Müller AO Classification of Fractures—Long Bones

This leaflet is designed to provide an introduction to the classification of long-bone fractures.
**Humerus**

11 proximal (types according to topography and extent of bone lesion)

- **11-A** extraarticular unifocal fracture
  - 11-A1 tuberosity
  - 11-A2 impacted metaphyseal
  - 11-A3 nonimpacted metaphyseal

- **11-B** extraarticular bifocal fracture
  - 11-B1 with metaphyseal impaction
  - 11-B2 without metaphyseal impaction
  - 11-B3 with glenohumeral dislocation

- **11-C** articular fracture
  - 11-C1 with slight displacement
  - 11-C2 impacted with marked displacement
  - 11-C3 dislocated

12 diaphyseal

- **12-A** simple fracture
  - 12-A1 spiral
  - 12-A2 oblique (≥ 30°)
  - 12-A3 transverse (< 30°)

- **12-B** wedge fracture
  - 12-B1 spiral wedge
  - 12-B2 bending wedge
  - 12-B3 fragmented wedge

- **12-C** complex fracture
  - 12-C1 spiral
  - 12-C2 segmental
  - 12-C3 irregular

13 distal

- **13-A** extraarticular fracture
  - 13-A1 apophyseal avulsion
  - 13-A2 metaphyseal simple
  - 13-A3 metaphyseal multifragmentary

- **13-B** partial articular fracture
  - 13-B1 sagittal lateral condyle
  - 13-B2 sagittal medial condyle
  - 13-B3 coronal

- **13-C** complete articular fracture
  - 13-C1 articular simple, metaphyseal simple
  - 13-C2 articular simple, metaphyseal multifragmentary
  - 13-C3 articular multifragmentary
21 proximal

21-A extraarticular fracture
- 21-A1 ulna fractured, radius intact
- 21-A2 radius fractured, ulna intact
- 21-A3 both bones

21-B articular fracture
- 21-B1 ulna fractured, radius intact
- 21-B2 radius fractured, ulna intact
- 21-B3 one bone articular fracture, other extraarticular

21-C articular fracture of both bones
- 21-C1 simple
- 21-C2 one artic. simple, other artic. multifragmentary
- 21-C3 multifragmentary

22 diaphyseal

22-A simple fracture
- 22-A1 ulna fractured, radius intact
- 22-A2 radius fractured, ulna intact
- 22-A3 both bones

22-B wedge fracture
- 22-B1 ulna fractured, radius intact
- 22-B2 radius fractured, ulna intact
- 22-B3 one bone wedge, other simple or wedge

22-C complex fracture
- 22-C1 ulna complex, radius simple
- 22-C2 radius complex, ulna simple
- 22-C3 both bones complex

23 distal

23-A extraarticular fracture
- 23-A1 ulna fractured, radius intact
- 23-A2 radius, simple and impacted
- 23-A3 radius, multifragmentary

23-B partial articular fracture of radius
- 23-B1 sagittal
- 23-B2 coronal, dorsal rim
- 23-B3 coronal, palmar rim

23-C complete articular fracture of radius
- 23-C1 articular simple, metaphyseal simple
- 23-C2 articular simple, metaphyseal multifragmentary
- 23-C3 articular multifragmentary
**31 proximal** (defined by a line passing transversely through the lower end of the lesser trochanter)

31-A extraarticular fracture, trochanteric area
- 31-A1 pertrochanteric simple
- 31-A2 pertrochanteric multifragmentary
- 31-A3 intertrochanteric

31-B extraarticular fracture, neck
- 31-B1 subcapital, with slight displacement
- 31-B2 transcervical
- 31-B3 subcapital, displaced, nonimpacted

31-C articular fracture, head
- 31-C1 split (Pipkin)
- 31-C2 with depression
- 31-C3 with neck fracture

**32 diaphyseal**

32-A simple fracture
- 32-A1 spiral
- 32-A2 oblique ($>30^\circ$)
- 32-A3 transverse ($<30^\circ$)
- 32-A(1–3).1 = subtrochanteric fracture

32-B wedge fracture
- 32-B1 spiral wedge
- 32-B2 bending wedge
- 32-B3 fragmented wedge
- 32-B(1–3).1 = subtrochanteric fracture

32-C complex fracture
- 32-C1 spiral
- 32-C2 segmental
- 32-C3 irregular
- 32-C(1–3).1 = subtrochanteric fracture

**33 distal**

33-A extraarticular fracture
- 33-A1 simple
- 33-A2 metaphyseal wedge and/or fragmented wedge
- 33-A3 metaphyseal complex

33-B partial articular fracture
- 33-B1 lateral condyle, sagittal
- 33-B2 medial condyle, sagittal
- 33-B3 coronal

33-C complete articular fracture
- 33-C1 articular simple, metaphyseal simple
- 33-C2 articular simple, metaphyseal multifragmentary
- 33-C3 articular multifragmentary
Tibia/fibula

41 proximal

41-A extraarticular fracture
- 41-A1 avulsion
- 41-A2 metaphyseal simple
- 41-A3 metaphyseal multifragmentary

41-B partial articular fracture
- 41-B1 pure split
- 41-B2 pure depression
- 41-B3 split-depression

41-C complete articular fracture
- 41-C1 articular simple, metaphyseal simple
- 41-C2 articular simple, metaphyseal multifragmentary
- 41-C3 articular multifragmentary

42 diaphyseal

42-A simple fracture
- 42-A1 spiral
- 42-A2 oblique ($\geq 30^\circ$)
- 42-A3 transverse (< 30°)

42-B wedge fracture
- 42-B1 spiral wedge
- 42-B2 bending wedge
- 42-B3 fragmented wedge

42-C complex fracture
- 42-C1 spiral
- 42-C2 segmental
- 42-C3 irregular

43 distal

43-A extraarticular fracture
- 43-A1 simple
- 43-A2 wedge
- 43-A3 complex

43-B partial articular fracture
- 43-B1 pure split
- 43-B2 split-depression
- 43-B3 multifragmentary depression

43-C complete articular fracture
- 43-C1 articular simple, metaphyseal simple
- 43-C2 articular simple, metaphyseal multifragmentary
- 43-C3 articular multifragmentary
44 malleolar

44-A infrasyndesmotic lesion
44-A1 isolated
44-A2 with fractured medial malleolus
44-A3 with posteromedial fracture

44-B transsyndesmotic fibular fracture
44-B1 isolated
44-B2 with medial lesion
44-B3 with medial lesion and Volkmann's fracture

44-C suprasyndesmotic lesion
44-C1 fibular diaphyseal fracture, simple
44-C2 fibular diaphyseal fracture, multifragmentary
44-C3 proximal fibular lesion
AO/OTA system for numbering the anatomical location of a fracture in three bone segments (proximal = 1, diaphyseal = 2, distal = 3)

Anatomical location of the fracture. Anatomical location is designated by two numbers: one for the bone and one for its segment (ulna and radius as well as tibia and fibula are regarded as one bone). The malleolar segment (44-) is an exception. The proximal and distal segments of long bones are defined by a square the sides of which have the same length as the widest part of the epiphysis (exceptions 31- and 44-).
### Definitions of fracture types for long-bone fractures in adults

Exception to this are fractures of the proximal humerus (11-), proximal femur (31-), malleoli (44-), subtrochanteric fractures (32-)

<table>
<thead>
<tr>
<th>Segment</th>
<th>Type</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Proximal</td>
<td></td>
<td><img src="image1" alt="Extraarticular" /></td>
<td><img src="image2" alt="Partial articular" /></td>
<td><img src="image3" alt="Complete articular" /></td>
</tr>
<tr>
<td></td>
<td>Extraarticular</td>
<td>No involvement of displaced fractures that extend into the articular surface</td>
<td>Part of the articular component is involved, leaving the other part attached to the meta-/diaphysis</td>
<td>Articular surface involved, metaphyseal fracture completely separates the articular component from the diaphysis</td>
</tr>
<tr>
<td></td>
<td>Partial articular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete articular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Diaphyseal</td>
<td></td>
<td><img src="image4" alt="Simple" /></td>
<td><img src="image5" alt="Wedge" /></td>
<td><img src="image6" alt="Complex" /></td>
</tr>
<tr>
<td></td>
<td>Simple</td>
<td>One fracture line, cortical contact between fragments exceeds 90% after reduction</td>
<td>Three or more fragments, main fragments have contact after reduction</td>
<td>Three or more fragments, main fragments have no contact after reduction</td>
</tr>
<tr>
<td>3 Distal</td>
<td></td>
<td><img src="image7" alt="Extraarticular" /></td>
<td><img src="image8" alt="Partial articular" /></td>
<td><img src="image9" alt="Complete articular" /></td>
</tr>
<tr>
<td></td>
<td>Extraarticular</td>
<td>No involvement of displaced fractures that extend into the articular surface</td>
<td>Part of the articular component is involved, leaving the other part attached to the meta-/diaphysis</td>
<td>Articular surface involved, metaphyseal fracture completely separates the articular component from the diaphysis</td>
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### Steps in identifying diaphyseal fractures

<table>
<thead>
<tr>
<th>Step</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Which bone?</td>
<td>Specific bone (X)</td>
</tr>
<tr>
<td>2</td>
<td>Is the fracture at the end or in the middle segment of the bone?</td>
<td>Middle segment (X2)</td>
</tr>
</tbody>
</table>
| 3    | Type: Is the fracture a simple or multifragmentary one (does it have >2 parts)? | Simple (X2-A)  
(If it is multifragmentary, go to step 3a) |
| 3a   | Is there contact between both fracture ends or not? | If there is contact, it is a wedge (X2-B)  
(If there is no contact, it is complex (X2-C)) |
| 4    | Group: Is the fracture pattern caused by a twisting (spiral) or bending force? | Spiral or twisting forces will result in a simple spiral (X2-A1), a spiral wedge (X2-B1), or a spiral fragmented complex fracture (X2-C1)  
Bending forces produce simple oblique (X2-A2), simple transverse (X2-A3), bending wedge (X2-B2), fragmented wedge (X2-B3), or complex (X2-C3) fractures  
C2 fractures are segmental by definition |

### Classification of fractures of the diaphysis into the three fracture groups

<table>
<thead>
<tr>
<th>Type</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>Simple</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Wedge</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Complex</td>
</tr>
</tbody>
</table>

- **Spiral**
- **Oblique**
- **Transverse**
- **Bending**
- **Multifragmentary**
- **Segmental**
- **Irregular**
## Steps in identifying end segment fractures

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<tr>
<th>Step</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Which bone?</td>
<td>Specific bone (X)</td>
</tr>
<tr>
<td>2</td>
<td>Is the fracture at the end or in the middle segment of the bone?</td>
<td>End segment</td>
</tr>
<tr>
<td>3</td>
<td>Is the fracture through the proximal or distal end segment?</td>
<td>Proximal (X1) Distal (X3)</td>
</tr>
<tr>
<td>4a</td>
<td>Type: Does the fracture enter the articular surface?</td>
<td>If it does not enter, it is extraarticular (XX-A), go to step 6 If it enters, it is articular, go to step 4b</td>
</tr>
<tr>
<td>4b</td>
<td>Type: Is it partial or total articular?</td>
<td>If part of the joint is still attached to the meta-/diaphysis, it is partial articular (XX-B) If it is not attached to the diaphysis, it is complete articular (XX-C)</td>
</tr>
<tr>
<td>5</td>
<td>Group: How many fracture lines cross the joint surface?</td>
<td>If there is one line, it is simple If there are &gt;2 lines, it is multifragmentary</td>
</tr>
<tr>
<td>6</td>
<td>Group: How is the metaphysis fractured?</td>
<td>Simple: extraarticular (XX-A1), or simple articular (XX-C1) Wedge: extraarticular (XX-A2) Complex: extraarticular (XX-A3), or simple articular (XX-C2), or complex articular (XX-C3)</td>
</tr>
</tbody>
</table>

## Classification of fractures of the end segment into the three fracture groups

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<tbody>
<tr>
<td><strong>A</strong> Extraarticular</td>
<td></td>
</tr>
<tr>
<td>Simple</td>
<td>Wedge</td>
</tr>
<tr>
<td><strong>B</strong> Partial articular</td>
<td></td>
</tr>
<tr>
<td>Split</td>
<td>Depression</td>
</tr>
<tr>
<td><strong>C</strong> Articular</td>
<td></td>
</tr>
<tr>
<td>Simple articular, simple metaphyseal</td>
<td>Simple articular, complex metaphyseal</td>
</tr>
</tbody>
</table>