Anatomy of the Upper Limb: Elbow Joint

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Elbow injuries result in occupational disability in 15% of all patients. Thus, it is plausible that the healthcare system has a great interest in limiting the consequences of such injuries, especially in refractory cases. Hence, physicians and therapists need to master the functional anatomy of the elbow joint to manage elbow lesions effectively. This article will help medical students learn the basic steps in the anatomy of the elbow joint.

Elbow Joint: Surface Anatomy

The elbow joint (medically referred to as articulatio cubiti) actually consists of three joints, which together form a functional unit. All three osseous components are covered by a common joint capsule. The three joints are:

- Humeroulnar joint (humerus + ulna)
- Humeroradial joint (humerus + radius)
- Proximal radioulnar joint (radius + ulna)

Note: The distal radioulnar joint is part of the wrist and not the elbow joint.

The elbow joint is capable of extension and flexion, as well as pronation and supination. Adduction and abduction are not active movements, rather are passive movements if the elbow is flexed or extended. The greatest degree of motion is observed at flexion with the extension of the return movement. Due to osseous inhibition via the olecranon, extension
movements exceeding 0 degrees are rare and represent hypermobility.

Osteology: Humeroulnar Joint (Humerus + Ulna)

The osseous structures of relevance for the elbow joint are located on the distal extremity of the upper arm bone. The following structures are discussed:

- Trochlea of the humerus
- Coronoid fossa
- Medial epicondyle of the humerus
- Supracondylar ridge
- Groove for the ulnar nerve
- Olecranon fossa

The following image illustrates this composition.
Trochlea of the humerus

The trochlea of the humerus is the osseous connection of the distal humerus to the ulna. Its medial diameter is greater than the lateral diameter, which leads to inward rotation of the ulna at the extension of the elbow joint. The trochlea carries a groove for ulnar movements. The ulna affects the final elbow flexion, e.g., at proximal-lateral courses, the lower arm has a lateral orientation. If the course is proximal-medial, the final position of the lower arm is medial. The course differs from person-to-person and is not considered pathologic as long as flexion is not significantly impaired or painful. Anterior to a posterior orientation, the trochlea is convex and flat in the medial-lateral orientation.

Coronoid fossa

The coronoid fossa is situated proximal to the trochlea of the humerus and forms the proximal articulating partner of the humerus to the distal ulna. It articulates with the ulnar coronoid process during elbow joint flexion.

Medial epicondyle of the humerus
The medial epicondyle of the humerus is an osseous medial protrusion of the distal humerus. Among other functions, it serves as the bony origin for the hand flexors.

**Supracondylar ridge**

The supracondylar ridge is a crest-like edge that originates from the medial epicondyle of the humerus and runs proximally. The brachial muscle, the pronator teres muscle, the medial belly of the triceps brachii muscle, and the medial brachial intermuscular septum are inserted on the supracondylar ridge.

**Groove for the ulnar nerve**

This osseous groove lies dorsal to the medial epicondyle of the humerus and guides the ulnar nerve running distally.

**Olecranon fossa**

The olecranon fossa is located proximal and dorsal to the trochlea of the humerus. It is filled with fatty tissue and forms the proximal articulating partner of the humerus to the distal ulna. It articulates with the tip of the olecranon of the ulna at the extension of the elbow joint.

**Humeroulnar joint: osseous structures and articulating surfaces of the ulna**

The following osseous structures of relevance for the elbow joint are situated on the proximal extremity of the ulna.

- Trochlear notch
- Olecranon
- Coronoid process
- Ulnar tuberosity
- Supinator crest

The following image shows the position of the mentioned structures:
Trochlear notch

The trochlear notch represents the articulating surface of the ulna with the humerus. It is ventral and surrounds the trochlea like pliers, which explains the hinge-like movement during flexion and extension of the elbow joint.

Olecranon process

The trochlear notch ends dorsally to the olecranon. This osseous protrusion is prominent and palpable. The olecranon process of the ulna fits into the olecranon groove of the humerus when the arm is fully extended. It serves as the insertion point for the triceps brachii muscle and as the origin of the ulnar belly of the flexor carpi ulnaris muscle.

Coronoid process

The coronoid process of the ulna, which should not be mistaken for the coronoid process of the mandible, is a prominent triangular bone protruding from the ulna and
forms the distal part of the trochlear notch. Its medial component is the origin of the superficial flexor digitorum and pronator teres muscles.

**Ulnar tuberosity**

The ulnar tuberosity, which is the insertion point of the brachial muscle and the origin of the superficial flexor digitorum muscle, is located distally from the coronoid process.

**Supinator crest**

The supinator crest is located dorsal to the trochlear notch and represents the origin of the supinator muscle.

**Humeroulnar joint: Joint capsule**

The joint capsule surrounds the olecranon fossa of the humerus dorsally and the coronoid fossa ventrally; however, the medial epicondyle and the groove for the ulnar nerve lie outside of the capsule. Parts of the joint capsule grow together with deep fibers of the medial collateral ligament. The joint capsule inserts at the bone-cartilage border of the trochlear notch on the ulna and surrounds the radial notch of the ulna medially. Dorsally, the capsule surrounds the olecranon fossa along with two additional connective tissue strands. During its course, it forms small dorsal and ventral recesses. The dorsal parts are tensed under flexion and the components of the ventral capsule are tensed under extension.

**Humeroulnar joint: Ligaments**
The **ulnar collateral ligament** and the **epicondylar ligament of the olecranon** are important elements for the humeroulnar joint.

The **ulnar collateral ligament** consists of **anterior, posterior, medial, and transverse strands**. In all joint positions, they are tensed and stabilize the humerus against valgus stress. The ligament relaxes under extension and pronation.

The **epicondylar ligament of the olecranon** is a split-off of the ulnar collateral ligament and stabilizes the **ulnar nerve** in the **sulcus of the ulnar nerve**.

**Humeroradial Joint (Humerus + Radius)**

**Humeroradial joint: osseous structures and articulating surfaces**

The osseous structures of the humerus in the humeroradial joint include:

- Capitalum
- Capitulotrochlear groove
- Radial fossa
- Lateral epicondyle of the humerus
- Lateral supracondylar ridge

**Capitulum**

The capitulum is the lateral circular and articular component of the distal humerus that articulates with the head of the radius.

**Capitulotrochlear groove**

The capitulotrochlear groove separates the capitulum from the trochlea of the humerus. The oblique lunula of the radius moves through this groove under all movements of the elbow joint.

**Radial fossa**

The radial fossa is situated proximally and ventral to the capitulum of the humerus. It articulates with the head of the radius during elbow joint flexion.
Lateral epicondyle of the humerus

The lateral epicondyle of the humerus is located laterally to the capitulum of the humerus and serves as the origin of the lateral collateral ligament and the hand/finger extensors.

Lateral supracondylar ridge

The lateral supracondylar ridge begins at the lateral epicondyle of the humerus and runs proximally. It represents the insertion point of the brachioradialis muscle, the extensor carpi radialis muscle, and the intermuscular septum.

Humeroradial joint: osseous structures and articulating surfaces of the radius

The osseous structures of the radius relevant to the humeroradial joint include:

- Fovea articularis radii
- Oblique lunula of the radius

Fovea articularis radii

The fovea articularis radii are the radial articulating surface for the humerus. They are oval and concave, and thus functionally define the humeroulnar joint as a concave joint.

Oblique lunula of the radius

The oblique lunula of the radius is a marginal bulge of the fovea articularis radii. It shifts in the capitulotrochlear groove at all movements of the elbow joint.

Humeroradial joint: Joint capsule

The joint capsule surrounds the radial fossa of the humerus, whereas the lateral epicondyle of the humerus remains outside of the capsule. The insertion of the capsule
on the radius lies distal to the bone-cartilage border of the articulating circumference of the radius. Dorsally and ventrally, the capsule forms several small recesses. The ventral capsule components are tense under elbow extension, whereas the dorsal components are tensed under flexion.

**Humeroradial joint: Ligaments**

Only the radial collateral ligament is relevant for the humeroradial joint.

**Radial collateral ligament**

The radial collateral ligament splits into two V-shaped components, with one running ventrally and the other dorsally. The ligament stabilizes the elbow joint against varus stress.

**Proximal Radioulnar Joint (Radius + Ulna)**

**Proximal radioulnar joint: osseous structures and articulating surfaces of the radius**

The caput radii is the head of the radius and is the most important osseous structure of the proximal radioulnar joint. Facing the ulna, there is the articulating circumference of the radius, which articulates with the ulnar joint surface and the annular ligament of the radius. The tuberosity of the radius is located roughly 2-3 cm distal to the proximal radius edge and is the insertion point of the biceps brachii muscle.
Proximal radioulnar joint: osseous structures and articulating surfaces of the ulna

The lateral side of the ulna bears a radial notch, which articulates with the radius. The supinator crest of the ulna emerges from the dorsal edge of the radial notch of the ulna, which is the origin of the supinator muscle.

Proximal radioulnar joint: joint capsule

The ulnar component of the joint capsule begins at the radial edge of the trochlear notch and transits into the radial notch of the ulna at the bone-cartilage border. On the radius, the capsule starts below the bone-cartilage border of the circumference and includes the annular ligament of the radius. The sacciform recess lies distal to the ligament and is a recess of the joint capsule.

Proximal radioulnar joint: ligaments

The annular ligament of the radius and the quadrate ligament serve the proximal radioulnar joint.

Annular ligament of the radius

The annular ligament of the radius surrounds the head of the radius but omits the oblique lunula. It is a tense half-way between pronation and supination positions. It forms an articulating surface for the circumference of the radius and centers the head of the radius towards the ulna.

Quadrate ligament

This ligament is not present in everyone. If present, it occurs together with the joint capsule of the proximal radioulnar joint and thus connects the radius and ulna. Further, it is connected with the fibers of the annular ligament of the radius on the ulnar side. Therefore, it acts similarly, although rather weakly.
Innervation of the Elbow Joint

The capsule-ligament apparatus of the elbow joint contains multiple receptors and displays remarkable proprioceptive features. Unfortunately, it results in neuronal deficits, which impair the joint movement.

The dorsal and ventral capsule-ligament apparatus are innervated by different nerve fibers.

**Innervation of the dorsal capsule-ligament apparatus**

The **ulnar nerve** branches into an **articular ramus** innervating the dorso-medial elbow joint, while the **radial nerve** supplies the dorsolateral capsule-ligament apparatus with a joint branch. The **cutaneus antebrachii nerve** supports the radial nerve dorsally. Further, subfascial rami belonging to the **muscular rami (anconeus muscle)** innervate the joint capsule of the humeroradial joint.

**Innervation of the ventral capsule-ligament apparatus**

The **median nerve** supplies the ventro-ulnar region of the elbow joint with joint rami. Further, the **musculocutaneous nerve** innervates the ventro-radial joint area with an **articular ramus (lateral cutaneus antebrachii muscle)**.

**Functional Anatomy of the Elbow Joint**

In this section, the most important aspects of the functional anatomy of the elbow joint are discussed, especially the resulting axis and plane, or angular positions, which are essential for the movement sequences of the joint.

**Retroversion angle of the humerus**

The proximal and distal ends of the humerus are twisted against each other. The resulting retroversion angle develops via the transversal axis of the epicondyles and the line, which connects the center of the major tubercle with the head of the humerus. While
this torsion angle is **roughly 60 degrees in infants** it is **around 20 degrees in adult human beings**.

**Distal diaphysis angle**

The trochlea and the capitulum of the humerus are ventrally angled from the shaft axis. In an **adult**, the distal diaphysis angle is **approx. 45°**. Studies do not indicate whether or not the angle is smaller or larger in infants.

**Note:** Due to the retroversion and diaphysis angle, the elbow joint is functionally better aligned ventrally than dorsally.

**Joint angles of the ulna**

The line between the tip of the olecranon and the coronoid process forms the ulnar joint angle together with the shaft axis. In an **adult**, it is **roughly 45°**. Studies do not indicate whether or not the angle is smaller or larger in infants.

**Note:** The angle position contributes to the extraordinary capacity for flexion of the elbow joint.

**Clinical Examples Concerning the Elbow Joint**

The potential for elbow joint disease is immense and associated with a range of lesions. This article only covers the most frequently encountered scenarios in clinical practice.

**Humerus fracture**

Fractures of the humerus primarily occur during falls on the maximally extended arm. They are divided into supra-, trans-, and inter-condylar fractures. Depending on the location and the degree of fracture, these injuries are managed and surgically treated. Plate osteosynthesis mostly represents first-line therapy.

**Olecranon fracture**

In contrast to the humerus fracture, the olecranon fracture mostly occurs following falls on the flexed arm. In addition to simple fractures, complex fractures may involve multiple tears and fragmentation of the olecranon. This injury is usually treated surgically using a
tension band osteosynthesis.

**Radial head fracture**

The radial head fracture may be sustained via falls on the extended arm, with or without dislocation or multiple fragmentations. While the multiple fractures are treated surgically, the other lesions can be treated conservatively.

**Babysitter’s elbow (Chassaignac’s paralysis)**

Also called nursemaid’s elbow or radial head subluxation, the babysitter’s elbow occurs due to abrupt longitudinal traction of the radius with rotation, e.g., if parents forcefully pull their child on the arm and the child turns away, resulting in complete or partial translation of the radial head into the sacciform recess, with loosening from the annular radial ligament. The subluxation of the radial head leads to painful clamping of the annular radial ligament. Pain and malposition may prevent active flexion or extension and the arm is held in pronation-relieving position, simulating a false neuronal paralysis. As soon as the radial head is repositioned by a physician, the symptoms promptly resolve. The two main methods for repositioning include hyperpronation and a combination of supination and flexion.

**References**


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