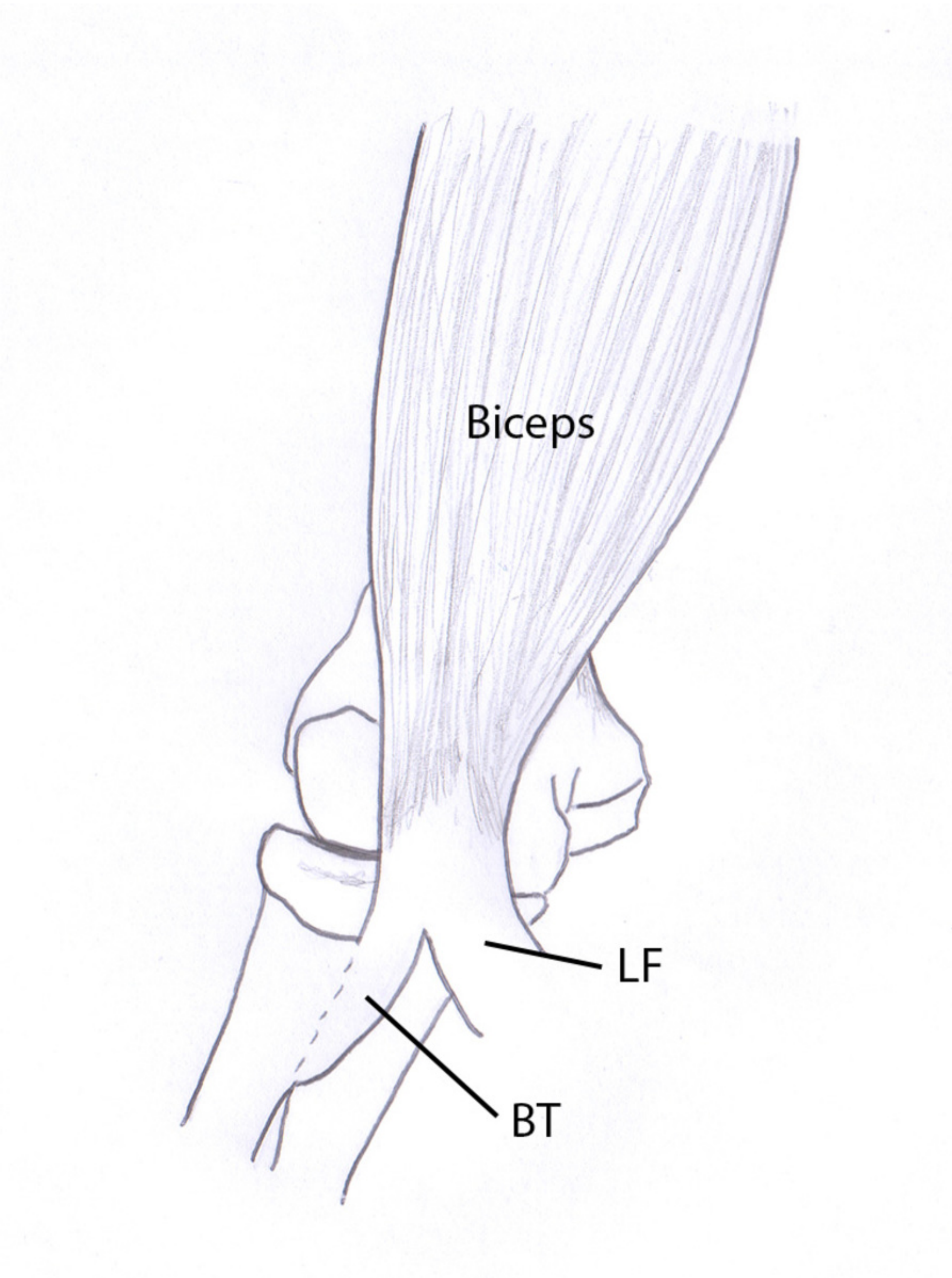
Biceps
LF
BT

Fig. 5: Drawing of an anterior view of the elbow. The distal biceps brachii muscle tendon (BT) inserts on the radial tuberosity, situated more posteriorly in pronation than in supination. The lacertus fibrosis (LF) or bicipital aponeurosis inserts on the fascia of the forearm and the ventral aspect of the ulna.

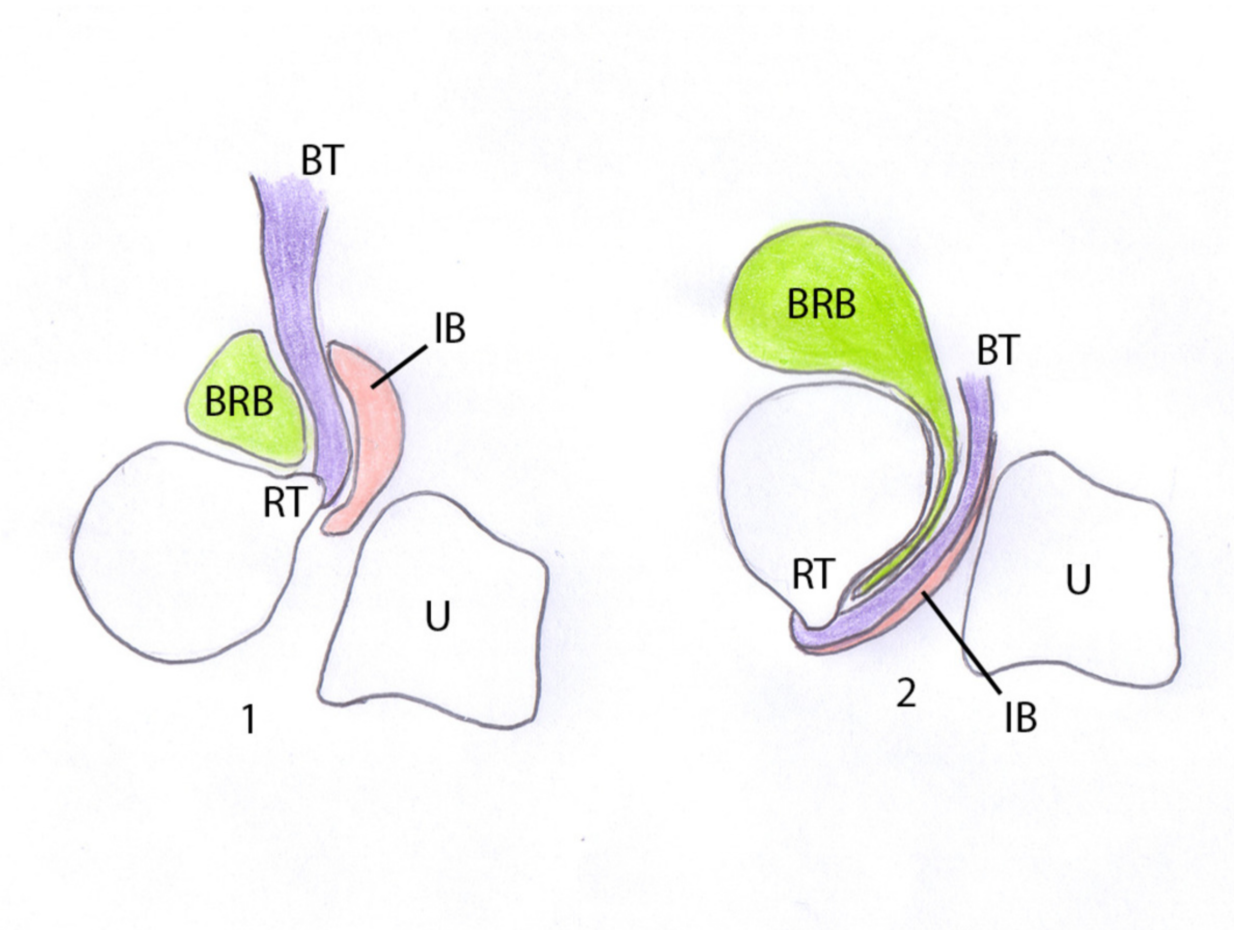

Fig. 6: Drawing of a transversal plane of the radius and ulna showing the distal biceps tendon (BT) being wound around the radius in pronation (2) and rotating the radius by pulling the radial tuberosity to a ventral position to acquire supination (1). A bicipitoradial bursa (BRB) and an interosseous bursa (IB) facilitate the movement between the radius, biceps tendon and ulna (U).

Table 3: Differential diagnosis of tendon pathology of the posterior compartment
- Olecranon bursitis
- Occult fracture or stress fracture of the olecranon
- Valgus extension overload syndrome with posterior impingement
- Posterolateral rotatory instability

Table 3: Differential diagnosis of tendon pathology of the posterior compartment

Imaging findings OR Procedure Details

Plain films are useful in initial workup to rule out occult fractures or stress fractures of the elbow (Table 1 on page 59 , Table 2 on page 59 , Table 3 on page 60). Indirect signs of tendinosis are bone spur formation or soft tissue calcifications at the insertion of the affected tendon. Plain films have limited role in early disease. The same indirect signs can be seen on *CT scan*, but CT is not preferred as the preferred imaging technique because of radiation restraints.

Ultrasound is the first line examination in the evaluation of the different elbow compartments. The probe is placed in a longitudinal and axial plane on the axis of the tendons. Tendon thickening, hypoechogenicity, hyperemia, calcifications and (partial) tears are seen. To evaluate hyperemia on *echo-Doppler* imaging, compression with the probe should be avoided not to compromise the blood flow. Hyperemia represents an angiofibroblastic reaction. *Elastography* is a more recent imaging technique within the ultrasonographic evaluation of soft tissues. It measures the stiffness of tissues, representing it on a color map. Healthy tendons are hard and have low compressibility, whereas in tendinopathy tendons become softer and have high compressibility.

MRI is a second line examination in the evaluation of elbow pain. It is excellent to show associated pathology and to rule out other causes of elbow pain than tendon pathologies (Table 1 on page 59 , Table 2 on page 59 , Table 3 on page 60). MRI is also helpful in pre-operative planning. Normal tendons and ligaments are of uniform low signal intensity (SI) on all imaging sequences. Tendon thickening, signal intensity changes of the tendon or underlying bone marrow and tears of the tendon and/or adjacent ligaments are seen in pathologic conditions. Slice thickness of 3 mm and a high resolution coil are recommended. The preferred field of view is 10-14 cm. The patient is placed in the gantry preferably in a "superman"-position with the elbow in extension and supination (Fig. 7 on page 60). T2-WI and proton density-weighted images with fat saturation are very useful to evaluate fluid. T1-WI are used for a structural evaluation.

Fig. 7: Photograph of a patient in "superman"-position with the elbow in extension and supination for the best image quality.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

<u>A) The lateral compartment</u>

Plain films can show bone spur formation or soft tissue calcifications near the lateral epicondyle in advanced cases (Fig. 8 on page 61).

Fig. 8: Plain film of the elbow showing a soft tissue calcification (arrow) near the lateral epicondyle suggesting lateral epicondylitis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

For *sonographic evaluation* of the extensor tendons, the probe is placed in a longitudinal and axial plane of the tendons with the elbow in a flexed position. The normal common extensor tendon is a continuous band of parallel fibers. Imaging features of lateral epicondylitis are thickening of the extensor tendons (> 4 mm), hypoechogenicity, hyperemia, calcifications and (partial) tears (Fig. 9 on page 63 , Fig. 10 on page 63 ,). On elastography, soft consistency of the affected tendon is seen (Fig. 11).

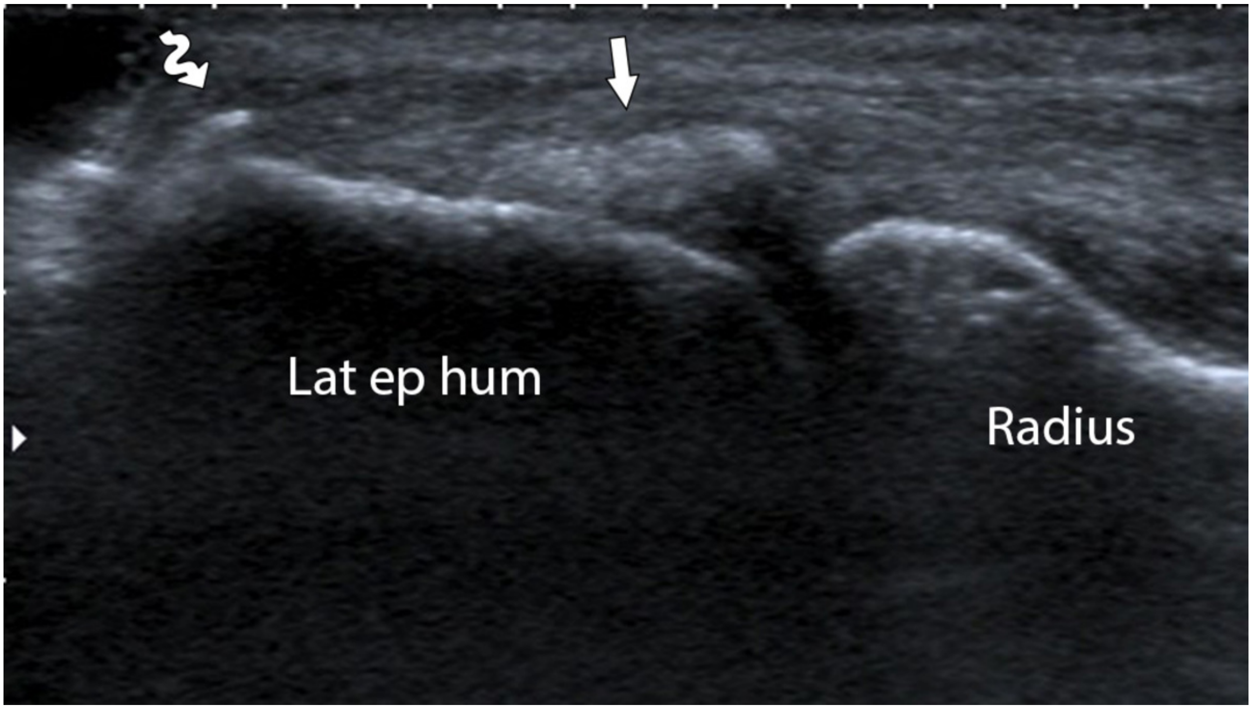

Fig. 9: Longitudinal ultrasound image of the common extensor tendon showing a large calcification (arrow) in the tendon and a smaller calcification more proximally (curved arrow): calcifying tendinopathy.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

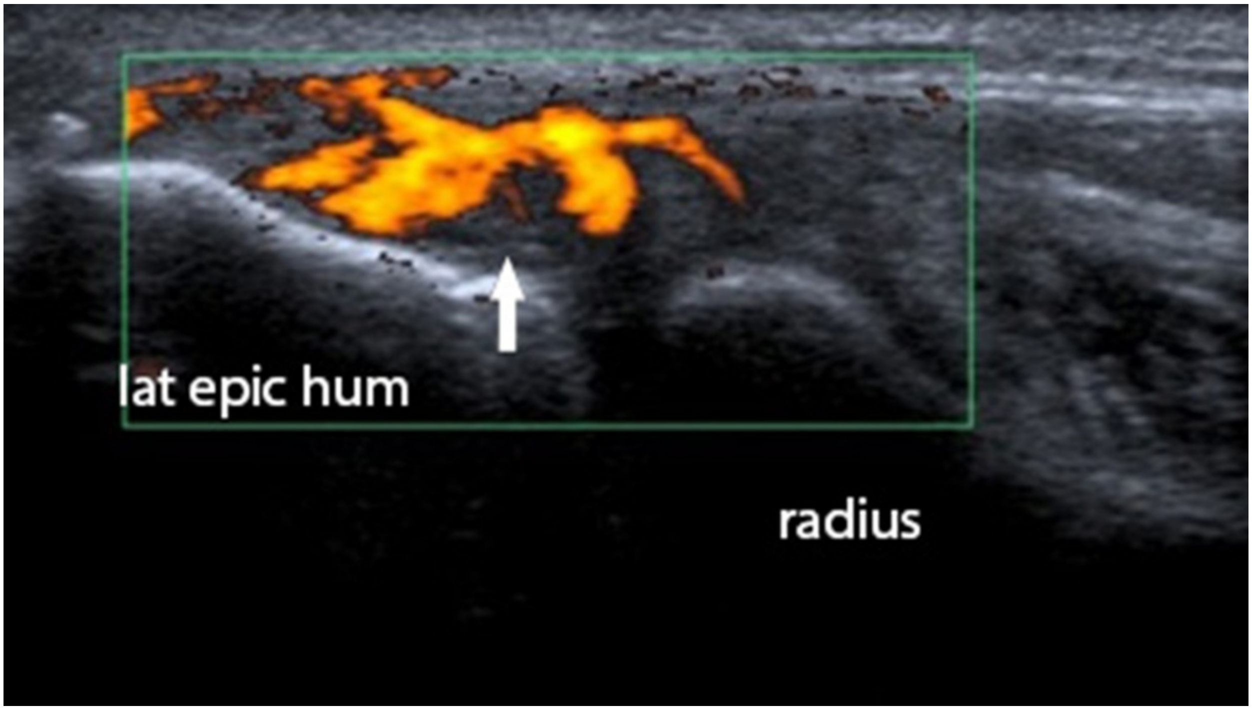

Fig. 10: Longitudinal ultrasound image of the common extensor tendon showing increased Doppler flow (arrow) in the tendon: hyperemia. This hyperemia is caused by an angiofibroblastic reaction, the repairative response to the (micro-)tearing with the formation of scar tissue.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

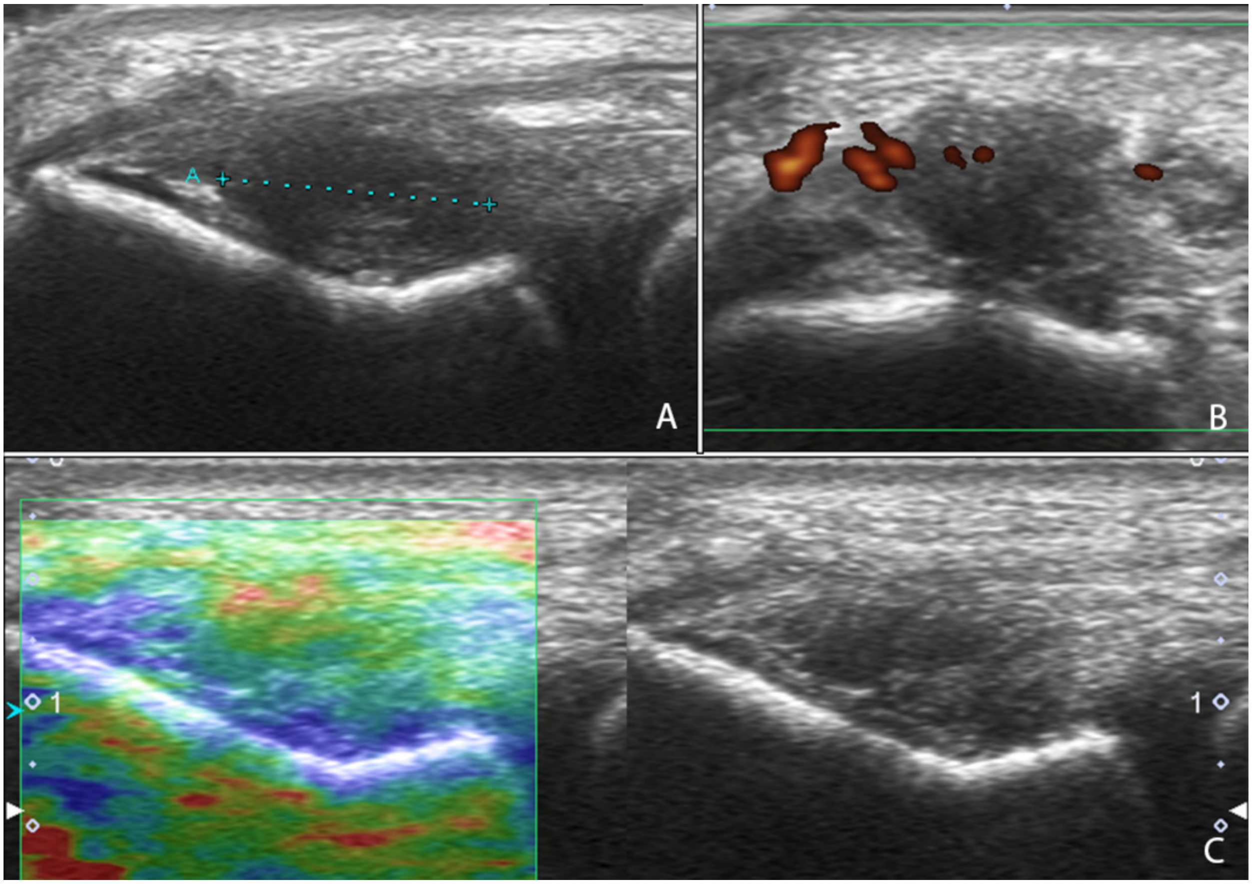

Fig. 11: Longitudinal (A,C) and transversal (B) ultrasound image of the extensor tendons showing a hypoechogenic zone (A,B,C) within the extensor tendons: tendinosis. There is an increased Doppler signal (B): hyperemia. The zone of tendinosis has on elastography (C) an increased compressibility of the tendon. The blue spots on the color map represent hard tissue with low compressibility and the red spots represent soft tissue with high compressibility.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

On *MRI*, the tendons and ligaments (Fig. 12 on page 64) of the lateral compartment are best evaluated on axial and coronal images.

Fig. 12: Coronal fat saturated (FS) T2-WI of the normal elbow. A is 2 slices anterior of B. The common extensor tendon (arrow) inserts on the lateral epicondyle and is in normal circumstances hypointense on all imaging sequences. The radial collateral ligament is deep of the common extensor tendon situated (curved arrow). The lateral ulnar collateral ligament is located posteriorly to the radial head.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Thickening of the common extensor tendon, SI-changes, tears and associated RCL tears can be efficiently evaluated on MRI (Fig. 13 on page 65 , Fig. 14 on page 67 , Fig. 15 on page 69 , Fig. 16 on page 69).


IAL

Fig. 13: Coronal T2-WI with FS showing a thickened common extensor tendon with a hyperintense zone in the proximal tendon (arrow): partial tear. There are no associated lesions.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium


A

Fig. 14: Coronal (A) T2-WI with FS and axial (B) dixon T2-WI with FS showing a severe tear of the conjoint extensor tendon (arrow) with perilesional edema (arrowhead). There is an associated radial collateral ligament rupture at its insertion on the lateral epicondyle, resulting in posterolateral rotatory instability of the elbow (curved arrow).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

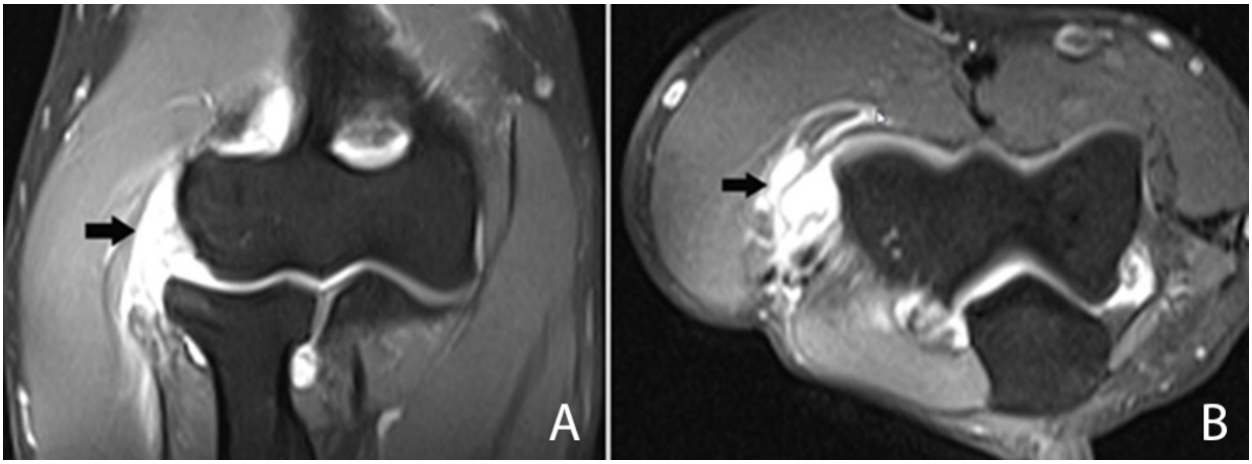

Fig. 15: Coronal (A) and axial (B) T2-WI with FS showing a full thickness tear of the conjoint tendon with retraction and involvement of the radial collateral ligament.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Fig. 16: Coronal pd T2-WI with FS showing a post-traumatic tear of the insertion of the radial collateral ligament at the lateral epicondyle. Avulsion type edema is seen in the lateral epicondyle.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Osteochondritis dissecans and *Panner's disease* are possible differential diagnoses of lateral epicondylitis (Fig. 17 on page 71).

Fig. 17: Sagittal T2-WI with FS of a patient with an osteochondritis dissecans (A) and a sagittal T1-WI of a patient with Panner's disease (B). In Panner's disease, there is also involvement of the growth plate and it is seen in children between the age of 7-12 years old. Osteochondritis dissecans is usually seen in young adolescents between the age of 12-15 years old.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

MRI manifestations of radial tunnel syndrome are denervation edema and atrophy within the muscles innervated by the posterior interosseous nerve (Fig. 18 on page 71).

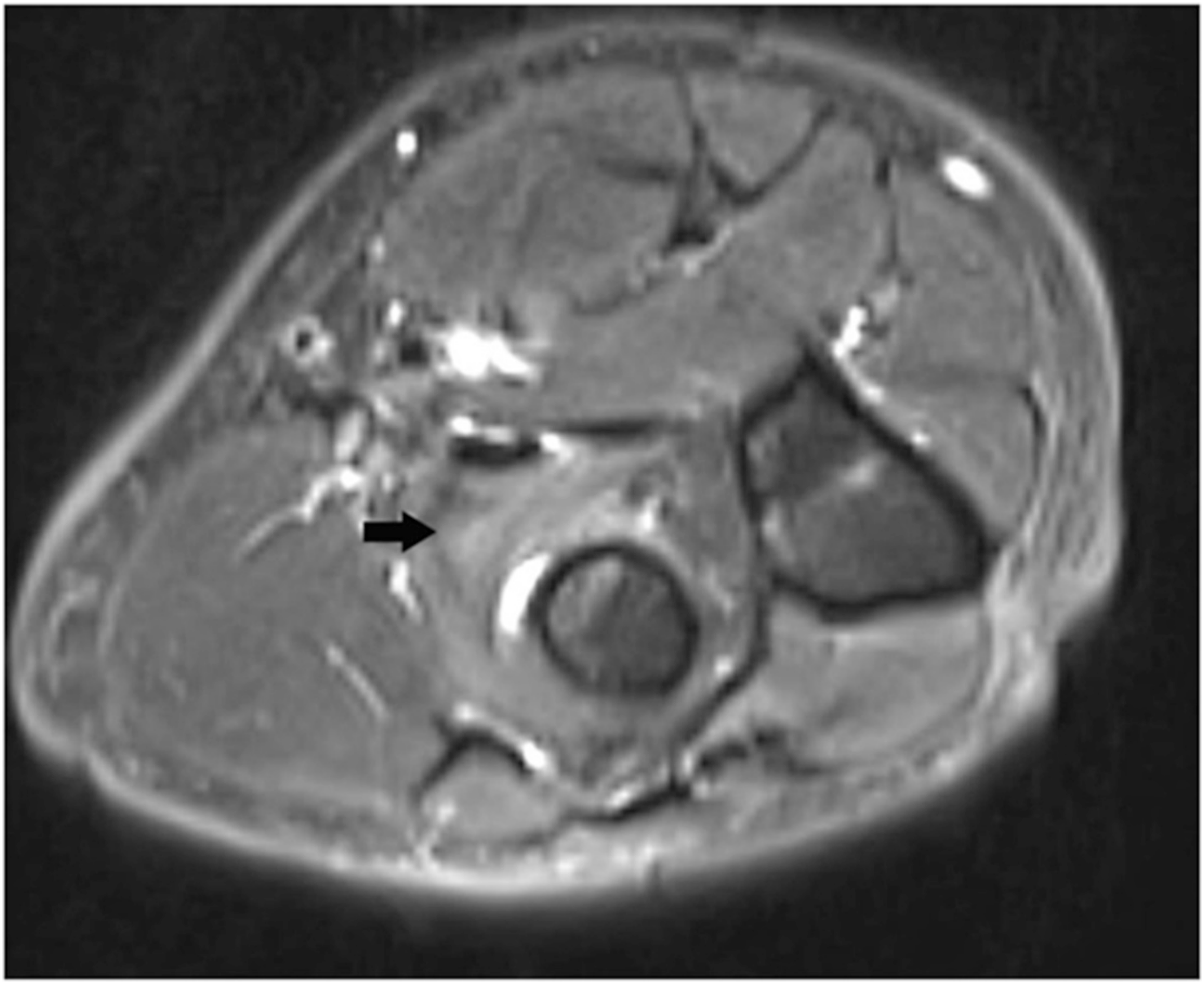

Fig. 18: Axial T2-WI with FS of a patient with a radial tunnel syndrome showing edema in the supinator muscle, a frequent location of entrapment of the posterior interosseous nerve, a branch of the radial nerve.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

B) The medial compartment

Plain films can show bone spur formation or soft tissue calcifications near the medial epicondyle in advanced tendinosis (Fig. 19 on page 72).

Fig. 19: Plain film of the elbow showing a soft tissue calcification (arrow) near the medial epicondyle suggesting medial epicondylitis.

References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

For *sonographic evaluation* of the extensor tendons, the probe is placed in a longitudinal and axial plane of the tendons with the elbow in an extended position. Looking at both planes is necessary to exactly locate the lesion (Fig. 20 on page 74).

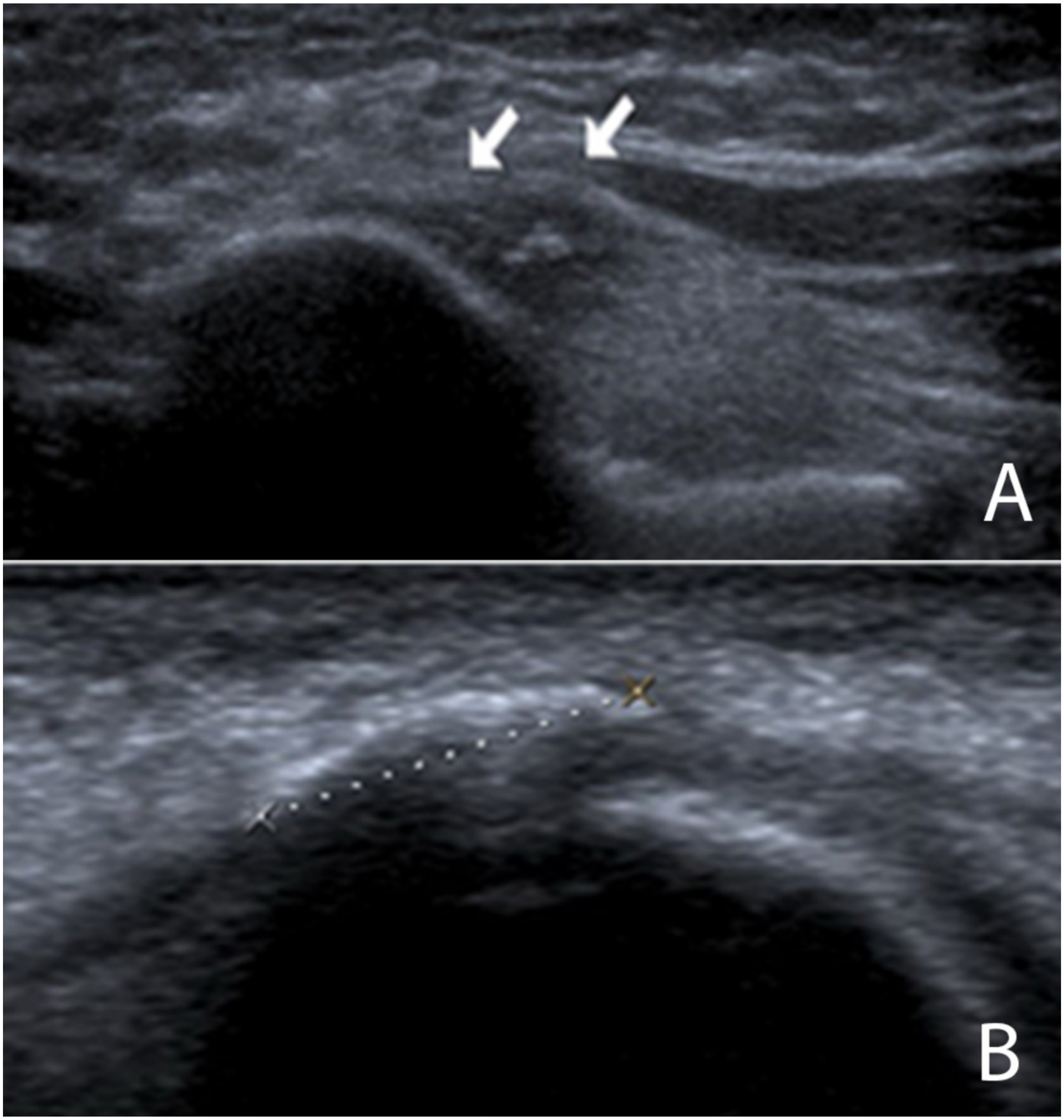

Fig. 20: Ultrasound in a longitudinal (A) and transversal (B) plane of the flexor-pronator mass showing a calcification surrounded by hypoechogenicity: medial

epicondylitis. Both planes are necessary to be able to exactly locate the lesion in the anterior aspect of the tendon.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

As in the evaluation of the lateral compartment, tendons and ligaments of the medial compartment are best evaluated on coronal and axial planes on *MRI* (Fig. 21 on page 74).

Fig. 21: Coronal T2-WI with FS of the normal elbow. The flexor-pronator mass (arrow) inserts on the medial epicondyle and is in normal circumstances hypointense on all imaging sequences. The medial collateral ligament is deep of the flexor-pronator mass situated (curved arrow).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Thickening, SI-changes, tears of the flexor-pronator mass and associated MCL tears can be efficiently evaluated on MRI (Fig. 22 on page 76 , Fig. 23 on page 78 , Fig. 24 on page 80). Bone marrow edema is more frequently seen in medial epicondylitis than in lateral epicondylitis (Fig. 22 on page 76).

Fig. 22: Coronal pd T2-WI with FS (A) with in the same patient a corresponding ultrasound image in the longitudinal plane at the flexor-pronator mass (B). The MRI shows thickening and hyperintensity (arrow) at the tendon of the flexor-pronator mass. Adjacent bone marrow edema is seen in the medial epicondyle. There is also a rupture of the medial collateral ligament at the insertion on the medial epicondyle (curved arrow). The ultrasound image shows the same tendon thickening with accompanying hypoechogenicity: medial epicondylitis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

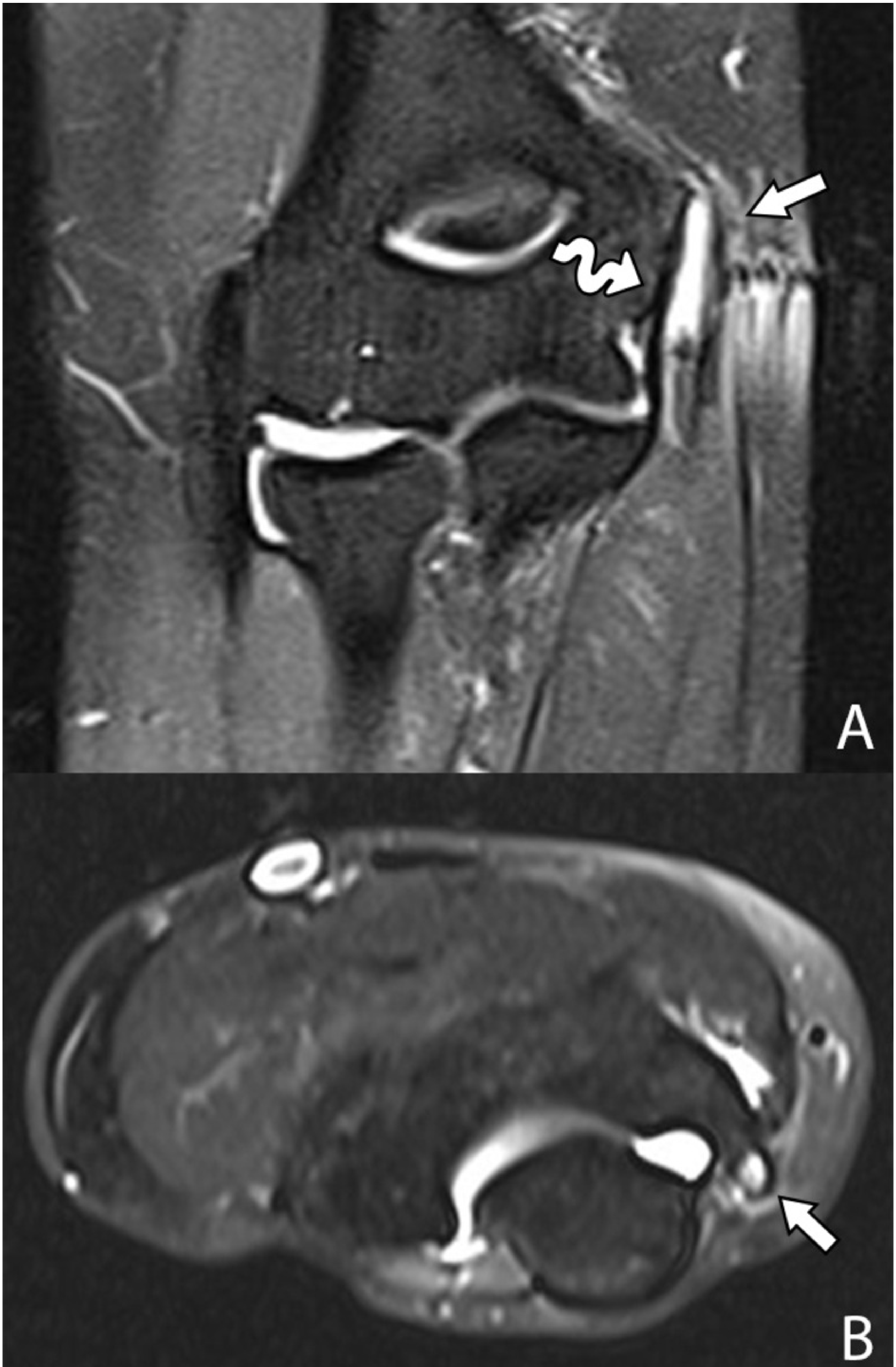
A
B

Fig. 23: Coronal (A) and axial (B) pd T2-WI with FS showing a hypointense zone in the tendon of the flexor-pronator mass. Some fibers are still attached to the medial epicondyle (arrow): partial tear. The MCL has a normal insertion on the medial epicondyle (curved arrow).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

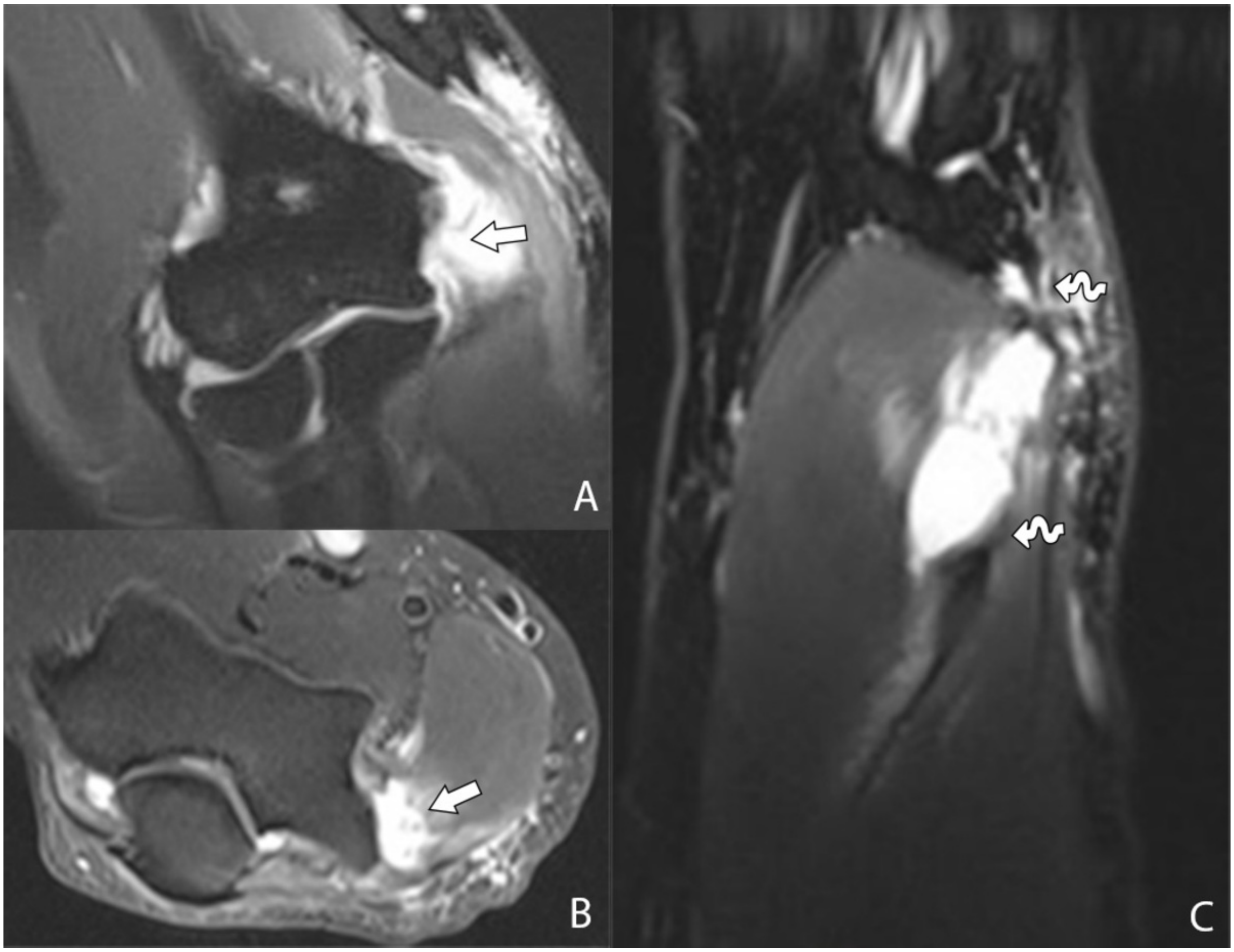

Fig. 24: Coronal (A), axial (B) and sagittal (C) T2-WI showing a complete tear of the flexor-pronator mass (arrow). The degree of retraction should be evaluated on sagittal images (distance between the curved arrows).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Following a valgus trauma in children, avulsion of the medial epicondyle is more frequent than tearing of the flexor-pronator mass (Fig. 25 on page 80)

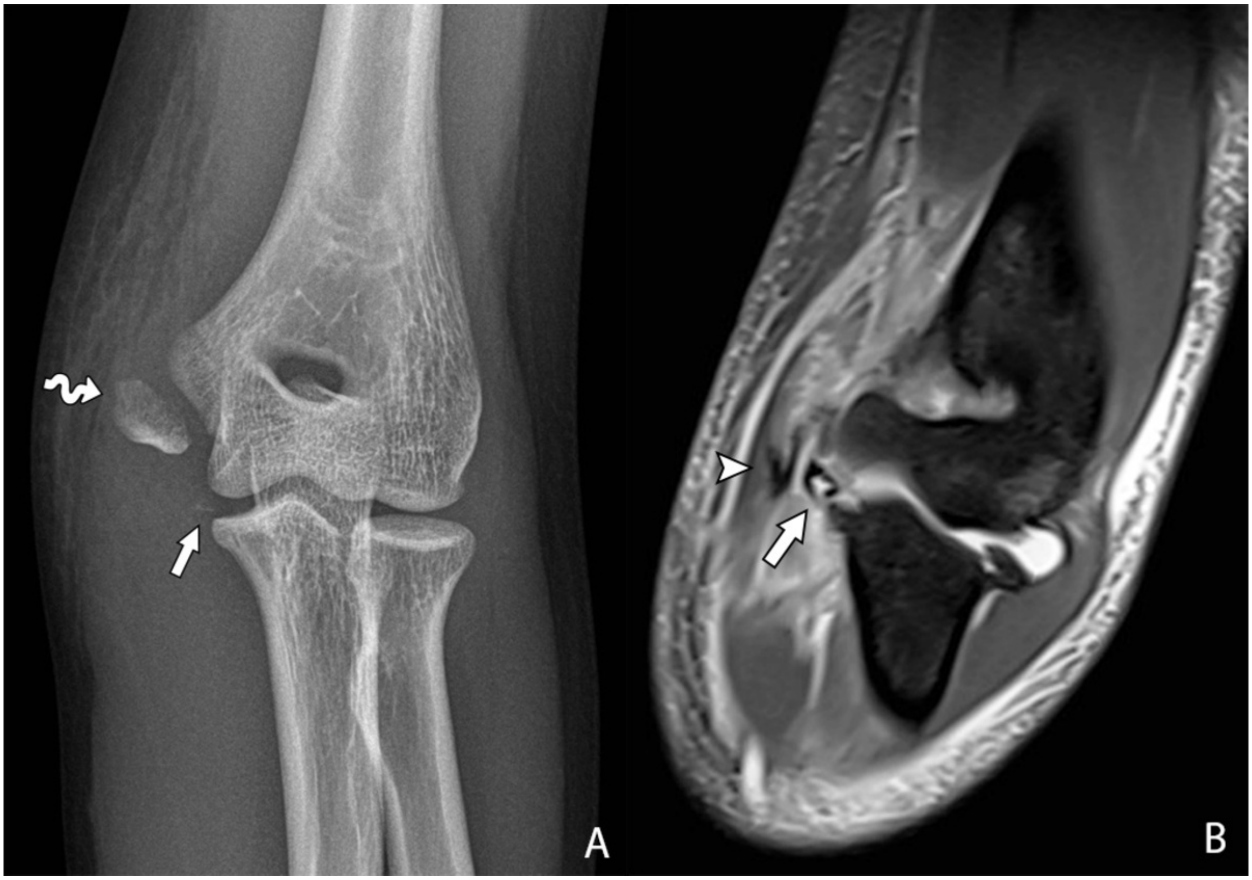

Fig. 25: Avulsion fracture of the medial epicondyle after a valgus trauma in a 15-year-old patient with a preexisting Little League elbow. Plain films (A) show the avulsion fragment (arrow) and a traumatic separation of the medial epicondyle apophysis (curved arrow) with accompanying soft tissue swelling. A subsequent MRI of the elbow reveals an avulsion fragment (arrow) on the pd T2-WI with FS (B). The tendons of the flexor-pronator mass do not seem to be ruptured (arrowhead).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Ulnar neuropathy should always be excluded in medial epicondylitis (Fig. 26 on page 81).

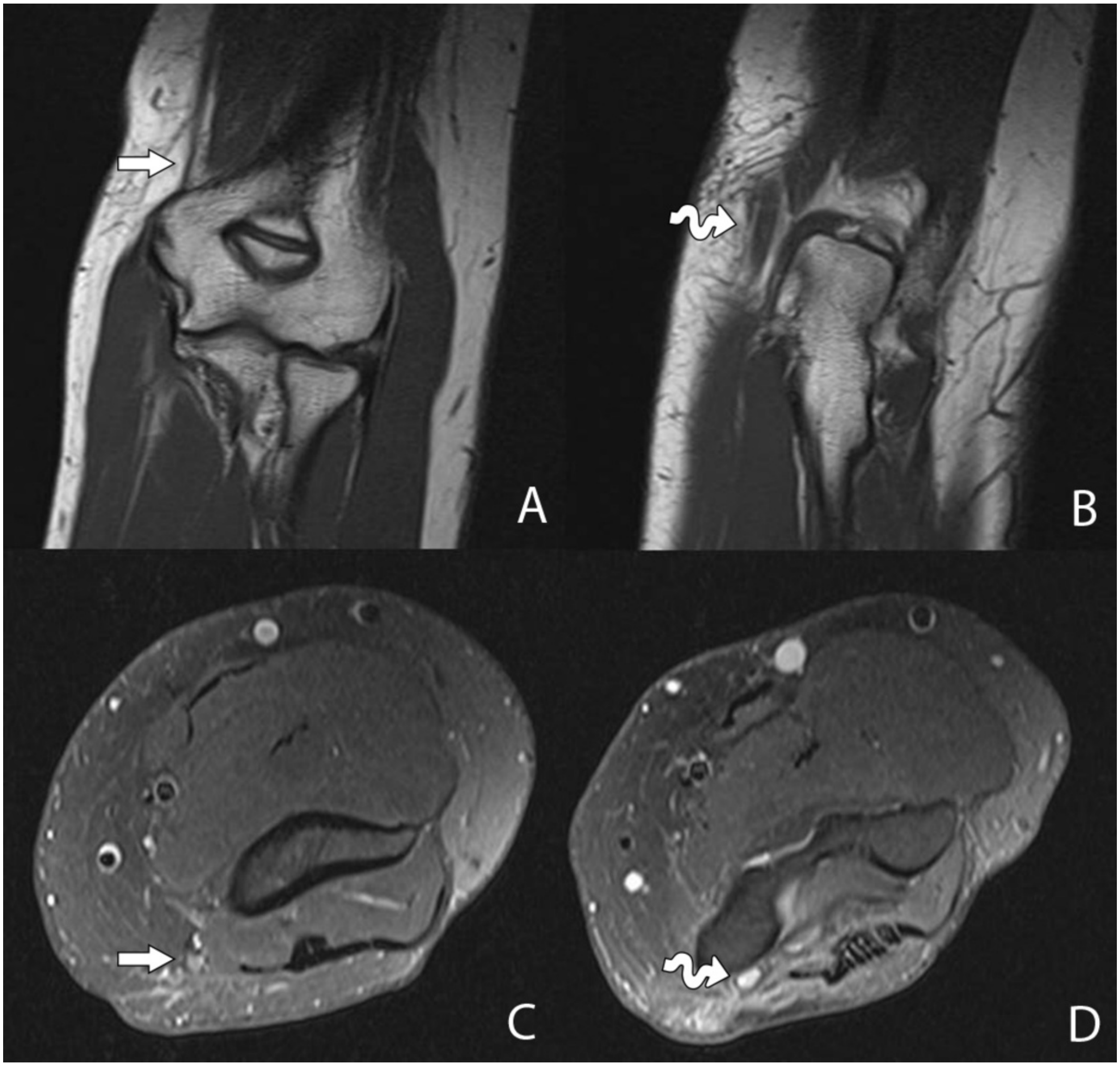

Fig. 26: Coronal T1-WI of the elbow showing the ulnar nerve in the cubital tunnel (B) and more proximally (A). Corresponding T2-WI in the axial plane at the level of the cubital tunnel (D) and more proximally (C). The ulnar nerve in the cubital fossa is thickened and hyperintense on the T2-WI compared to the images more proximally: ulnar neuropathy.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

On plain films, anchor material can be seen after tendon or ligament reinsertion (Fig. 27 on page 82).

Fig. 27: Plain film of the elbow showing a Mitek-anchor (arrow) after repair of the MCL and the flexor-pronator mass.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

C) The anterior compartment

Plain films have usually no added value caused by superposition. CT-scan can be useful to reveal bone spur formation in the distal biceps tendon (Fig. 28 on page 84).

Fig. 28: Coronal (A) and axial (B) CT-image in bone window of the elbow revealing a bone spur formation at the radial tuberosity (arrows). This can be misinterpreted as a tumor. The key to the diagnosis is the location at the insertion of the biceps tendon and the absence of a soft tissue mass.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Ultrasound of the distal biceps tendon is performed with the elbow in extension. Evaluation of this tendon is difficult in unexperienced hands because of the deep insertion of the tendon on the radial tuberosity. Ultrasound can be used for evaluation of tendinosis and (partial) tearing of the distal biceps tendon (Fig. 29 on page 84). The insertion site at the radial tuberosity can also be seen from posteriorly with the arm in pronation and flexion.

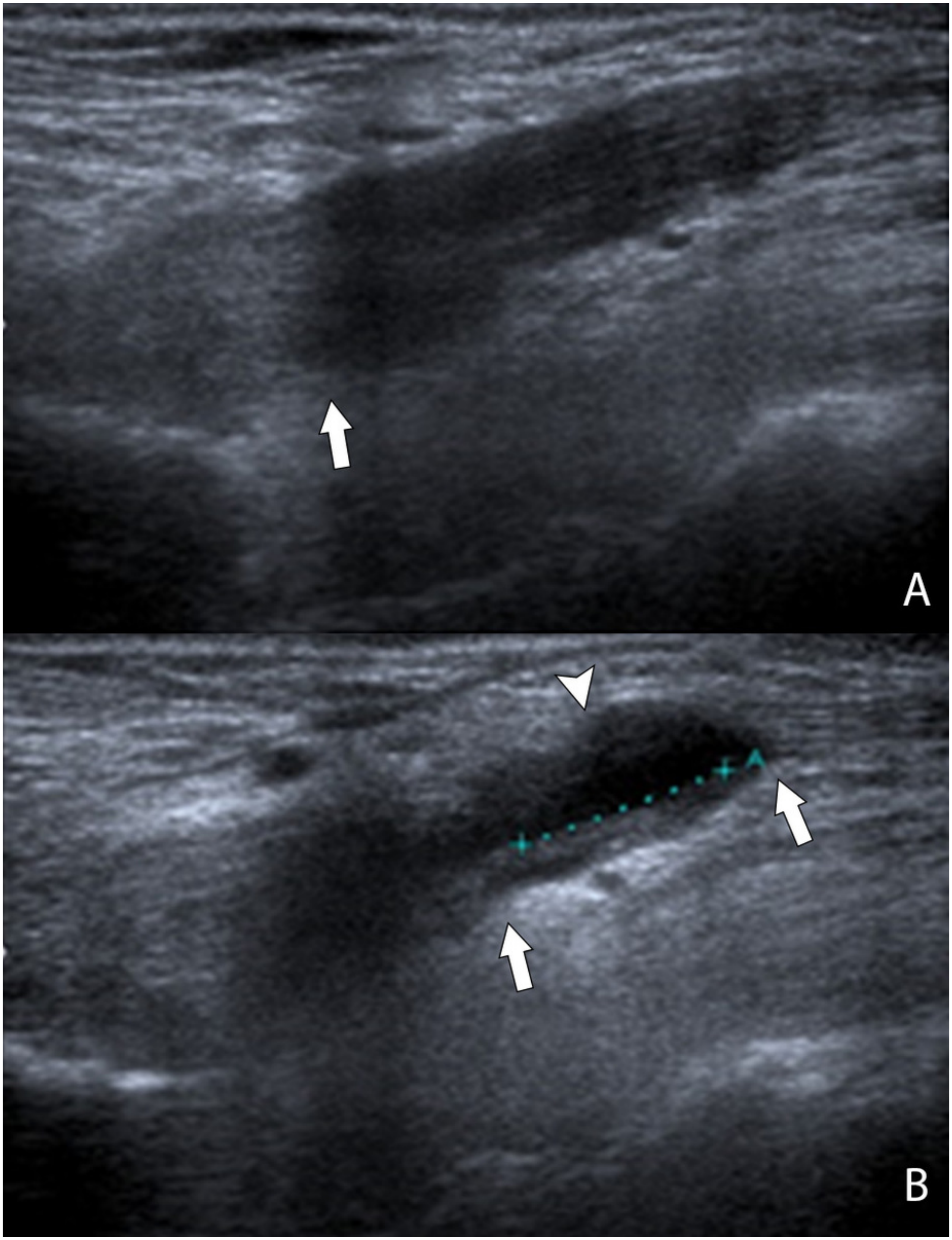
A
B

Fig. 29: Longitudinal ultrasound image of the distal biceps tendon revealing a partial tear. The fibers of the tendon are interrupted (arrow) and a soft tissue collection is seen (arrowhead).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

The *FABS-position* (flexion, abduction and supination) (Fig. 30 on page 86) is used for assessment of the distal biceps tendon on *MRI*. In this position, the tendon loses its oblique course seen in the standard imaging position. The tendon is now straight in a coronal and sagittal plane, resulting in an easier interpretation of the distal biceps tendon (Fig. 31 on page 86 , Fig. 32 on page 88). A full thickness tear of the distal biceps tendon with more than 8 cm of retraction indicates an accompanying tear of the lacertus fibrosis.

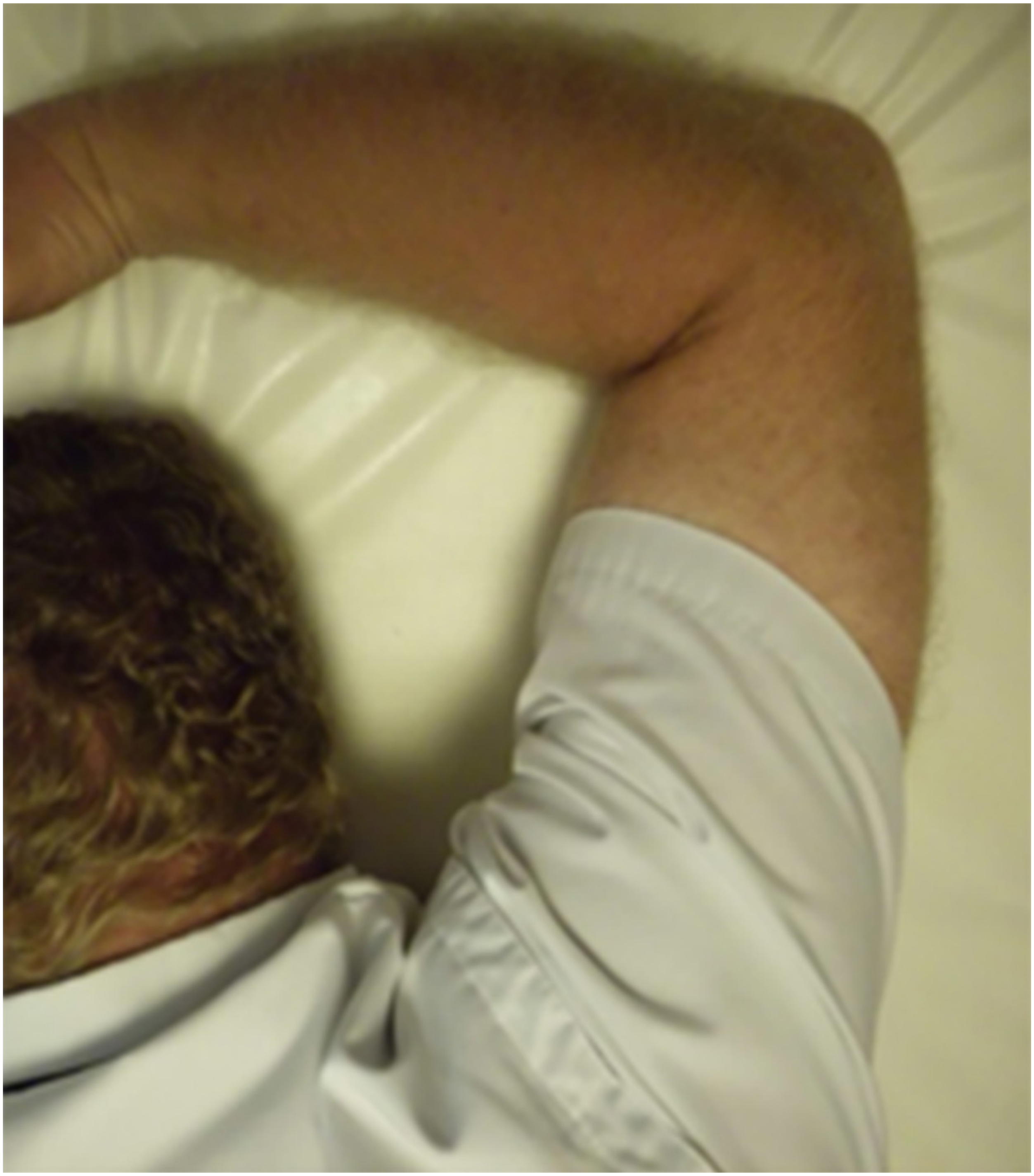

Fig. 30: The FABS position is used to obtain a straight distal biceps tendon in a sagittal and coronal plane on MRI. The elbow is flexed with the arm in abduction and the forearm in supination.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

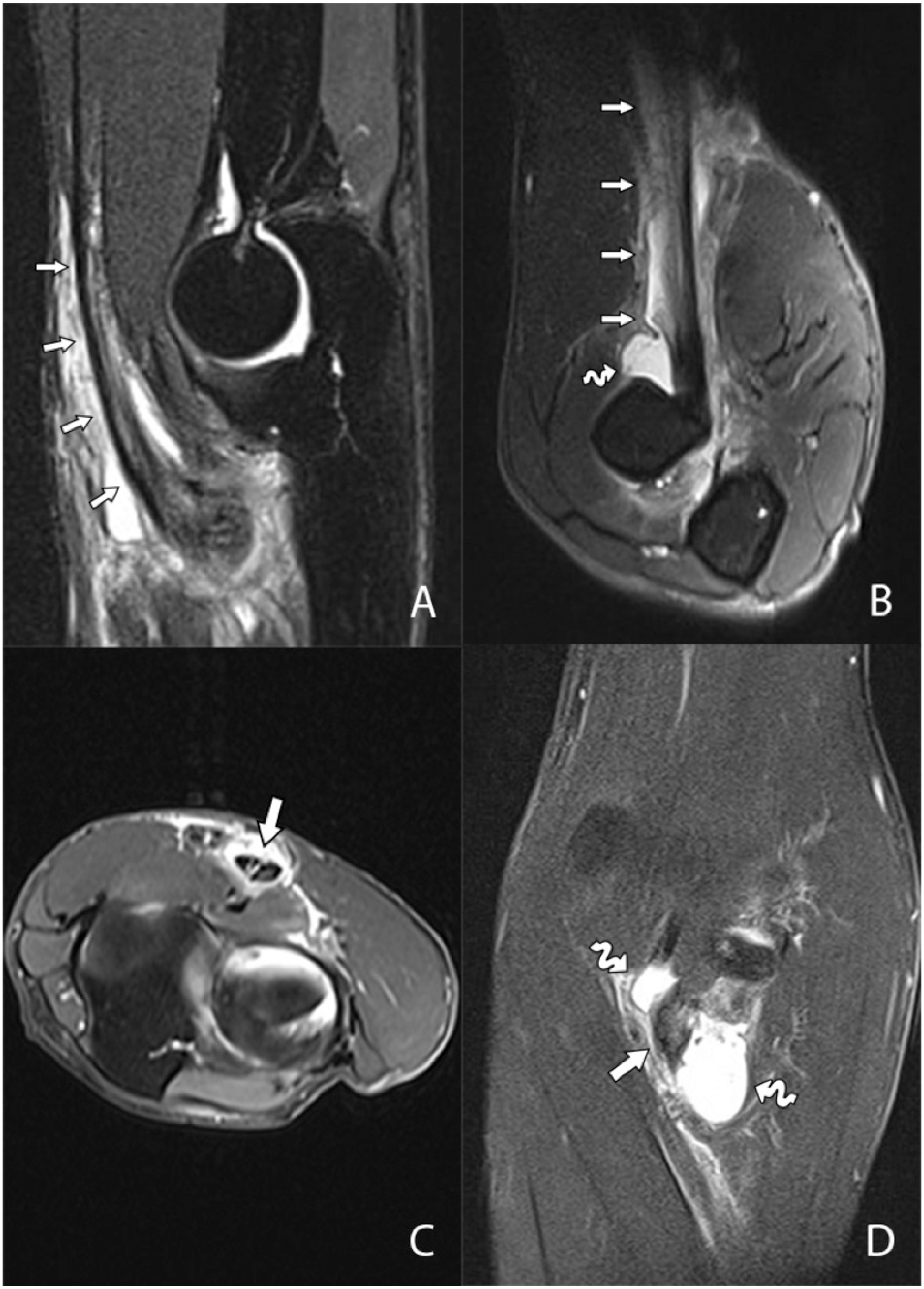
A
B
C
D

Fig. 31: Sagittal (A), axial (C) and coronal (D) T2-WI with FS and T2-WI with FS in FABS position (B). The distal tendon of the biceps muscle is hyperintense (arrows) on the sagittal image and on the image in FABS position with fluid signal intensity around the tendon (arrows): tendinosis of the distal biceps tendon with peritendinosis. Notice the better visualization of the distal portion of the biceps tendon in FABS position compared to the standard position in extension. On the axial images, a hyperintense longitudinal cleft (arrow) can be seen: partial longitudinal tear. Along the biceps tendon, a hyperintense, sharply delineated structure is seen (curved arrows): bicipitoradial bursitis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

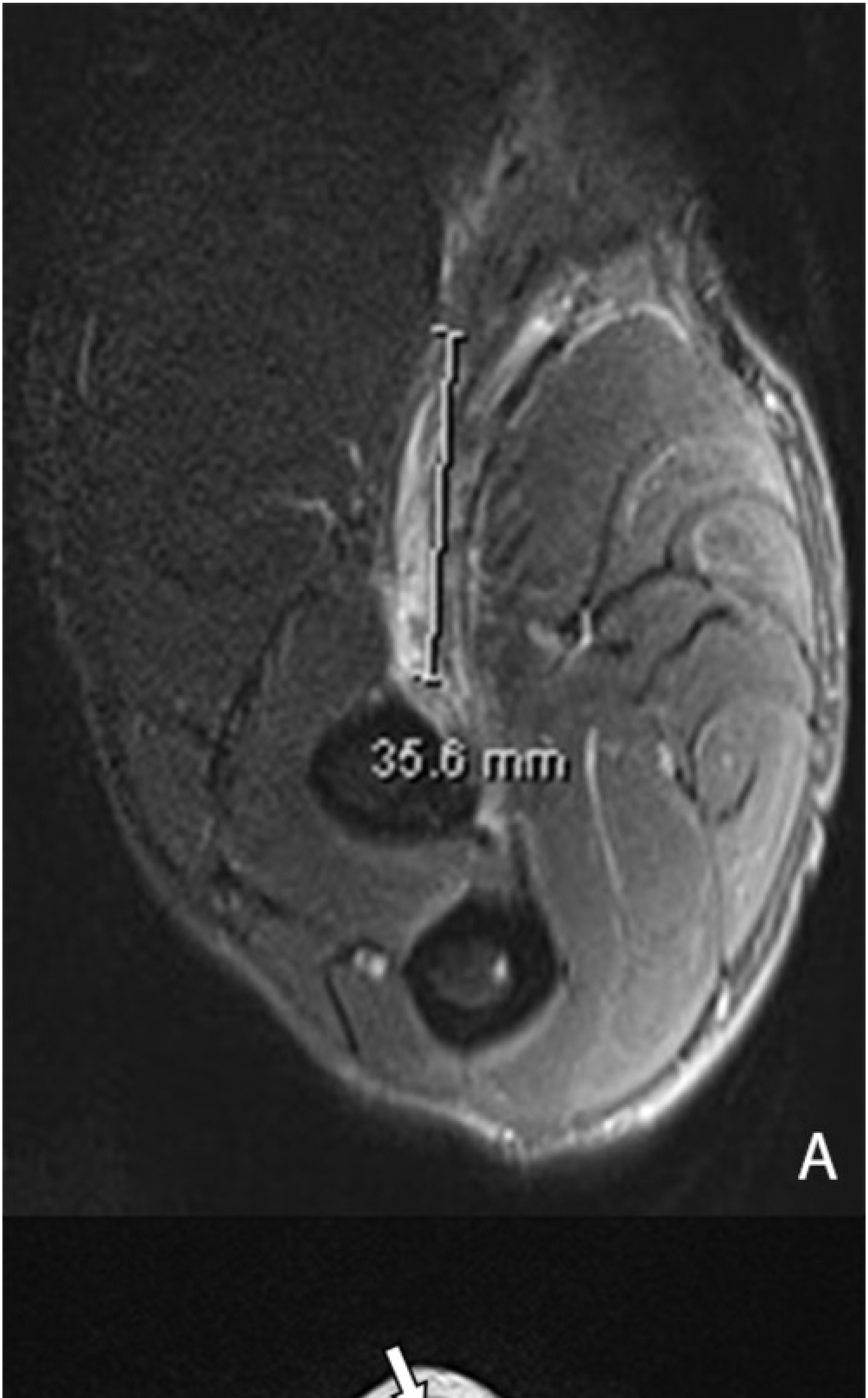
35.6 mm
A

Fig. 32: Dixon T2-WI with FS in FABS position at the level of the radial tuberosity (A) and an axial T1-WI at the level of the lacertus fibrosis (B). There is a full thickness tear at the radial tuberosity seen with retraction of 3,5 cm. The lacertus fibrosis is still intact (arrow), causing the biceps tendon not to retract any further. Retraction of more than 8 cm indicates rupture of the lacertus fibrosis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Placement of an anchor at the dorsal aspect of the proximal radius or ulna indicates distal biceps tendon repair (Fig. 33 on page 90).

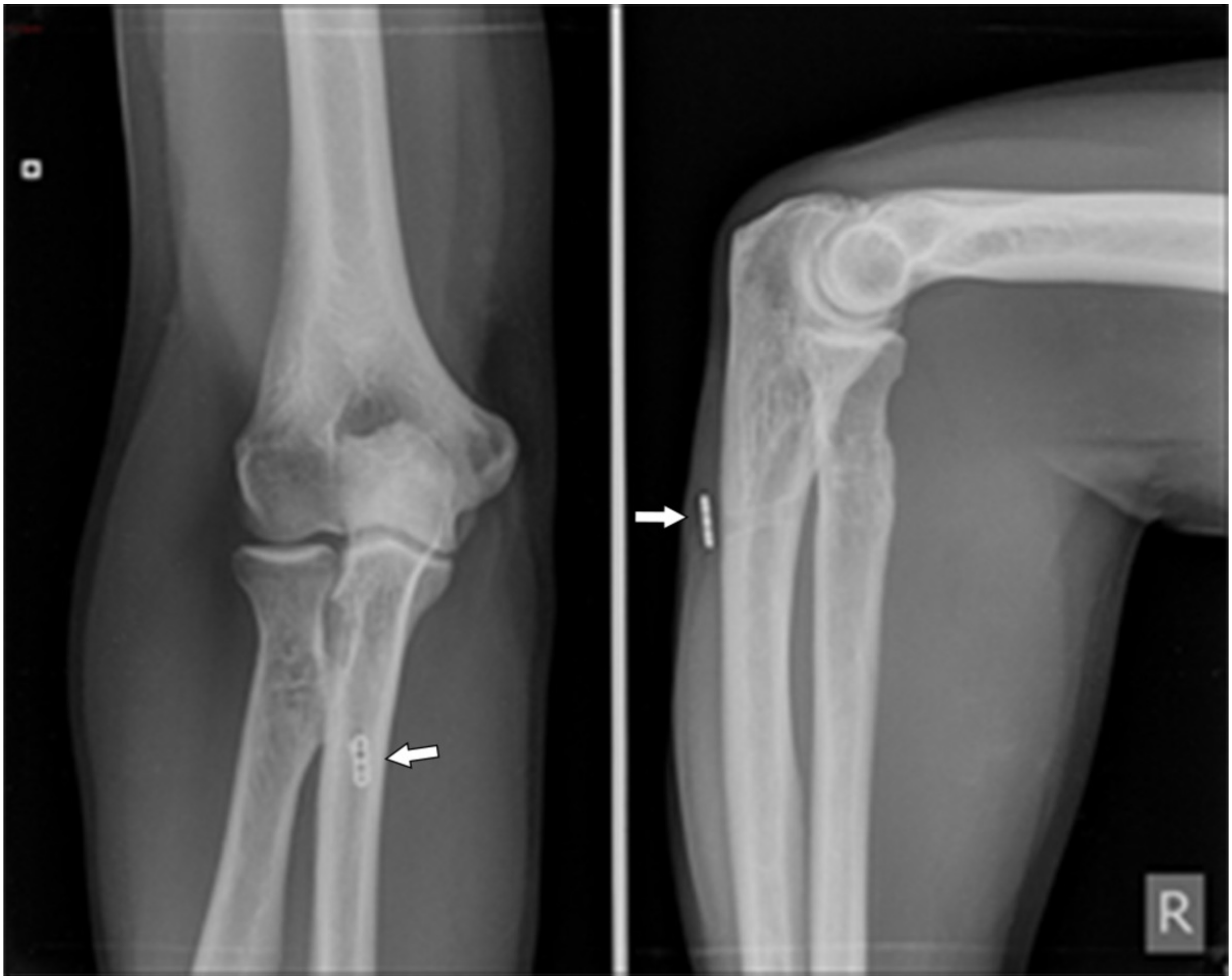

Fig. 33: Plain films of the elbow showing anchor placement (arrow) after distal biceps tendon repair.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

D) The posterior compartment

Plain films can show bone spur formation or soft tissue calcifications near the olecranon in advanced cases (Fig. 34 on page 90).

Fig. 34: Plain films showing spur formation (arrow) at the olecranon.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Ultrasound of the distal triceps tendon is performed with the elbow in flexion (Fig. 35 on page 91).

Fig. 35: Ultrasound of the distal triceps tendon showing thickening of the tendon, calcifications and adjacent hypoechogenicity in the tendon (arrows): calcifying tendinosis of the distal triceps tendon.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

MRI shows the same imaging features as in the other compartments. The triceps tendon is best evaluated in the sagittal and axial plane (Fig. 36 on page 92).


A

Fig. 36: Sagittal (A) and axial (B) T2-WI with FS showing hyperintensity at the distal portion of the triceps tendon (arrow) and peritendinous hyperintensity: tendinosis of the distal triceps tendon with peritendinosis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

After trauma or repetitive stress, avulsion fracture of the olecranon can occur (Fig. 37 on page 94).

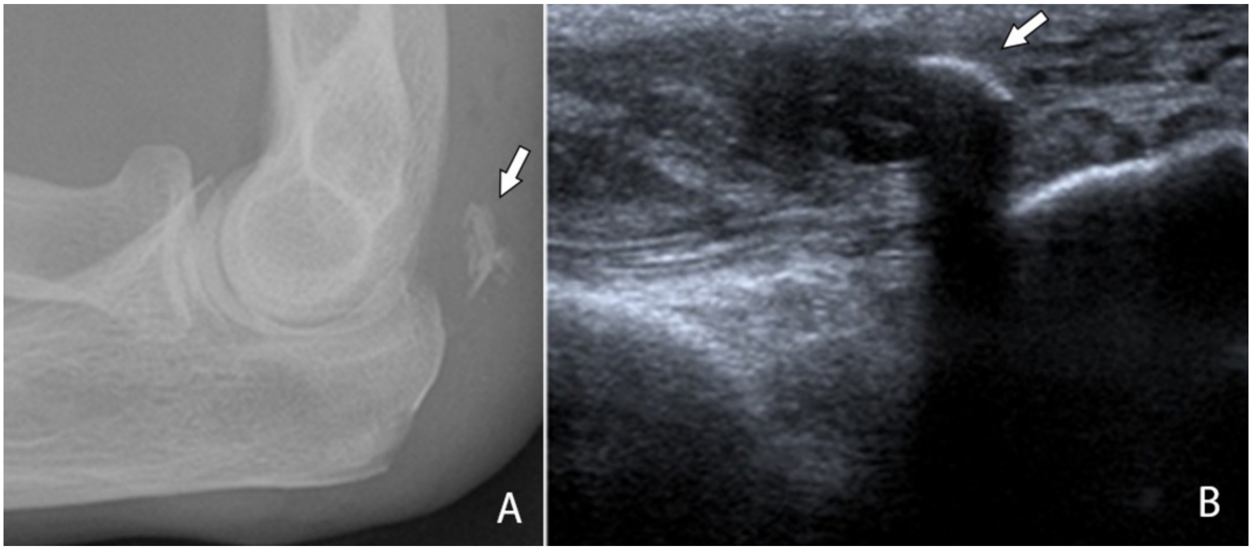

Fig. 37: Plain films (A) of the elbow and ultrasound (B) of the distal triceps tendon showing an avulsion fragment of the olecranon (arrow).
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Olecranon bursitis is usually a straightforward diagnosis on ultrasound due to its location at the olecranon and in the subcutaneous soft tissue (Fig. 38 on page 94). It shows a fluid collection with usually hyperaemia. There may be some debris in the collection.

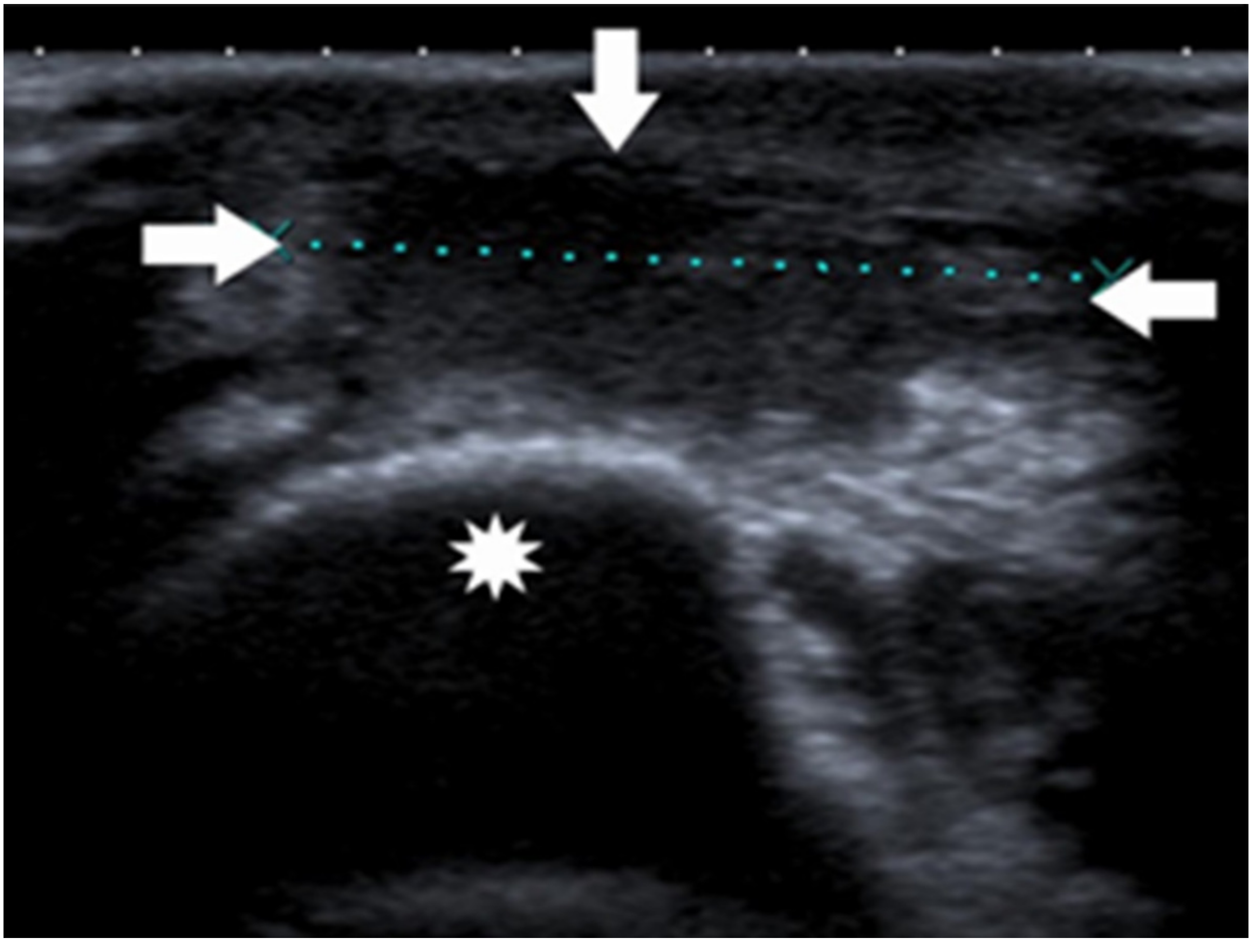

Fig. 38: Ultrasound of the posterior elbow showing a fluid collection (arrows) in the subcutaneous soft tissue at the olecranon (star): olecranon bursitis.
References: Department of Radiology, AZ Sint-Maarten, Mechelen-Duffel, Belgium

Images for this section:

Table 1: Differential diagnosis of lateral epicondylitis
- Occult fracture or stress fracture of the elbow
- Osteochodritis dissecans of the capitellum/Panner's disease
- Osteoarthritis
- Lateral Plica syndrome
- Posterolateral rotatory instability, LUCL lesion
- Radial tunnel syndrome

Table 1: Differential diagnosis of lateral epicondylitis

Table 2: Differential diagnosis of medial ecpicondylitis
- Occult fracture or stress fracture of the elbow
- Osteochondritis dissecans
- Osteoarthritis
- Ulnar collateral ligament lesion
- Little league elbow
- Flexor-pronator syndrome
- Ulnar neuropathy

Table 2: Differential diagnosis of medial epicondylitis

Table 3: Differential diagnosis of tendon pathology of the posterior compartment
- Olecranon bursitis
- Occult fracture or stress fracture of the olecranon
- Valgus extension overload syndrome with posterior impingement
- Posterolateral rotatory instability

Table 3: Differential diagnosis of tendon pathology of the posterior compartment

Fig. 7: Photograph of a patient in "superman"-position with the elbow in extension and supination for the best image quality.

Fig. 8: Plain film of the elbow showing a soft tissue calcification (arrow) near the lateral epicondyle suggesting lateral epicondylitis.

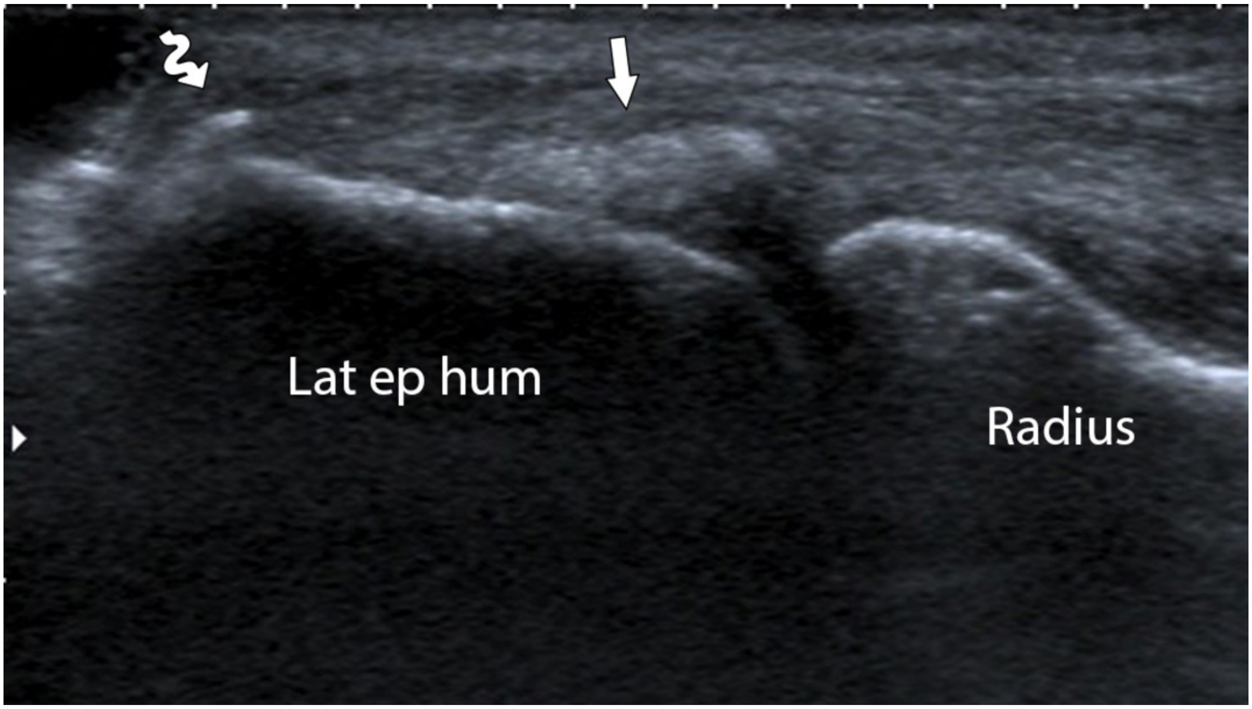

Fig. 9: Longitudinal ultrasound image of the common extensor tendon showing a large calcification (arrow) in the tendon and a smaller calcification more proximally (curved arrow): calcifying tendinopathy.

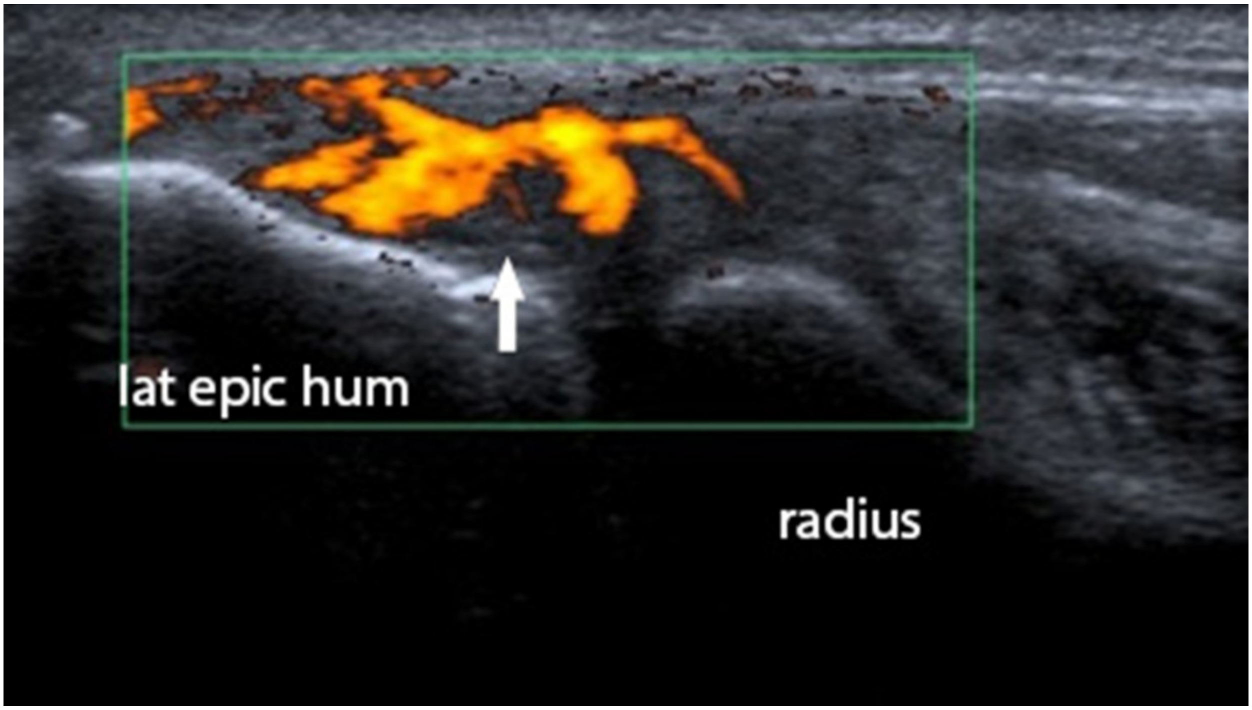

Fig. 10: Longitudinal ultrasound image of the common extensor tendon showing increased Doppler flow (arrow) in the tendon: hyperemia. This hyperemia is caused by an angiofibroblastic reaction, the repairative response to the (micro-)tearing with the formation of scar tissue.

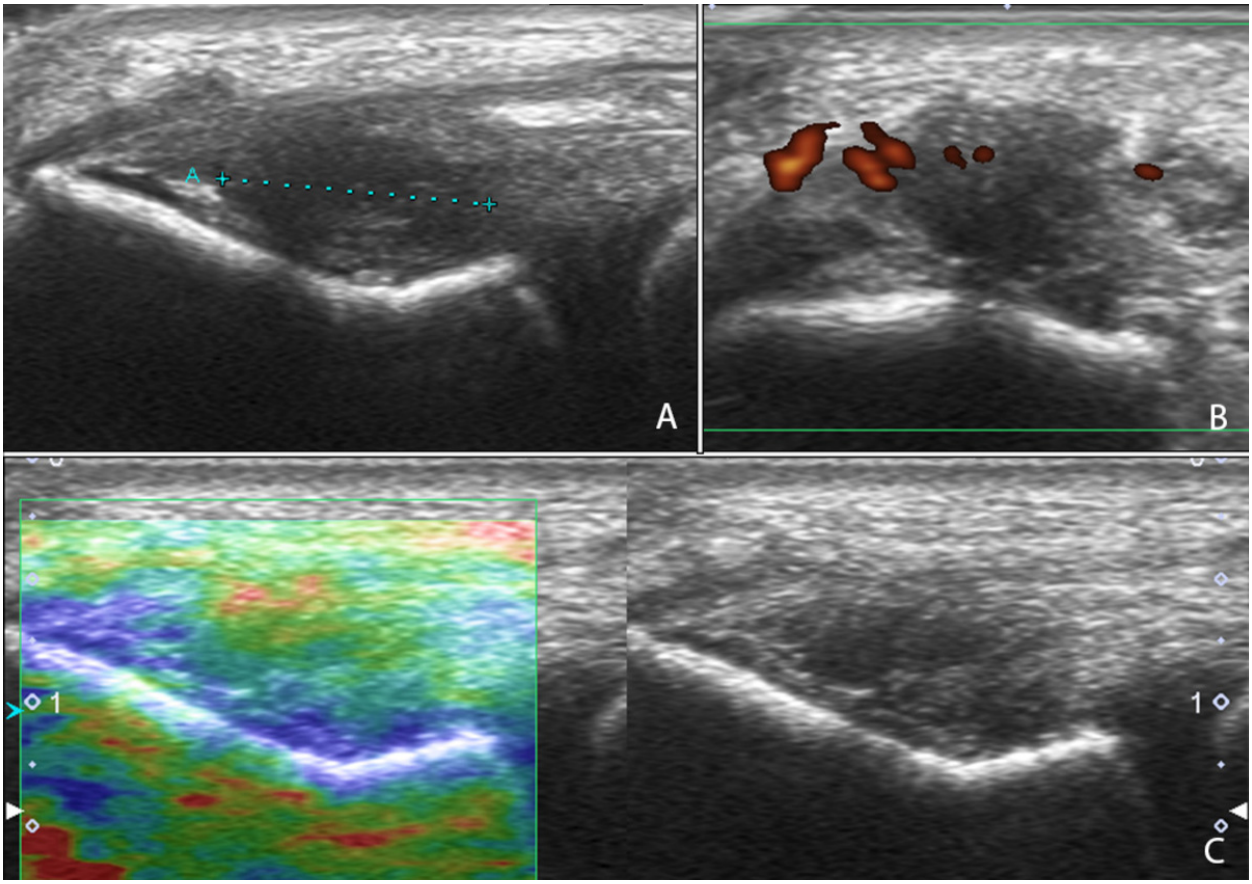

Fig. 11: Longitudinal (A,C) and transversal (B) ultrasound image of the extensor tendons showing a hypoechogenic zone (A,B,C) within the extensor tendons: tendinosis. There is an increased Doppler signal (B): hyperemia. The zone of tendinosis has on elastography (C) an increased compressibility of the tendon. The blue spots on the color map represent hard tissue with low compressibility and the red spots represent soft tissue with high compressibility.

Fig. 12: Coronal fat saturated (FS) T2-WI of the normal elbow. A is 2 slices anterior of B. The common extensor tendon (arrow) inserts on the lateral epicondyle and is in normal circumstances hypointense on all imaging sequences. The radial collateral ligament is deep of the common extensor tendon situated (curved arrow). The lateral ulnar collateral ligament is located posteriorly to the radial head.


IAL

Fig. 13: Coronal T2-WI with FS showing a thickened common extensor tendon with a hyperintense zone in the proximal tendon (arrow): partial tear. There are no associated lesions.


A

Fig. 14: Coronal (A) T2-WI with FS and axial (B) dixon T2-WI with FS showing a severe tear of the conjoint extensor tendon (arrow) with perilesional edema (arrowhead). There is an associated radial collateral ligament rupture at its insertion on the lateral epicondyle, resulting in posterolateral rotatory instability of the elbow (curved arrow).

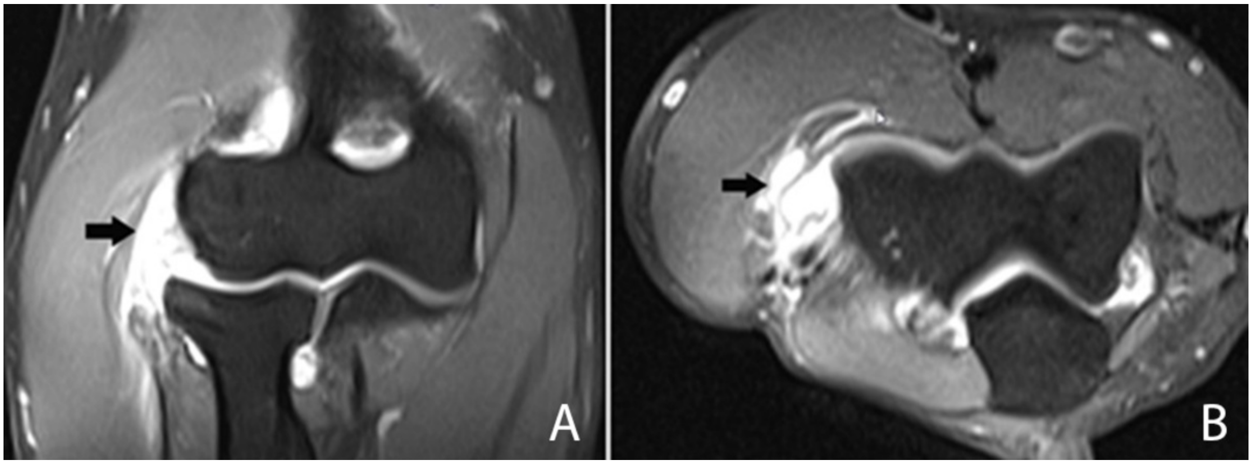

Fig. 15: Coronal (A) and axial (B) T2-WI with FS showing a full thickness tear of the conjoint tendon with retraction and involvement of the radial collateral ligament.

Fig. 16: Coronal pd T2-WI with FS showing a post-traumatic tear of the insertion of the radial collateral ligament at the lateral epicondyle. Avulsion type edema is seen in the lateral epicondyle.

Fig. 17: Sagittal T2-WI with FS of a patient with an osteochondritis dissecans (A) and a sagittal T1-WI of a patient with Panner's disease (B). In Panner's disease, there is also involvement of the growth plate and it is seen in children between the age of 7-12 years old. Osteochondritis dissecans is usually seen in young adolescents between the age of 12-15 years old.

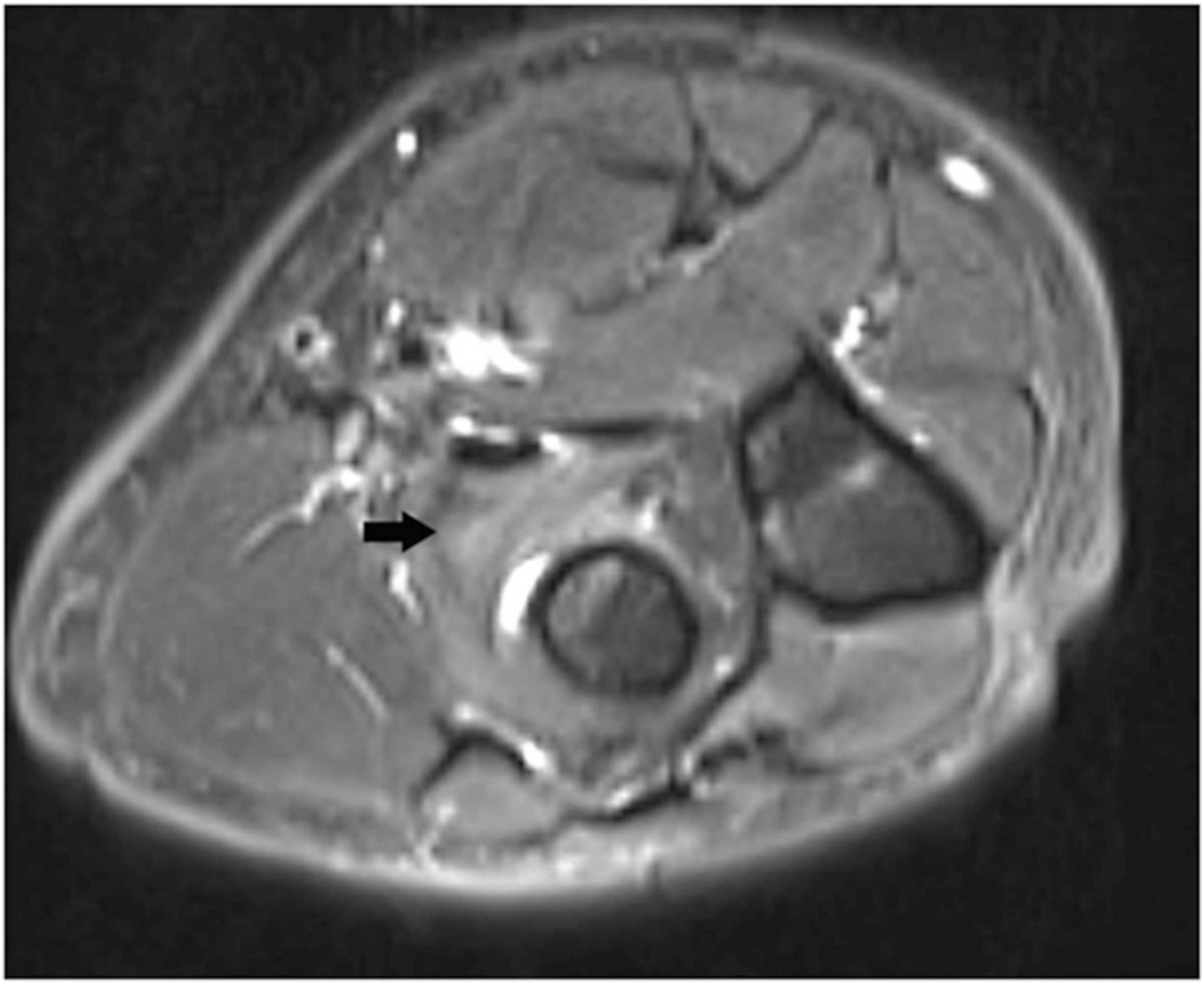

Fig. 18: Axial T2-WI with FS of a patient with a radial tunnel syndrome showing edema in the supinator muscle, a frequent location of entrapment of the posterior interosseous nerve, a branch of the radial nerve.

Fig. 19: Plain film of the elbow showing a soft tissue calcification (arrow) near the medial epicondyle suggesting medial epicondylitis.

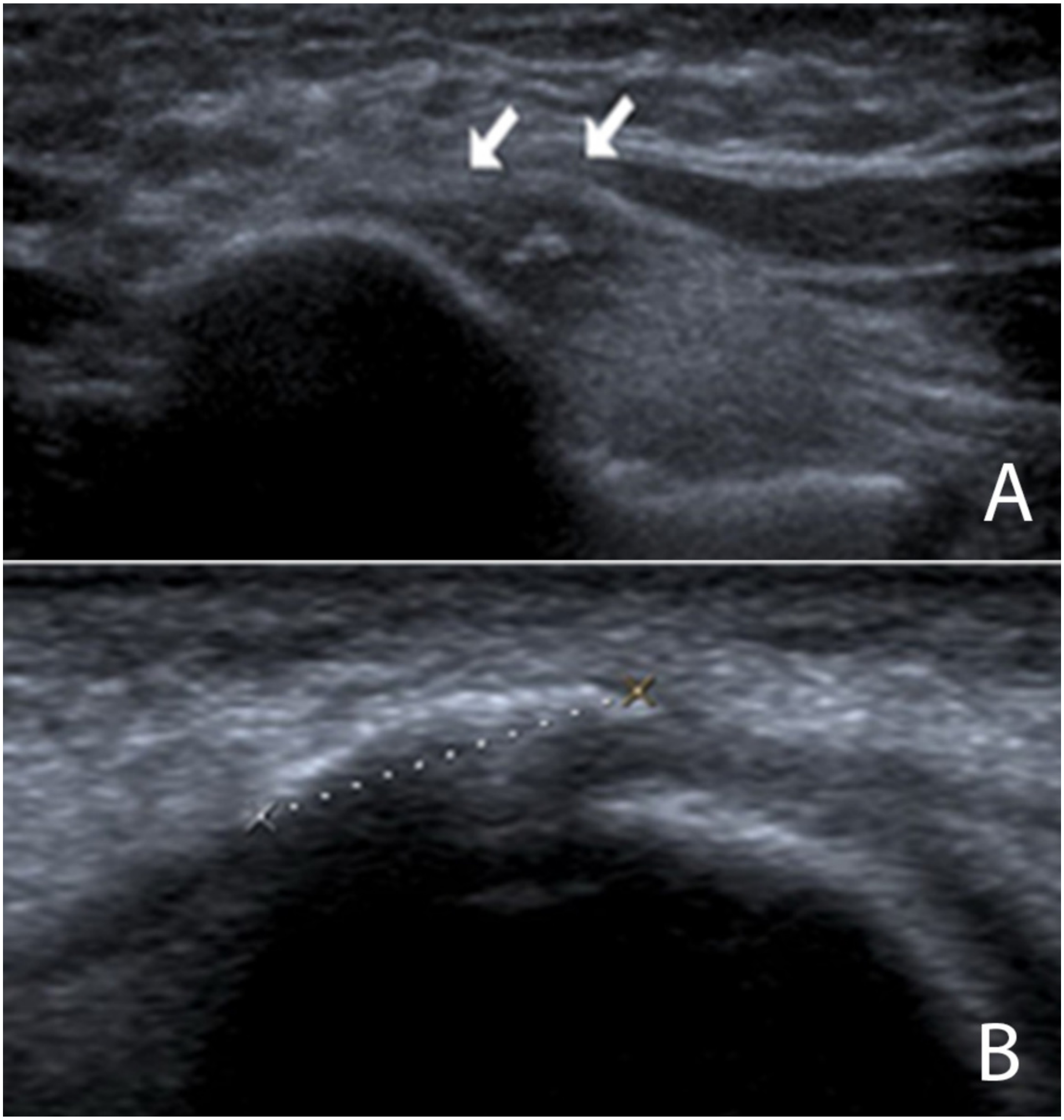

Fig. 20: Ultrasound in a longitudinal (A) and transversal (B) plane of the flexor-pronator mass showing a calcification surrounded by hypoechogenicity: medial epicondylitis. Both planes are necessary to be able to exactly locate the lesion in the anterior aspect of the tendon.

Fig. 21: Coronal T2-WI with FS of the normal elbow. The flexor-pronator mass (arrow) inserts on the medial epicondyle and is in normal circumstances hypointense on all imaging sequences. The medial collateral ligament is deep of the flexor-pronator mass situated (curved arrow).

Fig. 22: Coronal pd T2-WI with FS (A) with in the same patient a corresponding ultrasound image in the longitudinal plane at the flexor-pronator mass (B). The MRI shows thickening and hyperintensity (arrow) at the tendon of the flexor-pronator mass. Adjacent bone marrow edema is seen in the medial epicondyle. There is also a rupture of the medial collateral ligament at the insertion on the medial epicondyle (curved arrow). The ultrasound image shows the same tendon thickening with accompanying hypoechogenicity: medial epicondylitis.

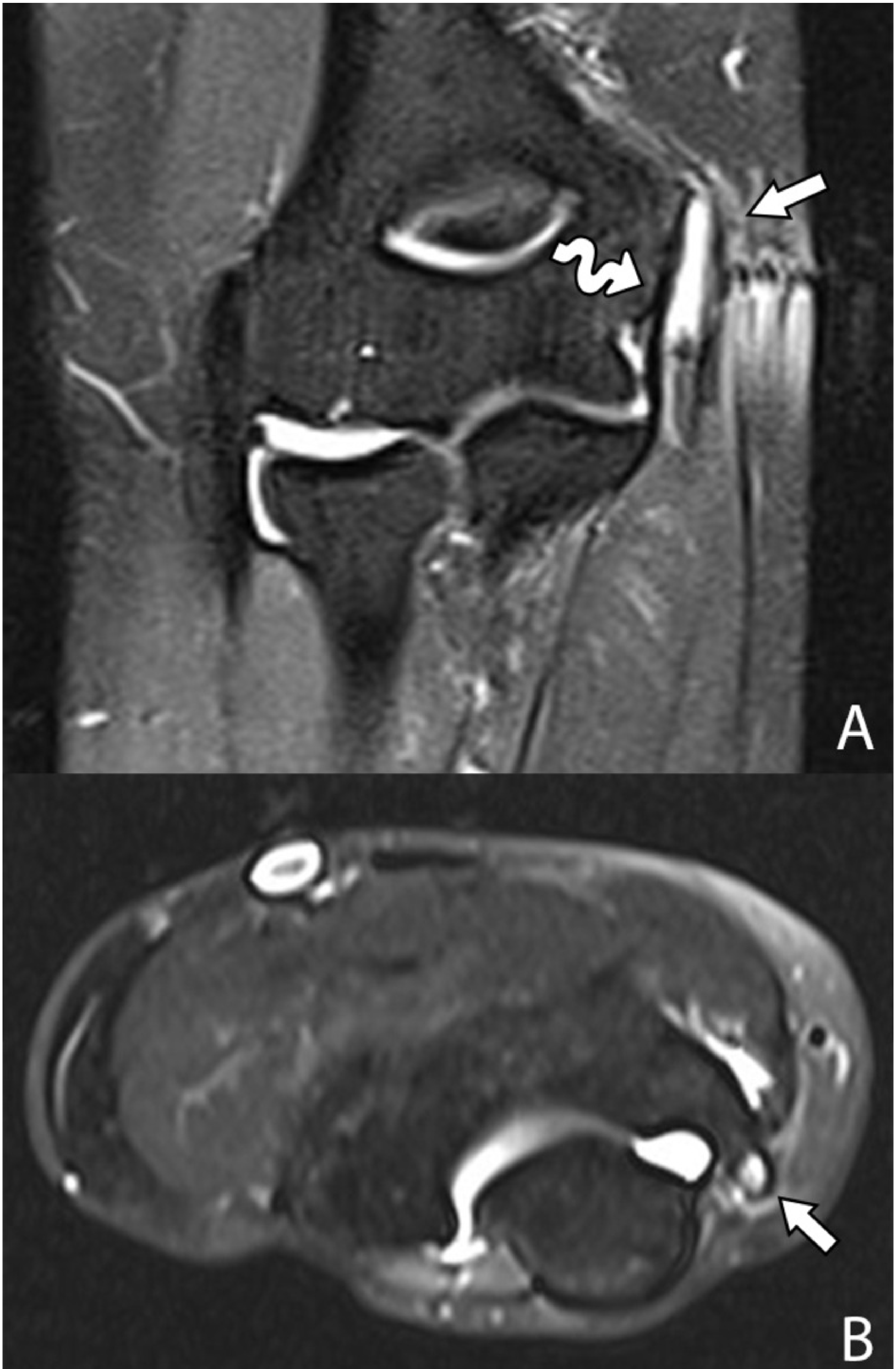
A
B

Fig. 23: Coronal (A) and axial (B) pd T2-WI with FS showing a hypointense zone in the tendon of the flexor-pronator mass. Some fibers are still attached to the medial epicondyle (arrow): partial tear. The MCL has a normal insertion on the medial epicondyle (curved arrow).

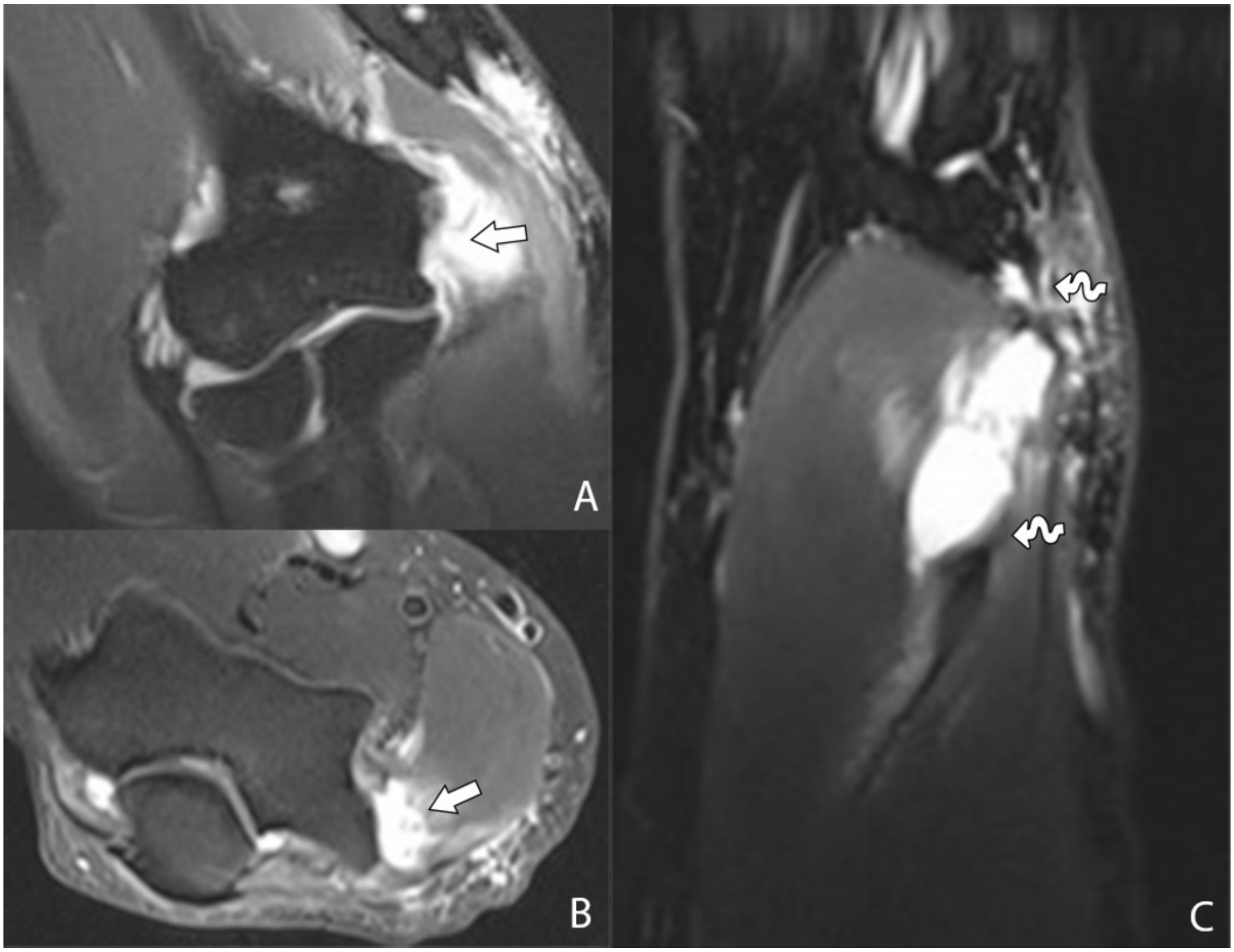

Fig. 24: Coronal (A), axial (B) and sagittal (C) T2-WI showing a complete tear of the flexor-pronator mass (arrow). The degree of retraction should be evaluated on sagittal images (distance between the curved arrows).

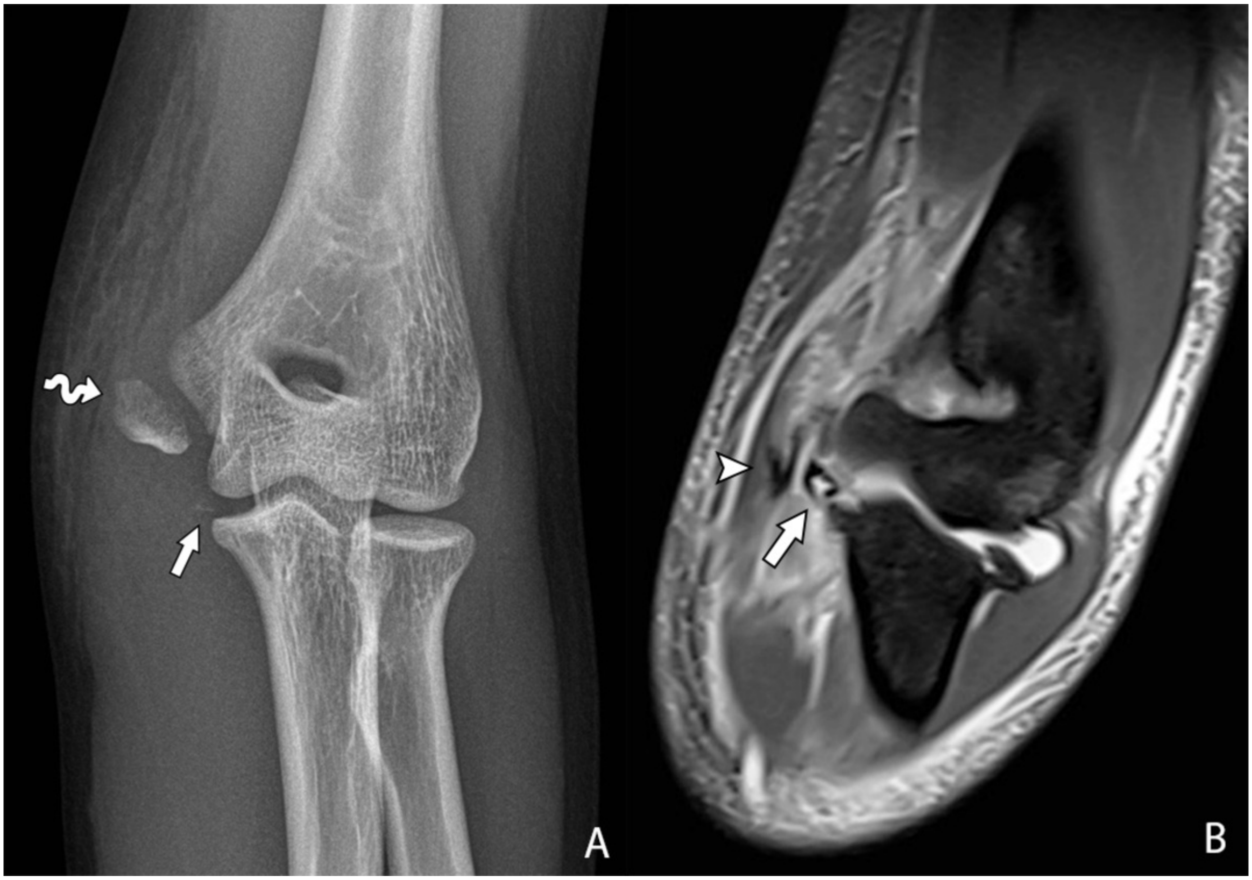

Fig. 25: Avulsion fracture of the medial epicondyle after a valgus trauma in a 15-year-old patient with a preexisting Little League elbow. Plain films (A) show the avulsion fragment (arrow) and a traumatic separation of the medial epicondyle apophysis (curved arrow) with accompanying soft tissue swelling. A subsequent MRI of the elbow reveals an avulsion fragment (arrow) on the pd T2-WI with FS (B). The tendons of the flexor-pronator mass do not seem to be ruptured (arrowhead).

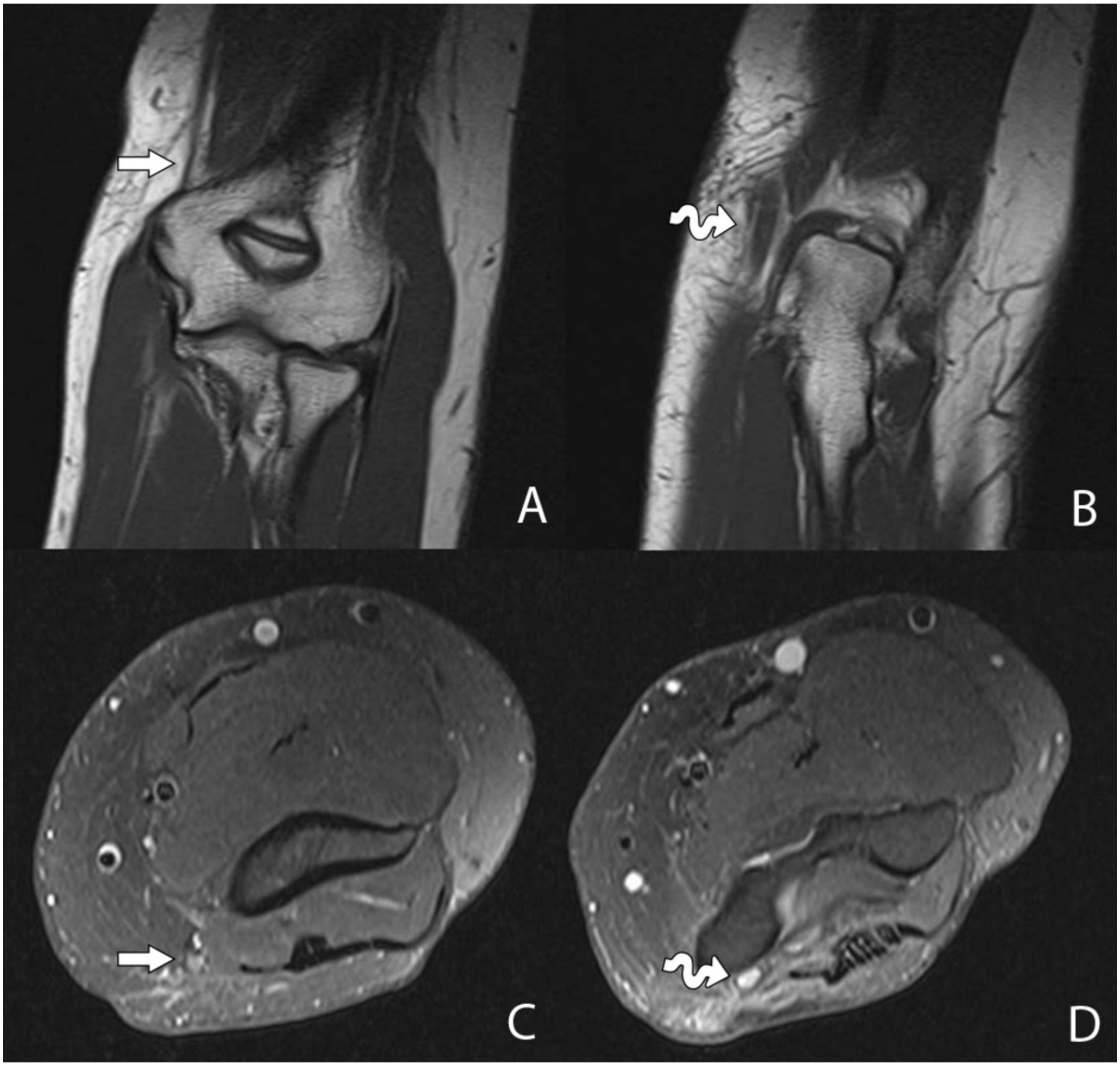

Fig. 26: Coronal T1-WI of the elbow showing the ulnar nerve in the cubital tunnel (B) and more proximally (A). Corresponding T2-WI in the axial plane at the level of the cubital tunnel (D) and more proximally (C). The ulnar nerve in the cubital fossa is thickened and hyperintense on the T2-WI compared to the images more proximally: ulnar neuropathy.

Fig. 27: Plain film of the elbow showing a Mitek-anchor (arrow) after repair of the MCL and the flexor-pronator mass.

Fig. 28: Coronal (A) and axial (B) CT-image in bone window of the elbow revealing a bone spur formation at the radial tuberosity (arrows). This can be misinterpreted as a tumor. The key to the diagnosis is the location at the insertion of the biceps tendon and the absence of a soft tissue mass.

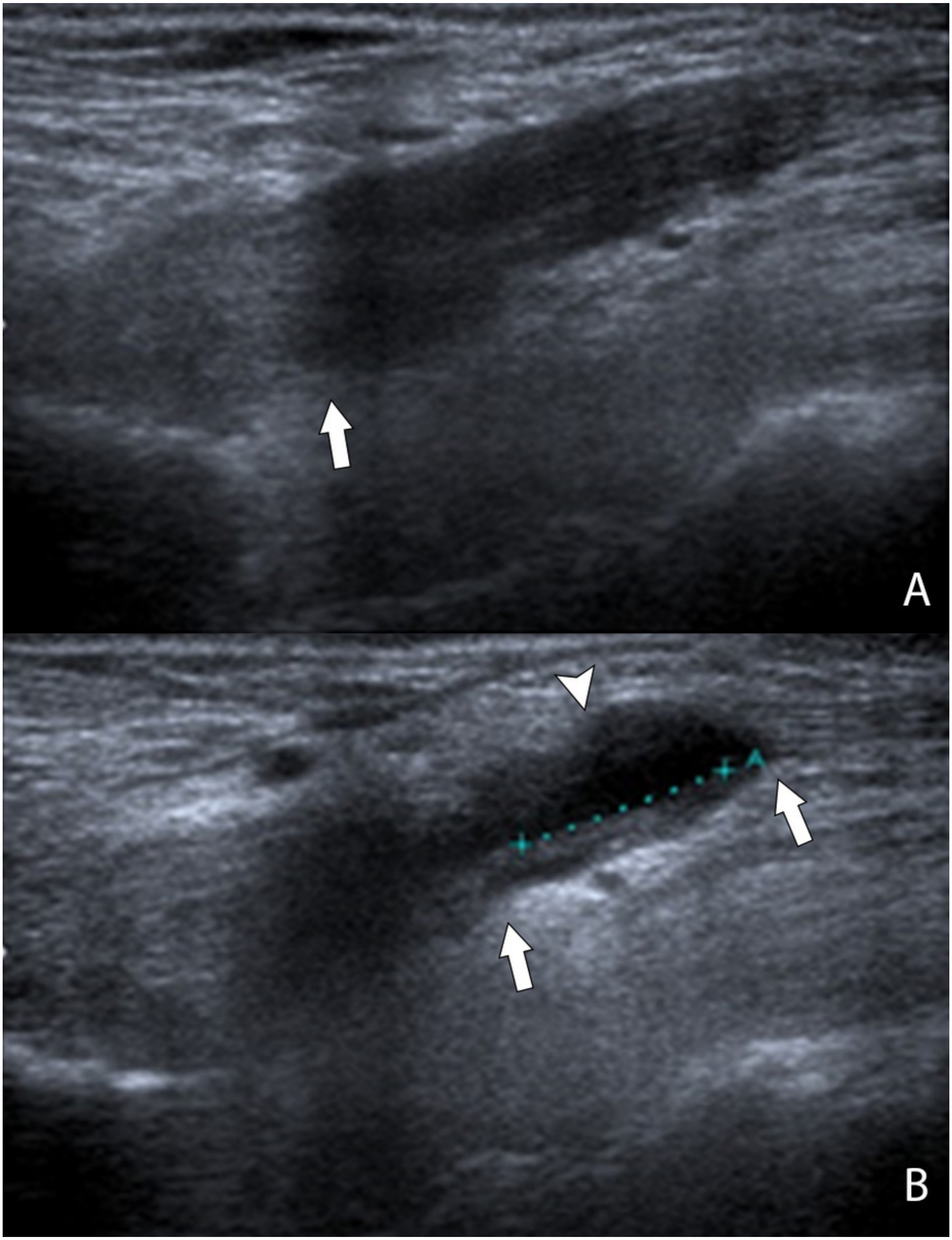
A
B

Fig. 29: Longitudinal ultrasound image of the distal biceps tendon revealing a partial tear. The fibers of the tendon are interrupted (arrow) and a soft tissue collection is seen (arrowhead).

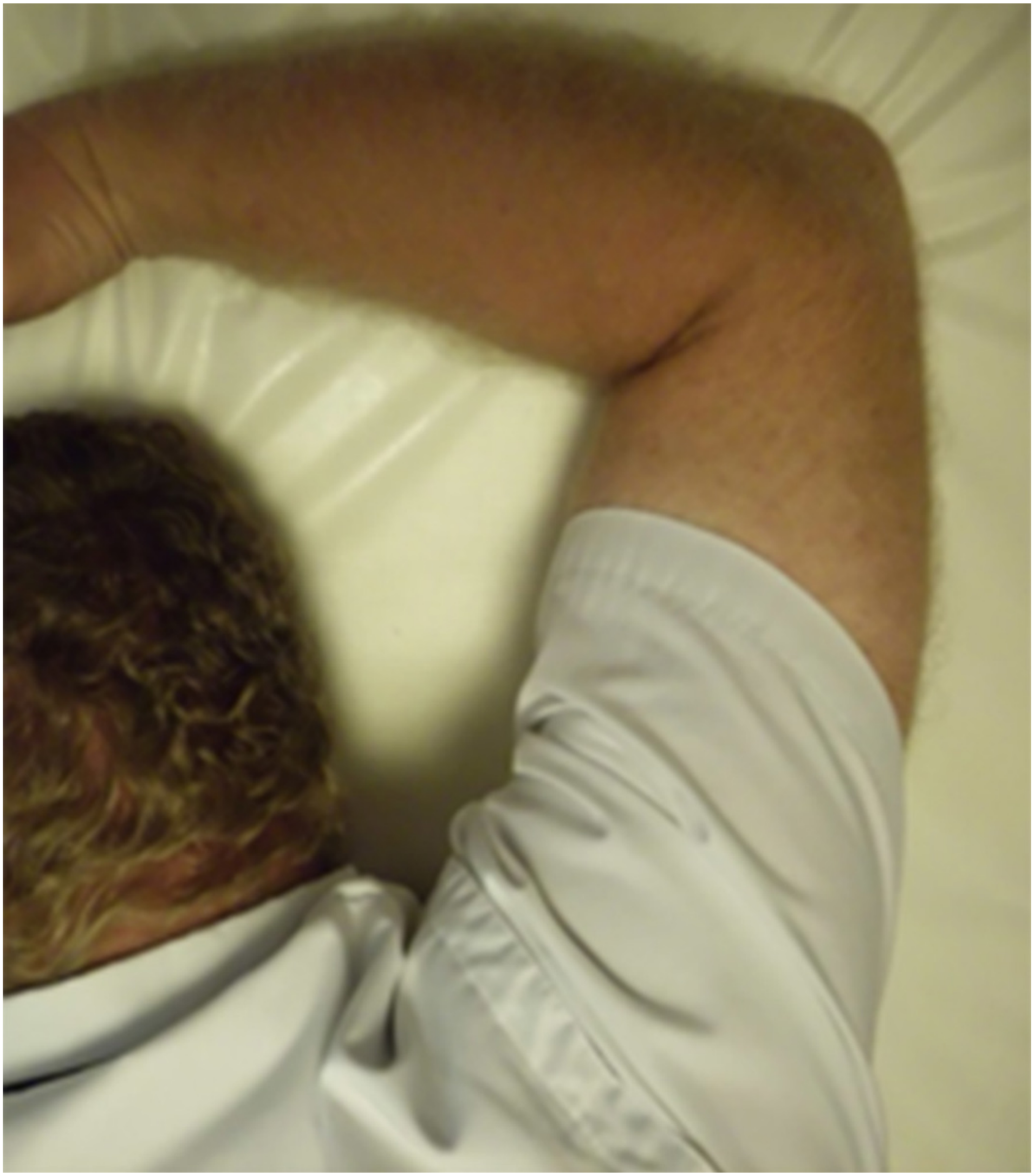

Fig. 30: The FABS position is used to obtain a straight distal biceps tendon in a sagittal and coronal plane on MRI. The elbow is flexed with the arm in abduction and the forearm in supination.

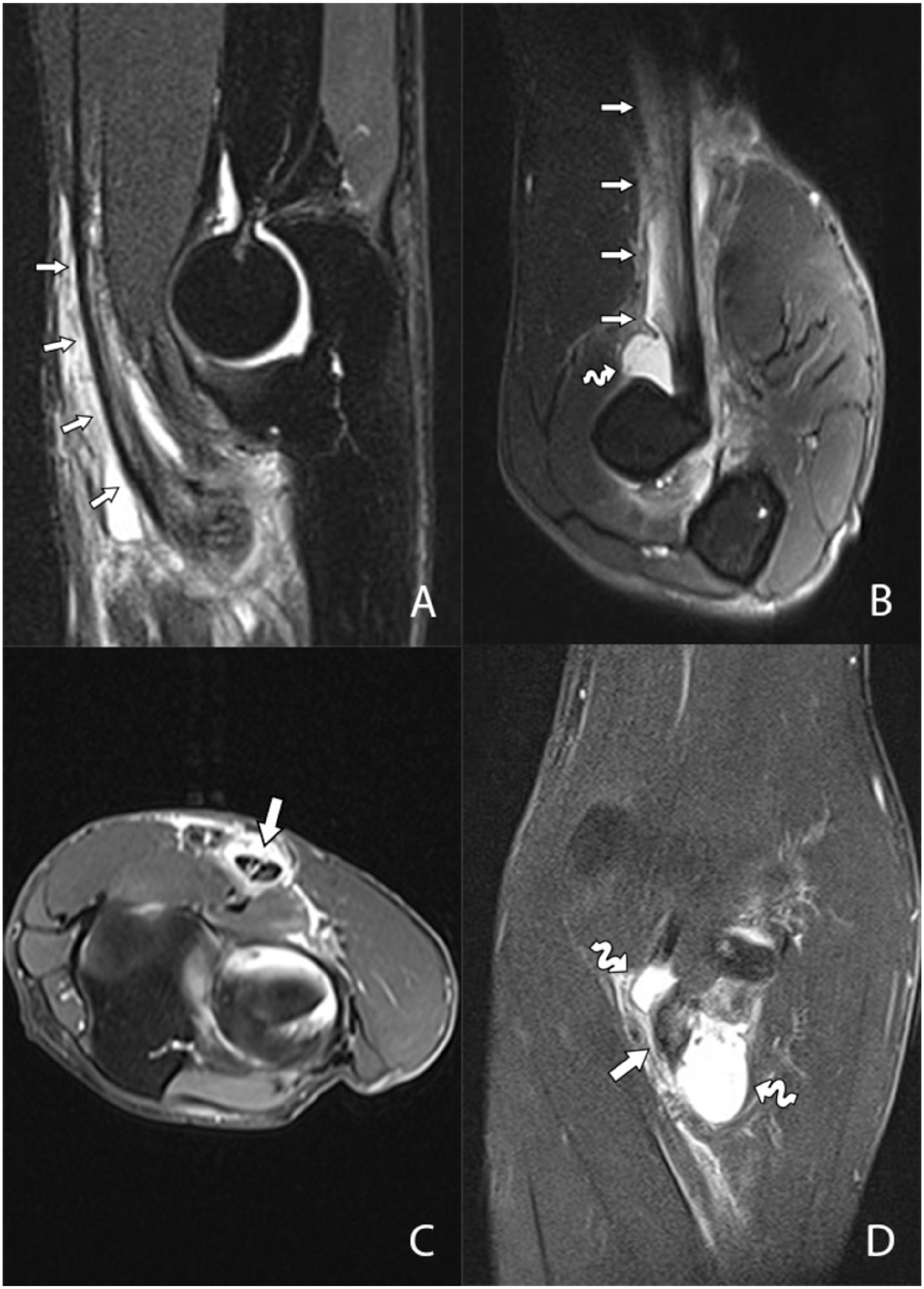
A
B
C
D

Fig. 31: Sagittal (A), axial (C) and coronal (D) T2-WI with FS and T2-WI with FS in FABS position (B). The distal tendon of the biceps muscle is hyperintense (arrows) on the sagittal image and on the image in FABS position with fluid signal intensity around the tendon (arrows): tendinosis of the distal biceps tendon with peritendinosis. Notice the better visualization of the distal portion of the biceps tendon in FABS position compared to the standard position in extension. On the axial images, a hyperintense longitudinal cleft (arrow) can be seen: partial longitudinal tear. Along the biceps tendon, a hyperintense, sharply delineated structure is seen (curved arrows): bicipitoradial bursitis.

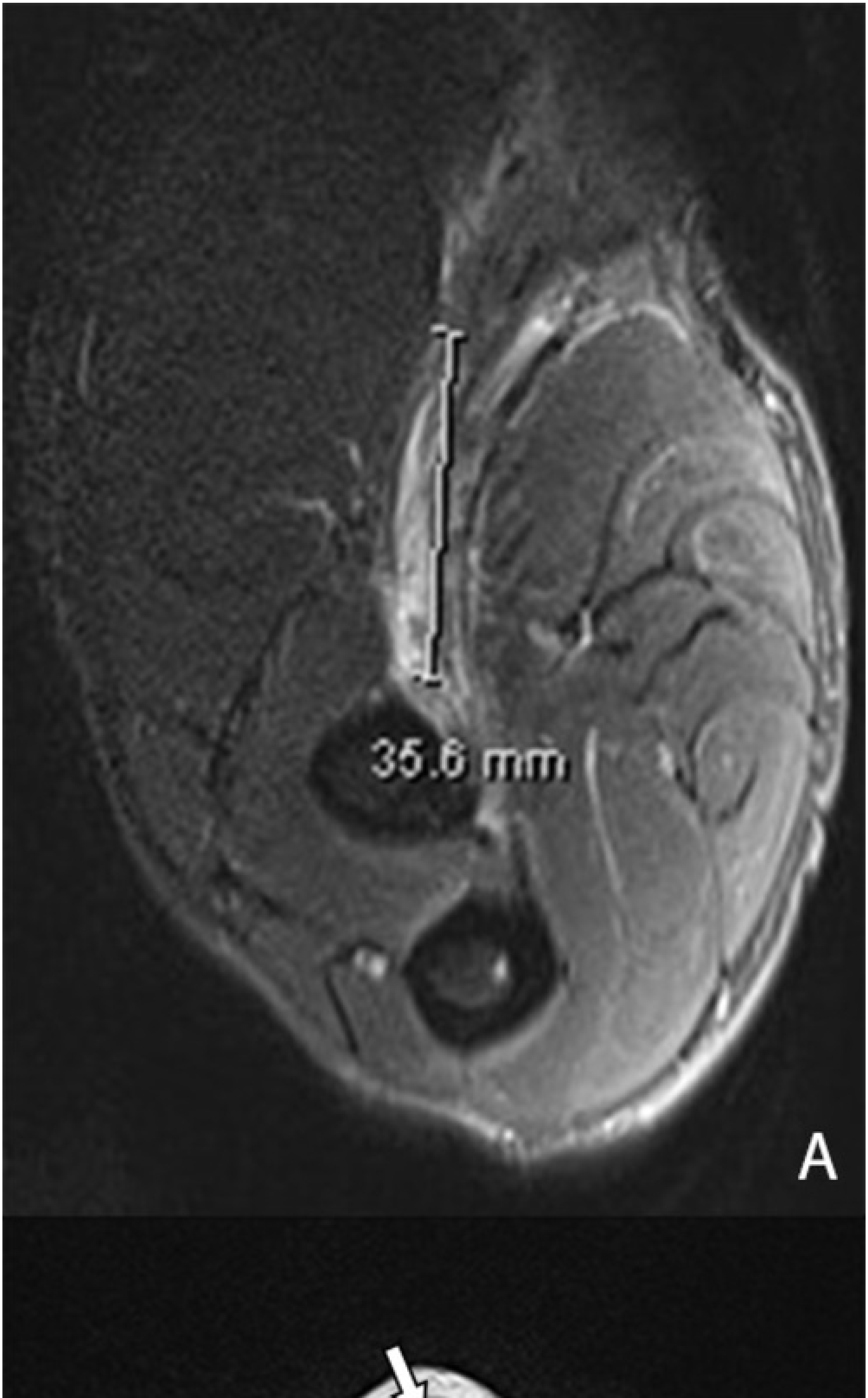
35.6 mm
A

Fig. 32: Dixon T2-WI with FS in FABS position at the level of the radial tuberosity (A) and an axial T1-WI at the level of the lacertus fibrosis (B). There is a full thickness tear at the radial tuberosity seen with retraction of 3,5 cm. The lacertus fibrosis is still intact (arrow), causing the biceps tendon not to retract any further. Retraction of more than 8 cm indicates rupture of the lacertus fibrosis.

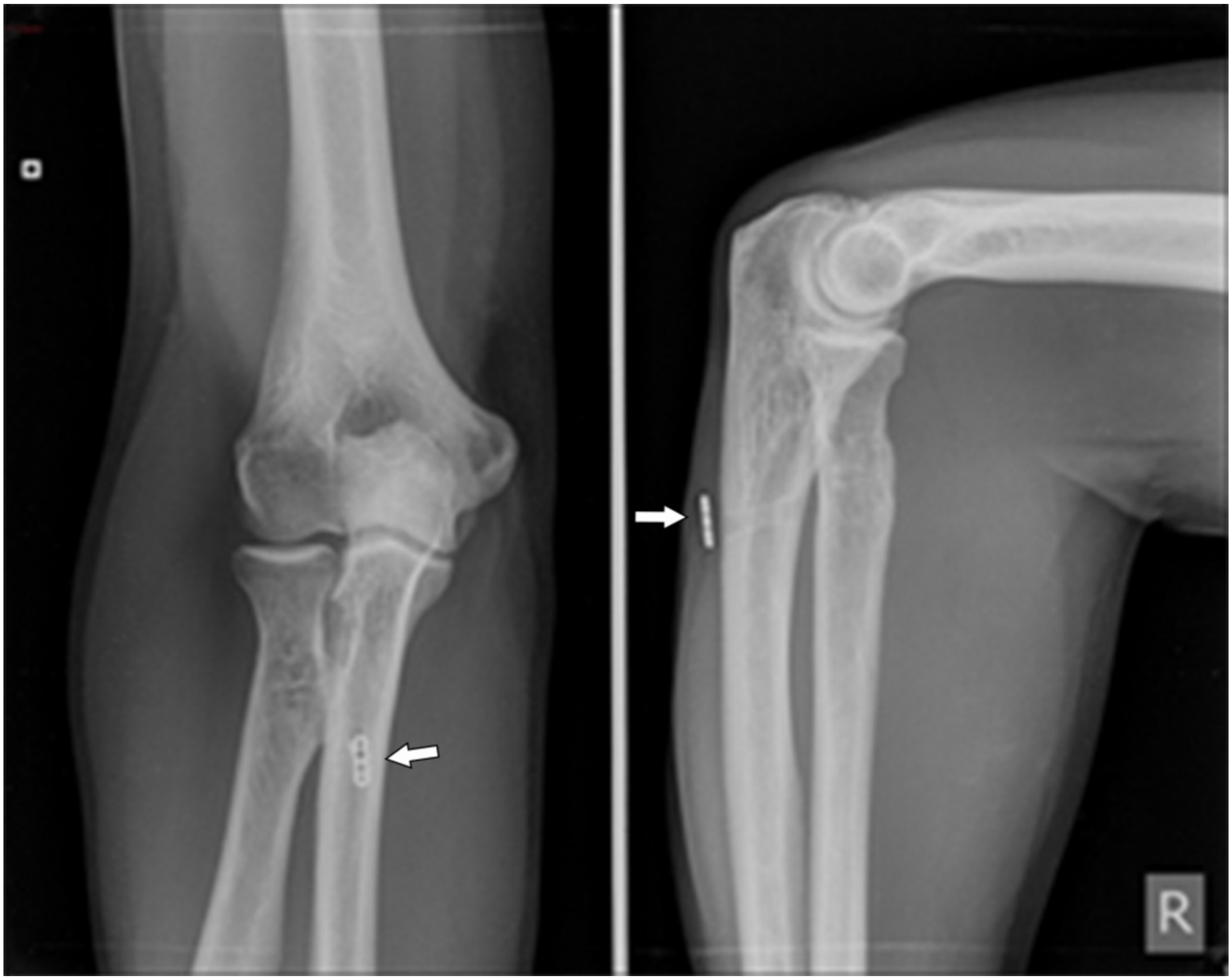

Fig. 33: Plain films of the elbow showing anchor placement (arrow) after distal biceps tendon repair.

Fig. 34: Plain films showing spur formation (arrow) at the olecranon.

Fig. 35: Ultrasound of the distal triceps tendon showing thickening of the tendon, calcifications and adjacent hypoechogenicity in the tendon (arrows): calcifying tendinosis of the distal triceps tendon.


A

Fig. 36: Sagittal (A) and axial (B) T2-WI with FS showing hyperintensity at the distal portion of the triceps tendon (arrow) and peritendinous hyperintensity: tendinosis of the distal triceps tendon with peritendinosis.

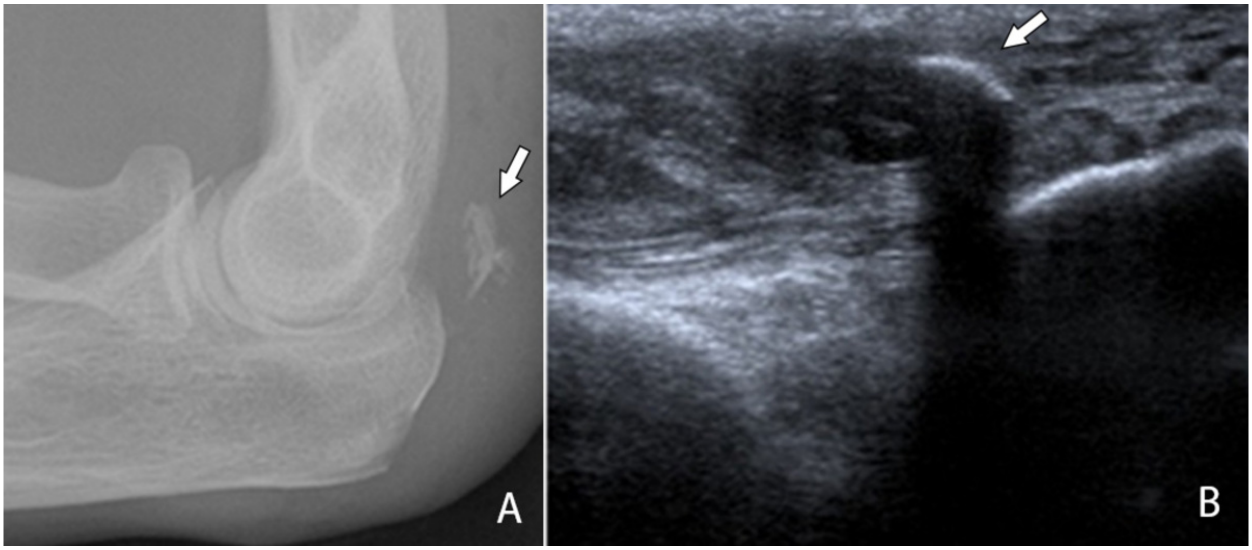

Fig. 37: Plain films (A) of the elbow and ultrasound (B) of the distal triceps tendon showing an avulsion fragment of the olecranon (arrow).

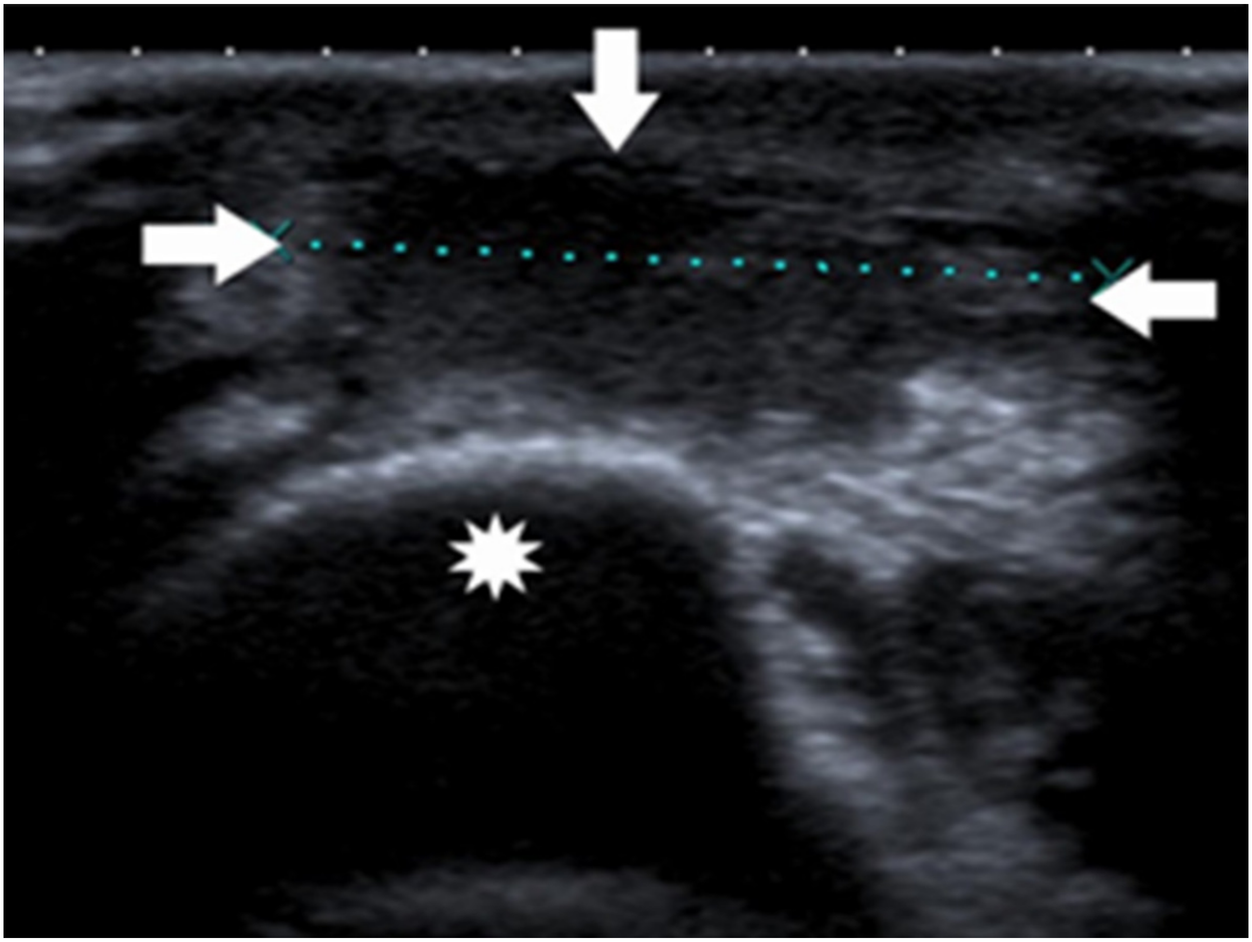

Fig. 38: Ultrasound of the posterior elbow showing a fluid collection (arrows) in the subcutaneous soft tissue at the olecranon (star): olecranon bursitis.

Conclusion

1. Clinical examination is a prerequisite in the assessment of tendon pathology at the elbow.

2. Plain films and ultrasound are first choice and usually sufficient for the lateral, medial and posterior compartment. Evaluation of the anterior compartment is difficult by ultrasonography.

3. MRI is useful in case of refractory symptoms, confounding cases, for a global overview and for differential diagnosis. The FABS-position is useful for the evaluation of the distal biceps tendon.

References

1) Walz D.M., Newman J.S., Konin G.P., Ross G. Epicondylitis: Pathogenesis, Imaging, and Treatment. Radiographics. 2010 Jan;30(1):167-84.

2) Chew M.L., Giuffrè B.M. Disorders of the distal biceps brachii tendon. Radiographics. 2005 Sep-Oct;25(5):1227-37.

Personal Information

M. Vansevenant[1,2] milan.vansevenant@ugent.be

F.M. Vanhoenacker[1,2,3] filip.vanhoenacker@telenet.be

J. De Roeck[4] jeoffreyderoeck@me.com

[1]Department of Radiology

University Hospital of Ghent

De Pintelaan 185

BE-9000 Ghent

Belgium

[2]Department of Radiology

AZ Sint-Maarten

Leopoldstraat 2

BE-2800 Mechelen

Belgium

[3]Department of Radiology

University Hospital of Antwerp

Wilrijkstraat 10

BE-2650 Edegem

Belgium

[4]Department of Radiology

AZ St.-Elisabeth Herentals

Nederrij 133

BE-2200 Herentals

Belgium