Elbow trauma: What the musculoskeletal radiologist and orthopedic surgeon need to know?

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Learning objectives

To demonstrate the anatomic structures which are important for the maintenance of elbow stability.

To understand the most important mechanisms which are responsible for characteristic fracture patterns and can be critical for the treatment decision.

To describe characteristics multimodality imaging finding of traumatic elbow fractures according to AO/OTA trauma classification system by presenting examples from our emergency department database.
Background

Elbow is a complex joint, consisted of three bones. It is frequently involved in injuries usually secondary to indirect trauma and they have been estimated to 15% of upper extremity's injuries which visit the emergency department annually. Although radiography is the initial imaging of choice, the availability of computed tomography (CT) and magnetic resonance (MRI) for comminuted and radiographically occult fractures at the emergency departments has increased. A better understanding of the normal anatomy and the various injury mechanisms from the radiologists improves the meaningful interpretation of different imaging fracture patterns, a better communication with orthopaedic surgeons and consequently the assistance of the appropriate surgical planning.
Imaging findings OR Procedure Details

In this retrospective study we systematically reviewed elbow examinations of 257 patients with elbow trauma which are performed during a 5-year period which were categorized according to AO classification system.

FUNCTIONAL ANATOMY

Elbow is a complex joint consisted of three bones and three primary articulations. The ulnohumeral and the radiohumeral joints allow flexion and extension, while the radiohumeral joint permits the rotation of the head of the radius on the capitellum of the humerus too. The proximal radioulnar joint facilitates rotation during supination and pronation.

There are also four secondary structural components that participate in the functional stabilization of the elbow. These are the radiocapitellar articulation, the common flexor pronator tendon, the common extensor tendon and the joint capsule.

The most important structures for keeping the functional stabilization of the elbow are the artihumeral articulation, the anterior bundle of the medial collateral ligament (MCL) complex and the lateral ulnar collateral ligament (LUCL). The anterior bundle of the MCL provides static stability to valgus forces whereas the LUCL provides primary static stability to varus forces and prevents posterolateral instability. Any injury to the anatomical structures that have been mentioned can lead to elbow instability.

Elbow movements are controlled by four muscle groups. These are the major flexors, the extensors, the supinators and the muscles that accomplish pronation. The major flexors include the biceps branchialis, branchioradialis and branchialis muscles. The extensors consist of the triceps and anconeus muscles. The supinators are the supinator and biceps branchialis muscles and the muscles which participate in pronation are the pronator quadrates, pronator teres and flexor carpi radialis muscles.

Other anatomical structures that should not be forgotten are the nerves which cross the elbow and may be at risk during certain injuries or surgical procedures. These are the median nerve, the ulnar and the radial nerve.

INJURY MECHANISM

Two are the most common injury mechanisms of the elbow. The most common mechanism involves valgus and pronation stress which typically occurs during a fall onto an outstretched hand. During these injuries a combination of distraction forces around
the medial elbow and concomitant compression of the lateral elbow is produced usually leading to radial head and neck fracture which are usually accompanied by anterior MCL injury.

The second, but not so usual, injury mechanism has to do with dierest blow that leads to fracture or dislocation of any bone that is part of the elbow.

FRACTURES

Distal humerus fractures can appear in both condyles often in continuation with the joint space and represent the 2% of adult fractures.

Location determines the classification of distal humerus fractures.

Patients with distal humerus fractures experience extensive swelling, deformities, and pain. These fractures also can produce bruising of the skin. Flexion of the arm may produce crackling or popping sounds from bone fragments.

There are fractures of radial head, olecranon nad coronoid process and combined fractures and dislocations. Monteggia fracture-dislocations involve a fracture of the ulnar shaft and displacement of the radial head. Galeazzi fracture-dislocations combine a distal radial head disruption with a distal radial fracture. Essex-Lopresti fracture-dislocation consists of a radial head fracture that is comminuted and a distal subluxation or dislocation of the radioulnar joint. The "terrible triad" is a devastating elbow injury that includes a radial head fracture, an MCL injury, and a coronoid process fracture.

IMAGING

1. Radiographic anatomy

Radiographically, there are several important anatomical lines for assessing possible elbow injuries in patients.

The radiocapitellar line: a line centered through the long axis of the radius, extending through the radial neck to the center of the capitulum. The anterior humeral line: in lateral radiograph - a line that begin at the anterior portion of the humerus, extending vertically through the middle third of the capitulum. The coronoid line: a line that proceed from the top of the coronoid process of the ulna, intersecting proximally the anterior portion of the capitulum and trochlea.
Fat pads are evaluated in lateral view. Correctly positioning of patient's elbow at 90° is essential. A minor extension of the arm can make the fat pad appear on the image due to the increased pressure on the posterior fat pad, leading to a false-positive diagnosis.

Radiography can assess ligament tears and joint stability, particularly with valgus or varus stress applied during a fluoroscopic examination.

On lateral view a posterior displacement of the humerus, that affects the orientation of the anterior humeral line suggest a distal humerus fracture. If the anterior humeral line passes through the anterior portion of the capitulum or does not meet the capitulum at all, a fracture is possible. Radial head fractures produce a positive posterior fat pad sign on radiographs and standard 2-projection radiographs of the elbow are necessary if there is suspicion of these fractures.

If the alignment of the radiocapitellar line does not point to the capitulum on all radiographic projections, a Monteggia fracture or lateral condyle fracture is likely.

2. MRI

Magnetic resonance imaging can evaluate the elbow joint's muscle and tendon attachments. The classic MR acquisition for the elbow involves axial, coronal, and sagittal images with T1- and T2-weighted images.

The injured ligament on MR scans may be thick or thin with increased signal intensity, hemorrhage, slackness, and other abnormalities. MR images of muscle injuries might show morphological changes, atrophy, fatty changes, and edema. Joint fluid increase with trauma. Gadolinium contrast often is used during MR imaging to help enhance MCL injuries. Although MR imaging is highly sensitive for complete tears of the MCL, it is not the method of choice for viewing partial tears.

3. CT

The multislice CT scanners with multiplanar reformation make accurate imaging of elbow fractures possible, it can show precise details of the fractures and it is beneficial for surgical planning.

AO CLASSIFICATION SYSTEM

AO Classification of fractures is introduced by Müller ME et al and published by AO Foundation at 1987. This method categorizes injuries taking into account their treatment and prognosis. It was validated by Audigé L et al at 2004 and it is remain in use still today. It is also provides a framework for the recognition, identification and description of the long bones fractures.
In this classification system first it is described the fracture localization (bone and segments). Different colors are used to denote the progressive levels of severity.

The long bones are divided in three segments from proximal to distal numbered 1, 2 and 3 respectively. The proximal and distal segment are defined by length of the widest part of the epiphysis. The center of fracture has to be determinate. It has to determined the type of the fracture (simple, wedge, complex) and numbered with A, B and C respectively.

The metaphyseal/epiphyseal fracture types are distinguished in extrarticular (A), partial intraarticular (B) and complete intraarticular (C). In partial intraarticular fractures a part of joint remains in continuity with diaphysis and in complete ones no part of joint remains in continuity with diaphysis. There are four types of partial articular fractures: a) pure split, resulting from a shearing force, in longitudinal direction of the split, b) pure depression, central or peripheral, without c) split-depression, a combination of a split and a depression, with separation of joint fragments and d) multifragmentary depression, in which part of the joint is depressed and the fragments are completely separated.

The fractures are divided in groups and subgroups according to ascending order of severity, to the morphological complexities and in relation to difficulties in their treatment and prognosis.

The types of fractures are labelled A, B, and C. Each type is divided into 3 groups:
A1, A2, A3 / B1, B2, B3 / C1, C2, C3. Thus, there are 9 groups.

Each group is further subdivided into 3 subgroups, denoted by a number .1, .2, .3. Thus, there are for each segment 27 subgroups.

According to AO classification in elbow following types of fractures are distinguished:

In distal humerus:

13-B partial articular (13-B1 sagittal lateral condyle, 13-B2 sagittal medial condyle, 13-B3 coronal)

13-C complete articular (13-C1 articular-metaphyseal simple, 13-C2 articular simple metaphyseal multifragmentary, 13-C3 articular-metaphyseal multifragmentary)

Radius/ulna:
21-A extraarticular (21-A1 ulna fractured/radius intact, 21-A2 radius fractured/ ulna intact, 21-A3 both bones)

21-B articular ( 21-B1 ulna fractured/radius intact , 21-B2 radius fractured/ ulna intact, 21-B3 one bone articular,other extrarticularnal)

21-C articular of both bones (21-C1 simple,, 21-C2 one aricular simple,other articularal multifragmentary,21-C3 both multifragmentary)
**Fig. 1:** Fig.1 Coronal CT image of the left elbow in a 48 years old male demonstrated a simple articular and metaphyseal fracture in distal humerus (AO, 13-C1)

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**Fig. 2:** Fig.2 Sagittal CT image in the same patient showed a simple articular fracture of the left olecranon (AO, 21-C1)

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Fig. 3: Fig.3 Coronal CT image of the right elbow in a 58 years old female showed a simple articular fracture in epicondyle and a multifragmentary metaphyseal fracture in distal humerus (AO,13-C2)

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Fig. 4: Fig.4 Axial CT image of the right elbow in 70 years old female showed a simple articular fracture of the radial head (AO,21-B2)

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Fig. 5: Fig.5 Axial CT image of the right elbow in a 54 years old female showed an extraarticular fracture of the olecranon (AO,21-A1)

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Fig. 6: Fig. 6, 7 Axial CT image of the right elbow in a 71 years old female demonstrated radial head dislocation and simple articular fracture (AO,21-B2)

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**Fig. 7:** Axial CT image of the right elbow in a 71 years old female demonstrated radial head dislocation and simple articular fracture (AO,21-B2) and apophyseal avulsion of distal humerus (AO,13-A1)

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Fig. 8: Fig.8 Anteroposterior radiograph of the left elbow in a 65 years old female showed a radial and ulnar dislocation

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Fig. 9: Fig.9 Axial CT image of the same patients confirmed the radiographic findings.

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**Fig. 10:** Fig. 10 Axial CT image of the same patient after reduction showed anatomic alignment of radius and lateral epicondyle and partial articular fracture of the radial head (AO,21-B2)

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Fig. 11: Fig.11 Axial T2FS image of the same patient after reduction confirmed the CT findings and also it showed disruption of the radial collateral ligament, subchondral bone marrow edema of the epicondyle and surrounding hemorrhage.

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Conclusion

Elbow fractures can present a diagnostic dilemma to the orthopedic surgeon clinician and to the emergency musculoskeletal radiologist. The imaging classification of elbow’s osseous injuries according to ##/OTA trauma system can minimize the potential for inappropriate treatment.
References


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