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
Radius/ulna

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°)
- 32-A3 transverse (<30°)
- 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
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 (≥ 30°)
- 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>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Proximal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Extraarticular&lt;br&gt;No involvement of displaced fractures that extend into the articular surface</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Partial articular&lt;br&gt;Part of the articular component is involved, leaving the other part attached to the meta-/diaphysis</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Complete articular&lt;br&gt;Articular surface involved, metaphyseal fracture completely separates the articular component from the diaphysis</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>2 Diaphyseal</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Simple&lt;br&gt;One fracture line, cortical contact between fragments exceeds 90% after reduction</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Wedge&lt;br&gt;Three or more fragments, main fragments have contact after reduction</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Complex&lt;br&gt;Three or more fragments, main fragments have no contact after reduction</td>
</tr>
<tr>
<td></td>
<td><strong>3 Distal</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Extraarticular&lt;br&gt;No involvement of displaced fractures that extend into the articular surface</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Partial articular&lt;br&gt;Part of the articular component is involved, leaving the other part attached to the meta-/diaphysis</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Complete articular&lt;br&gt;Articular surface involved, metaphyseal fracture completely separates the articular component from the diaphysis</td>
</tr>
</tbody>
</table>
### 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>
<tr>
<td>3</td>
<td>Type: Is the fracture a simple or multifragmentary one (does it have &gt;2 parts)?</td>
<td>Simple (X2-A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If it is multifragmentary, go to step 3a</td>
</tr>
<tr>
<td>3a</td>
<td>Is there contact between both fracture ends or not?</td>
<td>If there is contact, it is a wedge (X2-B)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If there is no contact, it is complex (X2-C)</td>
</tr>
<tr>
<td>4</td>
<td>Group: Is the fracture pattern caused by a twisting (spiral) or bending force?</td>
<td>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)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bending forces produce simple oblique (X2-A2), simple transverse (X2-A3), bending wedge (X2-B2), fragmented wedge (X2-B3), or complex (X2-C3) fractures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2 fractures are segmental by definition</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Simple</td>
<td>Spiral</td>
<td>Oblique</td>
<td>Transverse</td>
</tr>
<tr>
<td>B</td>
<td>Wedge</td>
<td>Spiral</td>
<td>Bending</td>
<td>Multifragmentary</td>
</tr>
<tr>
<td>C</td>
<td>Complex</td>
<td>Spiral</td>
<td>Segmental</td>
<td>Irregular</td>
</tr>
</tbody>
</table>
## Steps in identifying end segment 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>End segment</td>
</tr>
<tr>
<td>3</td>
<td>Is the fracture through the proximal or distal end segment?</td>
<td>Proximal (X1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If there are ≥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)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wedge: extraarticular (XX-A2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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

### Type Group

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

### Type Group

<table>
<thead>
<tr>
<th>B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial articular</td>
<td></td>
</tr>
<tr>
<td>Simple</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td></td>
</tr>
<tr>
<td>Split-depression</td>
<td></td>
</tr>
</tbody>
</table>

### Type Group

<table>
<thead>
<tr>
<th>C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Articular</td>
<td></td>
</tr>
<tr>
<td>Simple articular, simple metaphyseal</td>
<td></td>
</tr>
<tr>
<td>Simple articular, complex metaphyseal</td>
<td></td>
</tr>
<tr>
<td>Complex articular, complex metaphyseal</td>
<td></td>
</tr>
</tbody>
</table>