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A systematic, multimodality approach to emergency elbow imaging☆,☆☆

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ABSTRACT

The elbow is a complex synovial hinge joint that is frequently involved in both athletic and nonathletic injuries. A thorough understanding of the normal anatomy and various injury patterns is essential when utilizing diagnostic imaging to identify damaged structures and to assist in surgical planning. In this review, the elbow anatomy will be scrutinized in a systematic approach. This will be followed by a comprehensive presentation of elbow injuries that are commonly seen in the emergency department accompanied by multimodality imaging findings. A short discussion regarding pitfalls in elbow imaging is also included.

1. Introduction

The elbow is a complex joint that is frequently involved in both athletic and nonathletic injuries. Among emergency department (ED) visits for upper extremity injuries, each year, it has been estimated that 15% involve the elbow and forearm [1]. In a recent epidemiologic study of collegiate baseball injuries, 9–11% were to the elbow, and among those, approximately 70% were associated with throwing [2]. Although elbow injuries are well known in sports with overhead throwing activities (such as baseball), a wide range of professional, collegiate, and recreational athletic activities ranging from archery and gymnastics to canoeing and weight lifting may contribute to elbow injuries [3,4]. Elbow trauma may result in injury to musculotendinous structures, ligaments, nerves, cartilage, or osseous structures, and it could be either acute or chronic at the time of imaging. These injuries often result in decreased range of motion, pain, altered biomechanics, instability, or decreased athletic performance [3]. It is imperative to make an early diagnosis, especially in the high-performance athletic population, which would allow prompt treatment and subsequent rapid return to play.

Although radiography is the initial imaging modality of choice for elbow pain in the ED, a small percent of fractures may be radiographically occult and the inability of radiography to accurately detect soft tissue injuries is well known [3]. As 24/7 ED availability of magnetic resonance imaging (MRI), ultrasound (US), and computed tomography (CT) has increased, the ability to rapidly diagnose soft tissue injuries has enhanced as well [3]. The radiologist or emergency provider must know when to employ these advanced imaging techniques to optimize their utility and cost effectiveness. To achieve this, a thorough understanding of the normal anatomy and various injury patterns is essential when utilizing diagnostic imaging, not only to identify damaged structures but also to assist in surgical planning in appropriate cases. In this review, the elbow anatomy will be scrutinized in a systematic approach followed by a comprehensive description of common injury patterns using MRI, US, and CT. A short discussion on pitfalls in elbow imaging is included.

2. Anatomy and physiology

2.1. Osteochondral/osseous structures

The elbow is composed of the ulnohumeral, radiocapitellar, and proximal radioulnar joints, enveloped in a common joint capsule (Fig. 1). The ulnohumeral joint is made of the articular surfaces of the humeral trochlea and the ulnar trochlear notch. Along the trochlear groove (junction of the coronoid process and the olecranon), there is an elevated osseous ridge that is devoid of overlying cartilage and is

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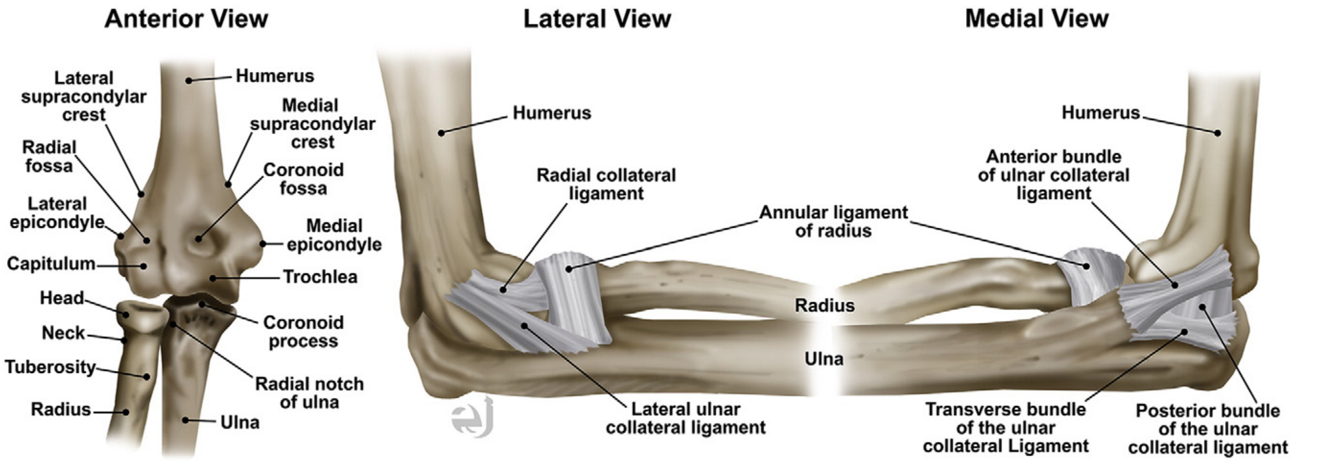

Fig. 1. Schematic drawing for osseous and ligamentous anatomy of the elbow joint.

known as the transverse trochlear ridge. The osseous structures of the elbow contribute to joint stability; however, the ulna and the humerus form 10–20° of lateral angulation (i.e., valgus carrying angle), which makes the elbow prone to valgus instability [5].

2.2. Musculotendinous structures

The medial compartment is composed of dynamic musculotendinous and static ligamentous stabilizers that resist valgus forces placed on the elbow [6]. The superficial musculotendinous stabilizers arise from the medial humeral epicondyle and include the common flexor tendon and the pronator teres. The common flexor tendon refers to a shared tendinous origin of the flexor carpi ulnaris, flexor carpi radialis, flexor digitorum superficialis, and palmaris longus muscles [1,6].

The musculotendinous structures located within the anterior compartment include the biceps brachii and brachialis. The brachialis is deep to the biceps, and both muscles contribute to forearm flexion as well as supination. The biceps tendon inserts on the radial tuberosity, whereas the brachialis tendon inserts on the ulnar coronoid process. The bicipital aponeurosis (also known as lacertus fibrosus) originates from the distal biceps insertion and reinforces the cubital fossa, thereby protecting the underlying brachial artery and the median nerve.

Like the medial compartment, the lateral compartment also contains both dynamic and static stabilizers comprised of musculotendinous and ligamentous structures, respectively. The musculotendinous structures include the common extensor tendon, supinator, brachioradialis, and extensor radialis longus. The common extensor tendon consists of origins of the extensor carpi radialis brevis (ECRB), extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris.

The posterior compartment is comprised of the triceps brachii tendon and the anconeus muscle. The triceps has both tendinous and direct muscular attachments to the olecranon. The tendons of the lateral and long heads of the triceps insert into the posterior olecranon, while a direct muscular attachment and the tendinous insertion of the medial head insert more anteriorly.

2.3. Ligamentous structures

The elbow joint capsule contains focal band-like thickenings that form the collateral ligaments (Fig. 1). In the medial compartment, deep to the common flexor tendon, is the ulnar collateral ligament (UCL), composed of the anterior, posterior, and transverse (also known as oblique) bundles [1,6]. Among these three bundles, the most important component in terms of stability is the anterior bundle. The posterior and transverse bundles play comparatively less supportive roles, but along with the joint capsule, these two bundles form the floor of the cubital tunnel.

The lateral collateral ligament (LCL) complex is located beneath the common extensor tendon and is comprised of four ligaments: the radial collateral ligament (RCL), the lateral ulnar collateral ligament (LUCL), the accessory LCL, and the annular ligament. The LUCL acts as the primary static stabilizer against varus forces and posterolateral rotary instability (PLRI). It has been shown that both the RCL and LUCL need to be injured for PLRI to occur [7].

2.4. Neurovascular structures

The ulnar nerve courses through the cubital tunnel. The roof of the cubital tunnel is comprised of two components: Osborne's ligament (also called the cubital tunnel retinaculum) and the aponeurosis of the flexor carpi ulnaris. The median nerve, the proximal radial nerve, and the brachial artery are located in the anterior compartment. The median nerve passes between the two heads of the pronator teres muscle as it enters the forearm, and it gives off anterior interosseous nerve (AIN) [8]. Rarely, a patient may have a supracondylar process at the anteromedial distal humerus with or without a ligament (Struthers ligament) connecting the process to the medial humeral epicondyle with median nerve coursing beneath these structures. The radial nerve crosses from the posterior arm to the volar aspect of the elbow and courses along the lateral superficial surface of the brachialis muscle [6]. It then travels within the radial tunnel before dividing into the motor posterior interosseous nerve (PIN) and the sensory superficial branch of radial nerve (SBRN) [9–11].

3. Pathology

3.1. Osteochondral/osseous structures

In the traumatic setting, radiography is often the first imaging modality used as the primary goal is to exclude a fracture or a joint dislocation (Fig. 2). In the younger population, the most common elbow fractures include the supracondylar fracture (60%), the Salter–Harris IV lateral condylar fracture (15–20%), and the Salter–Harris I medial epicondylar fracture (11–20%) [12,13]. In adults, the most frequent fracture involves the radial head or neck and accounts for up to 50% of cases (Fig. 2b) [1]. The presence of a posterior fat pad sign along with anterior fat pad elevation (implying joint effusion) in combination with a history of acute trauma suggests an acute intraarticular fracture, with a positive predicative value of approximately 75% [14]. Avulsion fractures may also be encountered (Fig. 3a–c). As no structure inserts on the tip of the coronoid process, such a fracture is not an avulsion injury but instead is indicative of previous dislocation and multiligamentous injury (Fig. 2c). Therefore, in the presence of such a fracture, MRI should be