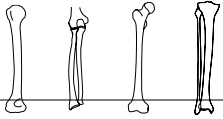




"A classification is useful only if it considers the severity of the bone lesion and serves as a basis for treatment and for evaluation of the results."

Maurice E. Müller, 1988



Müller AO Classification of Fractures

Long Bones

This leaflet is designed to provide an accessible and straightforward introduction to making an initial classification of long-bone fractures. For more detailed treatment of the subject it is advisable to consult the references from the attached list.

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Müller AO Classification of Fractures

The concept

When the long-bone classification was first published [1] the observer was offered a choice from a progressive sequence of 3 options, relative to each of three bone segments, to establish the TYPE, GROUP, and SUBGROUP of the fracture. Müller et al. have since introduced the binary concept, where each question has two alternative answers. Thus, while retaining the triad-based concept, it is ultimately possible to arrive precisely at one of two conclusions, either the correct diagnosis or the realization that more information is needed [2, 3, 4].

The Müller concept goes beyond the mere production of an alpha-numeric coding, valuable though that is in the acquisition, storage, and retrieval of data; what distinguishes Müller's system is that one is required to recognize, identify, and describe the injury to the bone [5].

The discipline of the alpha-numeric notation serves to guide the assessor of the fracture to whatever depth the situation requires and afterwards to record and store his observations. However, it is the surgeon's description of the fracture which is needed to permit good decision making in the light of the structured observations required by the classification protocol, and as well as to generate the code.

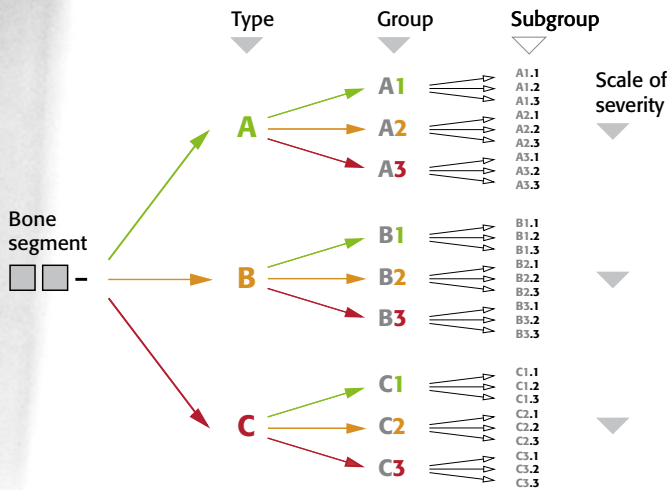
The principle

The fractures of each bone segment (see coding), according to their morphological characteristics, are divided into: types, groups, and subgroups.

Which type?... Which group?... Which subgroup?...

These three questions and the three (two with the binary system) possible answers to each are the key to the classification [6].

The scheme of the morphological characterization of the fractures:



The classification of the fractures is organized in order of **increasing severity**, according to the morphological complexity, the difficulty of treatment, and the prognosis. The colors green, orange, and red, as well as the darkening of arrows, indicate the increasing severity. A1 indicates the simplest fracture with the best prognosis and C3 the most difficult with the worst prognosis. When one has classified the fracture group, one has established its severity and thus obtained a guide to treatment. The subgroups represent three characteristic variations within the group.

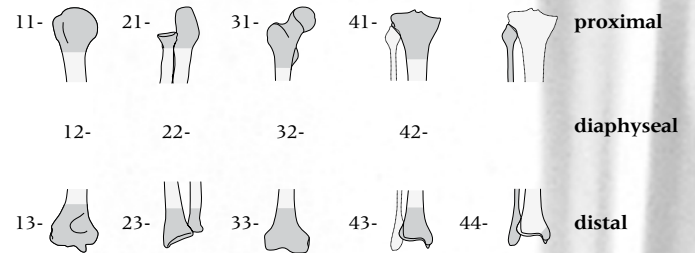
Coding of the diagnosis

To code the diagnosis of a fracture one must know its location and its morphology.

Location: *this is designated by two numbers:*

which bone? 1 humerus 2 radius/ulna 3 femur 4 tibia/fibula
 which segment? 1 proximal 2 diaphyseal 3 distal 4 malleolar

The segments of the long bones:



The **proximal** and **distal** segments of long bones are defined by a square whose sides are of the same length as the widest part of the epiphysis.

Exceptions: proximal humerus (11), proximal femur (31), and malleolar fractures (44)—q. v.

Before a fracture can be assigned to a segment, one must first determine its center. In a simple fracture, the center of the fracture is obvious. In a wedge fracture, the center is the broadest part of the wedge. In a complex fracture, the center can only be determined after reduction.

Any fracture associated with a displaced articular component is an articular fracture. If the fracture is associated only with an undisplaced fissure which reaches the joint, it is classified as metaphyseal or diaphyseal depending on where its center is.

For **coding**, the alpha-numeric format is used to conform with computing practice. The key which unlocks this fracture classification is accurate description. Each bone or bone region is numbered and the long bones are each divided into three segments.

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

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

The morphology

All fractures are either *simple* or *multifragmentary*.

simple: A term used to characterize a single circumferential disruption of a diaphysis, or metaphysis, or

a single disruption of an articular surface. Simple fractures of the diaphysis or metaphysis are spiral, oblique, or transverse.

multifragmentary: A term used to characterize any fracture with one or more completely separated intermediate fragments. In the diaphyseal and metaphyseal segments, it includes the wedge and the complex fractures.

The terms **wedge** and **complex** are used only for diaphyseal or metaphyseal fractures.

- **wedge:** A fracture with one or more intermediate fragments in which, after reduction, there is some contact between the main fragments. The spiral or bending wedge may be intact or fragmented.
- **complex:** A fracture with one or more intermediate fragments in which, after reduction, there is no contact between the main proximal and distal fragments. The complex fractures are spiral, segmented, or irregular.

The term **comminuted** is imprecise and should not be used.

impacted: A stable and usually simple fracture of the metaphysis or epiphysis in which the fragments are driven into each other.

Specific terms for the proximal and distal segments

Fractures of the proximal and distal segments are either *extra-articular* or *articular*.

extra-articular fractures: do not involve the articular surface although they may be intracapsular. They include apophyseal and metaphyseal fractures. **Articular fractures** involve the articular surface. They are subdivided into **partial** and **complete**.

partial articular fractures: involve only part of the articular surface while the rest of that surface remains attached to the diaphysis.

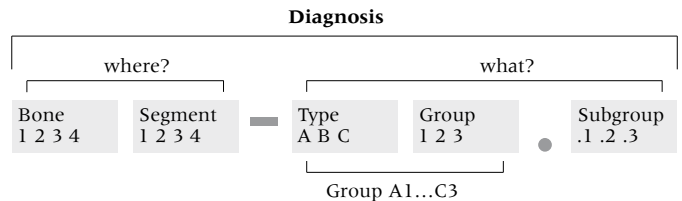
Types of partial articular fractures:

- **pure split:** A fracture, resulting from a shearing force, in which the direction of the split is usually longitudinal.
- **pure depression:** An articular fracture in which there is depression of the articular surface without a split. The depression may be central or peripheral.
- **split-depression:** A combination of a split and a depression, in which the joint fragments are usually separated.
- **multifragmentary depression:** A fracture in which part of the joint is depressed and the fragments are completely separated.

complete articular fractures: The articular surface is disrupted and completely separated from the diaphysis. The severity of these fractures depends on whether their articular and metaphyseal components are simple or multifragmentary.

The system

Alpha-numeric code of the classified diagnosis:



The wordings of the captions under the illustrations on the following pages have to be read in the order of the alpha-numeric code.

Example **32-B2.1:**

3 femur **2** diaphysis - **B** wedge fracture **2** bending wedge **.1** subtrochanteric

The essence

Müller places great emphasis on appreciating the essence of the fracture. This is the attribute which gives the fracture its particular significance and enables it to be assigned to one particular type rather than another. After this comes the process of putting into words what the surgeon understands as prime characteristics of the fracture, the challenges it brings, how it is to be managed, and what outcome may be anticipated with proper treatment [7]. The observer should express in words what he sees on the emergency x-ray and then try to match its features to a basic diagram on the leaflet. This will provide a starting point on the hierarchical path to accurate diagnosis, although for complex variations reference will be needed to the comprehensive texts listed below [8].

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5. Colton CL (1997) Fracture classification. J Bone Joint Surg [Br]; 79(5):706-707; discussion 708-709.
6. Bernstein J, Monaghan BA, Silber JS, et al. (1997) Taxonomy and treatment—a classification of fracture classifications. J Bone Joint Surg [Br]; 79(5):706-707; discussion 708-709.
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8. Müller ME (1994) CCF Comprehensive Classification of Fractures. Pamphlet I and II. Bern: M.E. Müller Foundation.

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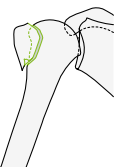
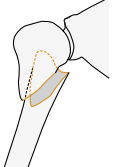
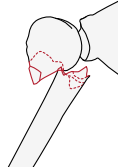






Clavadelstrasse, CH-7270 Davos Platz
phone: +41 (0)81 414 26 66
publishing@aofoundation.org
www.aopublishing.org

ISBN 3-905363-03-8

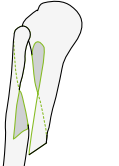








US\$ 5.-

1 Humerus

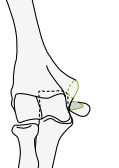






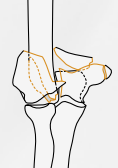

11 proximal; 3 types according to topography and extent of bony lesion

11-A1	11-A2	11-A3	11-B1	11-B2	11-B3	11-C1	11-C2	11-C3
								
11-A extra-articular unifocal fracture			11-B extra-articular bifocal fracture			11-C articular fracture		
11-A1 tuberosity 11-A2 impacted metaphyseal 11-A3 nonimpacted metaphyseal			11-B1 with metaphyseal impaction 11-B2 without metaphyseal impaction 11-B3 with glenohumeral dislocation			11-C1 with slight displacement 11-C2 impacted with marked displacement 11-C3 dislocated		

12 diaphysis

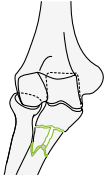
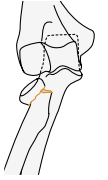

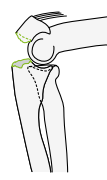
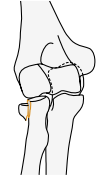
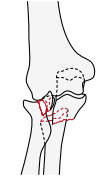


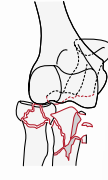
12-A1	12-A2	12-A3	12-B1	12-B2	12-B3	12-C1	12-C2	12-C3
								
12-A simple fracture			12-B wedge fracture			12-C complex fracture		
12-A1 spiral 12-A2 oblique ($\geq 30^\circ$) 12-A3 transverse ($< 30^\circ$)			12-B1 spiral wedge 12-B2 bending wedge 12-B3 fragmented wedge			12-C1 spiral 12-C2 segmental 12-C3 irregular		

13 distal










13-A1	13-A2	13-A3	13-B1	13-B2	13-B3	13-C1	13-C2	13-C3
								
13-A extra-articular fracture			13-B partial articular fracture			13-C complete articular fracture		
13-A1 apophyseal avulsion 13-A2 metaphyseal simple 13-A3 metaphyseal multifragmentary			13-B1 sagittal lateral condyle 13-B2 sagittal medial condyle 13-B3 frontal			13-C1 articular simple, metaphyseal simple 13-C2 articular simple, metaphyseal multifragmentary 13-C3 articular multifragmentary		

2 Radius / Ulna



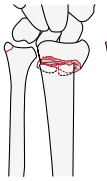

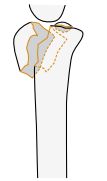
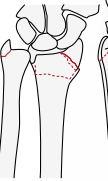



21 proximal

21-A1	21-A2	21-A3	21-B1	21-B2	21-B3	21-C1	21-C2	21-C3
								
21-A extra-articular fracture			21-B articular fracture			21-C articular fracture of both bones		
21-A1 ulna, radius intact 21-A2 radius, ulna intact 21-A3 both bones			21-B1 ulna, radius intact 21-B2 radius, ulna intact 21-B3 one bone, other extra-articular			21-C1 simple 21-C2 one artic. simple, other artic. multifragmentary 21-C3 multifragmentary		

22 diaphysis

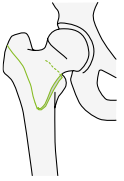
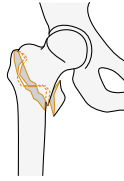

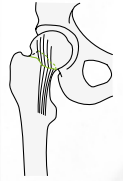




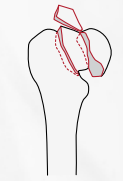
22-A1	22-A2	22-A3	22-B1	22-B2	22-B3	22-C1	22-C2	22-C3
								
22-A simple fracture			22-B wedge fracture			22-C complex fracture		
22-A1 ulna, radius intact 22-A2 radius, ulna intact 22-A3 both bones			22-B1 ulna, radius intact 22-B2 radius, ulna intact 22-B3 one bone wedge, other simple or wedge			22-C1 ulna complex, radius simple 22-C2 radius complex, ulna simple 22-C3 both bones complex		

23 distal

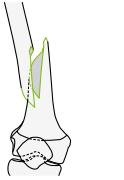

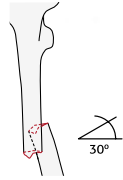
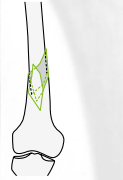
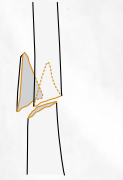
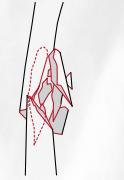
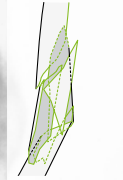
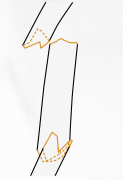

23-A1	23-A2	23-A3	23-B1	23-B2	23-B3	23-C1	23-C2	23-C3
								
23-A extra-articular fracture			23-B partial articular fracture			23-C complete articular fracture of radius		
23-A1 ulna, radius intact 23-A2 radius, simple and impacted 23-A3 radius, multifragmentary			23-B1 radius, sagittal 23-B2 radius, frontal, dorsal rim 23-B3 radius, frontal, volar rim			23-C1 articular simple, metaphyseal simple 23-C2 articular simple, metaphyseal multifragmentary 23-C3 articular multifragmentary		

3 Femur


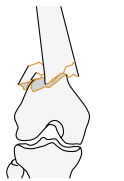
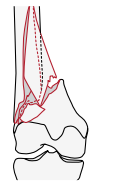

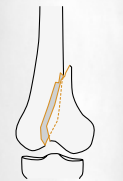


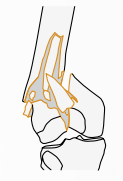

31 proximal; defined by a line passing transversely through the lower end of the lesser trochanter

31-A1	31-A2	31-A3	31-B1	31-B2	31-B3	31-C1	31-C2	31-C3
								
31-A extra-articular fracture, trochanteric area			31-B extra-articular fracture, neck			31-C articular fracture, head		
31-A1 pertrochanteric simple 31-A2 pertrochanteric multifragmentary 31-A3 intertrochanteric			31-B1 subcapital, with slight displacement 31-B2 transcervical 31-B3 subcapital, displaced, nonimpacted			31-C1 split (Pipkin) 31-C2 with depression 31-C3 with neck fracture		

32 diaphysis










32-A1	32-A2	32-A3	32-B1	32-B2	32-B3	32-C1	32-C2	32-C3
								
32-A simple fracture			32-B wedge fracture			32-C complex fracture		
32-A1 spiral 32-A2 oblique ($\geq 30^\circ$) 32-A3 transverse ($< 30^\circ$) 32-A(1-3).1 = subtrochanteric zone			32-B1 spiral wedge 32-B2 bending wedge 32-B3 fragmented wedge 32-B(1-3).1 = subtrochanteric zone			32-C1 spiral 32-C2 segmental 32-C3 irregular		

33 distal





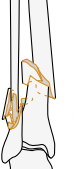



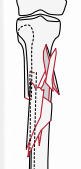
33-A1	33-A2	33-A3	33-B1	33-B2	33-B3	33-C1	33-C2	33-C3
								
33-A extra-articular fracture			33-B partial articular fracture			33-C complete articular fracture		
33-A1 simple 33-A2 metaphyseal wedge and/or fragmented wedge 33-A3 metaphyseal complex			33-B1 lateral condyle, sagittal 33-B2 medial condyle, sagittal 33-B3 frontal			33-C1 articular simple, metaphyseal simple 33-C2 art. simple, metaphyseal multifragmentary 33-C3 articular multifragmentary		

4 Tibia / Fibula



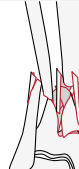






41 proximal

41-A1	41-A2	41-A3	41-B1	41-B2	41-B3	41-C1	41-C2	41-C3
								
41-A extra-articular fracture			41-B partial articular fracture			41-C complete articular fracture		
41-A1 avulsion 41-A2 metaphyseal simple 41-A3 metaphyseal multifragmentary			41-B1 pure split 41-B2 pure depression 41-B3 split-depression			41-C1 articular simple, metaphyseal simple 41-C2 artic. simple, metaphyseal multifragmentary 41-C3 articular multifragmentary		







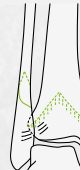


42 diaphysis

42-A1	42-A2	42-A3	42-B1	42-B2	42-B3	42-C1	42-C2	42-C3
								
42-A simple fracture			42-B wedge fracture			42-C complex fracture		
42-A1 spiral 42-A2 oblique ($\geq 30^\circ$) 42-A3 transverse ($< 30^\circ$)			42-B1 spiral wedge 42-B2 bending wedge 42-B3 fragmented wedge			42-C1 spiral 42-C2 segmental 42-C3 irregular		

43 distal

43-A1	43-A2	43-A3	43-B1	43-B2	43-B3	43-C1	43-C2	43-C3
								
43-A extra-articular fracture			43-B partial articular fracture			43-C complete articular fracture		
43-A1 simple 43-A2 wedge 43-A3 complex			43-B1 pure split 43-B2 split-depression 43-B3 multifragmentary depression			43-C1 articular simple, metaphyseal simple 43-C2 artic. simple, metaphyseal multifragmentary 43-C3 articular multifragmentary		

44 malleolar segment; based on the relationship of the lateral malleolar lesion to the syndesmotom ligament

44-A1	44-A2	44-A3	44-B1	44-B2	44-B3	44-C1	44-C2	44-C3
								
44-A infrasyndesmotom lesion			44-B transsyndesmotom fibular fracture			44-C suprasyndesmotom lesion		
44-A1 isolated 44-A2 with fractured medial malleolus 44-A3 with posteromedial fracture			44-B1 isolated 44-B2 with medial lesion 44-B3 with medial lesion and a Volkmann			44-C1 fibular diaphyseal fracture, simple 44-C2 fibular diaphyseal fracture, multifragmentary 44-C3 proximal fibular lesion		