Fracture Classifications

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Objectives

- To understand the need for classification systems
- To understand the evolution of classification systems
- To look at the importance of soft tissue injury associated with fractures

Why do we have classifications?

- **Organize knowledge**
- **Transfer information**
- **Guide treatment**
- **Estimate prognosis**
- **Enhance education and communication**

History of Classification Systems

- **Ancient Egypt**
  - **The Edwin Smith Papyrus classified injuries as:**
    - "An ailment which I will treat"
    - "An ailment with which I will contend"
    - "An ailment not to be treated"

History of Classification Systems

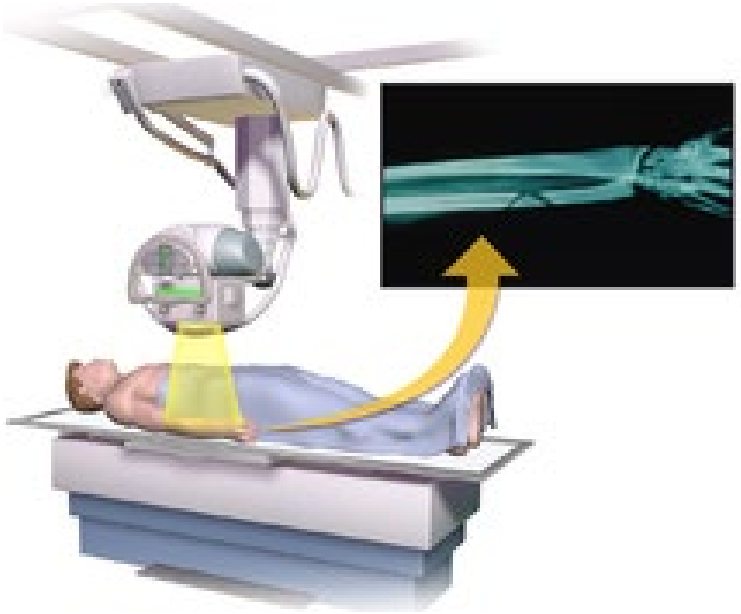
- **18th and 19th Century**

  -Descriptive classifications based on appearance of limb

“Dinner Fork Deformity”

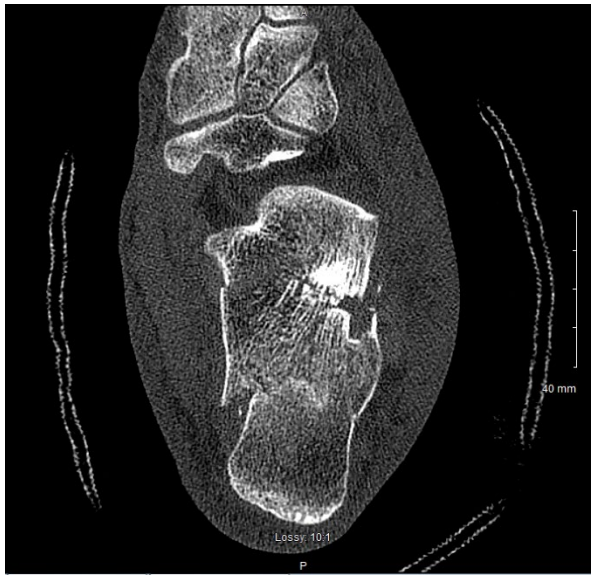
History of Classification Systems

- **20th Century**
  - **The advent of radiographs created numerous classification systems**
    - **Brought about the ability to identify location, amount, and displacement of fracture lines**
    - **Not without problems as radiographic views and quality can be inconsistent**



History of Classification Systems

- **The last 40 Years**
  - **CT has allowed for further understanding and classification of intra-articular fractures**



History of Classification Systems

- Believe it or not there's more to consider than just bones!
  - X-rays or CT alone can underestimate the severity of the overall injury and don't consider patient status

=

What makes a good classification?

- Inter-observer Reliability
  - Do different physicians agree on the classification of a particular fracture?

- Intra-observer Reproducibility
  - For a given fracture, does the same physician classify it the same way at different times?

Types of Classification Systems

- Fracture-Specific
- Universal
- Soft Tissue Injury Associated with Fracture

Examples of Fracture-Specific Descriptive Classifications

- Garden – guides management/surgical plan
- Neer – assists describing fracture for communication
- Schatzker – can predict associated injuries and prognosis
- Lauge-Hansen – provides insight into mechanism
- Sanders - an example of CT-based classification

Garden Classification

I Valgus impacted or incomplete

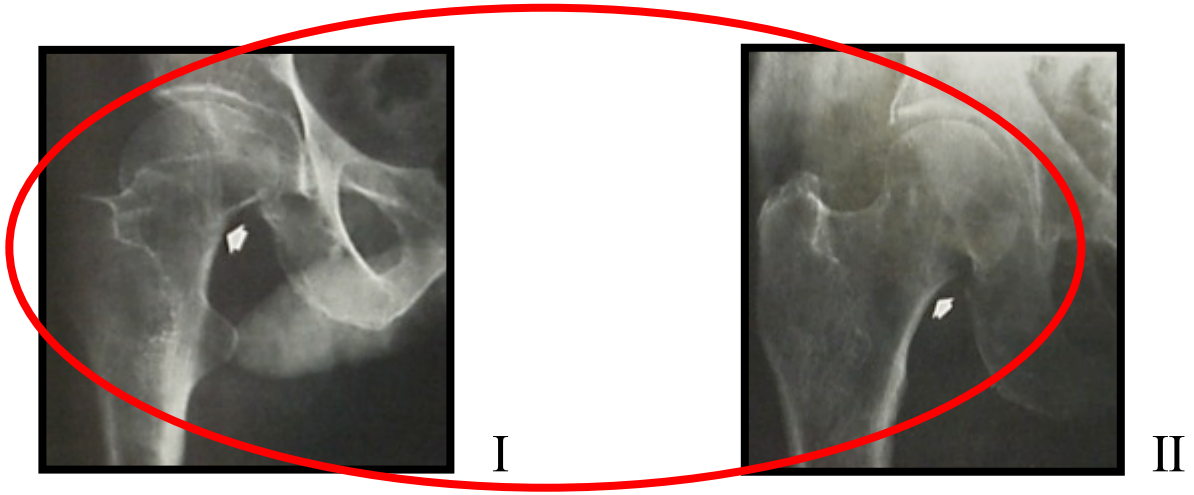
II Complete
Non-displaced

III Complete
Partial displacement

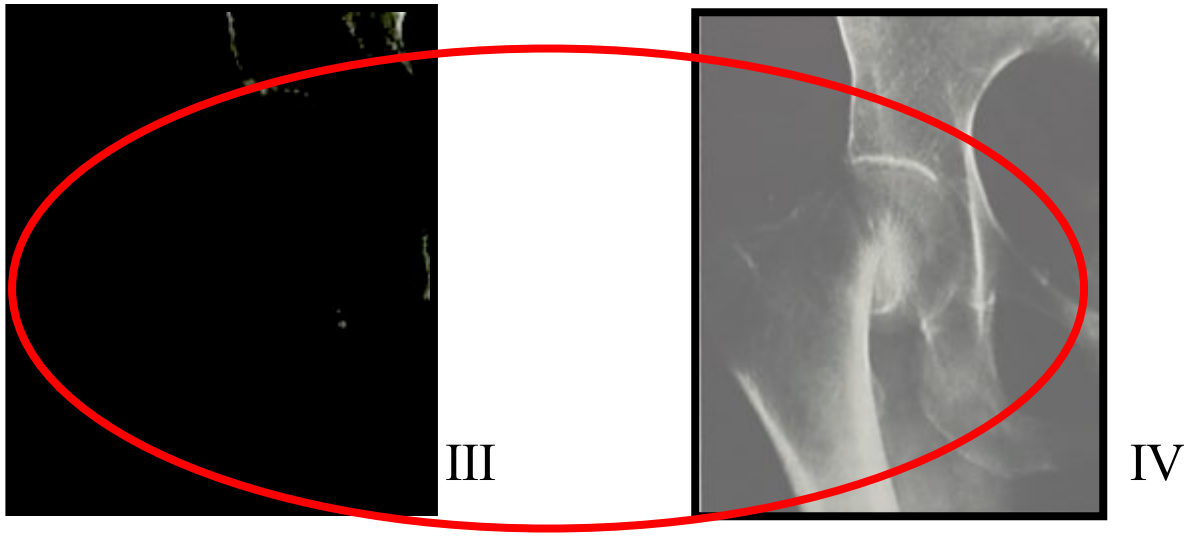
IV Complete
Full displacement

** Portends risk of AVN and Nonunion**

Non-Displaced



Displaced



Images courtesy of Frank Liporace, MD

Garden Classification

Pros

-Determining displaced vs nondisplaced is critical for dictating management

-Classification has highest inter- and intra- observer reliability when compared to Pauwel's and AO classifications

Cons

-Poor interobserver reliability between Types I and II

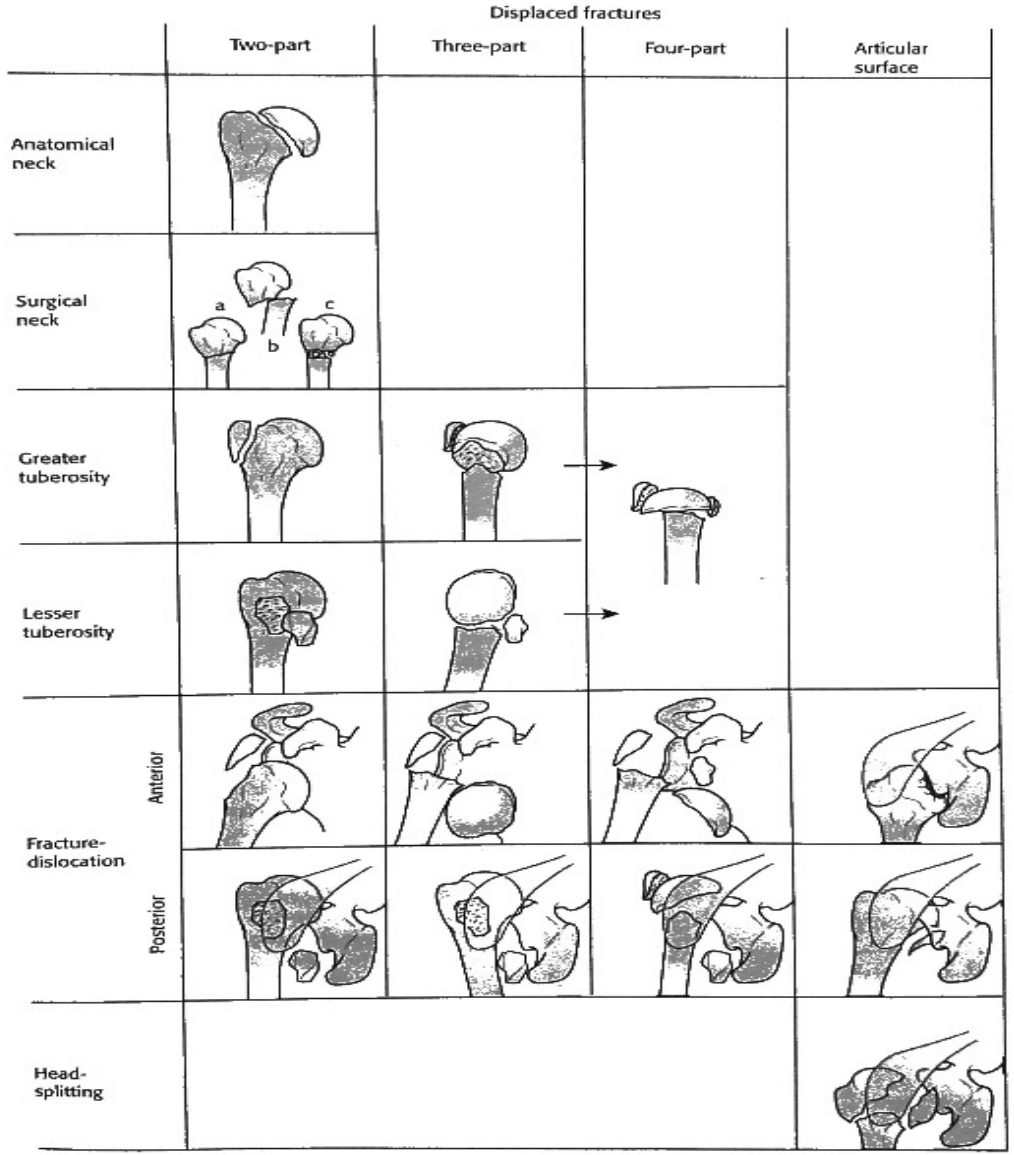
-Classification based on AP radiograph only

→ can underestimate degree of displacement

Kazley JM, Banerjee S, Abousayed MM, Rosenbaum AJ. (2018). *Classifications in brief: Garden classification of femoral neck fractures. Clin Orthop Relat Res.* 476:441-445.

Neer Classification

- Based on anatomic segments of the proximal humerus
- Considered to be a ”part” if arbitrarily displaced 1 cm or angulated 45º
- Classification has good intraobserver reliability, but only moderate interobserver reliability, though still useful for communication purposes



Dirschl DR. In: *Rockwood and Green's Fractures in Adults.* 8th ed. Court-Brown CM, Heckman JD, McQueen MM, Ricci WM, Tornetta III P, eds. Wolters Kluwer Health; 2015.

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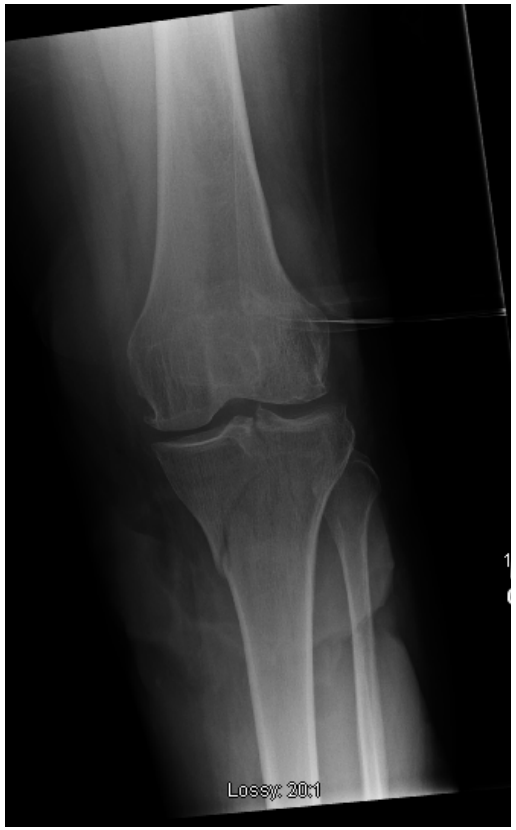
Schatzker Classification

I: Lateral Split

II: Split Depression

III: Lateral Depression

Schatzker Classification



IV: Medial Plateau

V: Bicondylar

VI: Metaphyseal-Diaphyseal Dissociation

Schatzker Classification

- Study to compare the inter-observer reliability and intra-observer reproducibility of the Schatzker, AO, and Hohl and Moore classifications of tibial plateau fractures

- Four observers at different points in their careers classified 50 tibial plateau fractures

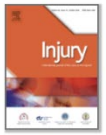
- **Schatzker showed superior inter-observer reliability and intra-observer reproducibility compared to AO and Hohl and Moore**

  --> though still not perfect

ELSEVIER

Injury

Volume 39, Issue 10, October 2008, Pages 1216-1221



The classification systems for tibial plateau fractures: How reliable are they?

Subramanyam Naidu Maripuri [a], Prabhakar Rao [b], Abraham Manoj-Thomas [a], Khitish Mohanty [c]

Table 2 Inter-observer reliability of classifications

Classification	κ co-efficient for reading 1	κ co-efficient for reading 2	Mean κ-value	Mean percent of observer agreement
AO overall	0.33	0.39	0.36	0.52
AO type	0.65	0.67	0.66	0.86
Schatzker	0.45	0.49	0.47	0.59
Hohl and Moore	0.14	0.14	0.14	0.34

Table 3 Intra-observer reproducibility of classifications

Classification	Observer 1	Observer 2	Observer 3	Observer 4	Mean κ	Mean percentage of observer agreement
AO overall	0.61	0.86	0.89	0.85	0.80	0.88
AO type	1.00	0.95	0.93	0.89	0.94	0.98
Schatzker	0.76	0.92	1.00	0.97	0.91	0.93
Hohl and Moore	0.60	0.67	0.80	0.95	0.76	0.85

Schatzker Classification

- Associated Injuries By Fracture Type
  - Schatzker II → Lateral meniscal tears
  - Schatzker IV → medial meniscal tears, ACL injury, vascular injury
  - Schatzker VI → ACL injury, compartment syndrome

Bennet WF and Browner B. (1994). *Tibial plateau fractures: A study of associated soft tissue injuries. J Orthop Trauma.* 8(3):183-188.

Lauge-Hansen Classification

Based on position of ankle and direction of force applied at time of injury

Supination External Rotation

Supination Adduction

Lauge-Hansen Classification

Based on position of ankle and direction of force applied at time of injury

Pronation External Rotation

Pronation Abduction

Lauge-Hansen Classification

Pros

-Provides understanding of mechanism for rotational ankle fractures

-Enables interprofessional communication for rotational ankle fractures

Cons

-Found to have the lowest interobserver reliability when compared to the AO and Danis-Weber classifications

-Classification cannot be used for non-rotational ankle fractures

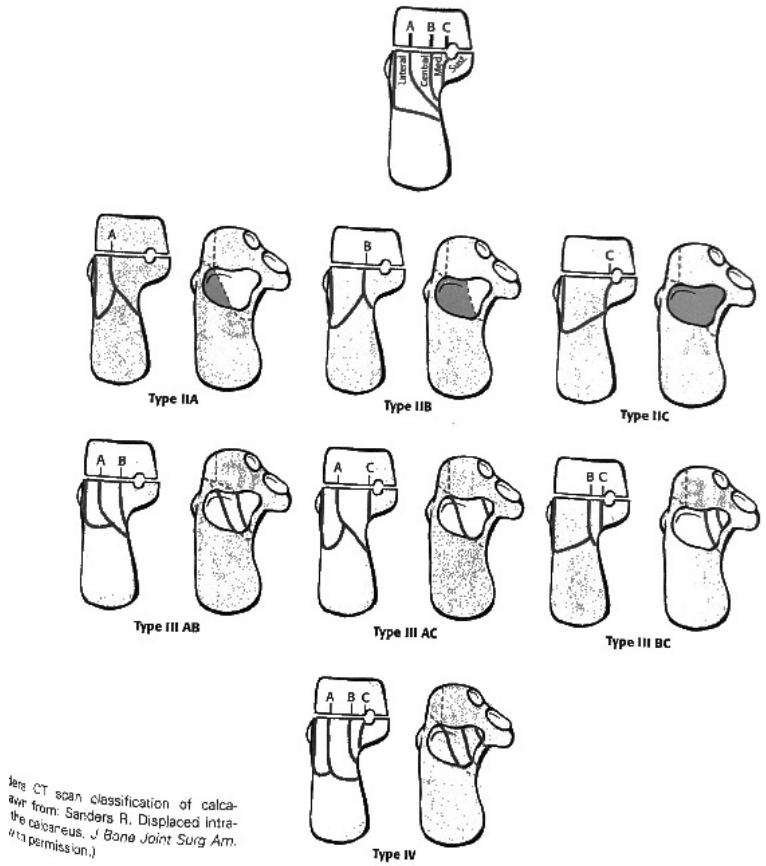
Lopes da Fonseca L, Nunes IG, Nogueira RR, Martins GEV, Mesencio AC, Kobata SI. (2018). *Reproducibility of the Lauge-Hansen, Danis-Weber, and AO classifications for ankle fractures. Rev Bras Ortop.* 53(1):101-106.

Sanders Classification

- CT-based classification looking at the widest part of the calcaneus:
  - Number articular fracture fragments
  - Location of fragments

- Compare to x-ray-based Essex-Lopresti it provides increased insight:
  - Fracture pattern
  - Pre-op planning
  - Prognosis

Sanders Classification



...ders CT scan classification of calca-
...wn from: Sanders R. Displaced intra-
...the calcaneus. *J Bone Joint Surg Am.*
...th permission.)

- Type I: all fractures with <2mm displacement
- Type II: two-part fractures of the posterior facet
- Type III: three-part fractures of the posterior facet
- Type IV: highly comminuted fracture with four or more fracture lines

Dirschl DR. In: *Rockwood and Green's Fractures in Adults.* 8th ed. Court-Brown CM, Heckman JD, McQueen MM, Ricci WM, Tornetta III P, eds. Wolters Kluwer Health; 2015.

Sanders Classification


Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/fas

Agreement between Sanders classification of intraarticular calcaneal fractures and assessment during the surgery☆

Amir Reza Vosoughi[a,*], Zahra Shayan[b], Ehsan Salehi[a], Fereidoon Mojtahed Jaberi[a], Saeed Solooki[a], Bahareh Kardeh[c]

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[b] Trauma Research Center, Department of Community Medicine, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran
[c] Bone and Joint Diseases Research Center, Chamran Hospital, Shiraz University of Medical Sciences, Shiraz, Iran

- Cross-sectional study of 100 pre-op CT scans of patients with intra-articular calcaneus fractures operated on by a single surgeon

- Researchers reported:
  - Good to excellent intra-observer reproducibility
  - Moderate inter-observer reliability (which was better than what was previously reported in the literature).

- Validity was reported to be fair

Universal Classification System

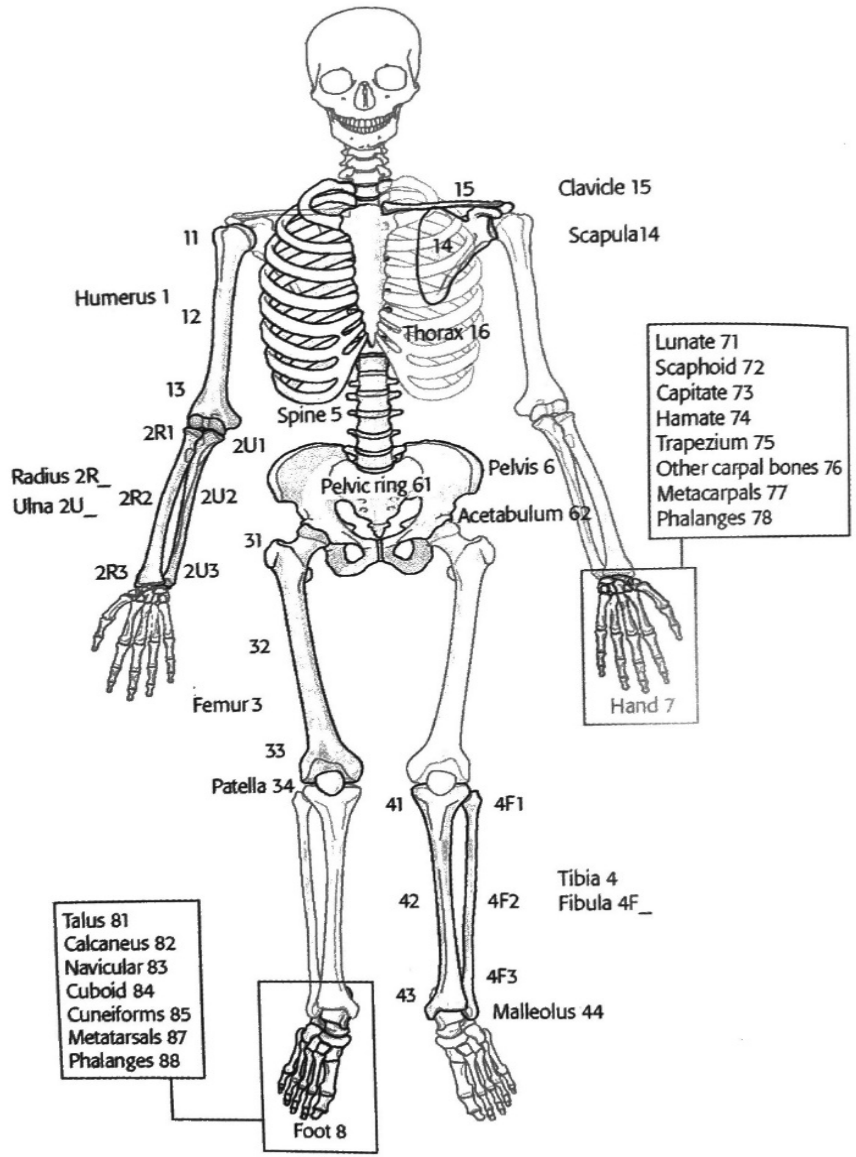
OTA/AO Classification

- Alphanumeric classification that can be applied throughout the skeleton, based on fracture location and morphology

- Created in the 1960's and multiply updated to include classifications of the pelvis and acetabulum

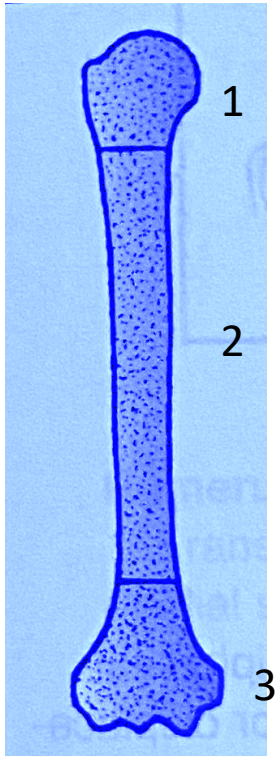
OTA/AO Classification

- Fracture Location
  - Which bone?
    - Each bone is assigned a specific number



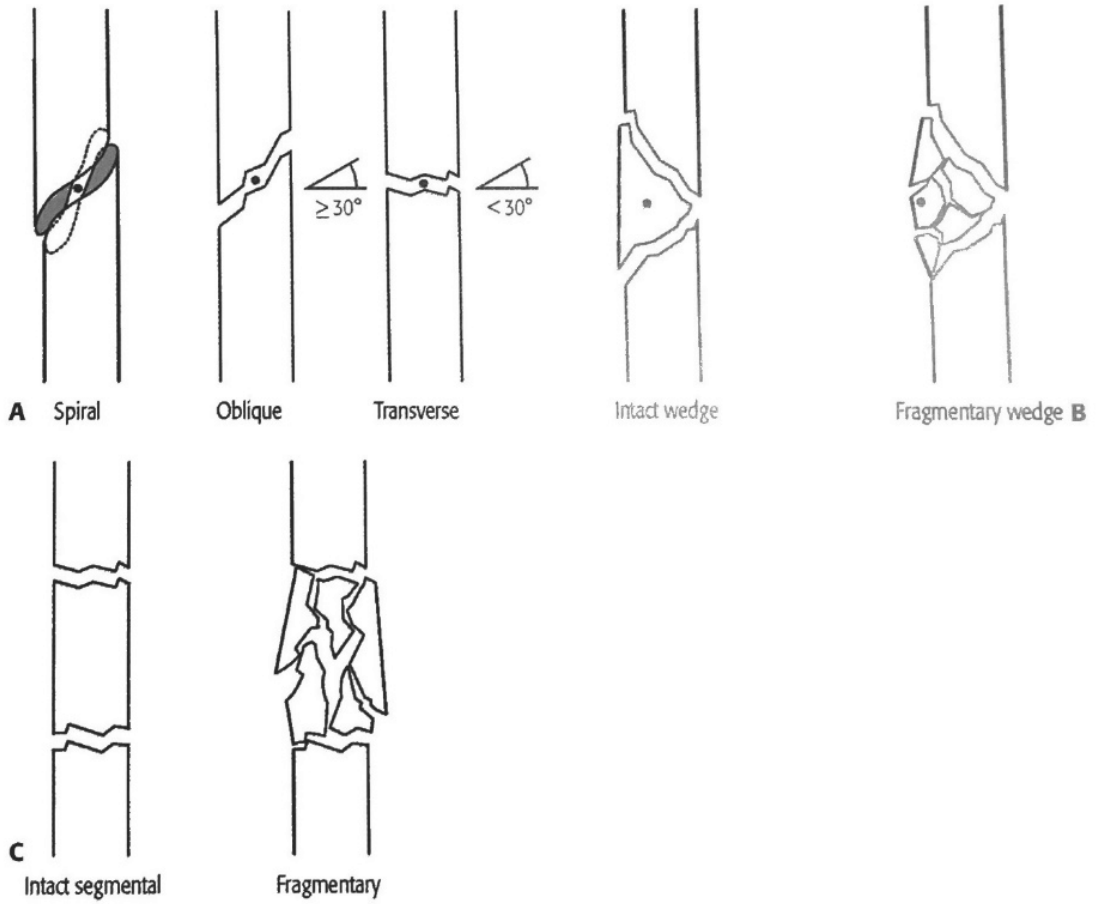
OTA/AO Classification

- Fracture Location
  - Which part of the bone?
    - 1. Proximal end segment
    - 2. Diaphyseal segment
    - 3. Distal end segment



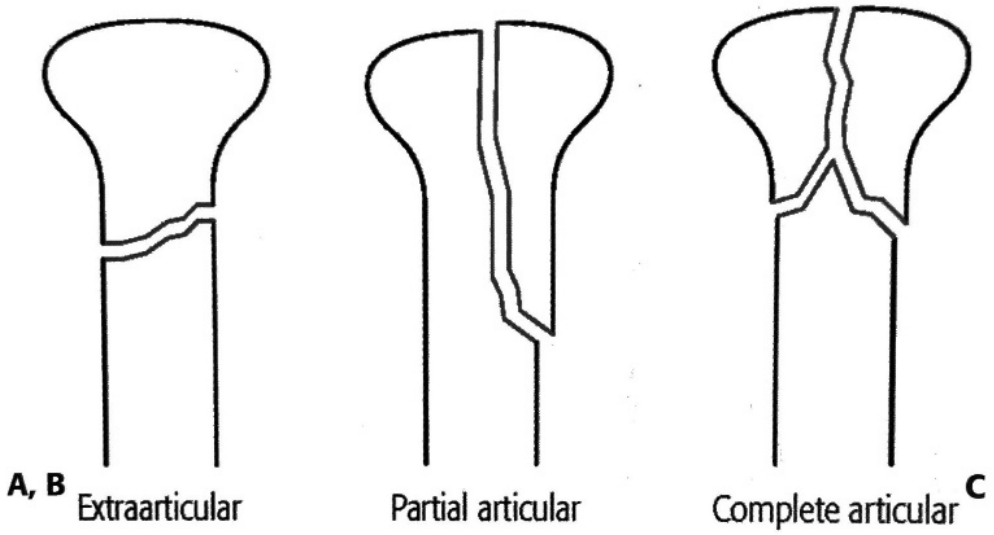
OTA/AO Classification

- Fracture Morphology
  - Diaphyseal segment
    - Type A: Simple fractures
      - spiral, oblique, transverse
    - Type B: Wedge fractures
      - spiral, bending, fragmented
    - Type C: Multifragmentary fractures
      - spiral wedge, segmented, irregular



OTA/AO Classification

- Fracture Morphology
  - End segment
    - Type A: Extra-articular
    - Type B: Partial articular
    - Type C: Complete articular

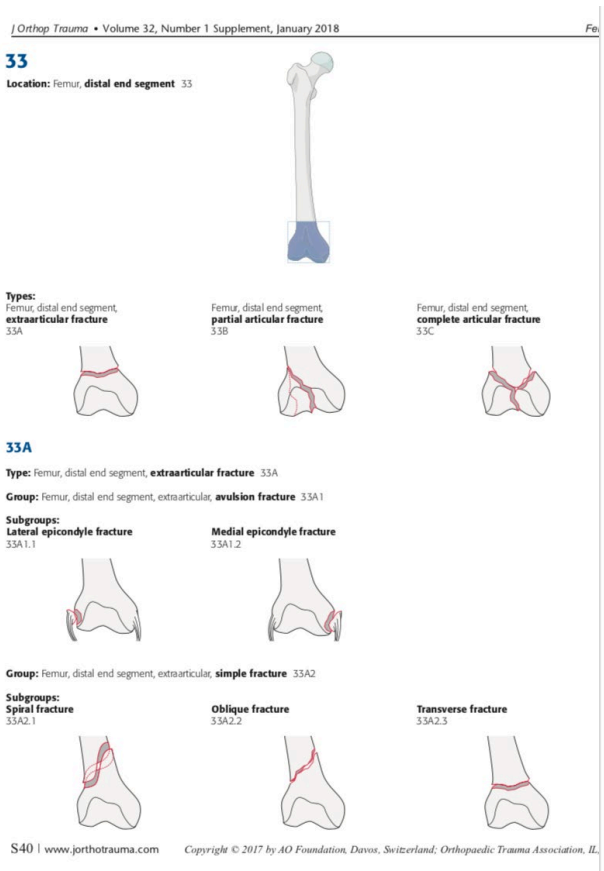


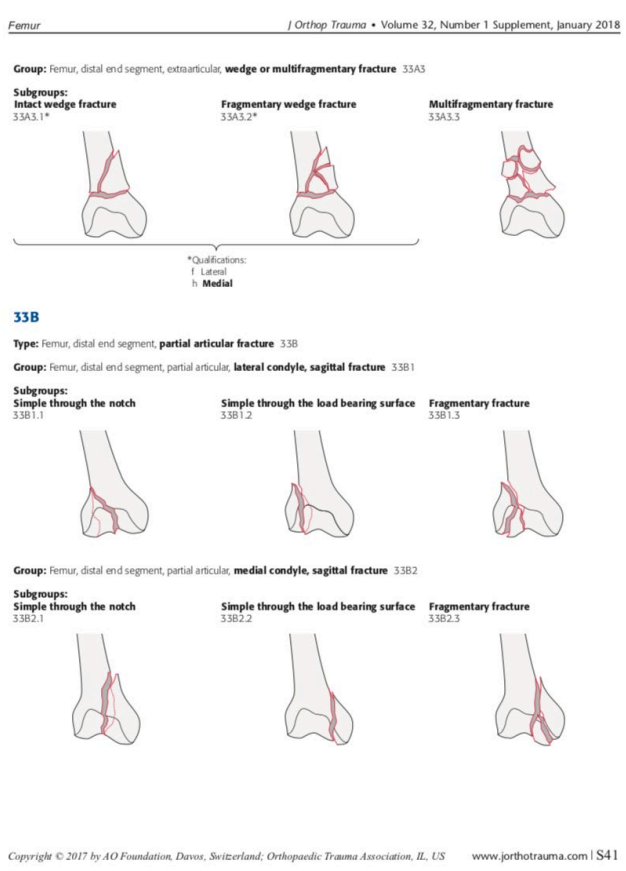
OTA/AO Classification

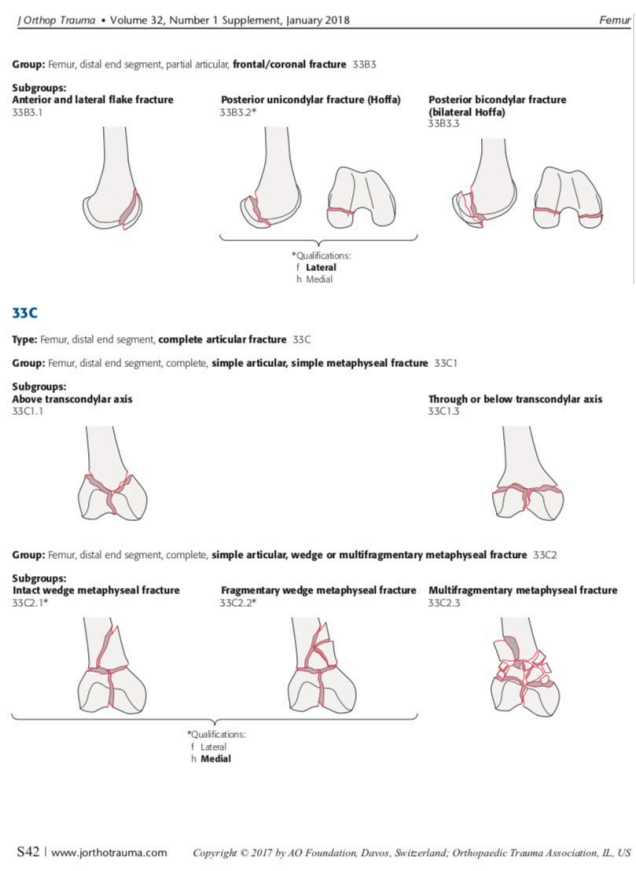
- Now have additional Subgrouping
  - Goal of Subgrouping: to increase the precision of the classification
  - Subgroups differ amongst each bone

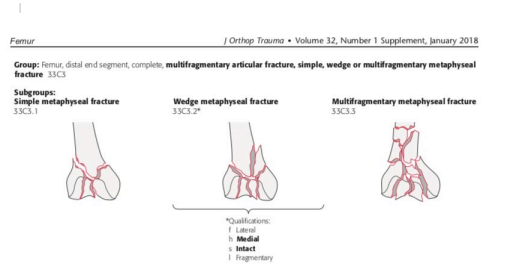
OTA / AO Classification Subgrouping

- Complex and value not fully known (Example: Distal Femur)









But what about the soft tissues?

Soft Tissue-Based Classifications

- Oesterne and Tscherne Classification
- Gustilo-Anderson Classification
- OTA Open Fracture Classification

Oesterne and Tscherne Classification

- Classification of soft tissue damage in the setting of a closed fracture

Grade	Soft Tissue Injury	Bony Injury
Grade 0	Minimal soft tissue damage Indirect injury to limb	Simple fracture pattern Ex: low energy spiral fractures
Grade 1	Superficial abrasion/contusion	Mild fracture pattern Ex: rotational ankle fracture-dislocations
Grade 2	Deep abrasion with skin or muscle contusion Direct trauma to limb	Severe fracture pattern Ex: segmental fractures
Grade 3	Extensive skin contusion or crush Severe underlying muscle damage Subcutaneous avulsion Possible compartment syndrome	Severe fracture pattern

Ibrahim DA, Swenson A, Sassoon A, Fernando ND. (2017). *Classifications in brief: The Tscherne Classification of soft tissue injury. Clin Orthop Relat Res.* 475:560-564.

Gustilo-Anderson Classification

- Type I: wound ≤1 cm, minimal contamination or muscle damage
- Type II: wound 1-10 cm, moderate soft tissue injury
- Type IIIA: wound usually >10 cm, high energy, extensive soft-tissue damage, contaminated, but with adequate tissue for flap coverage
- Type IIIB: extensive periosteal stripping, wound requires soft tissue coverage (rotational or free flap)
- Type IIIC: vascular injury requiring vascular repair, regardless of degree of soft tissue injury

****Appropriate classification can only be made intraoperatively****

Kim PH and Leopold SS. (2012). *Gustilo-Anderson classification. Clin Orthop Relat Res.* 470:3270-3274.

OTA Classification of Open Fractures

- Assigns severity to five essential factors for treatment

Essential Factor	Severity
Skin	1. Can be approximated 2. Cannot be approximated 3. Extensive degloving
Muscle	1. No muscle in area/no appreciable necrosis 2. Loss of muscle; intact function, localized necrosis 3. Dead muscle, loss of function
Arterial	1. No injury 2. Arterial injury without ischemia 3. Arterial injury with ischemia
Contamination	1. None or minimal 2. Surface contamination 3. Imbedded in bone or deep tissues
Bone Loss	1. None 2. Bone missing or devascularized, but still contact present between proximal and distal segments 3. Segmental bone loss

Orthopaedic Trauma Association: Open Fracture Study Group. (2010). *A new classification scheme for open fractures. J Orthop Trauma.* 24(8): 457-465.

Reliability of Classification Systems

- OTA Open Fracture Classification System appears superior to Gustillo-Anderson Classification System in both reliability and validity
  - 86% overall interobserver agreement vs 60% for G-A
  - JOT: 2013 vol 27; pp379-384
- Interobserver ***RELIABILITY*** is different than ***VALIDITY***
  - If surgeons agree on a measurement pre-operatively ("reliability"), that may not prove to be accurate intra-operatively ("validity")
  - JAAOS: 2002 vol 10; pp290-297

Use of Soft Tissue and Open Fracture Classifications

The Journal of Bone and Joint Surgery. British volume, Vol. 81-B, No. 1

Fractures of the tibia

CAN THEIR OUTCOME BE PREDICTED?

P. Gaston, E. Will, R. A. Elton, M. M. McQueen, C. M. Court-Brown

- Prospective study to determine if descriptive classifications of diaphyseal tibia fractures are predictive of prognosis
- Compared AO, Gustilo-Anderson, Tscherne, and Winquist-Hansen classifications and looked at union, need for future surgery, and subsequent infection
- **Found that the Tscherne Classification was most predictive of final outcome**

Summary

- Classifications are essential for communication, education, treatment guidelines, and as a prognostic tool
- As imaging technology has advanced so have our fracture classifications
- The soft tissue can’t be ignored and classification systems taking the soft tissue envelope into consideration are essential for creating a complete prognostic picture

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