MDCT analysis of elbow fractures patterns according to AO/OTA trauma classification system

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Elbow is a complex joint which is frequently involved in injuries usually secondary to indirect trauma. It has been estimated that up to 15% of upper extremity's injuries which visit the emergency department annually involve the elbow.

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.

There are fractures of radial head, olecranon and coronoid process and combined fractures and dislocations.

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.

Although radiography is the initial imaging of choice, the availability of computed tomography (CT) for the assessment of comminuted and radiographically occult fractures at the emergency departments has increased. The multislice CT scanners with multiplanar reformation make accurate imaging of elbow fractures possible. It can show precise details of the fractures since more bone fragment can be identified.
A better understanding of the normal anatomy and the various injury mechanisms from the radiologists improves the meaningful interpretation of different CT imaging elbow fracture patterns whereas the use of a standard classification such as the AO/OTA Trauma Classification leads to a better communication with orthopaedic surgeons and consequently the assistance of the appropriate surgical planning.

The aim of this retrospective study was to review multidetector computed tomography (MDCT) examinations of a large group of elbow trauma patient in order to describe different elbow fracture patterns using AO/OTA trauma classification system.
Methods and materials

MDCT examinations of 155 patients (males: 61 females: 94, aged 26-68 years) with history of elbow trauma from a time period of nearly 4 years were retrospectively evaluated. A 6 channel, multislice scanner (Philips, Brilliance 6) was used with 0,75mm collimation, at 3mm thickness, 200mAs and 120 kVp at the time of injury and clinical assessment and sagittal and coronal reformatted images of the shoulder were generated from the axial and sagittal images respectively using the epicondyles as an anatomical reference. Further humerus fracture classification using images reformatted parallel and perpendicular to the elbow joint space. The MDCT scans were evaluated in consensus, by two experienced musculoskeletal radiologists, two orthopaedic surgeons and one radiology and orthopaedic resident. All the fractures were analyzed according to AO/OTA trauma classification system and categorized in extra-articular, partial-articular and complete-articular types that label A, B and C respectively. Each type is further subdivided into 3 groups (A1, A2, A3/B1, B2, B3/C1, C2, C3) according to ascending order of severity, to morphological complexities and to difficulties in their treatment and prognosis. Each group is further subdivided into 3 subgroups, denoted by a number 1, 2, 3 (a total of 27 subgroups) as follows:

A) **Humerus**: 13-A extra-articular fracture (A1 apophyseal avulsion, A2 metaphyseal simple, A3 metaphyseal multifragmentary), 13-B partial articular fracture (B1 sagittal lateral condyle, B2 sagittal medial condyle, B3 coronal), 13-C complete articular fracture (C1 articular simple, metaphyseal simple, C2 articular simple, metaphyseal multifragmentary, C3 articular multifragmentary).

B) **Ulna and Radius**: 21-A extra-articular fracture (A1 ulna fractured, radius intact, A2 radius fractured, ulna intact, A3 both bones), 21-B articular fracture (B1 ulna fractured, radius intact, B2 radius fractured, ulna intact, B3 one bone articular fracture, other extra-articular), 21-C articular fracture of both bones (C1 simple, C2 one articular simple, other articular multifragmentary, C3 multifragmentary).
Results

Of the 155 patients with elbow trauma, 134 (86%) had a total of 152 elbow fractures that induce one of the following patterns: Extrarticular fractures were presented in 26 (17%) patients, partial articular fracture in 73 (51%) patients and complete articular were demonstrated in 53 patients (35%). Coronoid process of the ulna fractures (55 patients, 36%) and radial head (54 patients, 36%) were the most common fractures.

Fiftyone (38%) of the patients with elbow fractures were males, whereas 83 (62%) were females. Eighteen (13,4%) of the patients presented with two different types of elbow fractures (11 males and 7 females).

Of the patients with extrarticular fractures, 16 (11,9%) presented with apophyseal avulsion (13-A1 type), 5 (3,7%) presented with a simple fracture (13-A2 type), 1 (0,7%) had multifragmentary metaphyseal fracture (13-A3 type), 1 (0,7%) presented with fractured ulna and intact radius (21-B1 type), 26 (19,4%) presented with fractured radius and intact ulna (21-B2 type) and 5 (3,7%) presented with fractures of both bones (21-B3 type).

Partial articular fractures presented in 73 (51%) patients with the following patterns: 3 (2,2%) patients presented with a sagittal fracture of the lateral condyle (13-B1 type), 5 (3,7%) of the patients presented with a sagittal fracture of the medial condyle (13-B2 type), 7 (5,2%) had a coronal fracture of the condyle (13-B3 type), 27 (20,1%) presented with fractured ulna and intact radius (21-B1 type), 26 (19,4%) presented with radius fractured and intact ulna (21-B2 type) and 5 (3,7%) presented with articular fracture of one bone and extrarticular fracture of the other bone (21-B3 type).

The 73 (51%) complete articular fractures presented with the following patterns: 6 (4,5%) patients presented with an articular simple and a metaphyseal simple fracture (13-C1 type), 8 (6%) of the patients presented with an articular simple and a multifragmentary metaphyseal fracture (13-C2 type), 16 (11,9%) presented with an articular multifragmentary fracture (13-C3 type), 8 (6%) patients presented with a simple articular fracture of both bones (21-C1 type), 10 (7,5%) patients presented with an articular simple fracture of one bone and an articular multifragmentary fracture of the other bone (21-C2 type) and 5 (3,7%) of the patients presented with articular multifragmentary fractures of both bones (21-C3 type).

The most common subgroups include simple partial articular fractures of ulnar coronoid process (21-B1 type) in 27 patients (18 %) and simple articular radial head fractures (22-B2 type) in 26 patients (17%). The 21-B1 subgroup include 11 males (40,7%) and 16 females (59,3%) whereas the 22-B2 subgroup include 15 (57,7%) males and 11 females (42,3%).
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Table 2

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Fig. 1: Coronal reformatted CT elbow image of a 64-years old male showed a complete articular multifragmentary fracture of the left distal humerus (13-C3, AO)

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**Fig. 2:** Fig.2 Axial CT elbow image in a 32-years old female demonstrated a partial articular fracture of the left radial head (21-B2, AO)

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**Fig. 3:** Same patient. Sagittal reformatted CT elbow image showed a partial articular fracture of the left radial head (21-B2, AO)

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**Fig. 4:** Fig. 4 Sagittal reformatted CT elbow image in a 64-years old female showed a partial articular fracture of the left olecranon (21-B1, AO)

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**Fig. 5:** Fig. 5 Sagittal reformatted CT elbow image in a 32-years old female demonstrated a partial articular fracture of the right olecranon (21-B1, AO)

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**Fig. 6**: Fig.6 Coronal reformatted CT elbow image of a 67-years old female showed a complete articular multifragmentary fracture of the left distal humerus (13-C3, AO)

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**Fig. 7:** Axial CT elbow image in a 36-years old male demonstrated a partial articular fracture of the right radial head (21-B2, AO)

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Conclusion

In our study the most common anatomical fracture location was the ulnar coronoid process in 27 patients (18%, 21-B1 type), radial head in 26 patients (17%, 22-B2 type). 16 patients had a multifragmentary articular fracture of the distal humerus (11.9%, 13-C3 type). The diagnostic accuracy of the MDCT images provided valuable information on the mechanisms of injury, on the morphology of the fractures and origin of the fragments.

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

The surgical approach is the gold standard for treating distal humerus fractures whereas the conservative treatment is only playing a minor role in managing them. Non operative treatment seems only to be advisable in cases of non-displaced fractures for patients who are being assessed as not fitting for surgery or as a temporary solution in the elderly before arthroplasty to avoid stiffening and heterotopic ossification.

Successful management of distal humerus fractures means correct reduction of the fracture, reconstruction of the articular surface if needed, stability and rigidity of the fixation, and appropriate rehabilitation and it depends on the clear radiological imaging and understanding of the fractures lines and surfaces.

According to the literature, based on the OTA/AO classification, each type of fracture seems to need its appropriate exposure after appropriate surgical approach. The most frequently performed approaches in the surgical treatment of distal humerus fractures are olecranon osteotomy, triceps-reflecting (elevating), triceps-splitting, triceps-sparing, and triceps-lifting. Olecranon osteotomy (Chevron osteotomy) is the traditional standard approach for the distal humerus and elbow joint. The surgeon has a wide exposure of the articular surface of the distal humerus and make reduction and internal fixation of complex type fractures. Specifically the OTA/AO type C3 fractures are best managed by this approach. Maybe this approach has a relative contraindication for very anterior articular fractures (OTA/AO type B3), which can be difficult to visualize through an osteotomy. The triceps-reflecting (elevating) (Bryan-Morrey) approach allows the surgeon a widespread
view of the joint without olecranon osteotomy-and is used for arthroplasty and internal fixation of intraarticular fractures.

According to the triceps-sparing approach, the view of the distal articular surface is relatively impaired. It is indicated for open reduction and internal fixation (ORIF) in extra-articular (A) or simple articular fractures. Specifically, the several advantages of this approach certainly indicate its use for OTA/AO types A2, A3, B1, B2 and possibly C1 and C2 fractures. This approach may not provide sufficient exposure for type C3 fractures. The triceps-lifting approach, has been evaluated and established for intraarticular fractures (OTA/AO type B3 and C). This approach has been indicated as the treatment for distal diaphyseal fractures and less for intraarticular fractures (OTA/AO type C), due to the prementioned limited visibility of the articular surface. The triceps flexor carpi ulnaris approach, which is a modification of the triceps-reflecting approach, has been described to be used for extra and intra-articular fractures. Finally, for selected partial articular fractures (OTA/AO Type B fractures) of the distal humerus, the usage of minimal invasive approaches has proven to be sufficient for successful fracture reduction and fixation.

Specifically, for OTA/AO type B1 fractures a lateral approach has been shown to be feasible and safe. For OTA/AO type B2 fractures, after mobilization of the ulnar nerve and release of the medial intermuscular septum, the flexor carpi ulnaris and pronator teres are pulled anteriorly to display the joint capsule, thus enabling fracture reduction after incision of the capsule. For OTA/AO type B3 fractures, fragment excision should only be performed in case of a very small bony fragments or thin cartilaginous bowls. Excision of bigger capitellar fragments may lead to valgus instability, especially in medial collateral ligament insufficient elbow.

It must be underlined that there are several additional injury situations that will affect the management and the prognosis of the fractures of the radial head but are not consistently accounted for in this classification system. In particular, initially based on the OTA/AO classification which shows radial head or neck fracture, it must be actively sought and excluded three important injuries. These are Essex-Lopresti injury (a combination of a radial head fracture and an injury to the distal radio-ulnar joint,), Monteggia fracture dislocation (a combination of a radial head dislocation, with or without head fracture and ulnar fracture,) and "terrible triad" injury (after elbow dislocation there is combination of radius head fracture, coronoid process fracture and medial collateral ligament injury).

Based on them, the surgeon can have a clear image as a guide for the treatment of the olecranon fracture (collar and cuff for rest or splint, tension band technique or intramedullary fixation or excision of the fragment with triceps reattachment, or plate and screws osteosynthesis) and coronoid process fractures (closed reduction, brief splinting and gentle mobilization or internal fixation with screws or transossaeous suture and
fixation of disrupted ligaments and fractures of radial head and neck OR hinged external fixation).

In conclusion the MDCT analysis of elbow fracture according to ##/OTA trauma system seem to be necessary for the assessment of specific injury patterns and for the guiding of the appropriate treatment.
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References


