Classification of Humeral Fractures

2

Yingze Zhang and Bo Lu

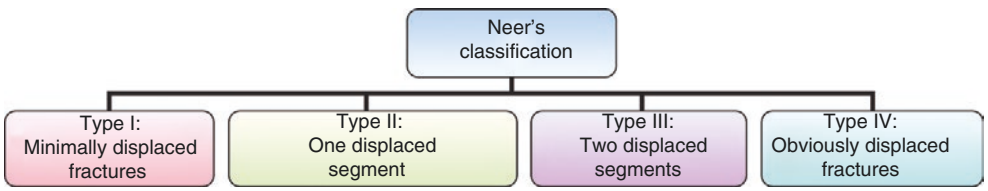
2.1 Classification of Proximal Humeral Fractures

Kocher first proposed his classification of proximal humeral fractures based on anatomic location in 1896; to date, there are >5 classification systems of proximal humeral fractures in literature. According to the literature over the last 5 years, the most commonly used system is the Neer's classification, followed by the AO/OTA classification.

2.1.1 Neer's Classification [1]

This system is based on the anatomic relations of the four major anatomic segments: articular segment, greater tuberosity, lesser tuberosity, and proximal shaft. For a segment to be considered displaced, it must be either displaced >1 cm or angulated >45° from its anatomic position.

1. One-part fractures or minimally displaced fractures: The most common type.
2. Two-part fractures: Characterized by displacement of one of the four segments, with the remaining three segments either not fractured or not fulfilling the criteria for displacement. Four types of two-part fractures can be encountered (greater tuberosity, lesser tuberosity, anatomic neck, and surgical neck).
3. Three-part fractures: Characterized by displacement of two of the segments from the remaining two nondisplaced segments. Two types of three-part fracture patterns can be encountered. The more common pattern is characterized by displacement of the greater tuberosity and the shaft, with the lesser tuberosity remaining with the articular segment. The less commonly encountered pattern is characterized by displacement of the lesser tuberosity and shaft, with the greater tuberosity remaining with the articular segment.
4. Four-part fractures: Characterized by displacement of all four segments.
5. Fracture dislocations: Displaced proximal humeral fractures: Two-part, three-part, or four-part fractures associated with either anterior or posterior dislocation of the articular segment.
6. Articular surface fractures: Two types: Impression fractures or head-splitting fractures.
7. Impression fractures: Most often occur in association with chronic dislocations. As such, they can be either anterior or posterior and involve variable amounts of articular surface.
8. Head-splitting fractures: Usually associated with other displaced fractures of the proximal humerus, in which the disruption or "splitting" of the articular surface is the most significant component.



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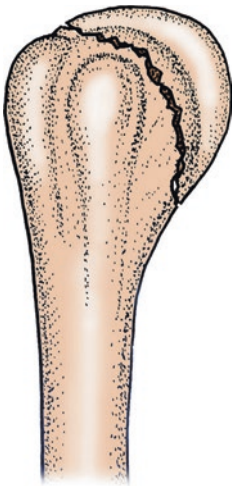
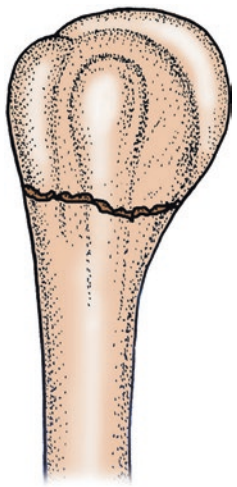
Y. Zhang (ed.), *Clinical Classification in Orthopaedics Trauma*, https://doi.org/10.1007/978-981-10-6044-1_2



Neer's classification

One-part fractures: Minimally displaced fractures, segments neither displaced more than 1 cm nor angulated more than 45 °

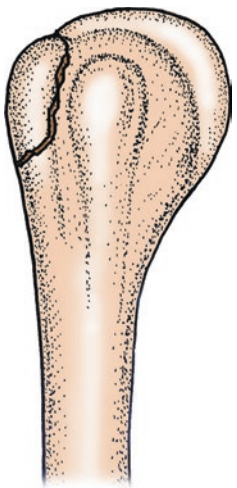
Anatomic neck fracture



Neer's classification

One-part fractures: Minimally displaced fractures, segments neither displaced more than 1 cm nor angulated more than 45 °

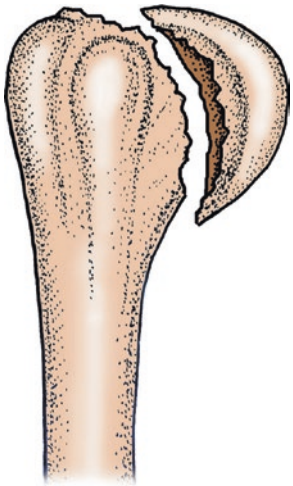
Femoral neck fracture



Neer's classification

One-part fractures: Minimally displaced fractures, segments neither displaced more than 1 cm nor angulated more than 45 °

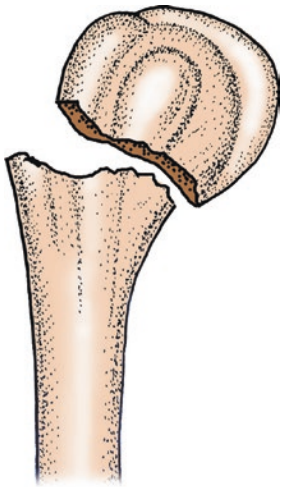
Greater trochanter fracture

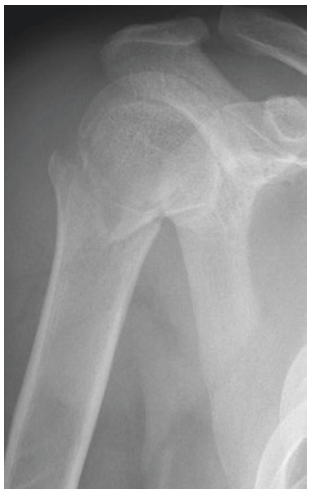


Neer's classification

Two-part fractures: Displacement of one of the four segments, either displaced more than 1 cm or angulated more than 45 °

Anatomic neck fracture

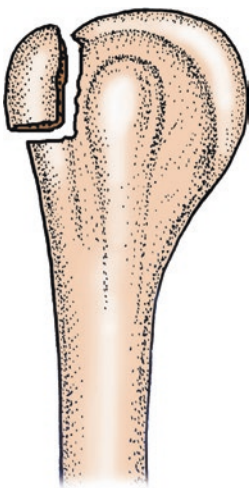




Neer's classification

Two-part fractures: Displacement of one of the four segments, either displaced more than 1 cm or angulated more than 45 °

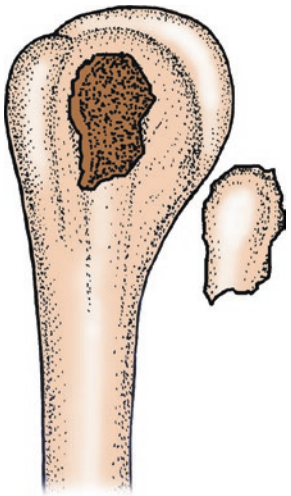
Surgical neck fracture



Neer's classification

Two-part fractures: Displacement of one of the four segments, either displaced more than 1 cm or angulated more than 45 °

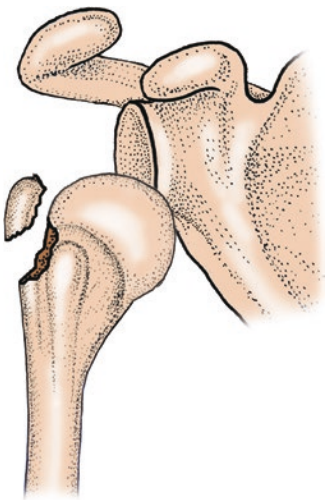
Greater tuberosity fracture



Neer's classification

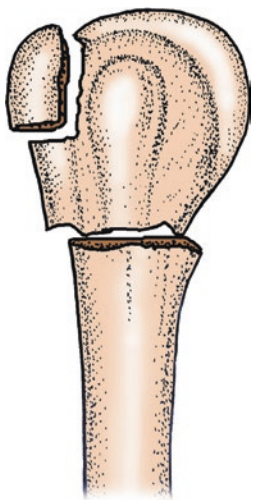
Two-part fractures: Displacement of one of the four segments, either displaced more than 1 cm or angulated more than 45 °

Lesser tuberosity fracture



Neer's classification

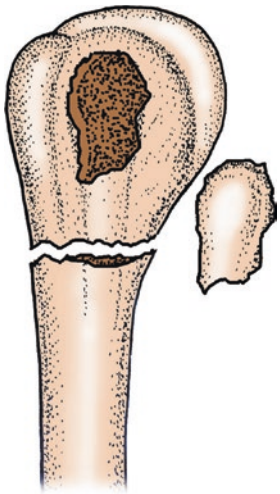
Fracture–dislocations: Displaced two-part proximal humerus fractures, associated with anterior dislocation of the articular segment

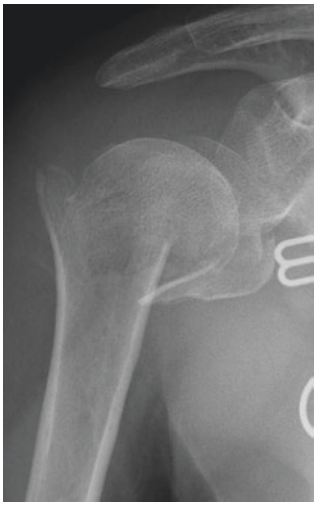


Neer's classification

Three-part fractures: Displacement of two of the segments, either displaced more than 1 cm or angulated more than 45 °

Displacement of the greater tuberosity and the shaft, with the lesser tuberosity remaining with the articular segment

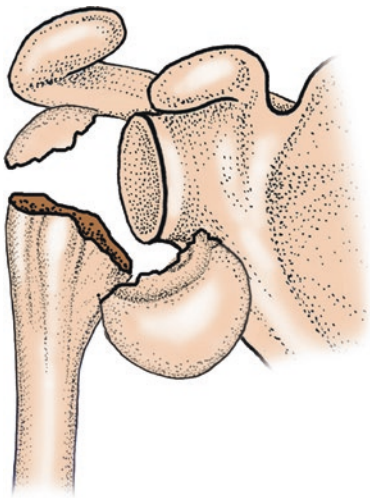




Neer's classification

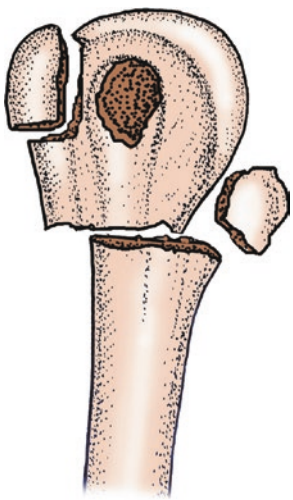
Three-part fractures: Displacement of two of the segments, either displaced more than 1 cm or angulated more than 45 °

Displacement of the lesser tuberosity and shaft, with the greater tuberosity remaining with the articular segment



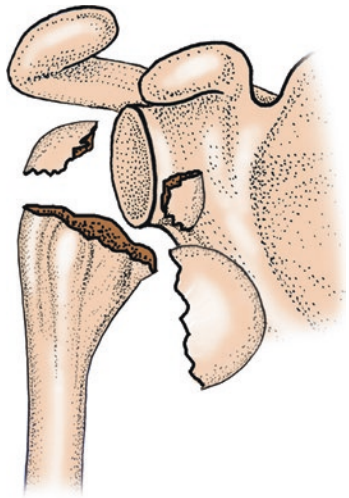
Neer's classification

Fracture–dislocations: Displaced three-part proximal humerus fractures, associated with anterior dislocation of the articular segment



Neer's classification

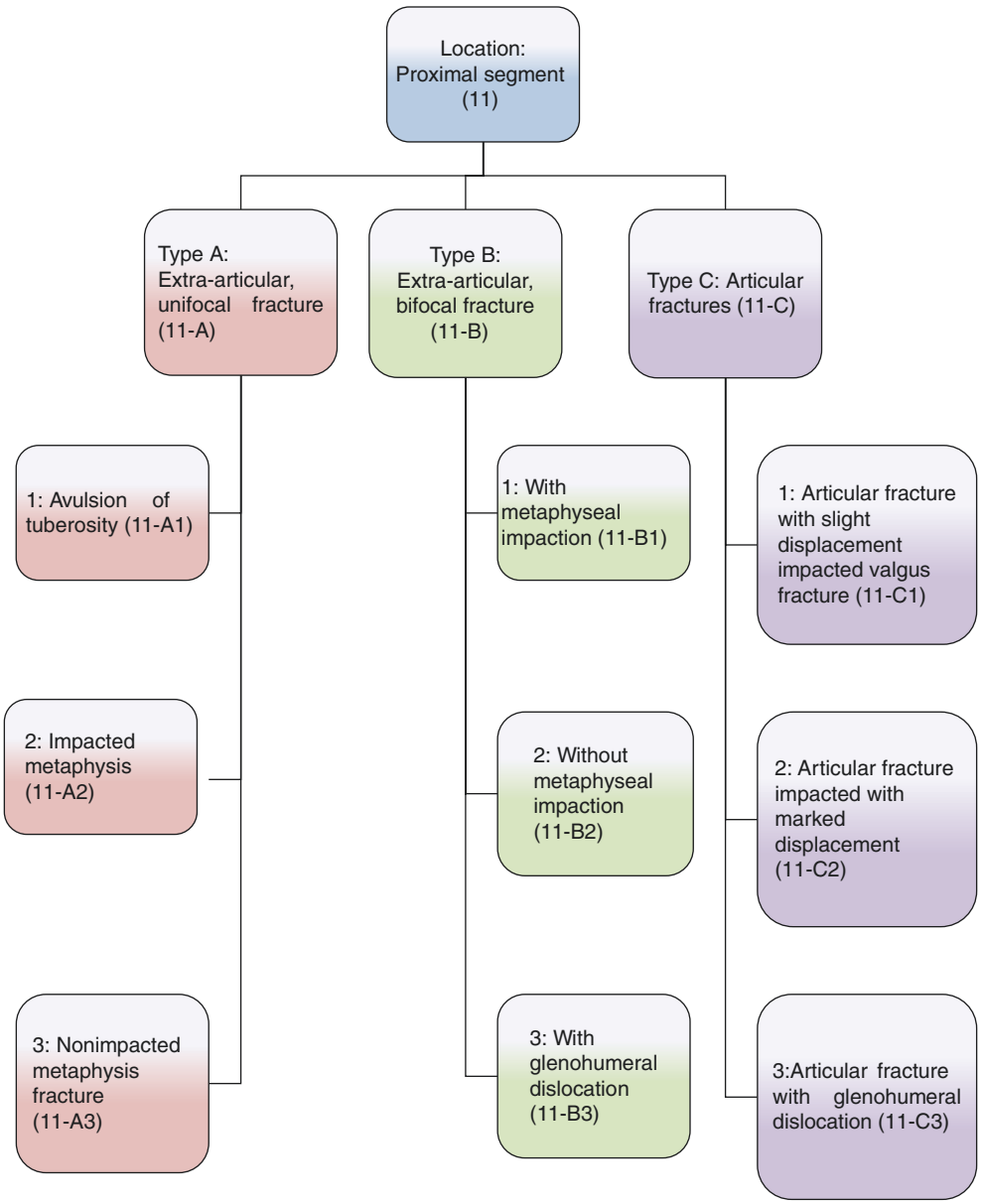
Four-part fractures: Displacement of all four segments, either displaced more than 1 cm or angulated more than 45 °



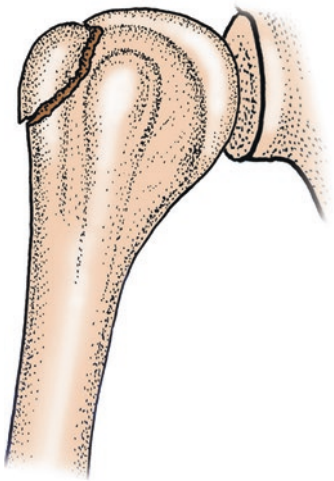
Neer's classification

Fracture–dislocations: Displaced four-part proximal humerus fractures, associated with anterior dislocation of the articular segment, the humeral head is isolated and lost main blood supply

2.1.2 AO/OTA Classification [2]



Type A: Extra-articular, unifocal fracture (11-A).
- A1: Avulsion of tuberosity (11-A1).
  - A1.1: Greater tuberosity not displaced (11-A1.1).
  - A1.2: Greater tuberosity displaced (11-A1.2).
  - A1.3: With glenohumeral dislocation (11-A1.3).
- A2: Impacted metaphysis (11-A2).
  - A2.1 Without frontal malalignment (11-A2.1).
  - A2.2 With varus malalignment (11-A2.2).
  - A2.3 With valgus malalignment (11-A2.3).
- A3: Non-impacted metaphysis fracture (11-A3).
  - A3.1: Simple with angulation (11-A3.1).
  - A3.2: Simple with translation (11-A3.2).
  - A3.3: Multifragmentary (11-A3.3).

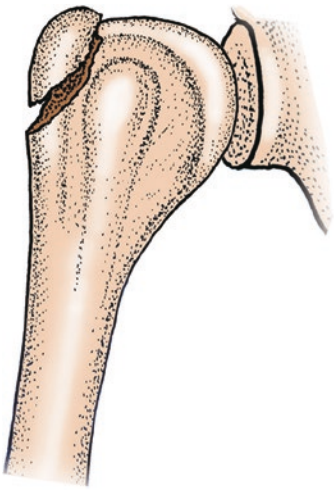


AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A1: Avulsion of tuberosity (11-A1)

A1.1: Greater tuberosity not displaced (11-A1.1)

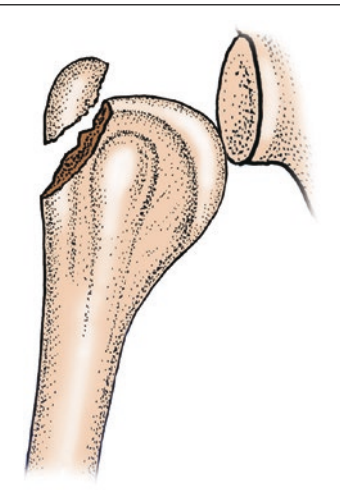


AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A1: Avulsion of tuberosity (11-A1)

A1.2: Greater tuberosity displaced (11-A1.2)

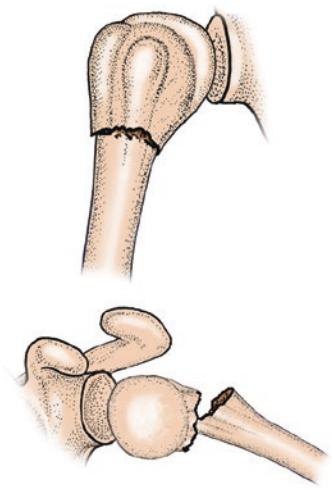


AO/OTA Classification

Type A: Extra-articular, unifocal fracture (11-A)

A1: Avulsion of tuberosity (11-A1)

A1.3: With glenohumeral dislocation (11-A1.3)

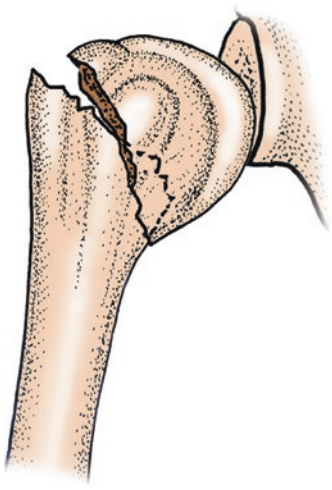


AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A2: Impacted metaphysis (11-A2)

A2.1: Without frontal malalignment (11-A2.1)

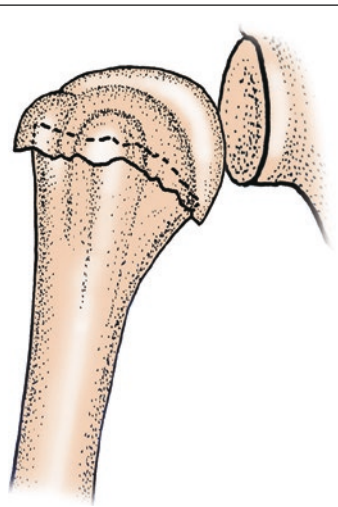


AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A2: Impacted metaphysis (11-A2)

A2.2: With varus malalignment (11-A2.2)

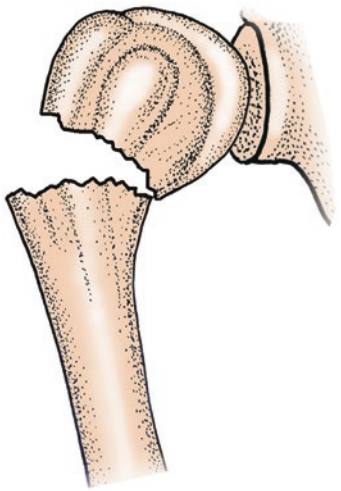


AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A2: Impacted metaphysis (11-A2)

A2.3: With valgus malalignment (11-A2.3)

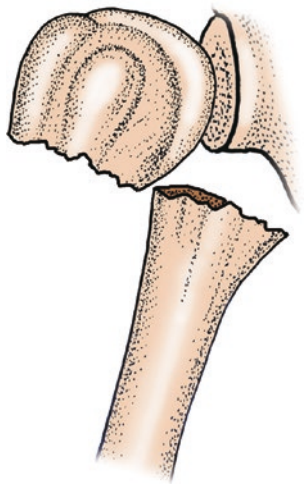


AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A3: Non-impacted metaphysis fracture (11-A3)

A3.1: Simple with angulation (11-A3.1)

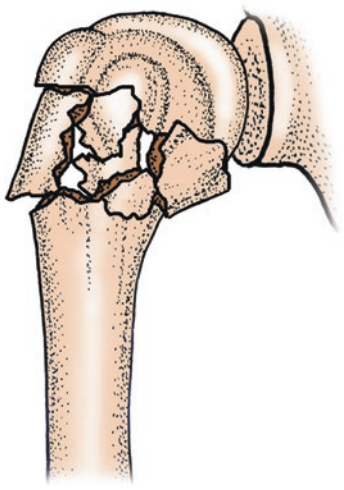


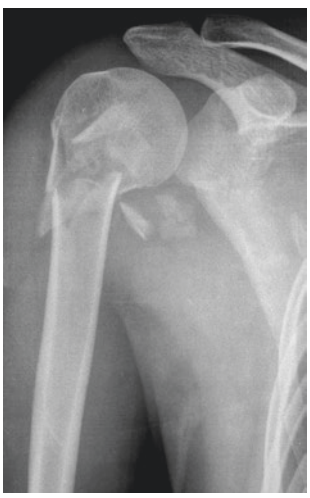
AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A3: Non-impacted metaphysis fracture (11-A3)

A3.2: Simple with translation (11-A3.2)





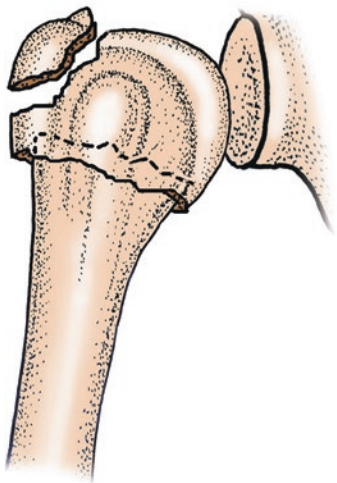
AO/OTA classification

Type A: Extra-articular, unifocal fracture (11-A)

A3: Non-impacted metaphysis fracture (11-A3)

A3.3: Multifragmentary (11-A3.3)

Type B: Extra-articular, bifocal fracture (11-B).
- B1: With metaphyseal impaction (11-B1).
  - B1.1: Lateral plus greater tuberosity (11-B1.1).
  - B1.2: Medial plus lesser tuberosity (11-B1.2).
  - B1.3: Posterior plus greater tuberosity (11-B1.3).
- B2: Without metaphyseal impaction (11-B2).
  - B2.1: Without rotatory displacement of the epiphyseal fracture fragment (11-B2.1).
  - B2.2: With rotatory displacement of the epiphyseal fragment (11-B2.2).
  - B2.3: Multifragmentary metaphysis plus one of the tuberosities (11-B2.3).
- B3: With glenohumeral dislocation (11-B3).
  - B3.1: "Vertical" cervical line plus greater tuberosity intact plus anterior medial dislocation (11-B3.1).
  - B3.2: "Vertical" cervical line plus greater tuberosity fracture plus anterior medial dislocation (11-B3.2).
  - B3.3: Lesser tuberosity fracture plus posterior dislocation (11-B3.3).

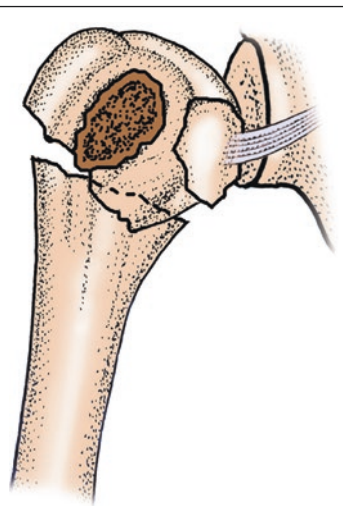


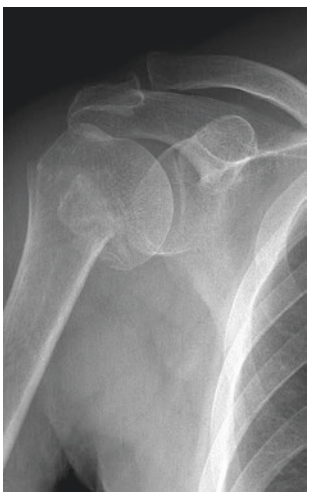
AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B1: With metaphyseal impaction (11-B1)

B1.1: Lateral plus greater tuberosity (11-B1.1)



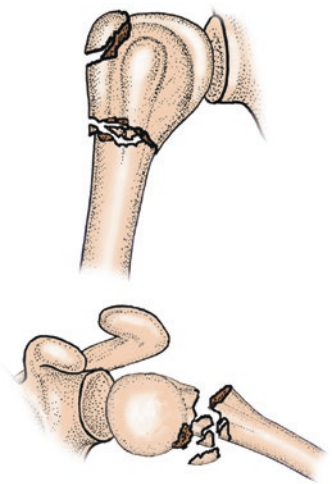


AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B1: With metaphyseal impaction (11-B1)

B1.2: Medial plus lesser tuberosity (11-B1.2)

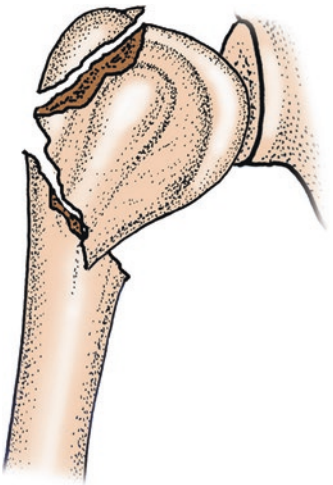


AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B1: With metaphyseal impaction (11-B1)

B1.3: Posterior plus greater tuberosity (11-B1.3)

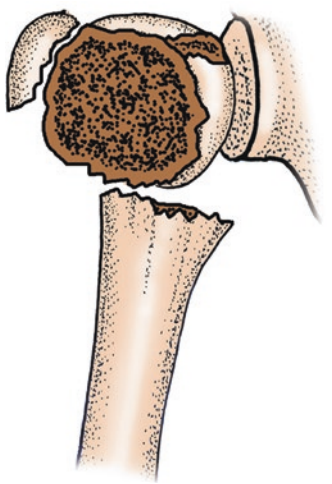


AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B2: Without metaphyseal impaction (11-B2)

B2.1: Without rotatory displacement of the epiphyseal fracture fragment (11-B2.1)

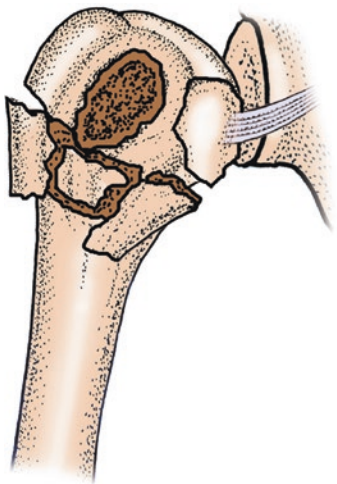


AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B2: Without metaphyseal impaction (11-B2)

B2.2: With rotatory displacement of the epiphyseal fragment (11-B2.2)

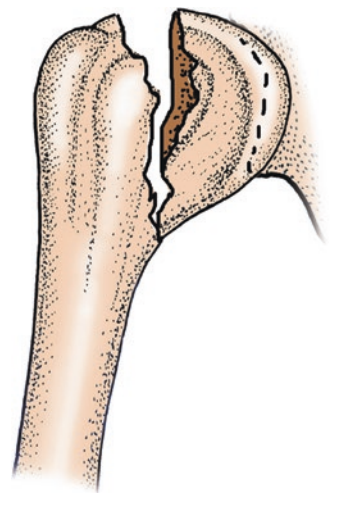


AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B2: Without metaphyseal impaction (11-B2)

B2.3: Multifragmentary metaphysis plus one of the tuberosities (11-B2.3)

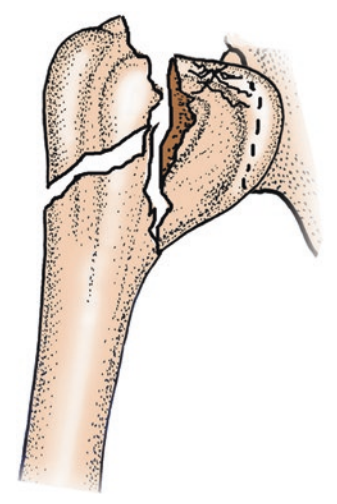


AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B3: With glenohumeral dislocation (11-B3)

B3.1: “Vertical” cervical line plus greater tuberosity intact plus anterior medial dislocation (11-B3.1)

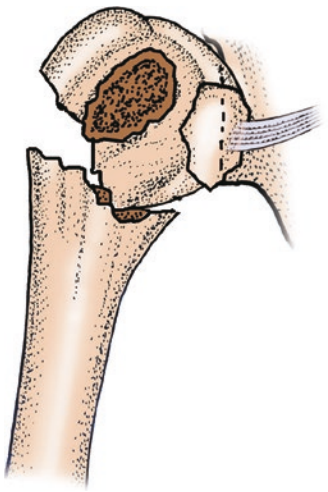


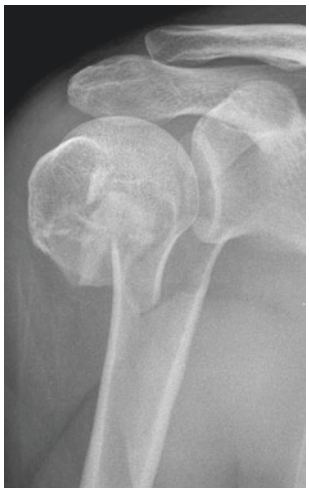
AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B3: With glenohumeral dislocation (11-B3)

B3.2: “Vertical” cervical line plus greater tuberosity fracture plus anterior medial dislocation (11-B3.2)





AO/OTA classification

Type B: Extra-articular, bifocal fracture (11-B)

B3: With glenohumeral dislocation (11-B3)

B3.3: Lesser tuberosity fracture plus posterior dislocation (11-B3.3)

Type C: Articular fractures (11-C).

C1: Articular fracture with slight displacement impacted valgus fracture (11-C1).

C1.1: Cephalotubercular with valgus malalignment (11-C1.1).

C1.2: Cephalotubercular with varus malalignment (11-C1.2).

C1.3: Anatomical neck (11-C1.3).

C2: Articular fracture impacted with marked displacement (11-C2).

C2.1: Cephalotubercular with valgus malalignment (11-C2.1).

C2.2: Cephalotubercular with varus malalignment (11-C2.2).

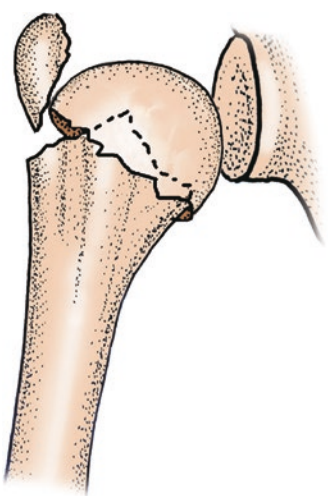
C2.3: Transcephalic (double-profile image on X-ray) and tubercular, with varus malalignment (11-C2.3).

C3: Articular fracture with glenohumeral dislocation (11-C3).

C3.1: Anatomical neck (11-C3.1).

C3.2: Anatomical neck and tuberosities (11-C3.2).

C3.3: Cephalotubercular fragmentation (11-C3.3).

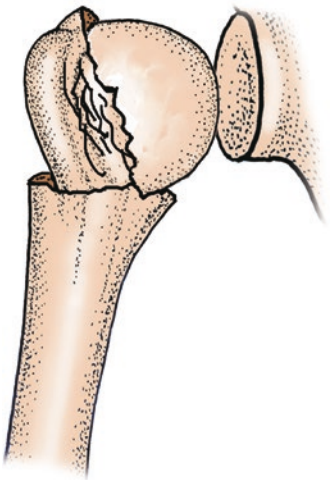


AO/OTA classification

Type C: Articular fractures (11-C)

C1: Articular fracture with slight displacement impacted valgus fracture (11-C1)

C1.1: Cephalotubercular with valgus malalignment (11-C1.1)

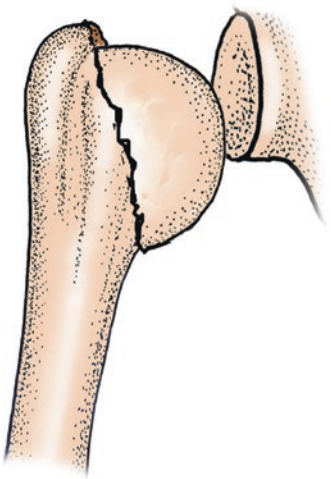


AO/OTA classification

Type C: Articular fractures (11-C)

C1: Articular fracture with slight displacement impacted valgus fracture (11-C1)

C1.2: Cephalotubercular with varus malalignment (11-C1.2)

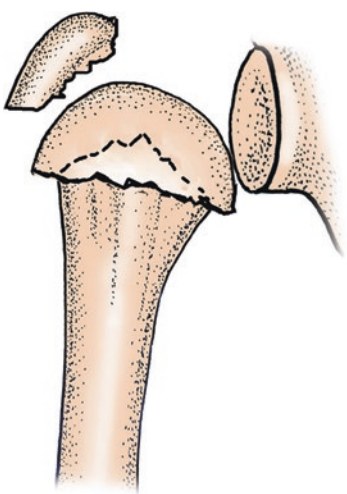


AO/OTA classification

Type C: Articular fractures (11-C)

C1: Articular fracture with slight displacement impacted valgus fracture (11-C1)

C1.3: Anatomical neck (11-C1.3)

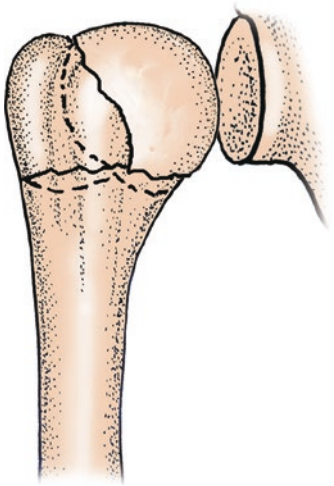


AO/OTA classification

Type C: Articular fractures (11-C)

C2: Articular fracture impacted with marked displacement (11-C2)

C2.1: Cephalotubercular with valgus malalignment (11-C2.1)

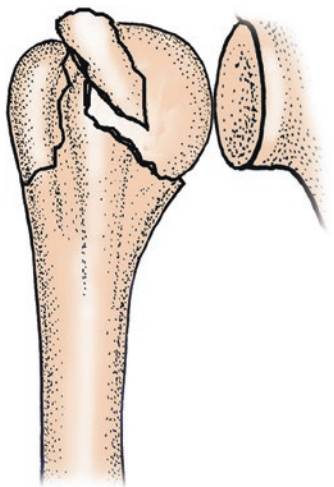


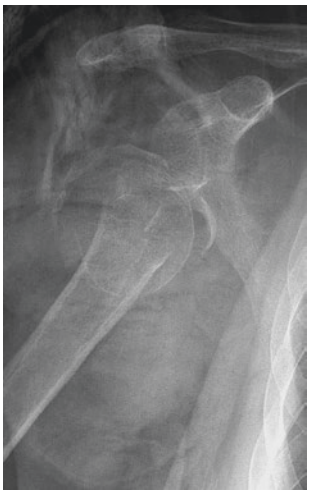
AO/OTA classification

Type C: Articular fractures (11-C)

C2: Articular fracture impacted with marked displacement (11-C2)

C2.2: Cephalotubercular with varus malalignment (11-C2.2)



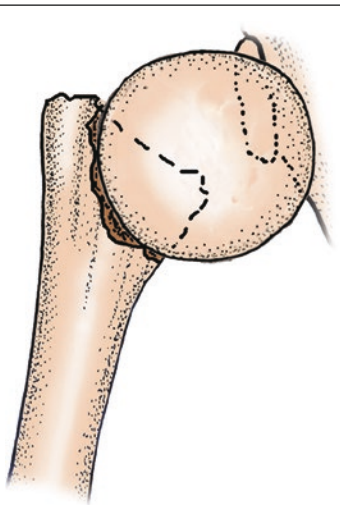


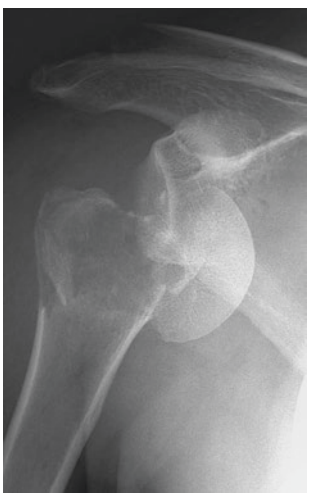
AO/OTA classification

Type C: Articular fractures (11-C)

C2: Articular fracture impacted with marked displacement (11-C2)

C2.3: Transcephalic (double-profile image on X-ray) and tubercular, with varus malalignment (11-C2.3)



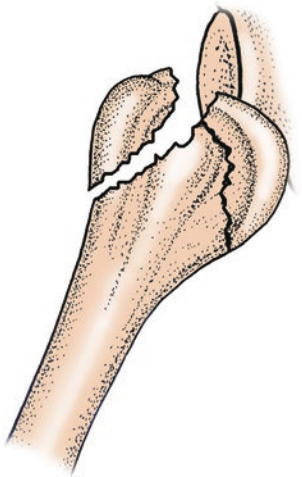


AO/OTA classification

Type C: Articular fractures (11-C)

C3: Articular fracture with glenohumeral dislocation (11-C3)

C3.1: Anatomical neck (11-C3.1)

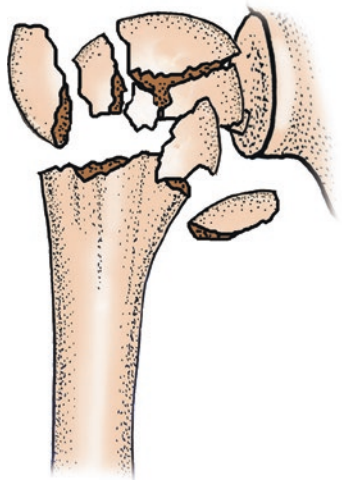


AO/OTA classification

Type C: Articular fractures (11-C)

C3: Articular fracture with glenohumeral dislocation (11-C3)

C3.2: Anatomical neck and tuberosities (11-C3.2)



AO/OTA classification

Type C: Articular fractures (11-C)

C3: Articular fracture with glenohumeral dislocation (11-C3)

C3.3: Cephalotubercular fragmentation (11-C3.3)

2.1.3 Codman Classification [3]

Codman divided the proximal end of the humerus into four distinct fragments according to anatomic lines of epiphyseal union: *a*, greater tuberosity; *b*, lesser tuberosity; *c*, head; and *d*, shaft. All those different types of fractures are variable combinations of the four major fragments mentioned above.

2.1.4 Watson-Jones Classification (in 1955) [4]

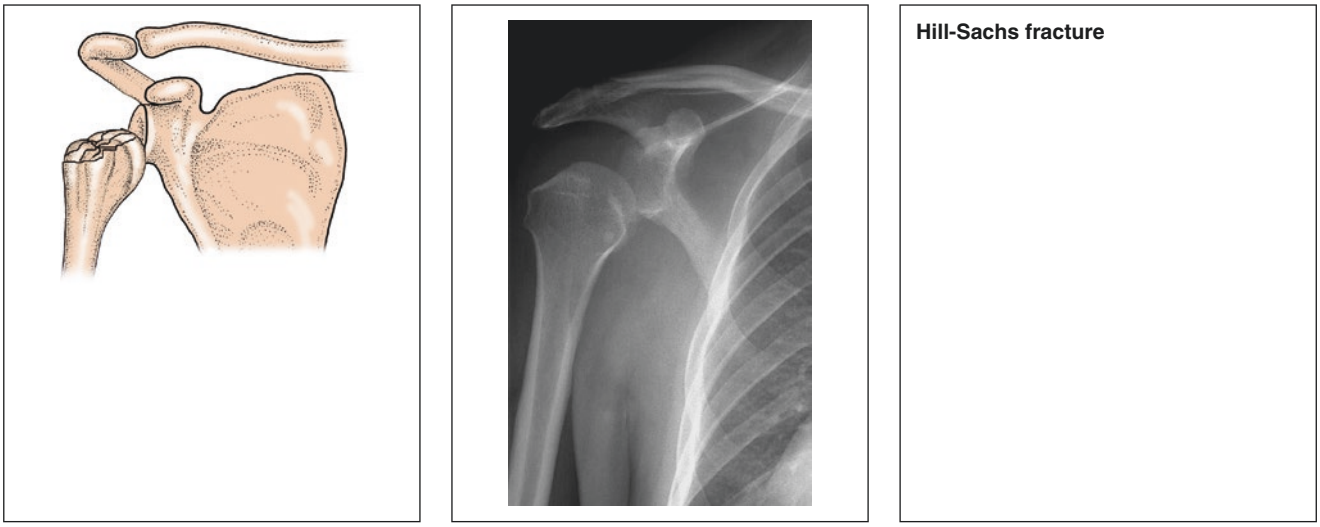
Watson-Jones divided the proximal humeral fractures into abduction fracture and adduction fracture according to injury mechanism. The apex of angulation of the proximal humerus usually is directed anteriorly, and anterior angulation can produce in X-rays either the abduction fracture or the adduction fracture, depending on the position of humerus rotation. Therefore, this classification can mislead the therapy as classifying criteria is not strict or accurate.

2.1.5 Kocher Classification (in 1896) [5]

The Kocher classification is based on three anatomic levels of fractures: anatomic neck, epiphyseal region, and surgical neck. This classification does not consider displacement of fractures and amount of fragments, so that it results in confusion of diagnosis and difficulty in treatment decision.

2.1.6 Hill-Sachs Fracture

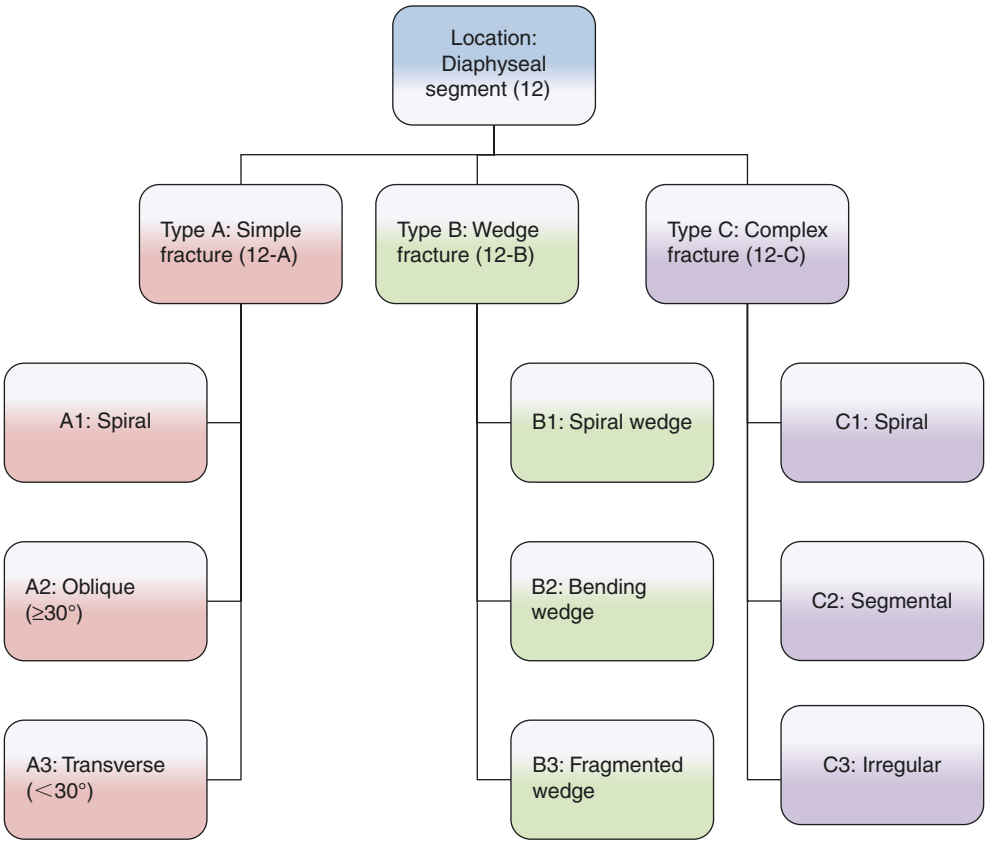
A bony trough in the posterior-superior region of the humeral head which occurs during the anterior dislocation of shoulder as the humeral head impacts against the front of the glenoid.



2.2 Classification Systems of Humeral Shaft Fractures

To date, there are five classification systems of humeral shaft fractures in literature. According to the literature over the last 5 years, the most frequently used system is the AO/OTA classification.

2.2.1 AO/OTA Classification [2]



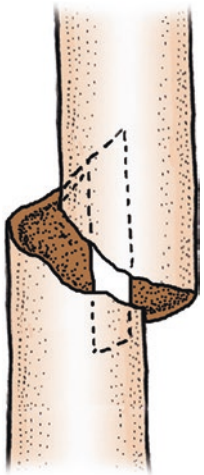
Type A: Simple fracture (12-A).
- A1: Spiral (12-A1).
  - A1.1: Proximal zone (12-A1.1).
  - A1.2: Middle zone (12-A1.2).
  - A1.3: Distal zone (12-A1.3).
- A2: Oblique (≥30°) (12-A2).
  - A2.1: Proximal zone (12-A2.1).
  - A2.2: Middle zone (12-A2.2).
  - A2.3: Distal zone (12-A2.3).
- A3: Transverse (<30°) (12-A3).
  - A3.1: Proximal zone (12-A3.1).
  - A3.2: Middle zone (12-A3.2).
  - A3.3: Distal zone (12-A3.3).

AO/OTA classification

Type A: Simple fracture (12-A)

A1: Spiral (12-A1)

A1.1: Proximal zone (12-A1.1)

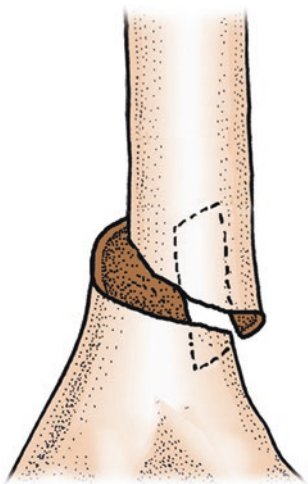


AO/OTA classification

Type A: Simple fracture (12-A)

A:1 Spiral (12-A1)

A1.2: Middle zone (12-A1.2)

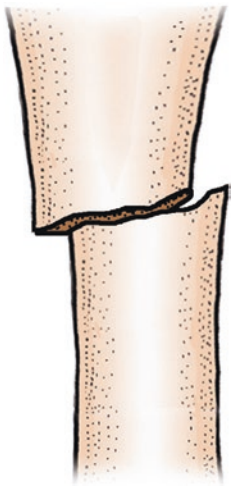


AO/OTA classification

Type A: Simple fracture (12-A)

A1: Spiral (12-A1)

A1.3: Distal zone (12-A1.3)

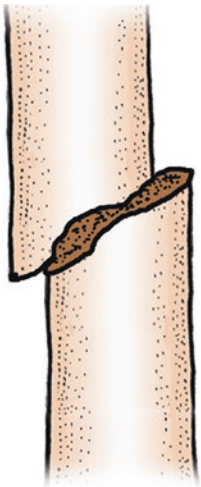


AO/OTA classification

Type A: Simple fracture (12-A)

A2: Oblique (≥30°) (12-A2)

A2.1: Proximal zone (12-A2.1)

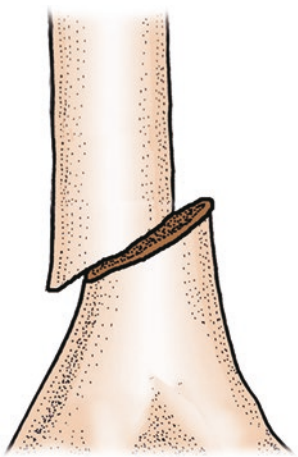


AO/OTA classification

Type A: Simple fracture (12-A)

A2: Oblique (≥30°) (12-A2)

A2.2: Middle zone (12-A2.2)

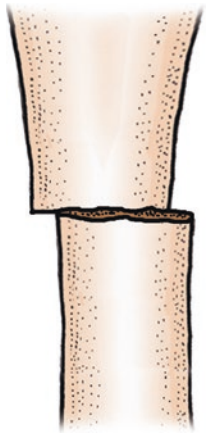


AO/OTA classification

Type A: Simple fracture (12-A)

A2: Oblique (≥30°) (12-A2)

A2.3: Distal zone (12-A2.3)

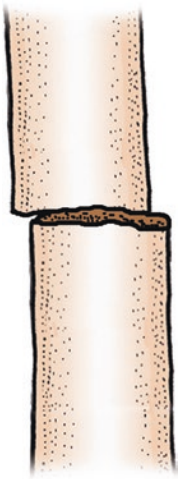


AO/OTA classification

Type A: Simple fracture (12-A)

A3: Transverse (<30°) (12-A3)

A3.1: Proximal zone (12-A3.1)

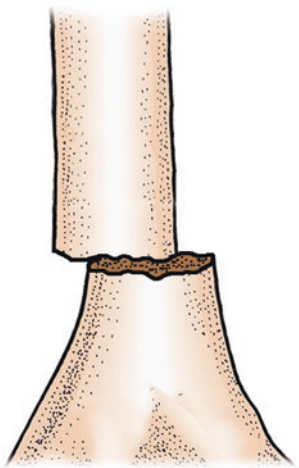


AO/OTA classification

Type A: Simple fracture (12-A)

A3: Transverse (<30°) (12-A3)

A3.2: Middle zone (12-A3.2)



AO/OTA classification

Type A: Simple fracture (12-A)

A3: Transverse (<30°) (12-A3)

A3.3: Distal zone (12-A3.3)

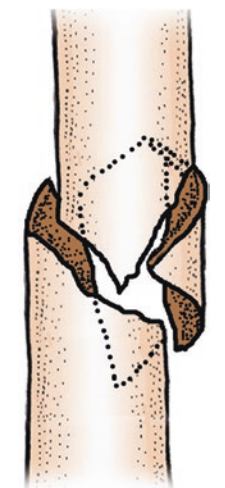
Type B: Wedge fracture (12-B)
- B1: Spiral wedge (12-B1).
  - B1.1: Proximal zone (12-B1.1).
  - B1.2: Middle zone (12-B1.2).
  - B1.3: Distal zone (12-B1.3).
- B2: Bending wedge (12-B2).
  - B2.1: Proximal zone (12-B2.1).
  - B2.2: Middle zone (12-B2.2).
  - B2.3: Distal zone (12-B2.3).
- B3: Fragmented wedge (12-B3).
  - B3.1: Proximal zone (12-B3.1).
  - B3.2: Middle zone (12-B3.2).
  - B3.3: Distal zone (12-B3.3).

AO/OTA classification

Type B: Wedge fracture (12-B)

B1: Spiral wedge (12-B1)

B1.1: Proximal zone (12-B1.1)

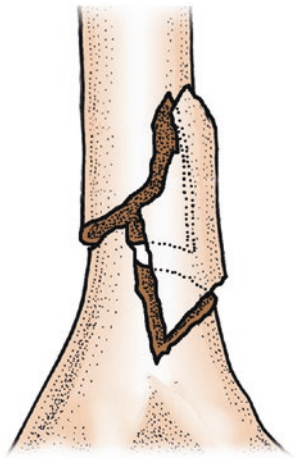


AO/OTA classification

Type B: Wedge fracture (12-B)

B1: Spiral wedge (12-B1)

B1.2: Middle zone (12-B1.2)



AO/OTA classification

Type B: Wedge fracture (12-B)

B1: Spiral wedge (12-B1)

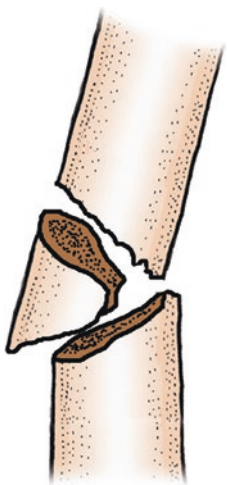
B1.3: Distal zone (12-B1.3)

AO/OTA classification

Type B: Wedge fracture (12-B)

B2: Bending wedge (12-B2)

B2.1: Proximal zone (12-B2.1)

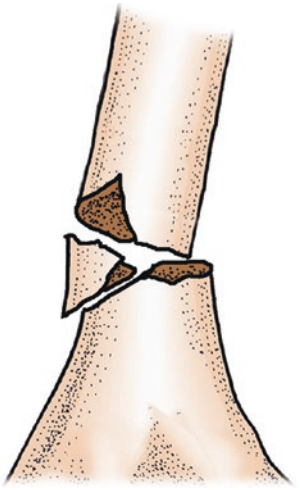


AO/OTA classification

Type B: Wedge fracture (12-B)

B2: Bending wedge (12-B2)

B2.2: Middle zone (12-B2.2)

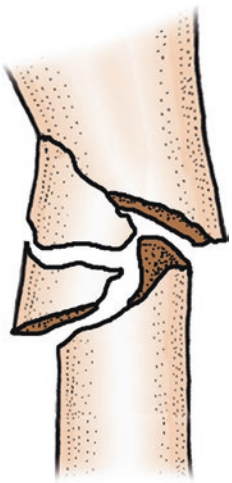


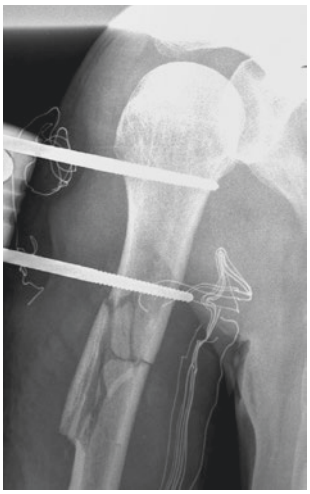
AO/OTA classification

Type B: Wedge fracture (12-B)

B2: Bending wedge (12-B2)

B2.3: Distal zone (12-B2.3)



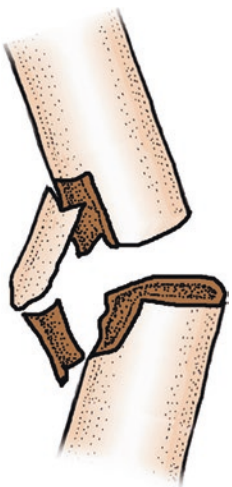


AO/OTA classification

Type B: Wedge fracture (12-B)

B3: Fragmented wedge (12-B3)

B3.1: Proximal zone (12-B3.1)

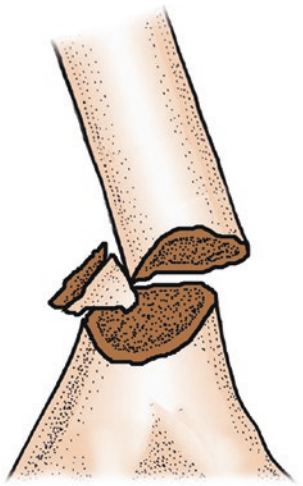


AO/OTA classification

Type B: Wedge fracture (12-B)

B3: Fragmented wedge (12-B3)

B3.2: Middle zone (12-B3.2)



AO/OTA classification

Type B: Wedge fracture (12-B)

B3: Fragmented wedge (12-B3)

B3.3: Distal zone (12-B3.3)

Type C: Complex fracture (12-C).

C1: Spiral (12-C1):

C1.1: With two intermediate fragments (12-C1.1).

C1.2: With three intermediate fragments (12-C1.2).

C1.3: With more than three intermediate fragments (12-C1.3).

C2: Segmental (12-C2):

C2.1: With one intermediate segmental fragment (12-C2.1).

C2.2: With one intermediate segmental and additional wedge fragments (12-C2.2).

C2.3: With two intermediate segmental fragments (12-C2.3).

C3: Irregular (12-C3):

C3.1: With two or three intermediate fragments (12-C3.1).

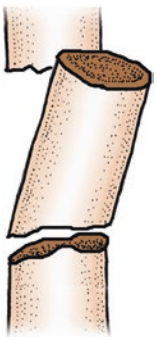
C3.2: With limited shattering (<4 cm) (12-C3.2).

C3.3: With extensive shattering (>4 cm) (12-C3.3).

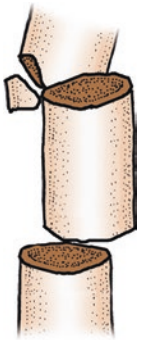
12C1.1

12C1.2

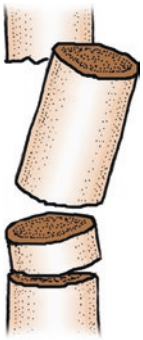
12C1.3



12C2.1



12C2.2



12C2.3

12C3.1

12C3.2

12C3.3

C1.1: With two intermediate fragments (12-C1.1)

C1.2: With three intermediate fragments (12-C1.2)

C1.3: With more than three intermediate fragments (12-C1.3)

C2.1: With one intermediate segmental fragment (12-C2.1)

C2.2: With one intermediate segmental and additional wedge fragments (12-C2.2)

C2.3: With two intermediate segmental fragments (12-C2.3)

C3.2: With limited shattering (<4 cm) (12-C3.2)

C3.3: With extensive shattering (>4 cm) (12-C3.3)

2.2.2 Classification According to Relative Position of Fracture Lines to Insertion of the Deltoid

1. Fracture line proximal to deltoid insertion of humerus:
   The proximal fragment is pulled medially and anteriorly by pectoralis major, latissimus dorsi, and teres major, while the distal fragment is pulled laterally and proximally by coracobrachialis, biceps brachii, and triceps brachii.
2. Fracture line distal to deltoid insertion of humerus:
   The proximal fragment is pulled laterally and anteriorly by the deltoid, while the distal fragment is pulled proximally by biceps brachii and triceps brachii.

2.2.3 Classification According to Anatomic Location of Fractures

Depending on the anatomic location of the fracture lines, fractures of the humeral shaft can be divided into proximal third, mid-third, and distal third.

2.2.4 Classification According to Morphology of Fracture Lines

Fractures of the humeral shaft can be transverse, oblique, spiral, or comminuted according to morphology of the fracture lines.

2.2.5 Classification According to Integrity of Soft-Tissue Envelope

Depending on whether the soft-tissue envelope at fracture site is integrated or not, there are two types: closed fracture and open fracture.

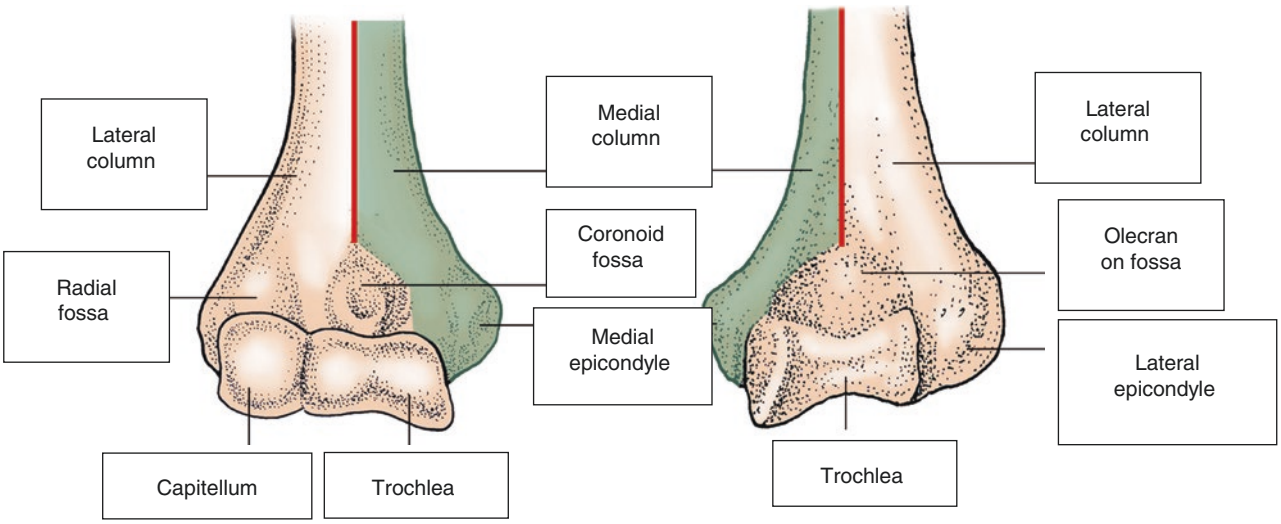
2.3 Classification of Distal Humeral Fractures

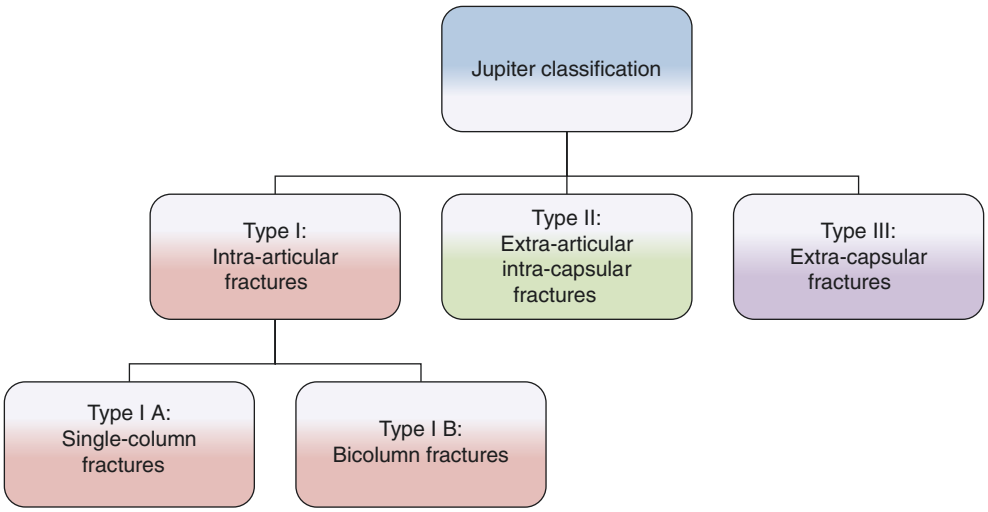
Distal humeral fractures are traditionally classified in accordance with the anatomic location. Reich first proposed the "T" shape and "Y" shape fractures in his classification of intercondylar fractures of the humerus in 1936. There have been >10 classification systems of distal humeral fractures to date in the literature. According to the literature over the last 5 years, the most commonly used system is the Jupiter classification, followed by the AO/OTA classification and that according to the anatomic location.

2.3.1 Jupiter Classification of Distal Humeral Fractures [6, 7]

The distal humerus consists of medial and lateral bony columns with an intervening trochlea.

The medial column ends ~1 cm proximal to the distal end of the trochlea, consisting of the medial cortex bone of the metaphysis and its extension, i.e., medial epicondyle. The lateral column extends to the level of the distal aspect of the trochlea, consisting of the lateral cortex bone of the metaphysis, lateral epicondyle, and capitellum. The trochlea, olecranon fossa, and coronoid fossa compose the inter-column triangle.

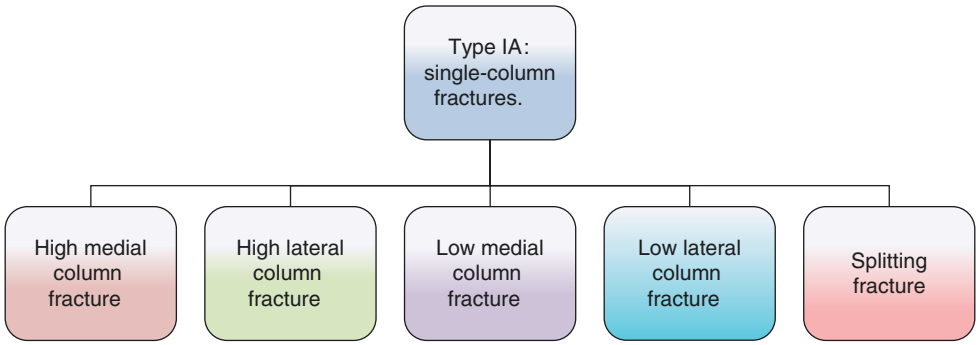




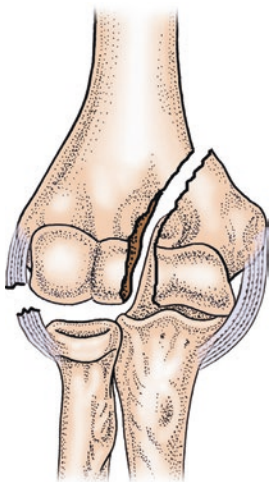
Type I: Intra-articular fractures:
Intra-articular fractures are divided into four groups, including single-column injury, bicolumn injury, capitellar fractures, and trochlea fractures.
Type IA: Single-column fractures. Single-columnar injuries are divided into medial or lateral column fractures and subdivided into high and low fractures.
Type IB: Bicolumn fractures. Subdivided into high "T", low "T", "Y", "H", and medial lambda, lateral lambda patterns.

Type II: Extra-articular intra-capsular fractures:
Transcolumn fractures, subdivided into high-extension fracture, high-flexion fracture, low-extension fracture, low-flexion fracture, abduction fracture, and adduction fracture.
Type III: Extracapsular fractures:
Type IIIA: Medial epicondyle.
Type IIIB: Lateral epicondyle.

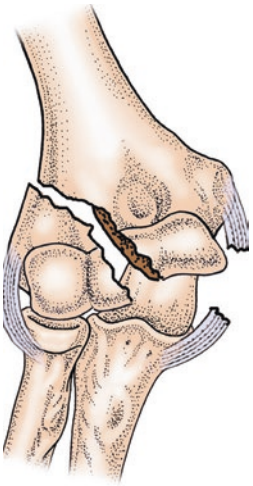
2.3.1.1 Type I A: Intra-articular Fracture, Single-Column Fracture



Single-column fractures: Single- columnar injuries are divided into medial or lateral column fractures and subdivided into high and low fractures, and splitting fractures.



Jupiter classification
Type I A: Intra-articular fracture
Single-column fracture
High medial column fracture

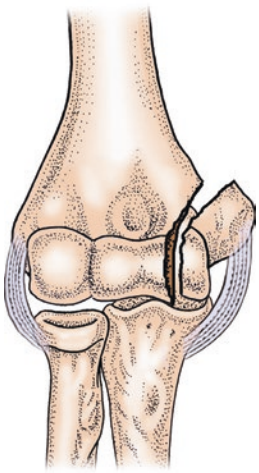


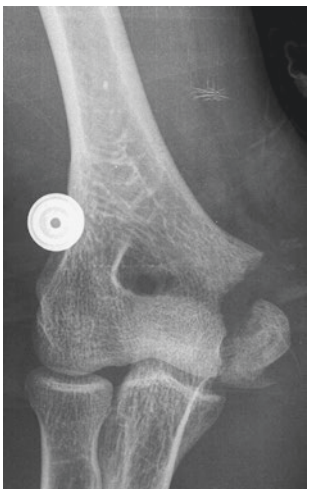
Jupiter classification

Type I A: Intra-articular fracture

Single-column fracture

High lateral column fracture



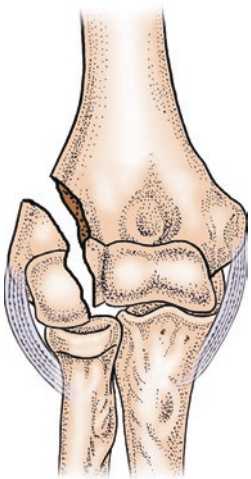


Jupiter classification

Type I A: Intra-articular fracture

Single-column fracture

Low medial column fracture

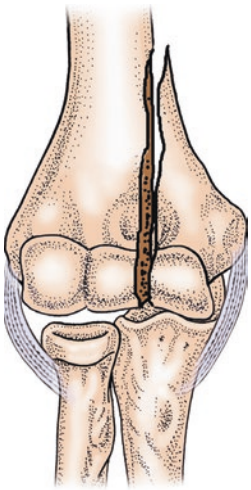


Jupiter classification

Type I A: Intra-articular fracture

Single-column fracture

Low lateral column fracture



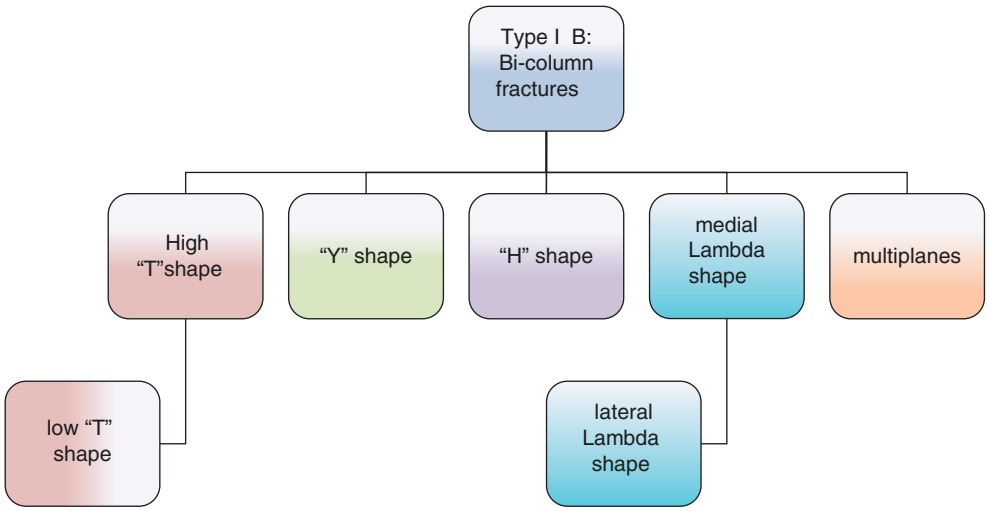
Jupiter classification

Type I A: Intra-articular fracture

Single-column fracture

Splitting fracture

2.3.1.2 Type I B: Intra-articular Fractures, Bicolumn Fractures



1. High "T" shape

   The fracture lines are T shape. A transverse fracture line divides both columns proximal to or at the upper limits of the olecranon fossa.
2. Low "T" shape

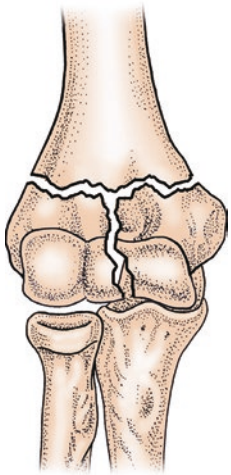
   The fracture lines are T shape. A transverse fracture line crosses the olecranon fossa, usually just proximal to the trochlea, leaving relatively small distal fragments.
3. "Y" shape

   The fracture lines are Y shape. Oblique fracture lines cross each column, joining into the olecranon fossa, extending distally as a vertical line.
4. "H" shape

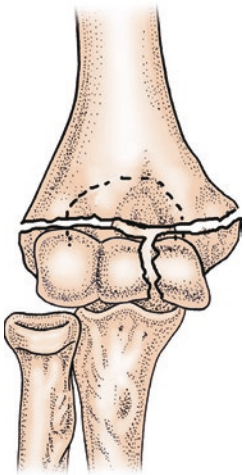
   Fracture lines of the medial column are above and below the medial epicondyle. Fracture lines of the lateral column are in a T or Y pattern. The trochlea is a free fragment and at risk for avascular necrosis.
5. Medial lambda shape

   The most proximal fracture line exits at the medial column. The lateral fracture line exits distal to the lateral epicondyle.
6. Lateral lambda shape

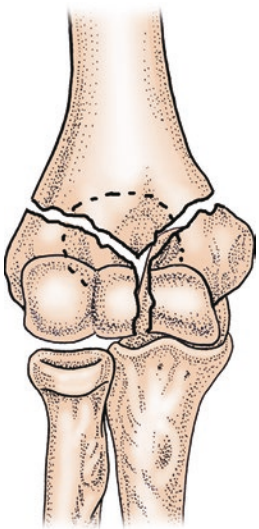
   The most proximal fracture line exits at the lateral column. The medial fracture line exits distal to the medial epicondyle.
7. Multiplanes: Standard T-shape fractures of distal humerus, combined with another fracture of which fracture lines, are in coronal plane.



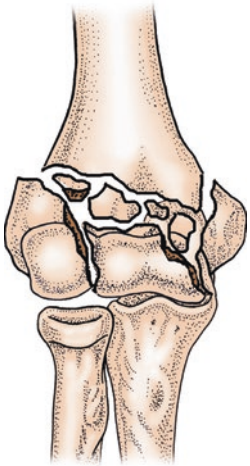
Jupiter classification
Type I B: Intra-articular fractures
Bicolumn fractures
High “T” shape



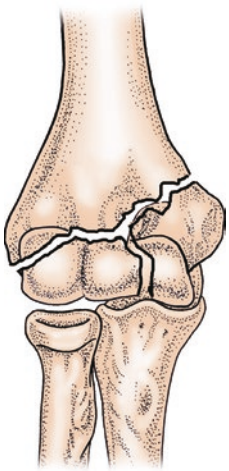
Jupiter classification
Type I B: Intra-articular fractures
Bicolumn fractures
Low “T” shape



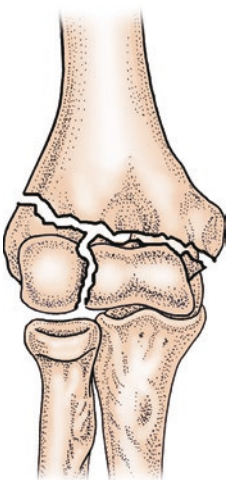
Jupiter classification
Type I B: Intra-articular fractures
Bicolumn fractures
“Y” shape



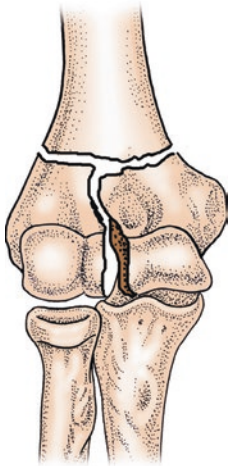
Jupiter classification
Type I B: Intra-articular fractures
Bicolumn fractures
“H” shape



Jupiter classification
Type I B: Intra-articular fractures
Bicolumn fractures
Medial lambda shape



Jupiter classification
Type I B: Intra-articular fractures
Bicolumn fractures
Lateral lambda shape



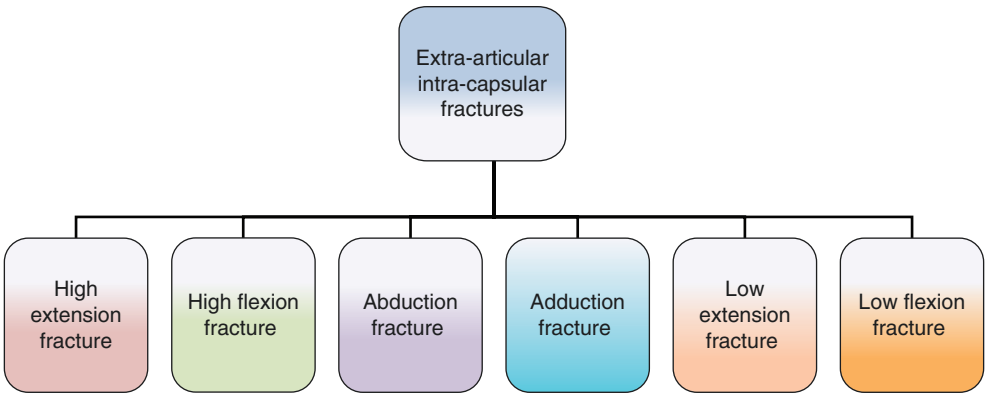
Jupiter classification

Type I B: Intra-articular fractures

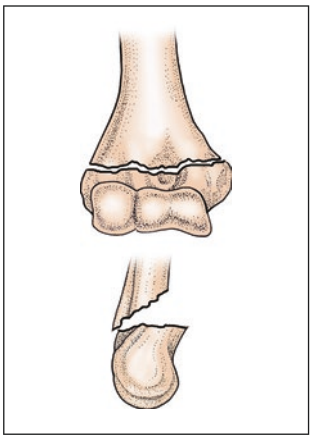
Bicolumn fractures

Multiplanes

2.3.1.3 Type II: Extra-Articular Intra-capsular Fractures, Transcolumn Fractures



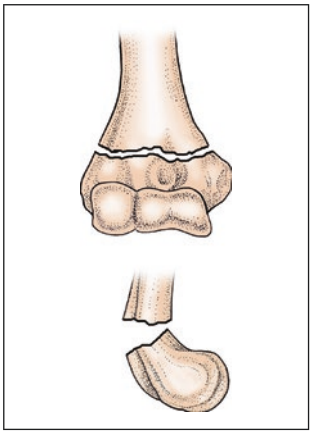
1. **High-extension fracture**: The oblique fracture line extends from a posterior proximal position to a low anterior position, and the distal fragment is displaced posteriorly (the same with the extension-type supracondylar fractures).
2. **High-flexion fracture**: The oblique fracture line extends from an anterior proximal position to a low posterior position, and the distal fragment is displaced anteriorly (the same with the flexion-type supracondylar fractures).
3. **Abduction fracture**: The oblique fracture line extends from a lateral proximal position to a distal medial position, and the distal fragment is displaced laterally.
4. **Adduction fracture**: The oblique fracture line extends from a medial proximal position to a distal lateral position, and the distal fragment is displaced medially.
5. **Low-extension fracture**: The fracture line is transverse or slightly oblique, and the distal fragment is displaced posteriorly.
6. **Low-flexion fracture**: The fracture line is transverse or slightly oblique, and the distal fragment is displaced anteriorly.



Jupiter classification

Type II: Extra-articular intra-capsular fractures.

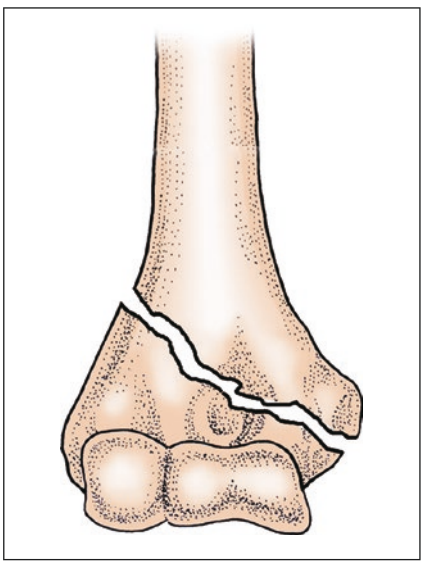
High-extension fracture



Jupiter classification

Type II: Extra-articular intra-capsular fractures.

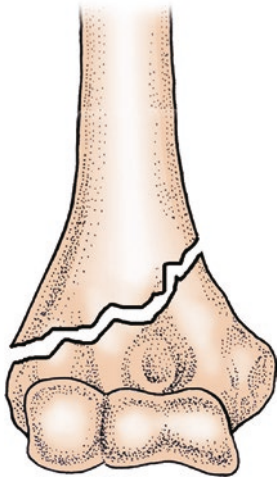
High-flexion fracture



Jupiter classification

Type II: Extra-articular intra-capsular fractures.

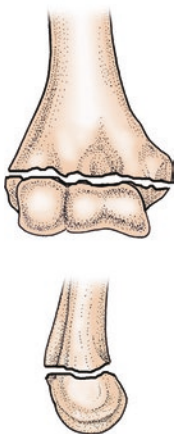
Abduction fracture



Jupiter classification

Type II: Extra-articular intra-capsular fractures.

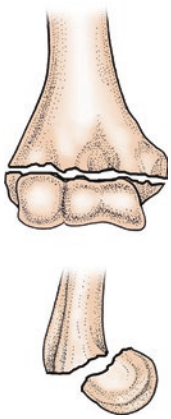
Adduction fracture



Jupiter classification

Type II: Extra-articular intra-capsular fractures.

Low-extension fracture

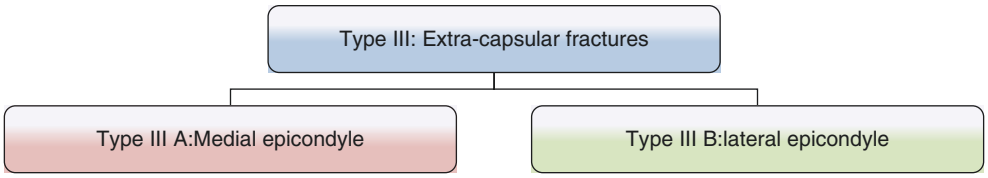


Jupiter classification

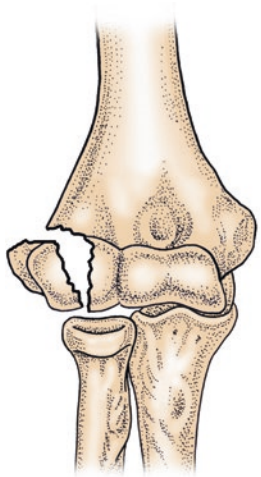
Type II: Extra-articular intra-capsular fractures.

Low-flexion fracture

2.3.1.4 Type III: Extracapsular Fractures



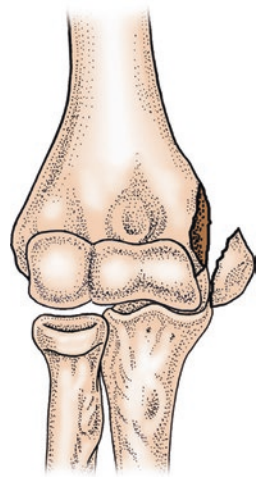
Type III A: Medial epicondyle.
Type III B: Lateral epicondyle.



Jupiter classification

Type III: Extracapsular fractures.

Type III B: Lateral epicondyle

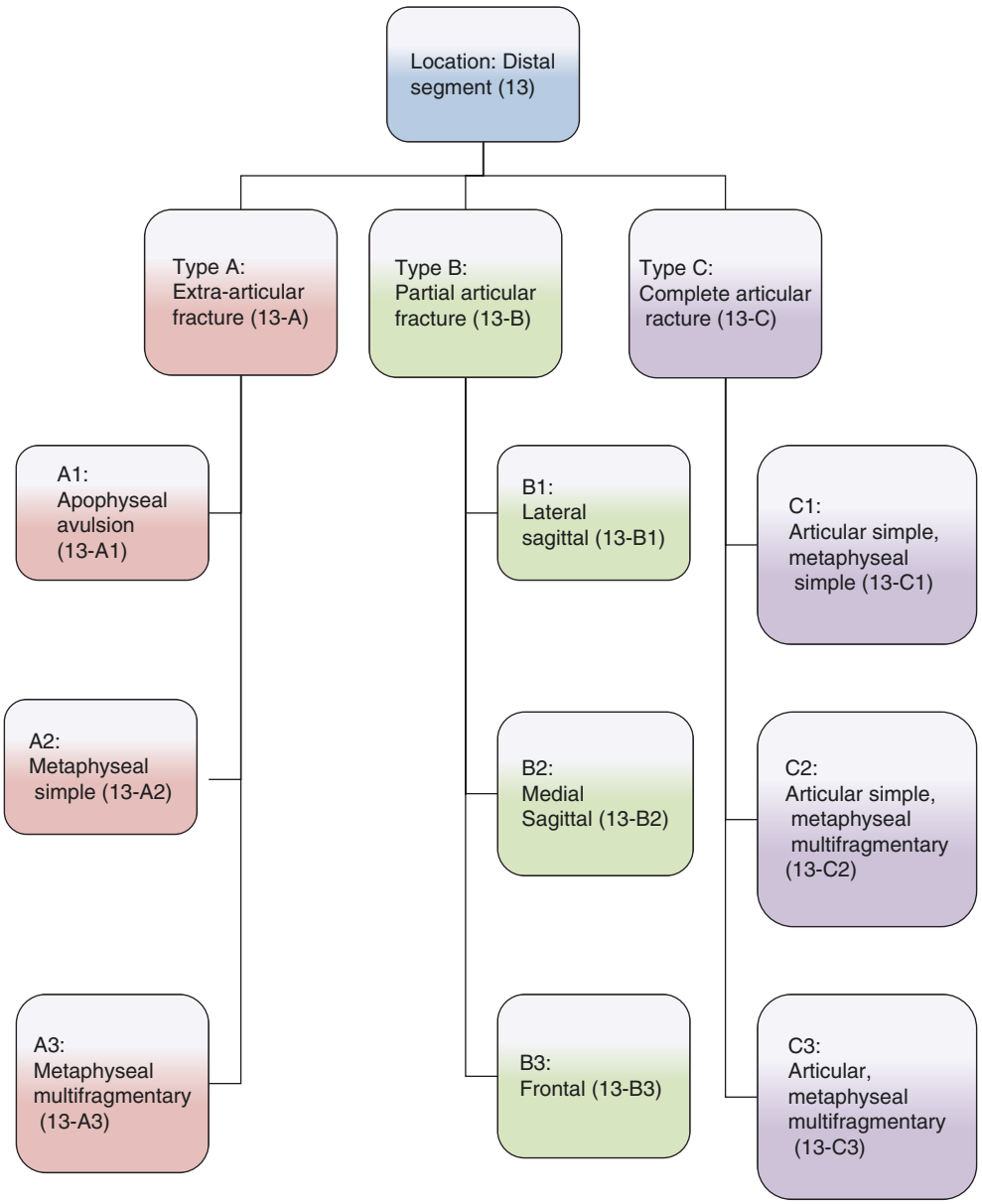


Jupiter classification

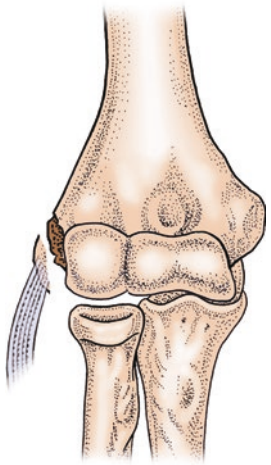
Type III: Extracapsular fractures.

Type III A: Medial epicondyle

2.3.2 AO/OTA Classification [2]



Type A: Extra-articular fracture (13-A).
- A1: Apophyseal avulsion (13-A1):
  - A1.1: Lateral epicondyle (13-A1.1).
  - A1.2: Medial epicondyle, non-incarcerated (13-A1.2).
  - A1.3: Medial epicondyle, incarcerated (13-A1.3).
- A2: Metaphyseal simple (13-A2):
  - A2.1: Oblique downwards and inwards (13-A2.1).
  - A2.2: Oblique downwards and outwards (13-A2.2).
  - A2.3: Transverse (13-A2.3).
- A3: Metaphyseal multifragmentary (13-A3):
  - A3.1: With intact wedge (13-A3.1).
  - A3.2: With fragmented wedge (13-A3.2).
  - A3.3: Complex (13-A3.3).

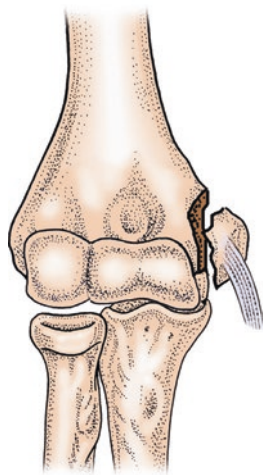


AO/OTA classification

Type A: Extra-articular fracture (13-A)

A1: Apophyseal avulsion (13-A1)

A1.1: Lateral epicondyle (13-A1.1)

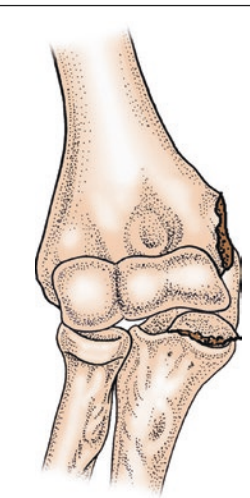


AO/OTA classification

Type A: Extra-articular fracture (13-A)

A1: Apophyseal avulsion (13-A1)

A1.2: Medial epicondyle, non-incarcerated (13-A1.2)



AO/OTA classification

Type A: Extra-articular fracture (13-A)

A1: Apophyseal avulsion (13-A1)

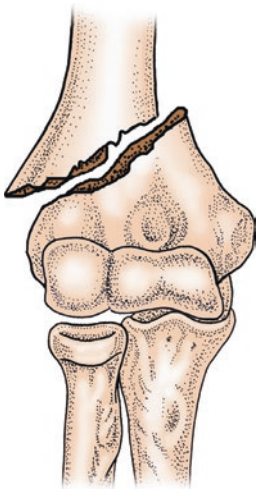
A1.3: Medial epicondyle, incarcerated (13-A1.3)

AO/OTA classification

Type A: Extra-articular fracture (13-A)

A2: Metaphyseal simple (13-A2)

A2.1: Oblique downwards and inwards (13-A2.1)

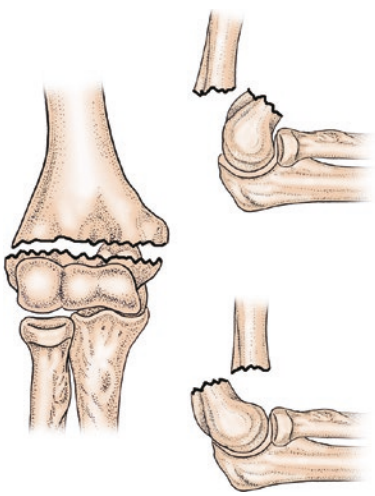


AO/OTA classification

Type A: Extra-articular fracture (13-A)

A2: Metaphyseal simple (13-A2)

A2.2: Oblique downwards and outwards (13-A2.2)

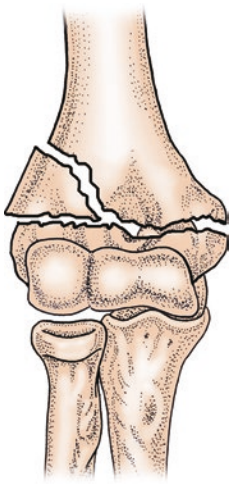


AO/OTA classification

Type A: Extra-articular fracture (13-A)

A2: Metaphyseal simple (13-A2)

A2.3: Transverse (13-A2.3)

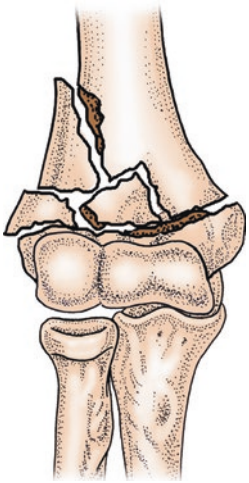


AO/OTA classification

Type A: Extra-articular fracture (13-A)

A3: Metaphyseal multifragmentary (13-A3)

A3.1: With intact wedge (13-A3.1)

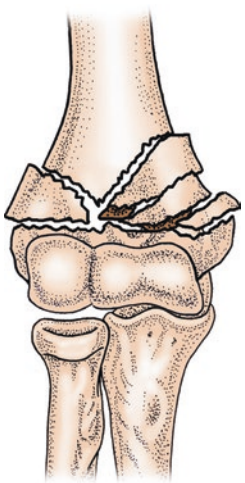


AO/OTA classification

Type A: Extra-articular fracture (13-A)

A3: Metaphyseal multifragmentary (13-A3)

A3.2: With fragmented wedge (13-A3.2)



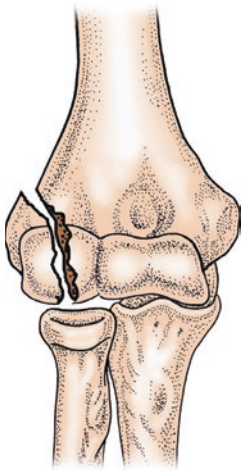
AO/OTA Classification

Type A: Extra-articular fracture (13-A).

A3: Metaphyseal multifragmentary (13-A3)

A3.3: Complex (13-A3.3)

Type B: Partial articular fracture (13-B).
- B1: Lateral sagittal (13-B1):
  - B1.1: Capitellum (13-B1.1).
  - B1.2: Transtrochlear simple (13-B1.2).
  - B1.3: Transtrochlear multifragmentary (13-B1.3).
- B2: Medial sagittal (13-B2):
  - B2.1: Transtrochlear simple, through medial side (Milch I) (13-B2.1).
  - B2.2: Transtrochlear simple, through the groove (13-B2.2).
  - B2.3: Transtrochlear multifragmentary (13-B2.3).
- B3: Frontal (13-B3):
  - B3.1: Capitellum (13-B3.1).
  - B3.2: Trochlea (13-B3.2).
  - B3.3: Capitellum and trochlea (13-B3.3).

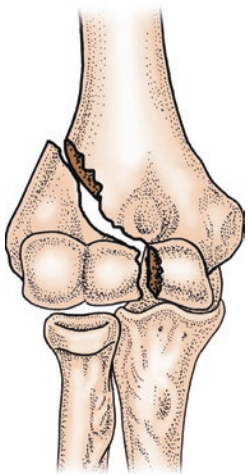


AO/OTA classification

Type B: Partial articular fracture (13-B).

B1: Lateral sagittal (13-B1).

B1.1: Capitellum (13-B1.1)

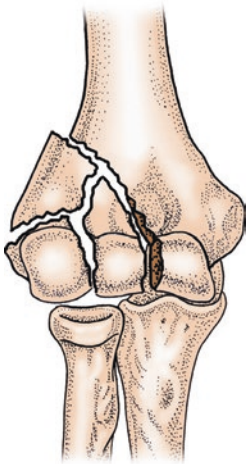


AO/OTA classification

Type B: Partial articular fracture (13-B).

B1: Lateral sagittal (13-B1).

B1.2: Transtrochlear simple (13-B1.2)

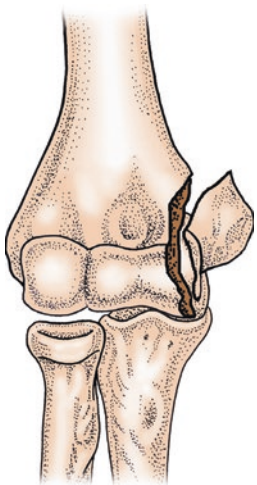


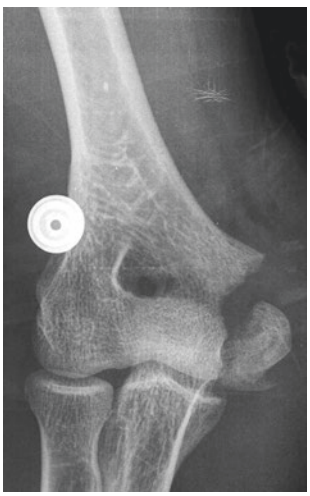
AO/OTA classification

Type B: Partial articular fracture (13-B).

B1: Lateral sagittal (13-B1).

B1.3: Transtrochlear multifragmentary (13-B1.3)



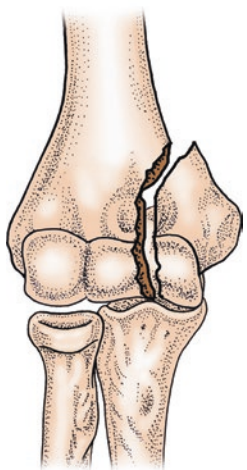


AO/OTA classification

Type B: Partial articular fracture (13-B).

B2: Medial sagittal (13-B2).

B2.1: Transtrochlear simple, through medial side (Milch I) (13-B2.1)

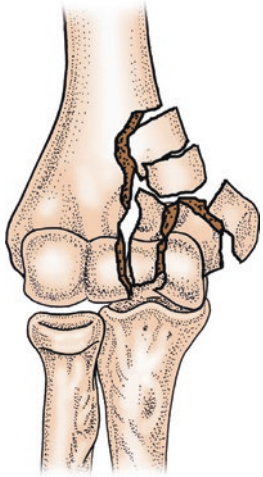


AO/OTA classification

Type B: Partial articular fracture (13-B).

B2: Medial sagittal (13-B2).

B2.2: Transtrochlear simple, through the groove (13-B2.2)

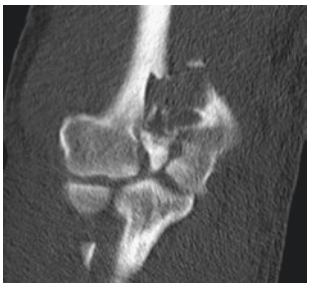


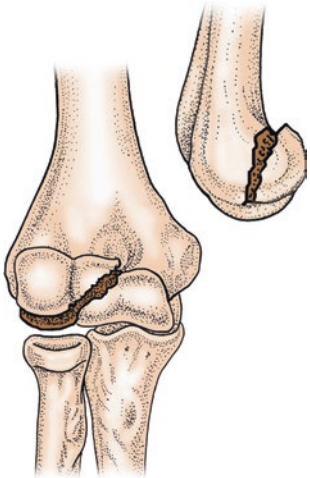
AO/OTA classification

Type B: Partial articular fracture (13-B)

B2: Medial sagittal (13-B2)

B2.3: Transtrochlear multifragmentary (13-B2.3)



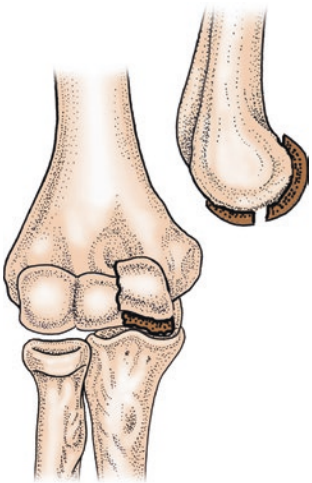


AO/OTA classification

Type B: Partial articular fracture (13-B)

B3: Frontal (13-B3).

B3.1: Capitellum (13-B3.1)

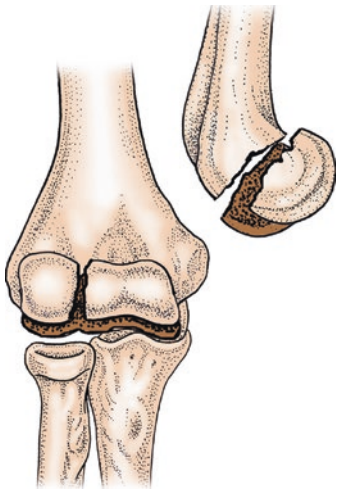


AO/OTA classification

Type B: Partial articular fracture (13-B).

B3: Frontal (13-B3)

B3.2: Trochlea (13-B3.2)



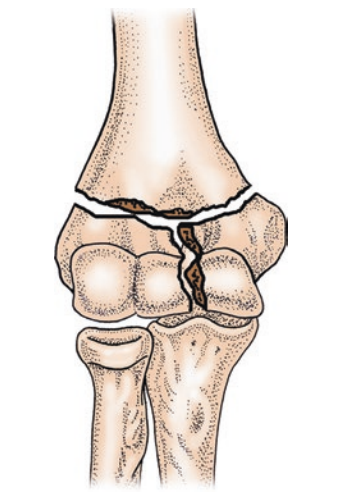
AO/OTA classification

Type B: Partial articular fracture (13-B).

B3: Frontal (13-B3).

B3.3: Capitellum and trochlea (13-B3.3)

Type C: Complete articular fracture (13-C)
- C1: Articular simple, metaphyseal simple (13-C1):
  - C1.1: With slight displacement (13-C1.1)
  - C1.2: With marked displacement (13-C1.2)
  - C1.3: T-shaped epiphyseal (13-C1.3)
- C2: Articular simple, metaphyseal multifragmentary (13-C2):
  - C2.1: With intact wedge (13-C2.1)
  - C2.2: With a fragmented wedge (13-C2.2)
  - C2.3: Complex (13-C2.3)
- C3: Articular, metaphyseal multifragmentary (13-C3):
  - C3.1: Metaphyseal simple (13-C3.1)
  - C3.2: Metaphyseal wedge (13-C3.2)
  - C3.3: Metaphyseal complex (13-C3.3)

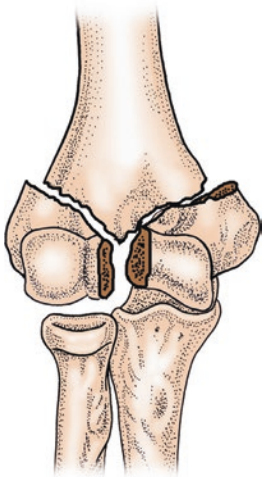


AO/OTA classification

Type C: Complete articular fracture (13-C).

C1: Articular simple, metaphyseal simple (13-C1).

C1.1: With slight displacement (13-C1.1)

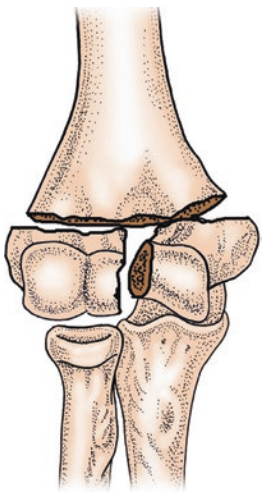


AO/OTA classification

Type C: Complete articular fracture (13-C).

C1: Articular simple, metaphyseal simple (13-C1).

C1.2: With marked displacement (13-C1.2)

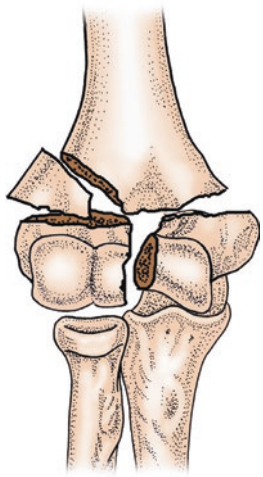


AO/OTA classification

Type C: Complete articular fracture (13-C)

C1: Articular simple, metaphyseal simple (13-C1)

C1.3: T-shaped epiphyseal (13-C1.3)

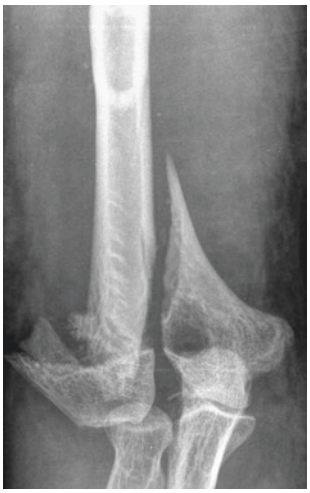


AO/OTA classification

Type C: Complete articular fracture (13-C)

C2: Articular simple, metaphyseal multifragmentary (13-C2)

C2.1: With intact wedge (13-C2.1)

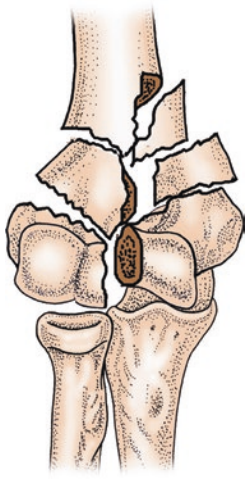


AO/OTA classification

Type C: Complete articular fracture (13-C)

C2: Articular simple, metaphyseal multifragmentary (13-C2)

C2.2: With a fragmented wedge (13-C2.2)

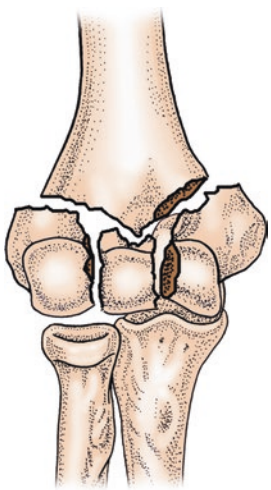


AO/OTA classification

Type C: Complete articular fracture (13-C)

C2: Articular simple, metaphyseal multifragmentary (13-C2)

C2.3: Complex (13-C2.3)

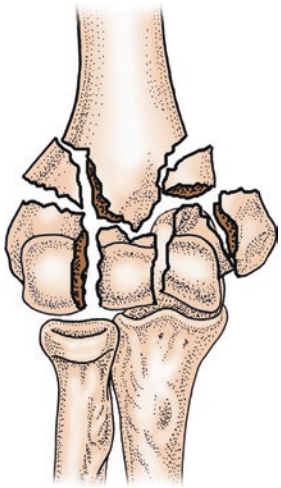


AO/OTA classification

Type C: Complete articular fracture (13-C)

C3: Articular, metaphyseal multifragmentary (13-C3)

C3.1: Metaphyseal simple (13-C3.1)



AO/OTA classification

Type C: Complete articular fracture (13-C)

C3: Articular, metaphyseal multifragmentary (13-C3)

C3.2: Metaphyseal wedge (13-C3.2)

AO/OTA classification

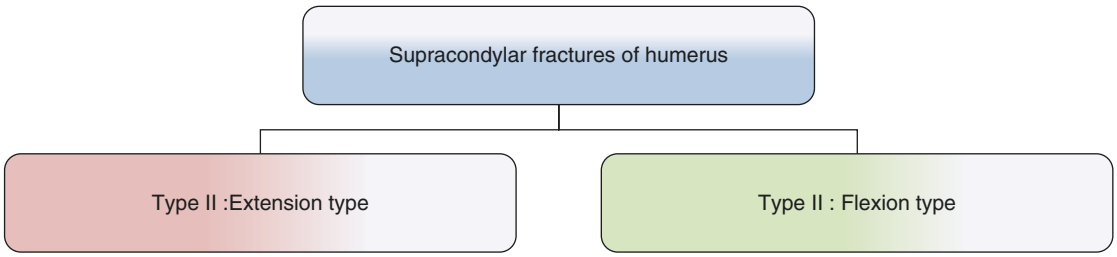
Type C: Complete articular fracture (13-C)

C3: Articular, metaphyseal multifragmentary (13-C3)

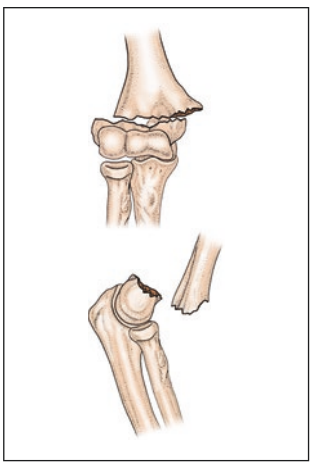
C3.3: Metaphyseal complex (13-C3.3)

2.3.3 Classification According to Anatomic Location

2.3.3.1 Supracondylar Fractures of Humerus

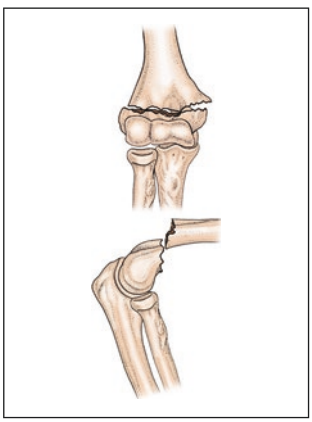


Type I: Extension type.
Type II: Flexion type.



Supracondylar fractures of humerus

Extension type



Supracondylar fractures of humerus

Flexion type

Gartland Classification System (in 1959) [8]

Extension-type supracondylar fractures may be further classified into three types according to the Gartland classification system:

TypeI: An undisplaced fracture.

Type II: A displaced fracture with an intact posterior periosteum, posterior displacement of the distal fracture fragment.

Type III: A displaced fracture with disrupted anterior and posterior periosteum, no continuity between the proximal and distal fracture fragments.

Pirone Modified Classification (in 1988) [9]

Pirone et al. modified Gartland classification, with type II divided into two subtypes:

Type IIa: Simple fracture with the distal fragment inclining posteriorly, and the posterior cortex bone integrated.

Type IIb: Fracture fragments laterally displaced, or with the distal fragment linking, and the broken ends of fractured bone still contact.

Mcintyre Classification (In 1994) [10]

Mcintyre supplemented to the traditional three-type classification with every type divided into two subtypes:

Type Ia: Bone fracture fragments undisplaced, the distal fragment has a posterior inclination less than 5°.

Type Ib: Bone fracture fragments undisplaced, the posterior inclination of the distal fragment ≤15–20°, medial (lateral) separation ≤1 mm.

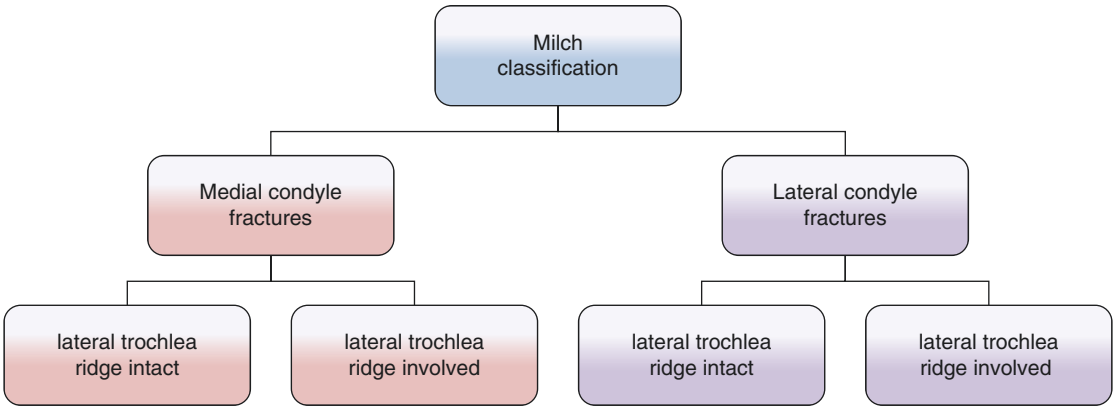
Type IIa: Fracture displaced 0–2 mm, the posterior inclination of the distal fragment ≤15–20°, separation at fracture site or compression distance of medial (lateral) cortex bone >1 mm.

Type IIb: Fracture displaced 2–15 mm, the broken ends of fractured bone still contact, different extent of fragment inclination.

Type IIIa: The broken ends no contact, overlap ≤20 mm or rotation >15 mm, the broken ends still contact, different extent of fragment inclination.

Type IIIb: Long distance between the broken ends or overlap >20 mm, or rotation >15 mm, with the broken ends no contact, different extent of fragment inclination.

2.3.3.2 Milch Classification of Humeral Condyle Fractures [11]



Humeral condyle fractures are divided into medial condyle fractures and lateral condyle fractures according to Milch classification, further divided into subtype depending on whether or not the lateral trochlea ridge is involved.

Medial condyle fractures:

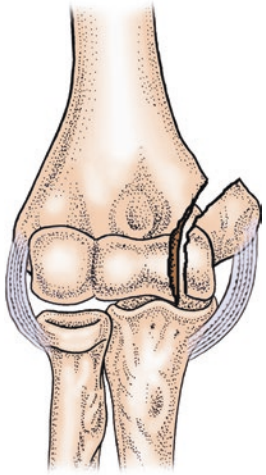
Type I: Lateral trochlea ridge intact.

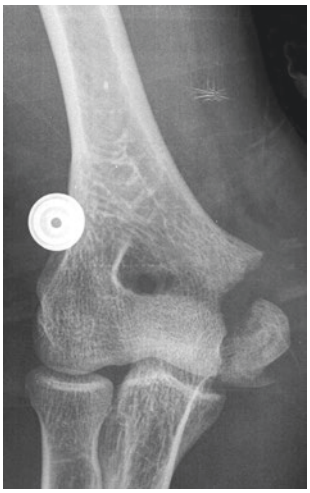
Type II: Lateral trochlea ridge involved.

Lateral condyle fractures:

Type I: Lateral trochlea ridge intact.

Type II: Lateral trochlea ridge involved.

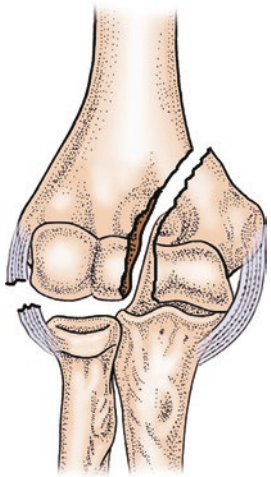




Milch classification

Medial condyle fractures

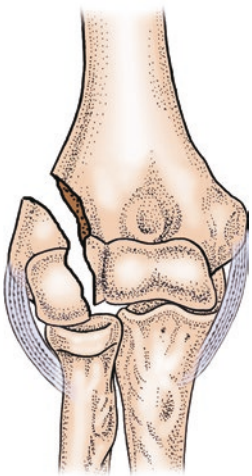
Type I: Lateral trochlea ridge intact



Milch classification

Medial condyle fractures

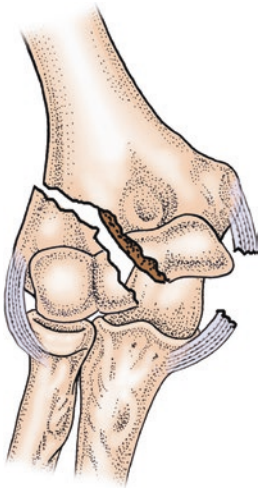
Type II: Lateral trochlea ridge involved



Milch classification

Lateral condyle fractures

Type I: Lateral trochlea ridge intact



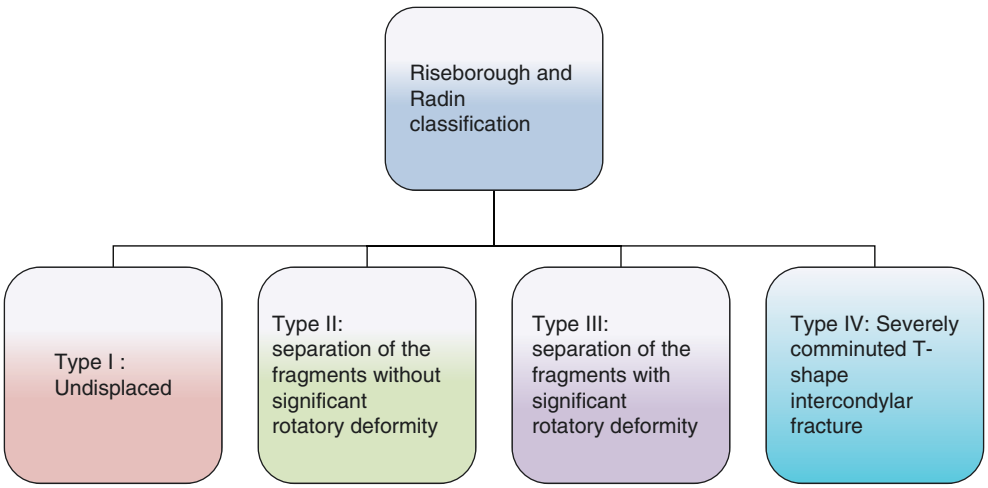
Milch classification

Lateral condyle fractures

Type II: Lateral trochlea ridge involved

2.3.3.3 Classification of Intercondylar Fractures of Humerus

Riseborough and Radin Classification [12]

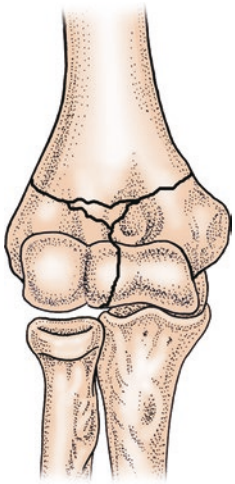


Type I: Undisplaced T-shaped intercondylar fracture.

Type II: T-shaped intercondylar fracture with separation of the fragments but without significant rotatory deformity.

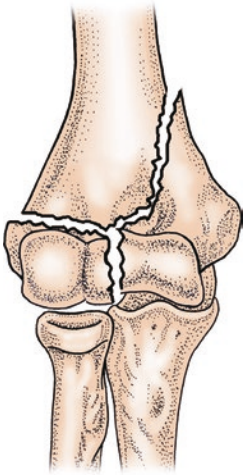
Type III: T-shaped intercondylar fracture with separation of the fragments with significant rotatory deformity.

Type IV: Severely comminuted T-shape intercondylar fracture of the humerus.



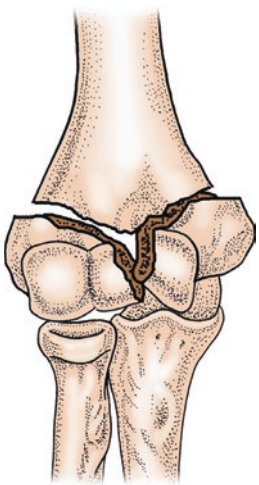
Riseborough and Radin classification

Type I: Undisplaced T-shaped intercondylar fracture



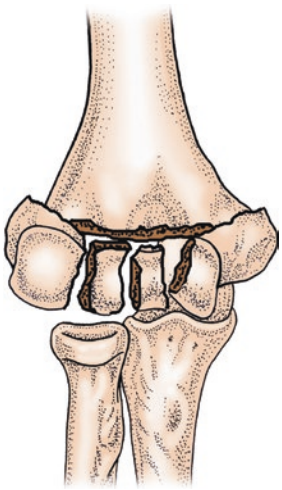
Riseborough and Radin classification

Type II: T-shaped intercondylar fracture with separation of the fragments but without significant rotatory deformity



Riseborough and Radin classification

Type III: T-shaped intercondylar fracture with separation of the fragments with significant rotatory deformity



Riseborough and Radin classification

Type IV: Severely comminuted T-shape intercondylar fracture of the humerus

Men Zhenwu-Yong Yimin Classification [13]

Intercondylar fractures of the humerus are divided into two types according to the injury mechanism and direction of fracture displacement: extension introversion or flexion introversion.

Type A: Extension introversion.

The elbow is injured in an extension position, with an evident stress on elbow introversion. Fracture fragments are displaced medially and posteriorly. This type can be further divided into three degrees of injury depending on the severity of the injury.

I°: Equivalent to C1 in the AO classification; the fracture lines lie medially and extend proximally and medially, with the medial epicondyle and bone proximal to the medial epicondyle intact.

II°: More stress on elbow introversion; a wedge bone fragment exists in the medial proximal site of the fracture, which is not completely separated from the medial periosteum of the distal humerus.

III°: Most stress on elbow introversion; the medial wedge-shaped fragment is completely separated.

Type B: Flexion introversion

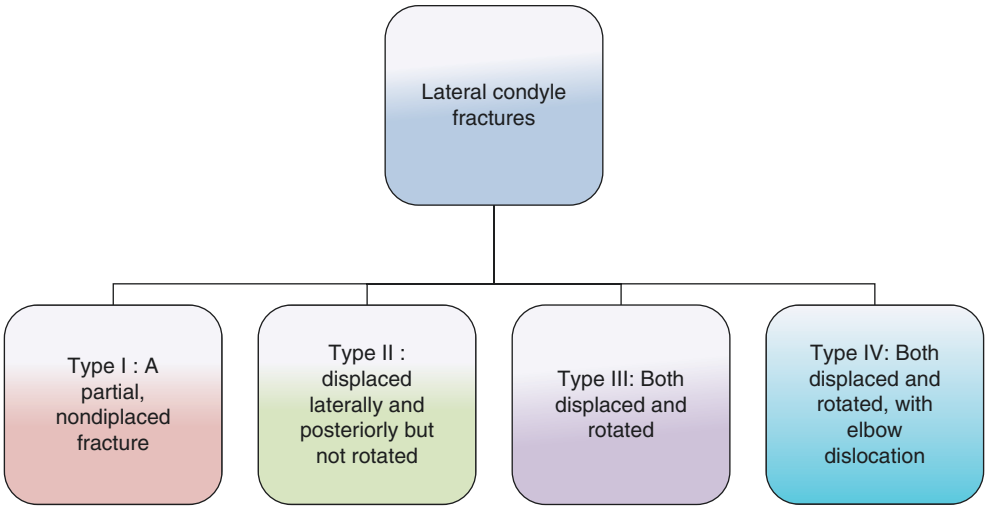
The elbow is injured in a flexion position, with an evident stress on elbow introversion. This type can be further divided into three degrees of injury depending on the severity of the injury.

I°: A typical T-shaped fracture with the elbow injured in a flexion position. Under the combination of flexion stress and introversion stress, a fracture similar to I° of the extension introversion type appears, except for an anterior displacement of the fragment.

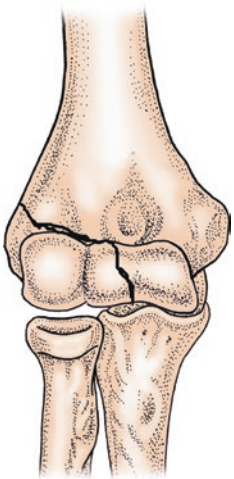
II°: Under the combination of flexion stress and introversion stress, a fracture similar to II° of the extension introversion type appears, except for an anterior displacement of the fragment.

III°: The injury stress is similar to that of III° of the extension introversion type; however, the medial wedge-shaped fragment is not as typical as that in the extension type and lies in the anterior site of the elbow joint.

2.3.3.4 Lateral Condyle Fractures of Humerus

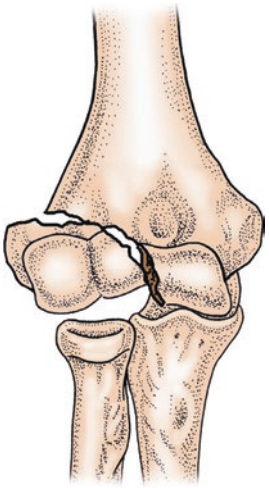


Type I: A partial, non-displaced fracture that does not traverse the entire cartilaginous epiphysis.
Type II: A complete fracture that extends through the articular surface and may be displaced laterally and posteriorly but not rotated.
Type III: Both displaced and rotated, with loss of the normal relationship of the capitellum to the proximal radius.
Type IV: Both displaced and rotated, with elbow dislocation.



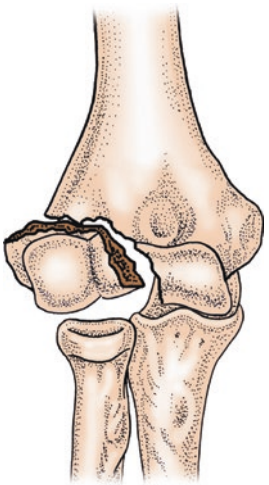
Lateral condyle fractures of humerus

Type I: A partial, non-displaced fracture



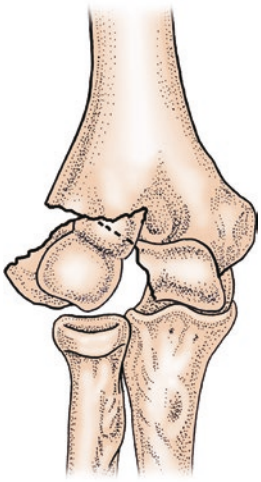
Lateral condyle fractures of humerus

Type II: Displaced laterally and posteriorly but not rotated



Lateral condyle fractures of humerus

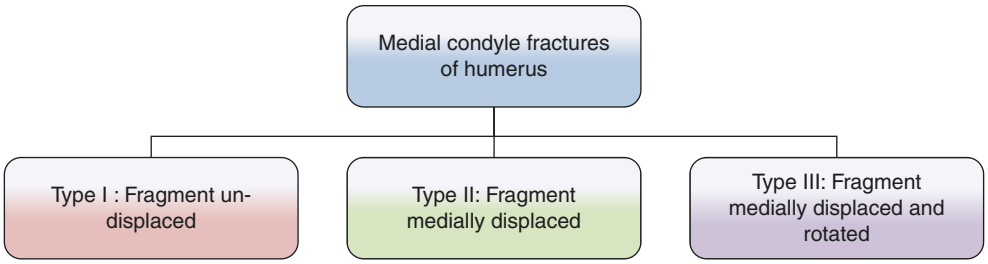
Type III: Both displaced and rotated



Lateral condyle fractures of humerus

Type IV: Both displaced and rotated, with elbow dislocation

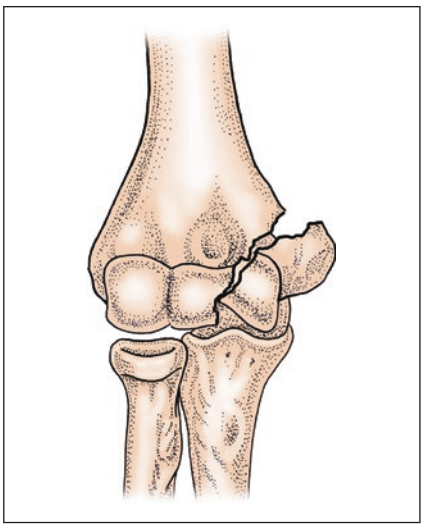
2.3.3.5 Medial Condyle Fractures of Humerus



Type I: Fragment undisplaced, with the fracture line starting from proximal position of medial epicondyle towards distally and laterally ended in trochlea articular surface.

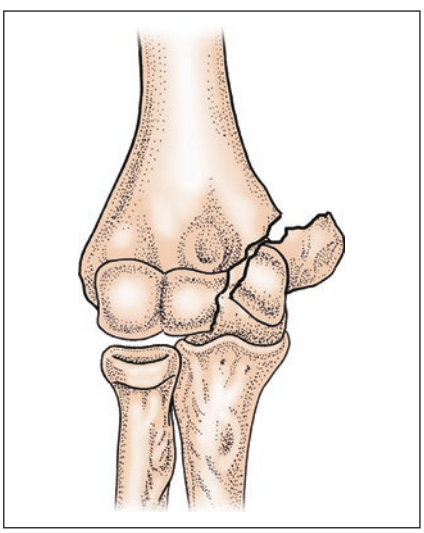
Type II: Fracture line similar to type I, fragment medially displaced or mildly proximally displaced, without rotation.

Type III: The same fracture line with type II, fragment medially or anteriorly displaced and rotated.



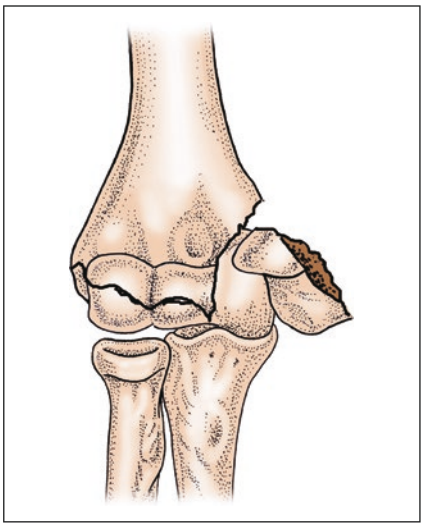
Medial condyle fractures of humerus

Type I: Fragment undisplaced, with the fracture line starting from proximal position of medial epicondyle towards distally and laterally ended in trochlea articular surface



Medial condyle fractures of humerus

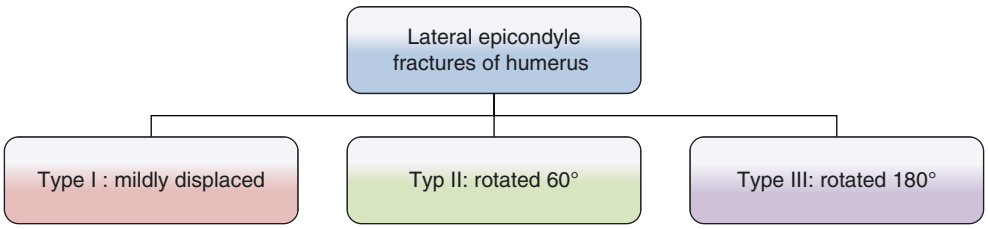
Type II: Fracture line similar to type I, fragment medially displaced or mildly proximally displaced, without rotation



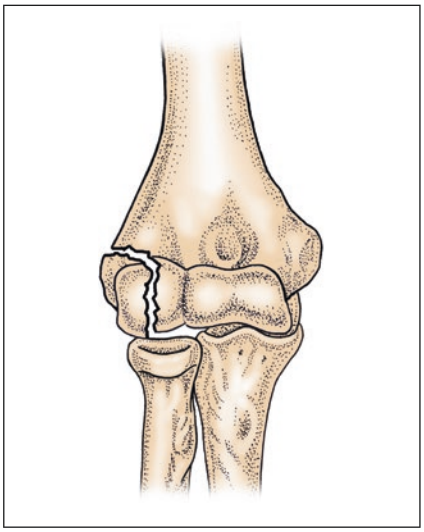
Medial condyle fractures of humerus

Type III: The same fracture line with type II, fragment medially or anteriorly displaced and rotated

2.3.3.6 Lateral Epicondyle Fractures of Humerus

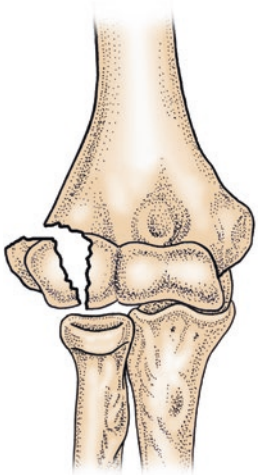


The fracture fragment could be mildly displaced, or rotated 60°–180°.



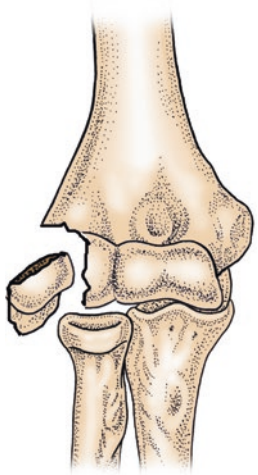
Lateral epicondyle fractures of humerus

Type I: Mildly displaced



Lateral epicondyle fractures of humerus

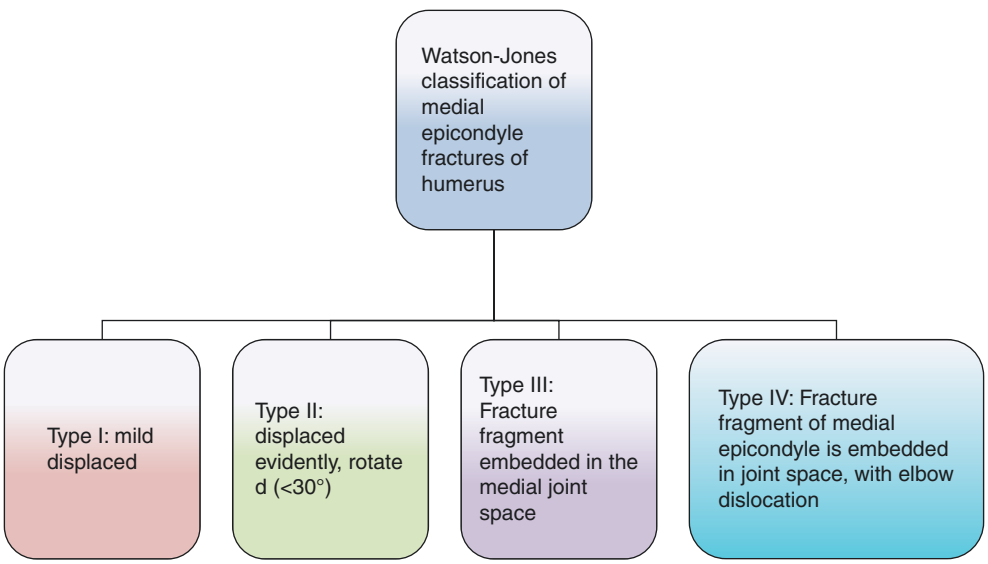
Type II: Rotated 60°



Lateral epicondyle fractures of humerus

Type III: Rotated 180°

2.3.3.7 Watson-Jones Classification of Medial Epicondyle Fractures of Humerus [14]

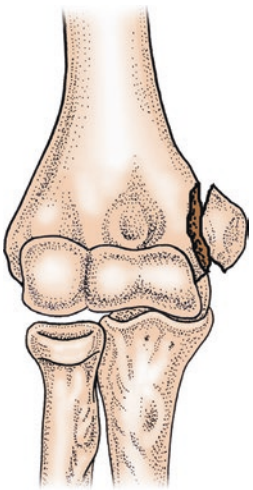


Type I: Fracture fragment of medial epicondyle mildly displaced.

Type II: Fracture fragment of medial epicondyle displaced evidently under traction, can reach the medial joint space, can be rotated (<30°).

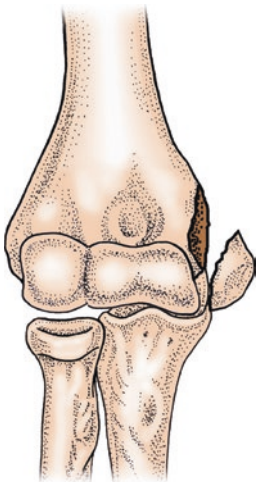
Type III: Fracture fragment of medial epicondyle is embedded in the medial joint space, with elbow subluxation.

Type IV: Fracture fragment of medial epicondyle is embedded in joint space, with elbow dislocation.



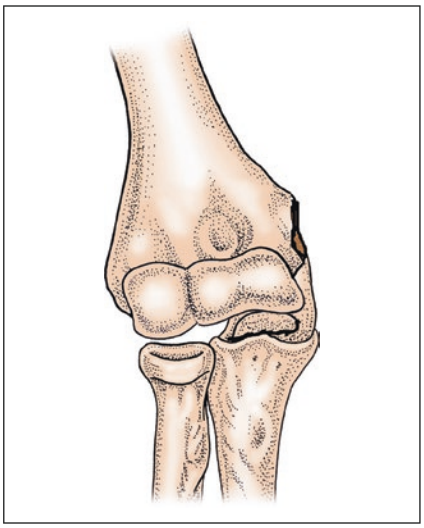
Watson-Jones classification of medial epicondyle fractures of humerus

Type I: Fracture fragment of medial epicondyle mildly displaced



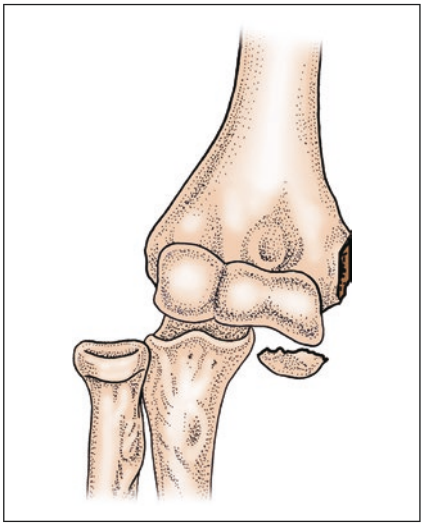
Watson-Jones classification of medial epicondyle fractures of humerus

Type II: Fracture fragment of medial epicondyle displaced evidently under traction, can reach the medial joint space, can be rotated (<30°)



Watson-Jones classification of medial epicondyle fractures of humerus

Type III: Fracture fragment of medial epicondyle is embedded in the medial joint space, with elbow subluxation

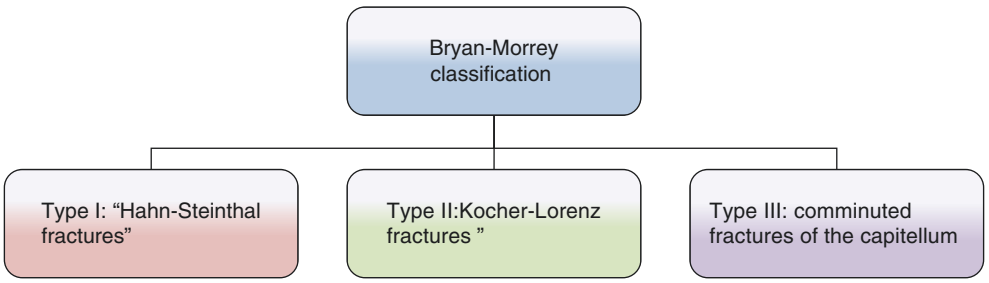


Watson-Jones classification of medial epicondyle fractures of humerus

Type IV: Fracture fragment of medial epicondyle is embedded in joint space, with elbow dislocation

2.3.3.8 Classification of Capitellar Fractures

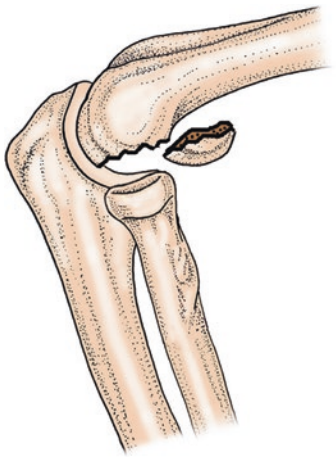
Bryan-Morrey Classification [15]



Type I: "Hahn-Steinthal fractures", involve the entire capitellum and lateral trochlear ridge.

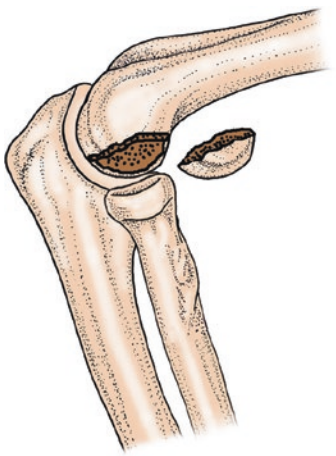
Type II: "Kocher-Lorenz fractures", involve only the articular surface of the capitellum with subchondral bone. Sometimes a very small fragment is difficult to be detected in radiograph.

Type III: Comminuted fractures of the capitellum.



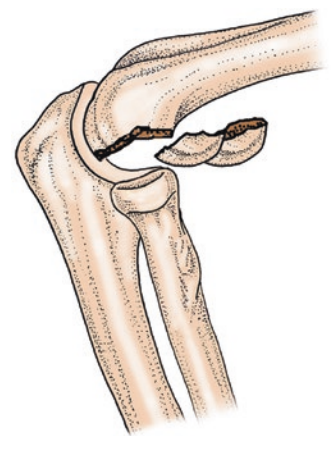
Bryan-Morrey classification

Type I: “Hahn-Steinthal fractures”, involve the entire capitellum and lateral trochlear ridge



Bryan-Morrey classification

Type II: “Kocher-Lorenz fractures”, involve only the articular surface of the capitellum with subchondral bone. Sometimes a very small fragment is difficult to be detected in radiograph



Bryan-Morrey classification

Type III: Comminuted fractures of the capitellum

Wang Chengwu Classification [13]

Type I: Complete fracture, with the fracture fragments involving the capitellum and partial trochlea.

Type II: Isolated complete fracture of the capitellum, which is sometimes difficult to detect because of the very small fracture fragments.

Type III: Cartilage shearing injury in the coronal plane of the capitellum.

2.3.4 Ring Classification [16]

Ring et al. identified five patterns of simple shearing injury of the distal humeral articular surface, on the basis of radiographs and operative findings.

Type I: A single articular fragment including the capitellum and the lateral portion of the trochlea.

Type II: A type I fracture (occasionally comminuted) with an associated fracture of the lateral epicondyle.

Type III: A type II fracture with impaction of the metaphyseal bone behind the capitellum in the distal and posterior aspect of the lateral column.

Type IV: A type III fracture with a fracture of the posterior aspect of the trochlea.

Type V: A type IV fracture with fracture of the medial epicondyle.

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