Calcanial fractures anatomy and classification

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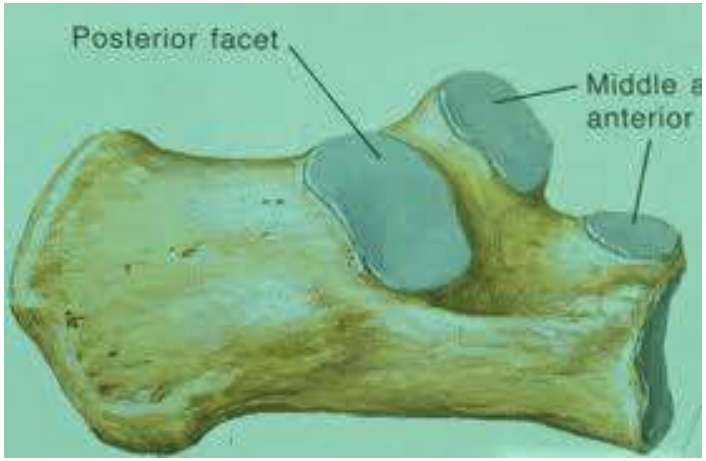
Learning objectives

- Anatomy of calcanium
- Anatomical basis of the fracture
- lines and angles
- Classifications
- Brief literature review about use of classifications

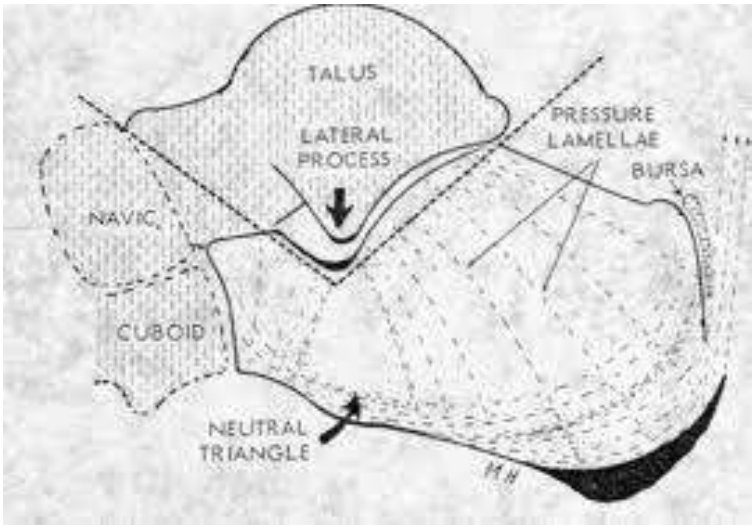
Anatomy

- Largest of the tarsal bones
- 4 articular facets,
- Relatively thin cortex



Trabeculae arrangment

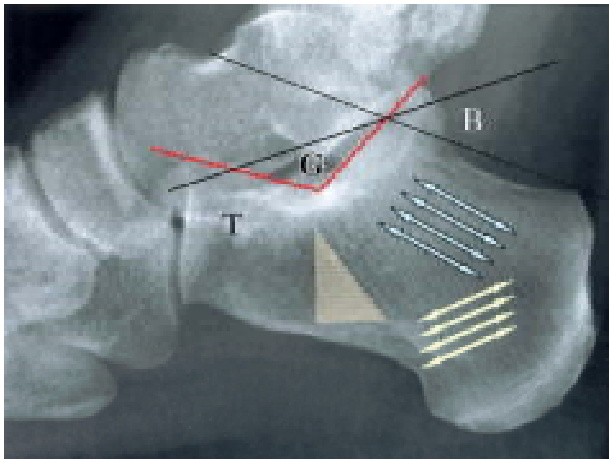
- Traction trabeculae radiate from the inferior cortex
- compression trabeculae support the anterior and posterior articular facets
- a "neutral triangle" between them with sparse trabeculations



Trabeculae arrangment

- compression (light blue arrows)
- Traction (yellow arrows) trabeculae
- Neutral triangle (brown triangle)
- The thickened cortical is called the thalamic portion of the bone

Figure 1b. (a) Lateral radiograph of the normal calcaneus.



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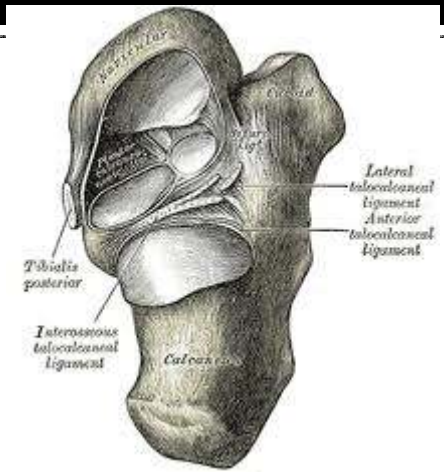
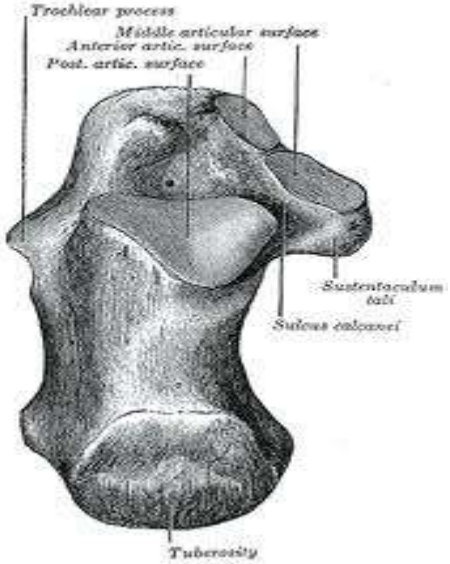
Articular surfaces

- Four articulating surfaces, Three superior and one anterior.
- posterior, middle, and anterior facets
- *calcaneal sulcus*
- The canal formed between the calcaneal sulcus and the talus is called the *sinus tarsi*.

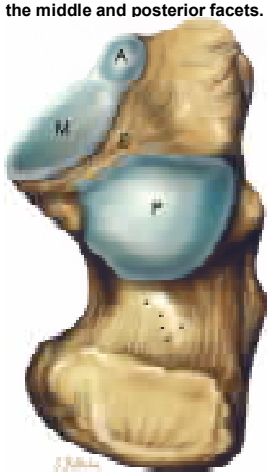




Articular surfaces

- The middle calcaneal - the sustentaculum tali -with the middle facet of the talus.
- The anterior calcaneal facet -the anterior talar facet - the calcaneal beak.
- The triangular anterior surface -cuboid

Figure 2. Drawing of the superior surface of the calcaneus shows the anterior (A), middle (M), and posterior (P) facets of the calcaneus, as well as the calcaneal sulcus (S) that runs between the middle and posterior facets.



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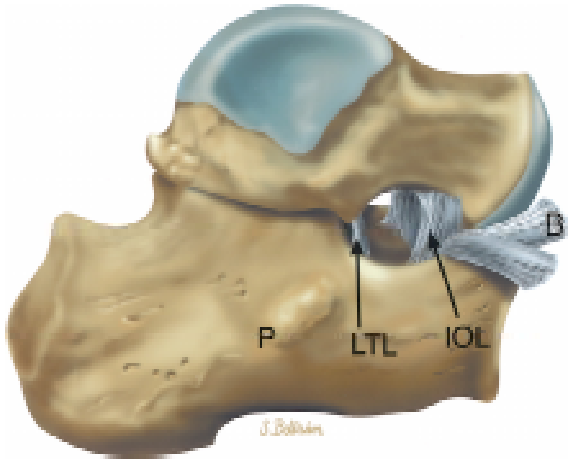
The lateral surface

- The lateral surface
  - is flat and subcutaneous, with a central peroneal tubercle for the attachment of the calcaneofibular ligament centrally. The lateral talocalcaneal ligament attaches antero-superiorly to the peroneal tubercle

Figure 3. Drawing of the lateral surface of the calcaneus shows the peroneal tubercle (P), as well as the lateral talocalcaneal (LTL), interosseous (IOL), and bifurcate (B) ligaments.



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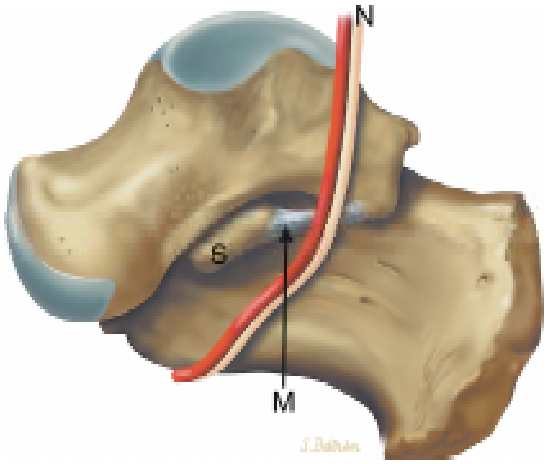
Medial surface

- Medially
  - Interosseous ligament
  - Medial talocalcaneal ligaments
- The sustentaculum tali
  - The groove inferior to it transmits the flexor hallucis longus tendon.
  - The neurovascular bundle runs adjacent to the medial border

Figure 4. Drawing of the medial surface of the calcaneus shows the neurovascular bundle (N), sustentaculum tali (S), and medial talocalcaneal ligament (M).



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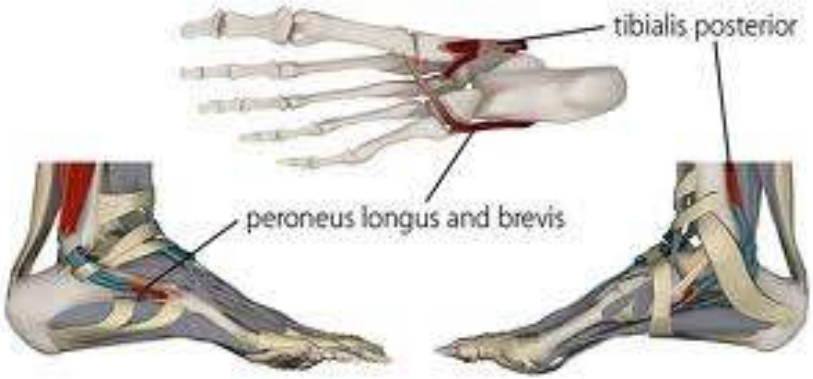
Anatomical relations

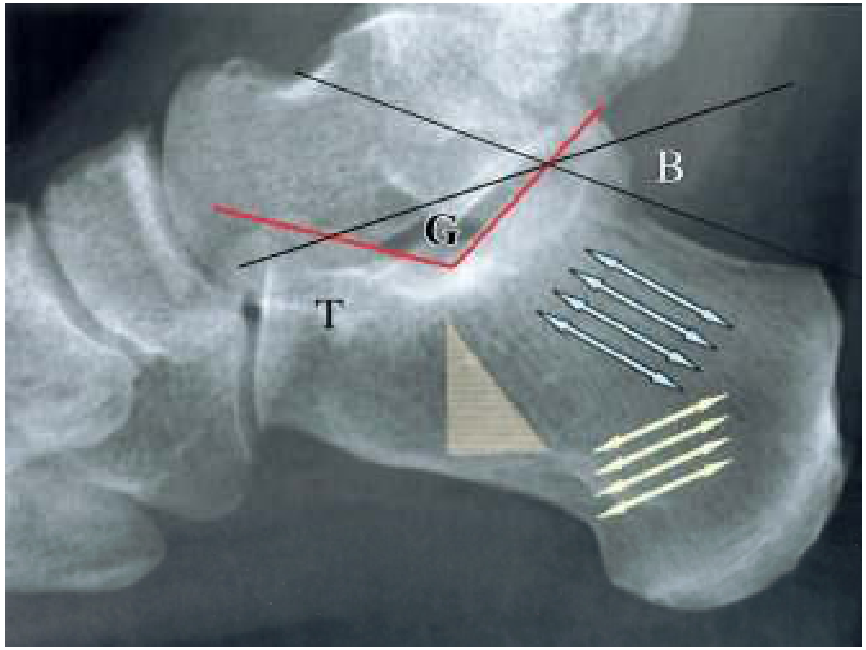
- The tibial artery, nerve, posterior tibial tendon, and flexor hallucis longus tendon course along the medial wall of the calcaneus,
- Laterally, the peroneal tubercle provides a groove for the peroneal tendons (the brevis superiorly, and the longus inferiorly).



Important angles

- The critical angle of Gissane *(G)*
- The Boehler angle *(B)* normally 20°–40°.

Figure 1b. (a) Lateral radiograph of the normal calcaneus.



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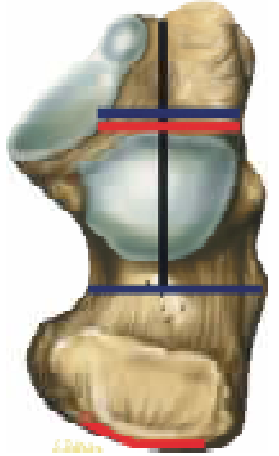
Understanding the Intraarticular Fractures

- Axial loading-
  - shear and –primary line
  - compression –secondry line
- *Shear fracture*
  - occurs in the sagittal plane through the posterior facet, it into anteromedial and posterolateral fragments
  - hindfoot is in varus position
  - hindfoot is in valgus position
  - extreme valgus position

Figure 6a. Diagrams of the superior (a) and lateral (b) surfaces of the calcaneus show the shear (solid black line) and compression fracture lines from joint depression (blue lines) and tongue (red lines) type fractures.



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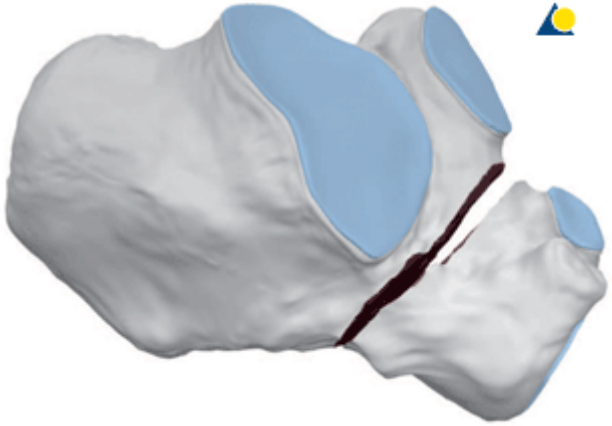


Primary lines

- sagittal shear fracture
  - the anteromedial or "sustentacular" fragment and
  - the posterolateral or "tuberosity" fragment
  - The medial fragment is not substantially displaced
  - The lateral fragment is dislocated laterally, leading to a "step off" in the posterior facet
  - "double split"

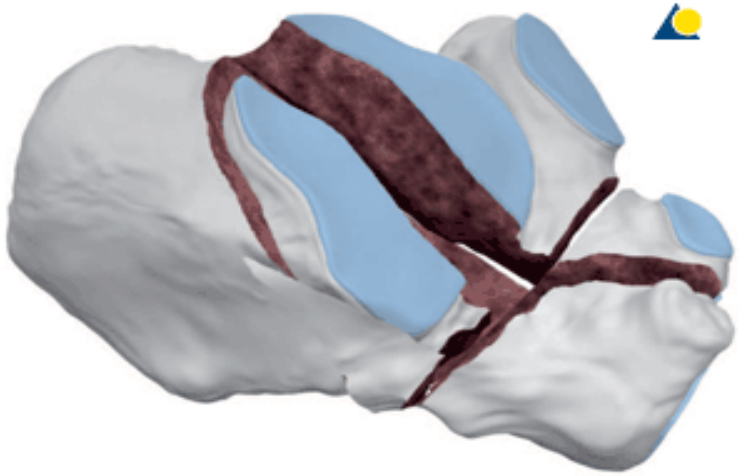
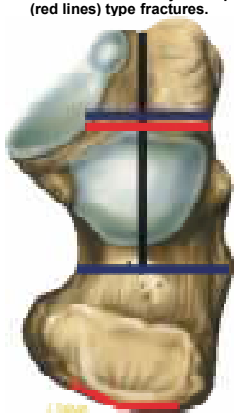


Figure 6a. Diagrams of the superior (a) and lateral (b) surfaces of the calcaneus show the shear (solid black line) and compression fracture lines from joint depression (blue lines) and tongue (red lines) type fractures.



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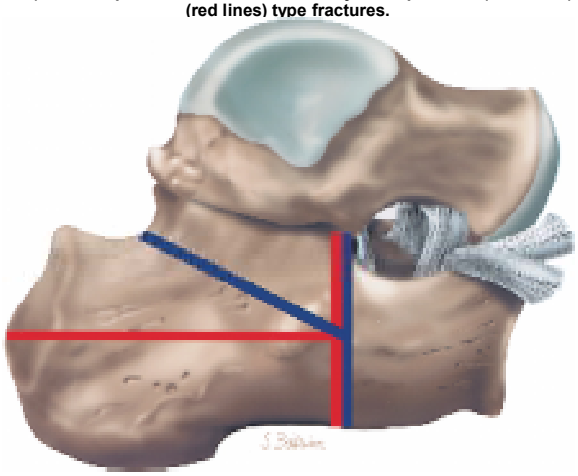
The compression fracture lines

- runs in the coronal plane,
- anterior limb running through angle of Gissane
- and the posterior limb extending either
  - horizontally toward the tuberosity as a tongue ty fracture (red line)
  - more vertically, just posterior to the posterio facet, as a joint depression type fracture (blue line).

Figure 6b. Diagrams of the superior (a) and lateral (b) surfaces of the calcaneus show the shear (solid black line) and compression fracture lines from joint depression (blue lines) and tongue (red lines) type fractures.



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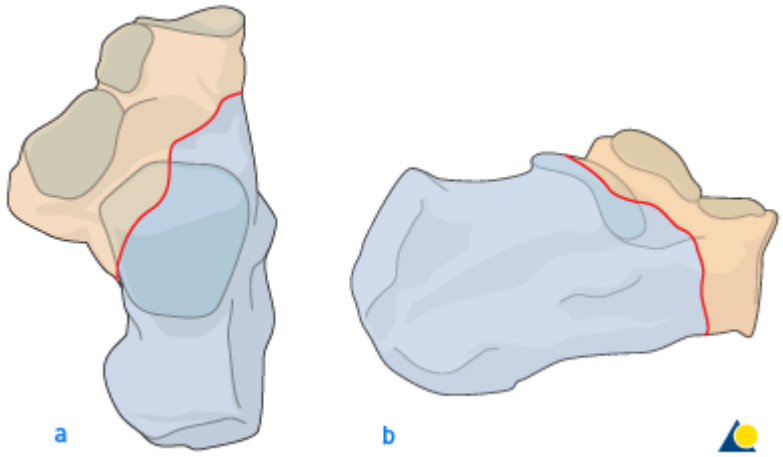
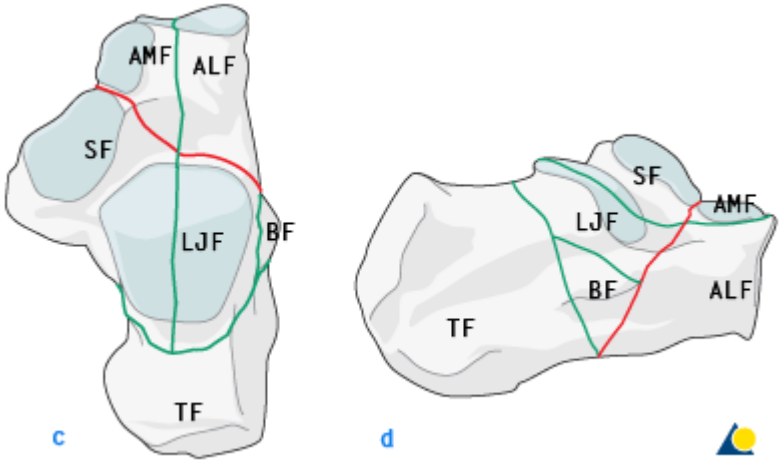
Primary intraarticular fracture line

- *shown in a superior (a) and lateral (b) view of the calcaneus. It divides the calcaneus into an anteromedial fragment (red) and a posterolateral fragment (blue). This fracture usually crosses the posterior articular surface*



Secondary intraarticular fracture lines

- *Green-shown on a superior (c) and lateral view (d). (Joint depression type.)*
  - *LJF- Lateral joint fragment,*
  - *SF- Sustentacular fragment.*
  - *TF Tuberosity or body fragment*
  - *ALF Anterolateral fragment*
  - *AMF Anteromedial fragment.*



shear fracture line- coronal

Figure 7a. (a) Coronal CT image shows the shear fracture line (arrow) separating the anteromedial or sustentacular fragment (S) and the posterolateral or tuberosity fragment (T).

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shear fracture line- Sagital

Figure 7b. (a) Coronal CT image shows the shear fracture line (arrow) separating the anteromedial or sustentacular fragment (S) and the posterolateral or tuberosity fragment (T).

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Classification-History

- In 1843, Malgaigne described 2 types -the first rudimentary classification system.
- Bohler (in 1931), Essex-Lopresti (in 1951-2), Rowe et al (in 1963), and many others.
- Essex-Lopresti -distinguish intra-articular fractures from extra-articular, and they correctly associated the intra-articular variety with a poorer long-term prognosis.

Classification-Extra-articular

- Approximately 25%–30%
- do not involve the posterior facet
- Extraarticular calcaneal fractures
  - *(a)* anterior process fractures
  - *(b)* fractures of the mid calcaneus
    - body, sustentaculum tali, peroneal tubercle, and lateral calcaneal process
  - *(c)* fractures of the posterior calcaneus
    - Tuberosity and medial calcaneal tubercle

Extraarticular fractures

- When contemplating extraarticular calcaneal fractures, it is important to differentiate complex fractures that separate articular facets and distort the three-dimensional anatomy of the subtalar joint from the more simple extraarticular fractures.

Classification-Intraarticular

- X-ray Based
  - Essex-Lopresti
  - Rowe
- CT Based
  - Hannover
  - Regazzoni (AO)
  - Crosby and Fitzgibbons
  - Sanders

Intraarticular fractures

- The Essex-Lopresti Classification
- Type A - Tongue type

  Type B - Joint depression type

  Depends upon mechanism of injury
- Crosby and Fitzgibbons (1993)
  - undisplaced,
  - displaced but non-comminuted,
  - comminuted,

showed that severity corelated with outcome and response to surgery.

The Rowe Classification

Type 1a - Tuberosity fracture medial or lateral
Type 1b - Fracture of the sustentaculum tali
Type 1c - Fracture of the anterior process
Type 2A - Beak fracture of the posterior calcaneus
Type 2b - Avulsion fracture -tendo-Achillles
Type 3 - Oblique fracture not involving subtalar joint
Type 4 - Body fracture involving the subtalar joint
Type 5 - Body fracture with subtalar joint depression and comminution

Hannover classification

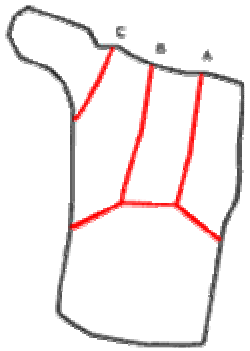
- Assigns one point to each of a possible five fragments and one point to involvement of each of three articular surfaces.
- One to four points are also assigned for soft-tissue damage and comminution or involvement of other tarsal bones, yielding a maximum of 12 points.

Sanders classification

- The is used more commonly
- Based on the pathophysiology proposed by Soeur and Remy
- Relies on sagittally reconstructed CT images reformatted parallel and perpendicular to the posterior facet of the subtalar joint

The Sanders Classification

- Type I fractures are nondisplaced
- Type II are two-part or split fractures
- Type III are three-part or split depression fractures
- Type IV are four-part or highly comminuted fractures.

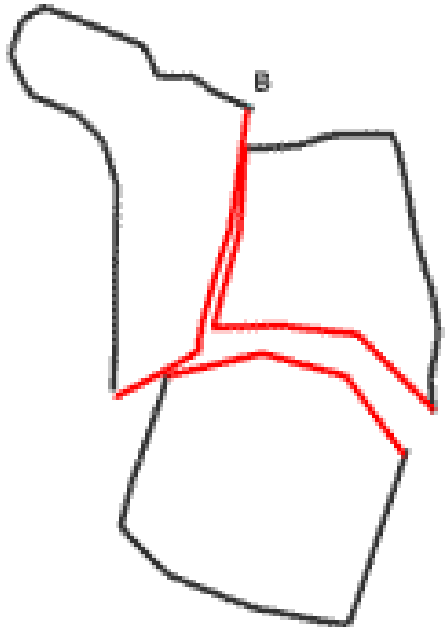


The basis of the Sanders classification.The groups are denoted by the number of main fragments and the approximate main fracture lines as marked

Type II fractures

- two articular pieces, involve the posterior facet
- types A,
- B, and
- C,

depending on the medial or lateral location of the fracture line



- main fracture line through the mid-part of the joint - type 2B

Type III fractures

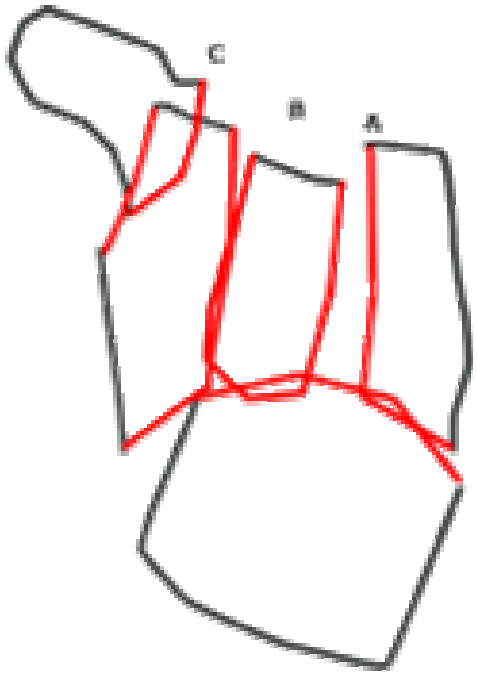
- Three articular pieces- include an additional depressed middle fragment
- AB,
- AC,
- and BC,

depending on the position and location of the fracture lines.

- A three-part fracture with the main fracture lines lateral and central - type 3AB

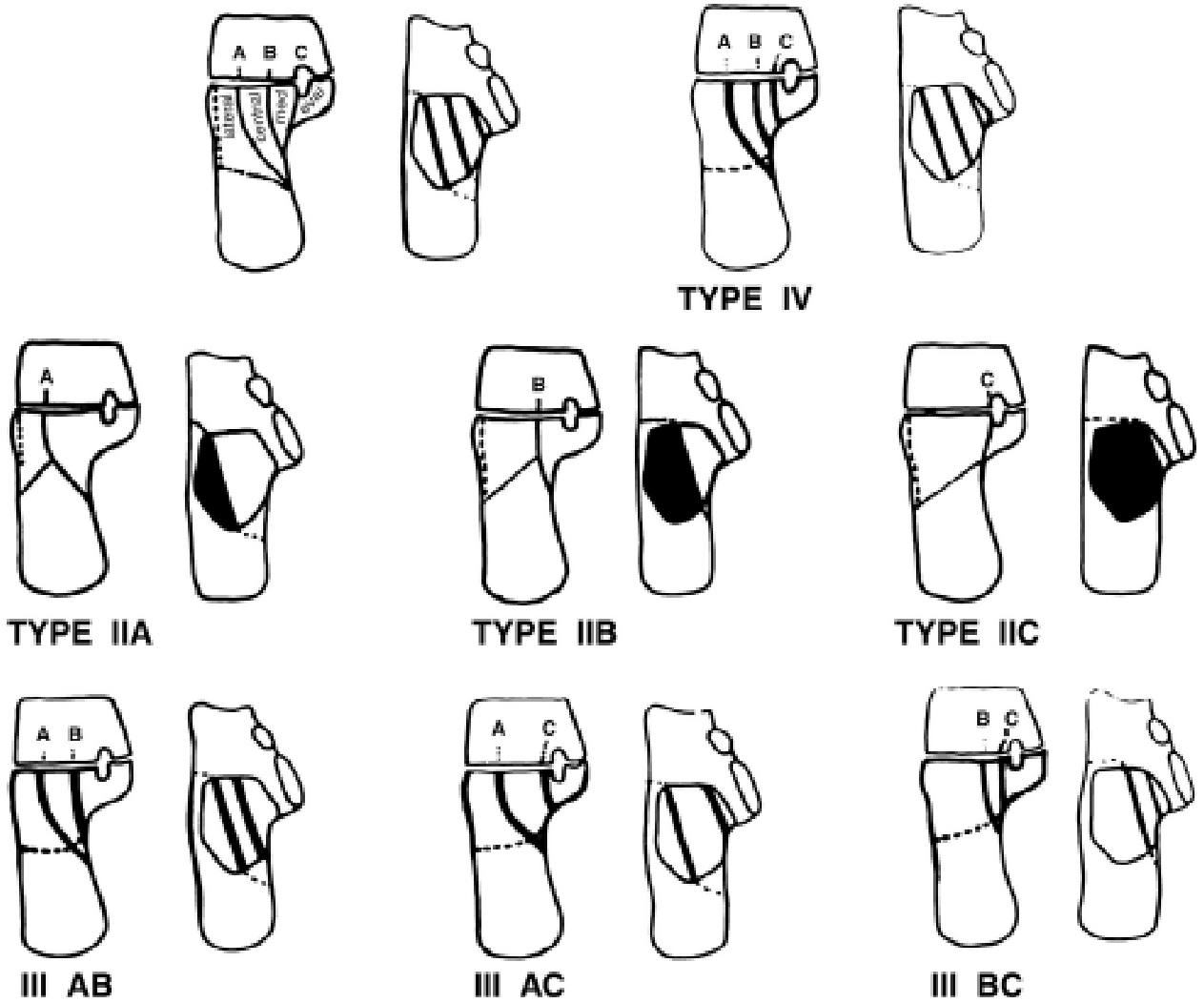
Type IV fractures

- Four or more articular fragments- are highly comminute d



- A four-part fracture with fracture lines lateral, medial and central - type 4ABC

Figure 11. Schematic depicts the Sanders classification of intraarticular fractures of the calcaneus in coronal and axial views.



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What literature says about classifications

SandersR, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures: results using a prognostic computed tomography scan classification. Clin Orthop Relat Res1993; 290: 87–95.

- is useful not only in treatment planning but in helping to determine prognosis.
  - 120 intraarticular fractures
    - type I fractures were treated without surgery.
    - type II and type III fractures who underwent surgery experienced excellent or good clinical results in 73% and 70% of cases, respectively.
    - only 9% of patients with type IV fractures had excellent or good clinical results after surgical treatment.

Schepers T, van Lieshout EM, Ginai AZ, Mulder PG, Heetveld MJ, Patka P. Calcaneal fracture classification: a comparative study. J Foot Ankle Surg. 2009 Mar-Apr;48(2):156-62. Review

- Most prevalent were the Essex-Lopresti, Zwipp, Crosby, and Sanders classifications
- None of these showed a direct correlation with treatment, although each of these systems showed positive correlations with outcome.
- Moderate interobserver agreement and variability were found for the Crosby and Sanders classifications (overall $\kappa = 0.48$)

Schepers T, van Lieshout EM, Ginai AZ, Mulder PG, Heetveld MJ, Patka P. Calcaneal fracture classification: a comparative study. J Foot Ankle Surg. 2009 Mar-Apr;48(2):156-62. Review

- Interobserver reliability was poor for the Essex-Lopresti classification (overall κ = 0.26).
- Four classifications systems showed positive correlations with outcome, but no correlation with choice of treatment.
- The Sanders and Crosby classifications displayed comparable, moderate interobserver variability among surgeons and radiologists

Humphrey CA, Dirschl DR, Ellis TJ. Interobserver reliability of a CT-based fracture classification system. J Orthop Trauma. 2005 Oct;19(9):616-22. USA

- The mean kappa value for interobserver reliability for fracture types I-IV was 0.41 +/- 0.02 (mean +/- standard error of the mean; range, 0.07-0.64). Observers disagreed by more than 1 fracture type (ie, I vs. III or II vs. IV) in 10% of the cases. Observers agreed on the location of the fracture lines (A, B, C) in 90% of type II fractures and 52% of type III fractures.

Rubino R, Valderrabano V, Sutter PM, Regazzoni P. Prognostic value of four classifications of calcaneal fractures. Foot Ankle Int. 2009 Mar;30(3):229-38. Switzerland

- 189 fractures; average follow up, 9.9 years
- All fractures were classified in accordance with the Essex-Lopresti, OTA, Regazzoni, and Sanders classifications
- Matched with the following scores:
  - AOFAS score, CNHF, FOA, MFS, Rowe, MFA, SF-36, and VAS.

- The Essex-Lopresti classification showed no statistically significant relation with any of the clinical scores ($p > 0.05$).

- The Sanders classification corrrelated with the AOFAS score ($p = 0.007$), MFS ($p = 0.001$), Rowe ($p = 0.001$), CNHF ($p = 0.024$), FOA ($p = 0.021$), MFA score ($p = 0.036$), and VAS ($p = 0.014$).

- Compared to radiological based classifications, the CT based classifications, exhibited higher prognostic value compared to ultimate outcome scores

Lauder AJ, Inda DJ, Bott AM, Clare MP, Fitzgibbons TC, Mormino MA. Interobserver and intraobserver reliability of two classification systems for intra-articular calcaneal fractures. Foot Ankle Int. 2006 Apr;27(4):251-5.

- Although intraobserver kappa values reached substantial levels and the Crosby-Fitzgibbons system generally showed greater agreement, we were unable to demonstrate excellent interobserver or intraobserver reliability with either **classification** scheme. While a system with perfect agreement would be impossible, our results indicate that these classifications lack the reproducibility to be considered ideal.

Bhattacharya R, Vassan UT, Finn P, Port A. Sanders classification of fractures of the os calcis. An analysis of inter- and intra-observer variability. J Bone Joint Surg Br. 2005 Feb;87(2):205-8.

- Our results show that, despite its popularity, the classification system of Sanders has only fair agreement among users.

Furey A, Stone C, Squire D, Harnett J.Os calcis fractures: analysis of interobserver variability in using Sanders classification. J Foot Ankle Surg. 2003 Jan-Feb;42(1):21-3.

- The weighted kappa value achieved was.56, with a 95% confidence interval of.45-.67.
- The subcategories of the classification -weighted kappa value achieved was.48, with a 95% confidence interval of 0.37-0.59.
- Sanders' classification system did prove to achieve moderate agreement among users, thus representing a useful classification system.

"the man who breaks his heel bone is done so far as his industrial future is concerned" Cotton 1916

Thank you