# Anatomy

# 12

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## 12.1 Osseous Anatomy

The elbow involves three joints: the radiohumeral, ulnohumeral, and proximal radioulnar joint (Fig. 12.1). The centre of rotation of the elbow runs from the inferior edge of the medial epicondyle to the small tubercle of the lateral epicondyle. The condyles show a 30° anterior flexion in relation to the humeral axis, a 6–8° valgus tilt and a 5° internal rotation in relation to the epicondylar axis. The lateral condyle, the capitellum, is shaped spherically and just covered by cartilage [1]. At the base of the coronoid, the ligament is attached to the sublime tubercle [2–4]. The ulnar collateral complex and the flexor compartment start from the medial condyle, and the ligament inserts to the sublime tubercle. The lateral ligament and the extensor compartment originate from the lateral epicondyle and the ligament is attached to the supinator crest. The radial neck has a 15° angle with the long axis and the greater sigmoid notch angulates 30° with the ulna shaft. While performing osteosynthesis of the proximal ulna, the dorsal, varus, and torsion angulation should be considered [5]. The transverse portion is covered by a smaller area of cartilage, and it divides the sigmoid notch into an anterior part and the olecranon. The bare area of articular cartilage is comprised between the coronoid and the olecranon articular surface [6]. Elbow ossification during the childhood occurs at the six elbow ossification centreds. The order of appearance is capitellum, radial head, internal epicondyle, trochlea, olecranon, and external epicondyle (CRITOE).

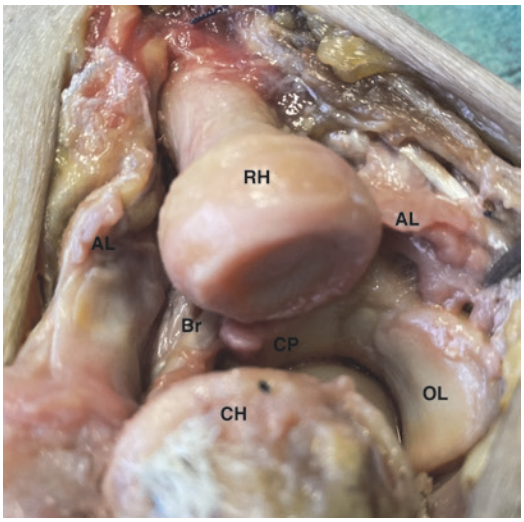


**Fig. 12.1** Osseous anatomy. Osseous anatomy of the elbow with the radiohumeral, ulnohumeral, and proximal radioulnar joint; capitellum (CH) with the radial head (RH), coronoid (CP), anular ligament (AL), olecranon (OL), brachialis muscle inserts to the proximal ulna behind the MCL complex

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## 12.2 Capsular Ligamentous Complex

The joint capsule surrounds the elbow joint, the olecranon, coronoid, and the radial fossa. Its thickness on the medial and lateral aspects forms the collateral ligaments. The mean capacity of the capsule is approximately 20 mL in 80° flexion of the elbow [7, 8]. In case of a capsular pathology patients, prefer this position [9]. In extension, the anterior capsule stabilizes the elbow joint against varus and valgus stress.

The chorda Oblique has a relevant influence on longitudinal stability. It traverses from the lateral base of the coronoid to the proximal radius and inserts distal on the neck of the radius [10].

### 12.2.1 Ulnar Collateral Complex

The medial collateral ligament complex is made of three different elements: the anterior, posterior, and transverse ligament. The anterior ligament consists of parallel fibres running from its origin on the antero-inferior aspect of the medial epicondyle and inserts onto the medial coronoid process, sublime tubercle [11]. It can be separated into anterior, posterior, and central fibres which have different functions (Fig. 12.2). The anterior ligament stabilizes against valgus stress [12]. Its anterior fibres are the primary restraint up to 90° flexion, while the posterior fibres are more important between 60° and maximum of flexion [13, 14]. In case of a fracture of the coronoid process, valgus instability should be considered [15]. Fracture type 2.2 (according to the O'Driscoll classification) have a high risk to cause valgus instability [4, 16]. The posterior ligament inserts onto the medial margin of the semilunar notch of the olecranon. It stabilizes the elbow pronation and represents the secondary restraint to the valgus stress when the anterior ligament is ruptured. The transverse ligament connects the medial coronoid to the olecranon processes [17].

### 12.2.2 Lateral Collateral Ligament Complex

The lateral collateral ligament complex contains four bundles: lateral ulnar collateral ligament (LUCL), accessory lateral ulnar ligament, radial collateral ligament (RCL), and annular ligament (AL) (Fig. 12.3). The AL encircles the radial head

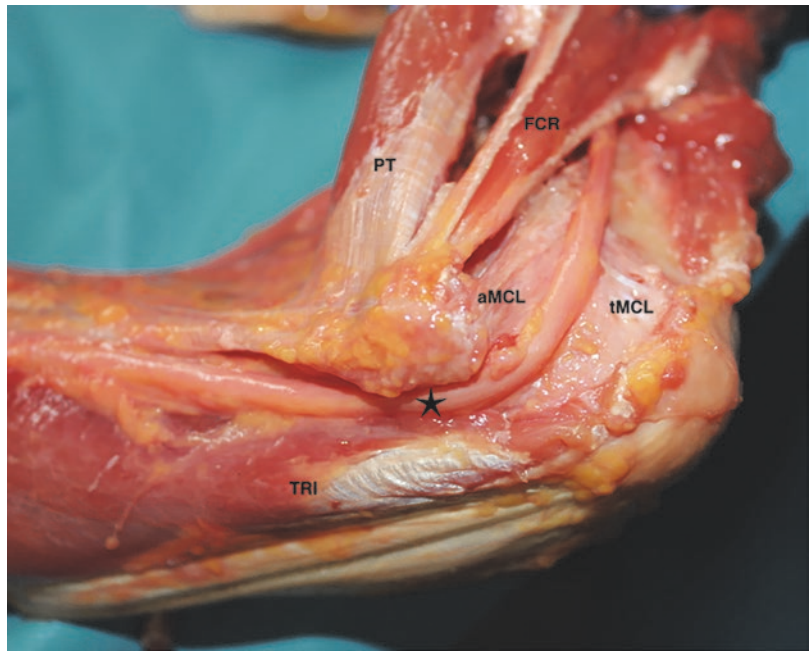


**Fig. 12.2** The medial collateral ligament complex has three separate components: anterior (aMCL), posterior (pMCL), and transverse ligament (pMCL); the relation between the MCL complex and the ulnar nerve (star); *TR* triceps muscle, *PT* pronator teres muscle, *FCR* flexor carp radialis muscle

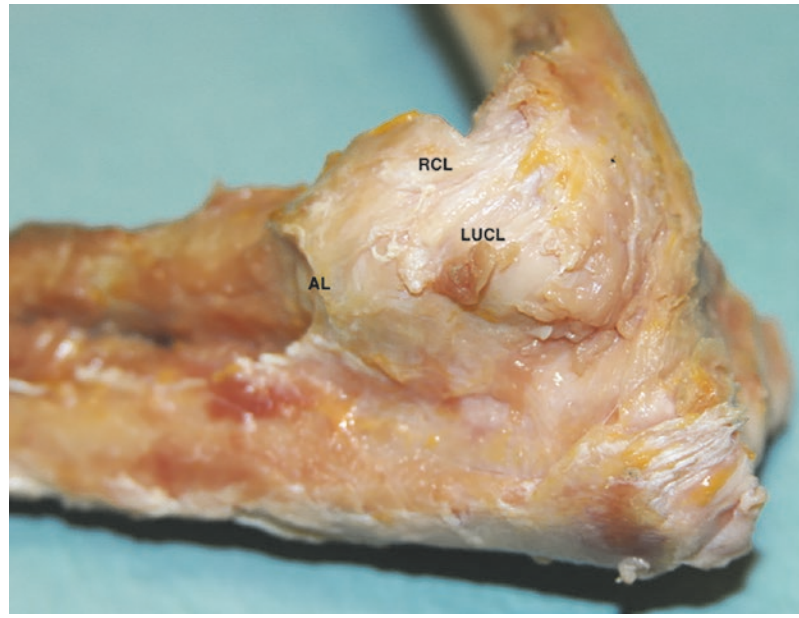


**Fig. 12.3** Lateral ligament complex, with the lateral ulnar collateral ligament (LUCL), accessory lateral ulnar ligament, radial collateral ligament (RCL), and annular ligament (AL)

and stabilizes the proximal radioulnar joint [10, 18]. The RCL originates at the lateral epicondyle and extends to the AL, and together stabilizes against varus stress [19]. The anterior and the posterior parts of the RCL are tight in extension and flexion, while the middle part is tight in extension and flexion. The accessory lateral ulnar ligament inserts onto the supinator crest of the ulna and the inferior margin of the AL [11, 20]. The LUCL attachment on the supinator crest of the ulna can vary: with a bilobed insertion (type I), a coalesced with AL (type II) and with a conjoined broad base (type III). The most common way is type III (50%).

## 12.3 Muscle Layer

### 12.3.1 Triceps Brachii Muscle

The triceps brachii muscle covers the entire posterior part of the arm and inserts with his three heads (long, lateral, and medial) on the tip of the olecranon. The subtendinous olecranon bursa protects the tendon from the tip of the olecranon. The radial nerve provides muscular branches for every three heads of the triceps. The long head arises from the infraglenoid tuberosity of the scapula, the lateral head origins proximally to the spiral groove of the humerus and the medial head has an extensive origin distally to the spiral groove [21]. The lateral head is the strongest head of the triceps. The triceps is the extensor of the elbow, the long head has also an effect on the shoulder [22]. At the lateral side, the triceps continues with the anconeus muscle and the antebrachial fascia and inserts at the ulna. Snapping of the medial head can lead to triceps tendon and ulnar nerve pathology. The posterior approach through the triceps muscle can be challenging [23, 24].

### 12.3.2 Anconeus Muscle

The anconeus is triangle shaped, it originates from the posterior lateral epicondyle and inserts into the proximal ulna. The anconeus provides an important landmark for the lateral approach to the elbow. It has a joint stabilizing function [25]. In case of radiohumeral instability or loss of the radial head, it has been used as a local interposition flap between the radial neck and capitellum [26].

### 12.3.3 Biceps Brachii Muscle

The biceps brachii muscle occupies the entire anterior part of the distal arm and inserts with the two heads onto the bicipital tuberosity. The

short head is inserted more distally, whereas the long head is inserted more eccentrically and medially. The long head is attached to the supraglenoid tubercle and the short head to the coracoid process [27]. It is innervated by a branch of the musculocutaneous nerve. The biceps muscle acts on three joints: the glenohumeral, ulnohumeral, and proximal radioulnar joints. Functional independence of the two heads is caused by the different moment arms. The long head has a greater moment arm in supination, while the short head is greater in pronation and neutral position. So, an isolated rupture of each can be explained. The biceps muscle continues to the fascia antebrachia with the lacertus fibrosus; the lacertus fibrosus serves as a stabilizer of the distal biceps tendon (Fig. 12.4). The lacertus is tensed as the forearm flexors contract, subsequently causing a medial pull on the tendon and increase its force. An intact lacertus with a distal biceps tendon tear can decrease the functional deficit.

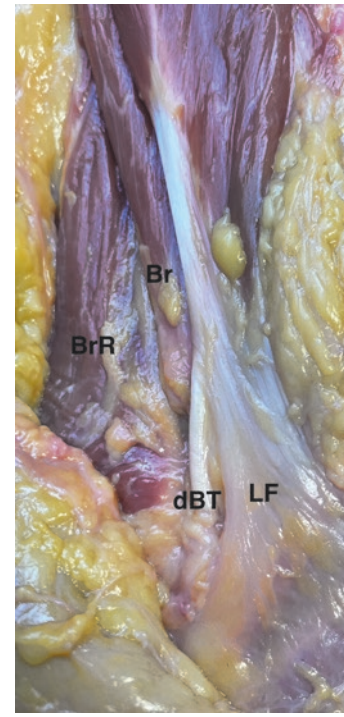


**Fig. 12.4** Muscle layer. The biceps muscle continues to the fascia antebrachia with the lacertus fibrosus (LT), the lacertus fibrosus serves as a stabilizer of the distal biceps tendon (dBT); brachialis muscle (Br) is the strongest flexor, it works like an "anterior anconeus" and stabilize with the true anconeus the elbow against rotatory instability; the brachioradialis muscle (BrR) originates from the intermuscular septum and the lateral aspect of the distal humerus and inserts into the distal styloid process of the radius

### 12.3.4 Brachioradialis

The brachioradialis muscle has the greatest mechanical advantage of any elbow flexor. It originates from the intermuscular septum and the lateral aspect of the distal humerus and inserts into the distal styloid process of the radius. Besides the flexion, it pronates the supinated forearm. It is innervated by a branch of the radial nerve and is the leading muscle of the radial nerve.

### 12.3.5 Brachialis

The brachialis muscle has two heads, the superficial and the deep head. The superficial head has a long proximal origin with a cordlike tendon that attaches to the anterior proximal humerus, while the deep head takes origin from the anterior distal humerus and inserts obliquely into the proximal ulnar [27]. It works like an "anterior anconeus" and stabilizes with the true anconeus the elbow against rotatory instability. The brachialis muscle is the strongest flexor [28]. The deep head is more involved at the beginning of the elbow flexion, while the superficial head provides greater power once the elbow is flexed. It is innervated by the musculocutaneous nerve, which runs on its distal surface.

### 12.3.6 Extensor Muscles

The common extensor origin (CEO) of the extensor group of the forearm is the lateral condyle. The extensor group includes the extensor carpi radialis longus and brevis, extensor digitorum communis, extensor digiti minimi, and extensor carpi ulnaris. The extensor radialis longus originates from the supracondylar ridge just below the

origin of the brachioradialis muscle. It is an extensor of the wrist, but it can act as a flexor of the elbow. The extensor carpi radialis brevis originates below the extensor carpi radialis longus, while the origin of the extensor digitorum beyond it. The supinator muscle has a complex origin on the lateral epicondyle, lateral collateral ligament complex and ulna. At the proximal border of the superficial part of the supinator could represent an entrapment of the radial nerve, ramus profundus. The lateral approach to the elbow, called Kocher approach, is realized between the extensor carpi ulnaris muscle and the anconeus muscle [29].

## 12.4 Neuroanatomy

The three major nerves cross the elbow inside fibrous tunnels. The most common sides of nervous entrapment are Osborne's fascia for the ulnar nerve, the lacertus fibrosus or the pronator teres muscle for the median nerve, and the Arcade of Frohse for the radial nerve.

### 12.4.1 Median Nerve

The median nerve is formed by the lateral (C5–7) and the medial cords (C8–T1) of the brachial plexus. It lies in the cubital fossa, anteriorly to brachioradialis and medially to the brachial artery and the biceps tendon. The median nerve passes below the lacertus fibrosus, between the two heads of the pronator teres and the flexor digitorum superficialis. The joint of the elbow is innervated by sensory branches of the median nerve. Until it passes below the lacertus fibrosus, the median nerve is enveloped by a fascia of the biceps and brachialis muscles. In extension, the median nerve lies 4–7 mm ventral onto the trochlea, while in flexion the distance between the trochlea and the nerve becomes increasingly wider to 12–18 mm [30]. Knowledge of this distance is important for elbow arthroscopy [31]. In case of filling the joint before the arthroscopy, the distance to the osseous structures and the nerves increase. However, the joint capsule is very close the nerves. This should be considered in case of an anterior capsulotomy.

### 12.4.2 Radial Nerve

The radial nerve is a branch of the posterior cord of the plexus brachialis (C5/T1). Before entering the spiral groove, it provides branches to the medial and the long head of the triceps muscle. It follows the spiral groove of the humeral shaft and enters into the anterior compartment, 13 cm proximal of the lateral epicondyle after perforating the lateral intermuscular septum (Fig. 12.5). It lies between the brachialis and brachioradialis muscle. At the level of the elbow, it passes through the radial tunnel and lies on the joint capsule. It bifurcates into the PIN and

**Fig. 12.5** The radial nerve follows the spiral groove of the humeral shaft and enters the anterior compartment 13 cm proximal of the lateral epicondyle after perforating the lateral intermuscular septum. It lies between the brachialis and brachioradialis muscle

the superficial branch [32]. The PIN courses between the two heads of the supinator, supplying the extensor carpi ulnaris and the extensor of all digits [33]. The anterolateral portal for arthroscopy could be a risk for the radial nerve [31]. The rotation of the forearm can influence the close position to the radiohumeral joint. A supinated forearm can increase the distance between the radial nerve and the proximal radius to 3.6 cm [34].

### 12.4.3 Ulnar Nerve

The ulnar nerve is a branch of the medial cord of the plexus brachialis (C8–T1). The ulnar nerve passes about 10 cm proximally to the medial epicondyle on the arcade of Struthers, a fibrosus tissue that spans from the triceps fascia to the medial intermuscular septum, the cubital tunnel, and the arcade of Osborne. The cubital tunnel is a fibro-osseous tunnel, which is bordered by the cubital retinaculum, a groove in the medial epicondyle and the medial collateral ligament. The cubital tunnel is a cause of common entrapment of the ulnar nerve. The anconeus epitrochlearis muscle is another cause of entrapment of the ulnar nerve, that is present in approximately 2% of cases. After the cubital tunnel, the ulnar nerve provides motor branches to the two heads of the flexor carpi ulnaris. In case of a neurolysis and anterior transposition, these branches should be protected [35].

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