"…the bone is a plant, with its roots in the soft tissue, and when its vascular connections are damaged, it often requires, not techniques of a cabinet maker, but the patient care and understanding of a gardener."

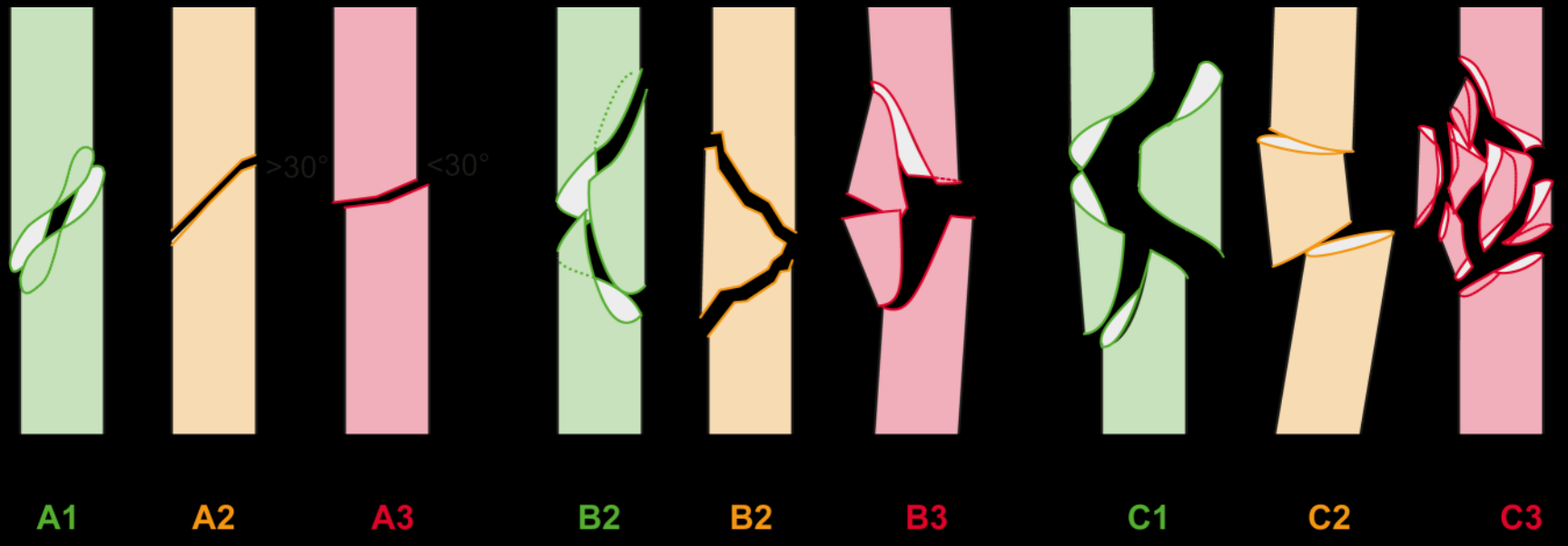
Girdlestone

A fracture involves:

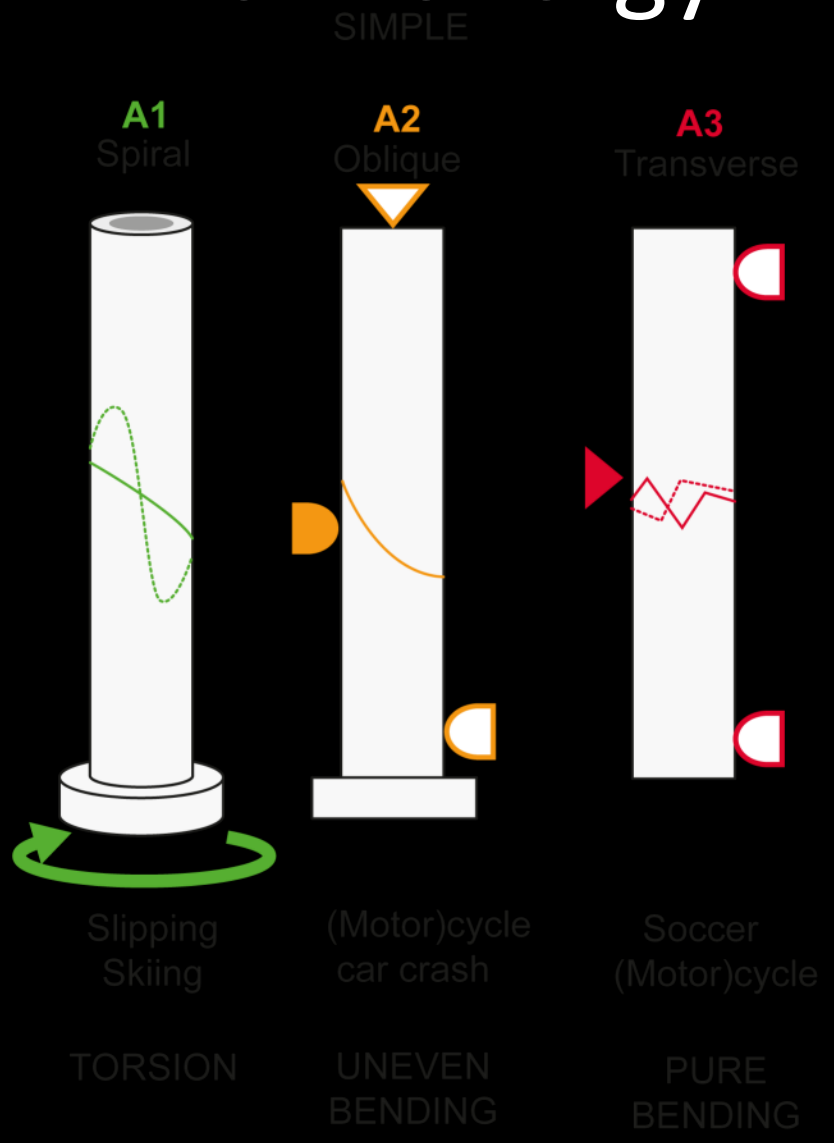
- Skin and subcutaneous fat
- Muscles and tendons
- Vessels and nerves
- Periosteum and bone

Fracture mechanisms diaphysis

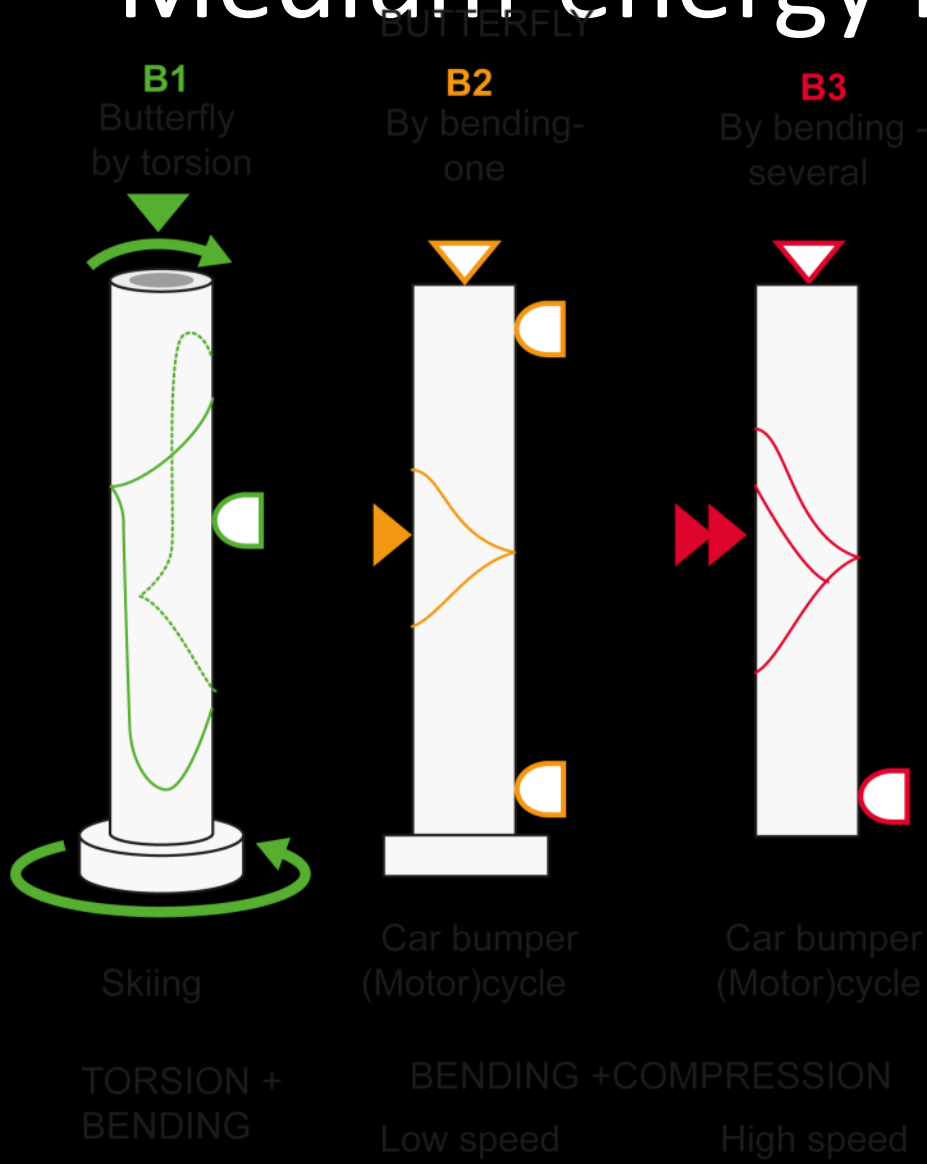
- Torsion (skiing)
- Bending (indirect)
- Compression (fall from a height)
- Contusion (direct, bumper injury)
- Combinations



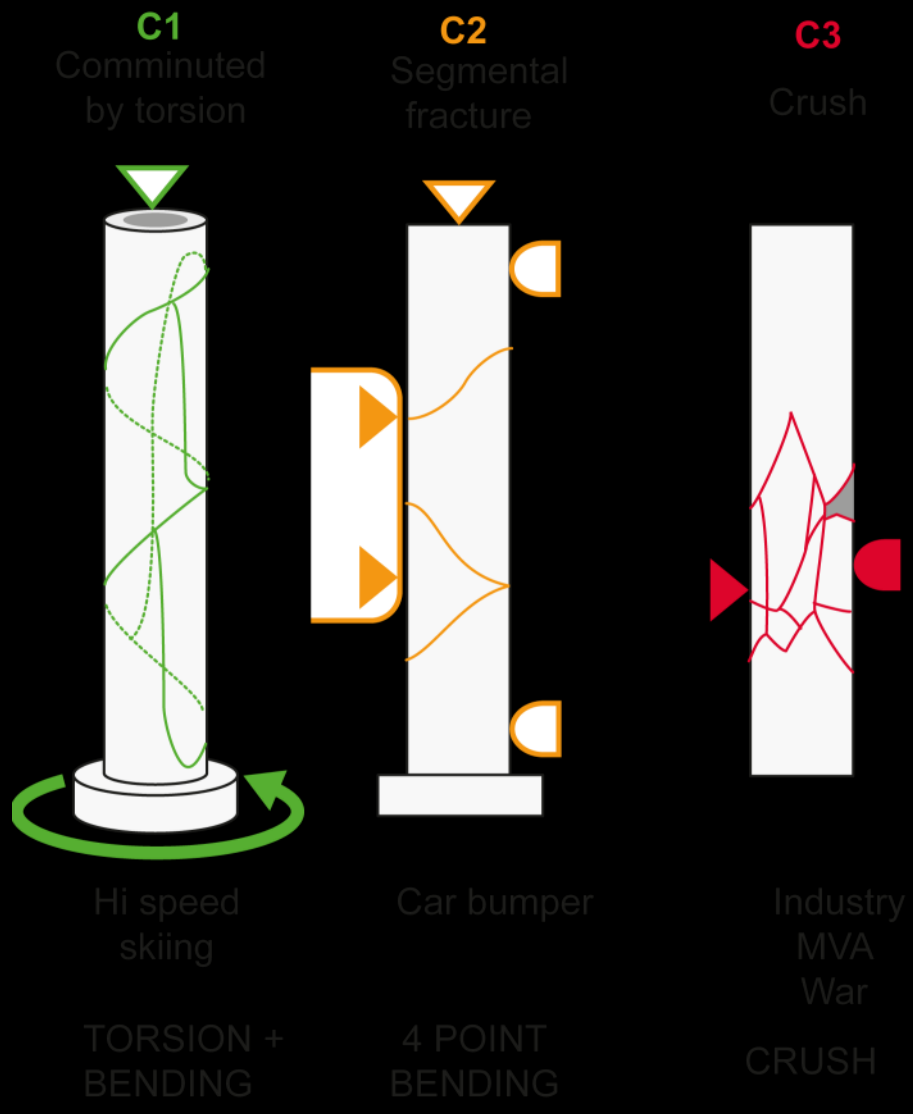
Low-energy fracture patterns



Medium-energy fracture patterns

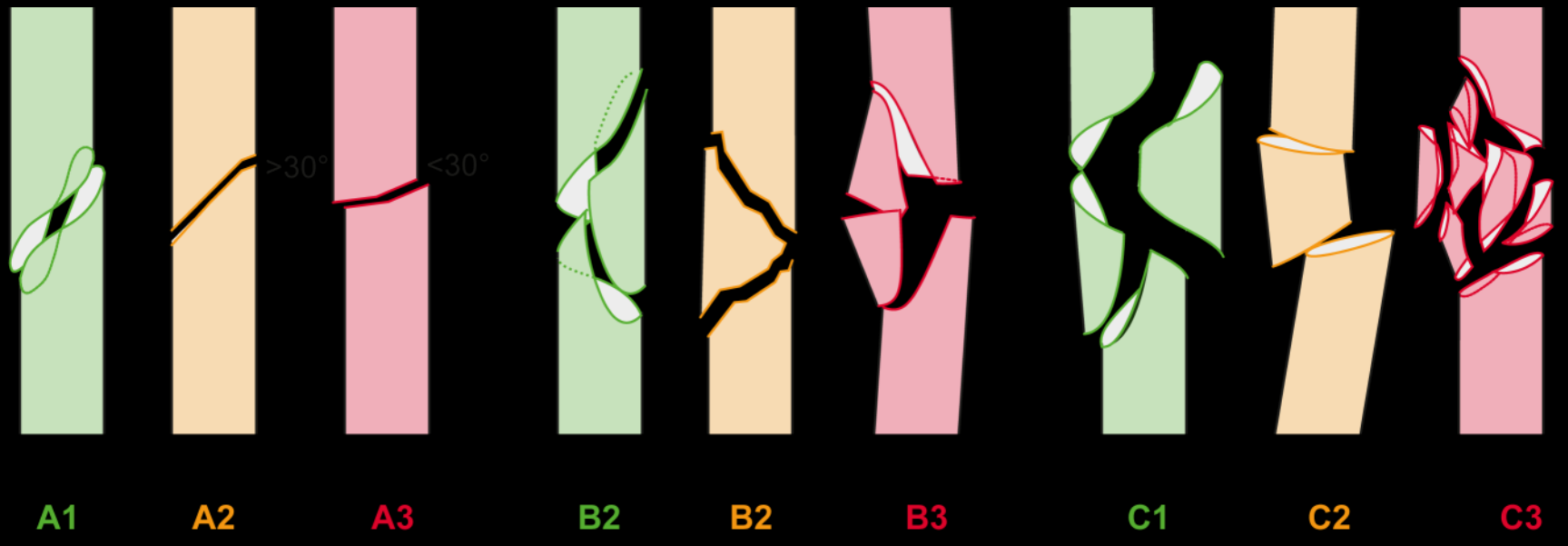


High-energy fracture patterns

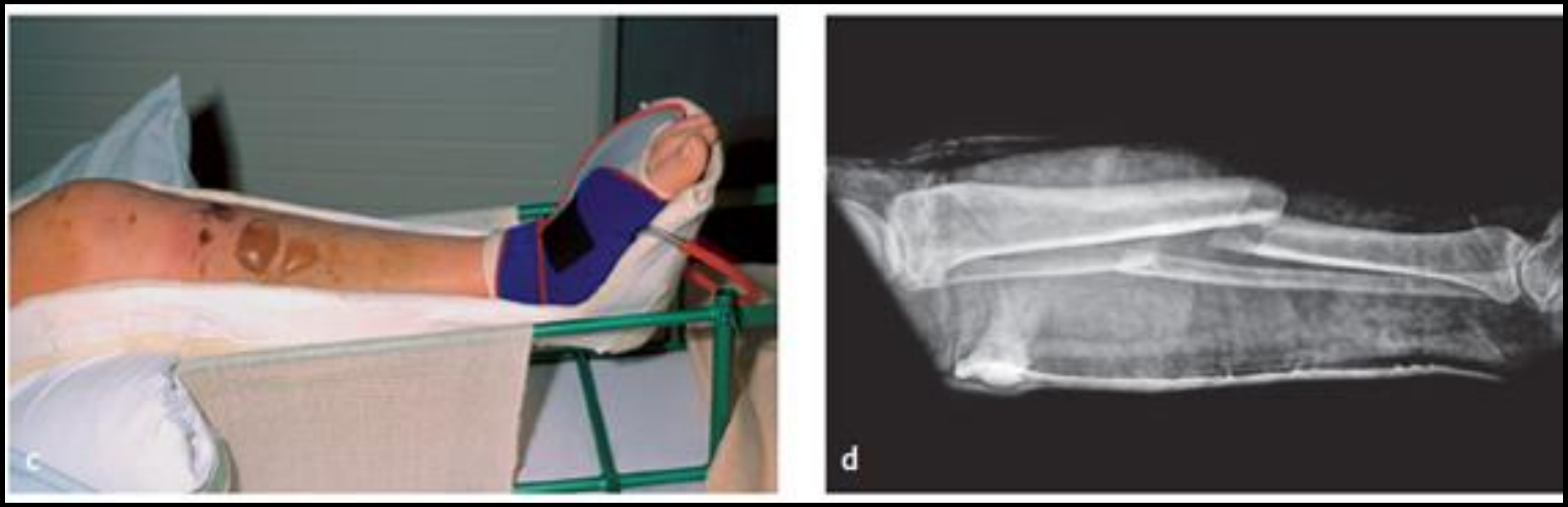


Fracture mechanisms diaphysis

- Torsion (skiing)
- Bending (indirect)
- Compression (fall from a height)
- Contusion (direct, bumper injury)
- Combinations




d

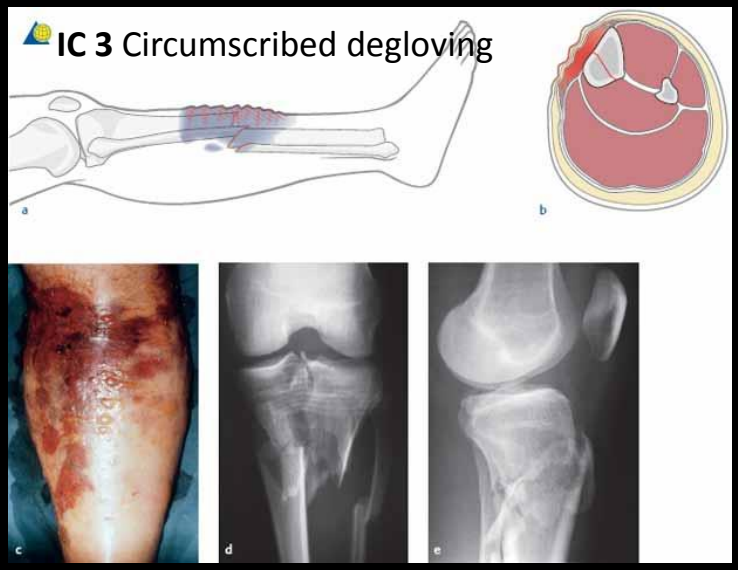

c
d

AO soft-tissue classification: closed skin lesions

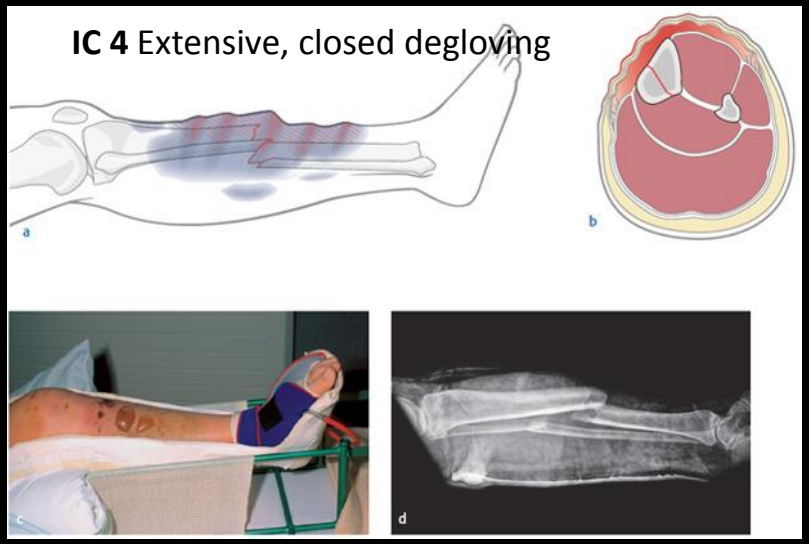
IC 1 No skin lesion

IC 2 No skin laceration, but contusion

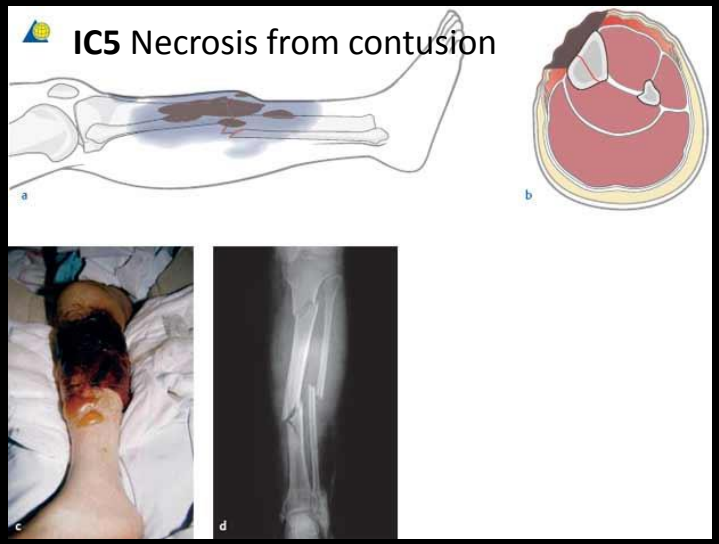
IC 3 Circumscribed degloving



IC 4 Extensive, closed degloving

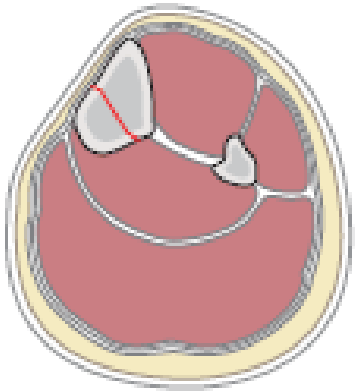


IC5 Necrosis from contusion



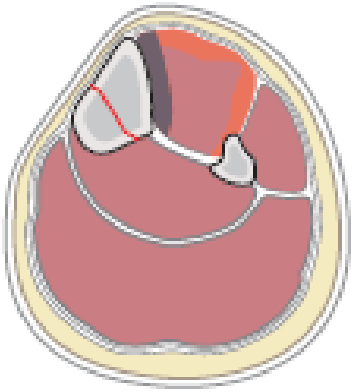
AO soft-tissue classification: MT=Muscle and tendon

MT 1



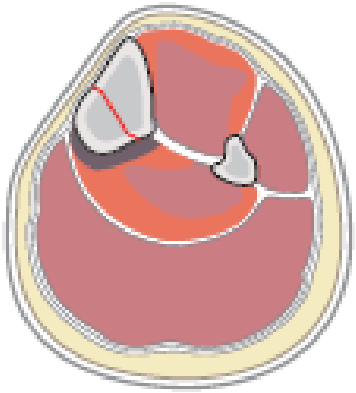
No muscle injury

MT 2



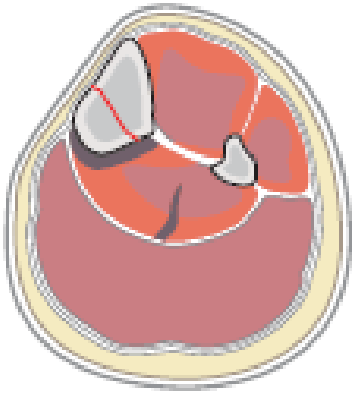
Circumscribed muscle injury, one compartment only

MT 3



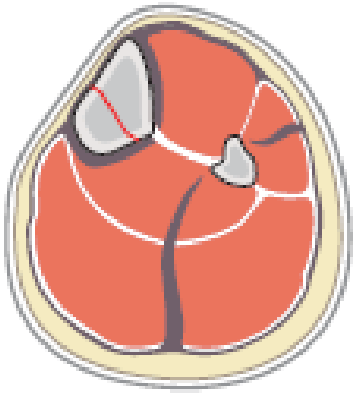
Considerable muscle injury, two compartments

MT 4

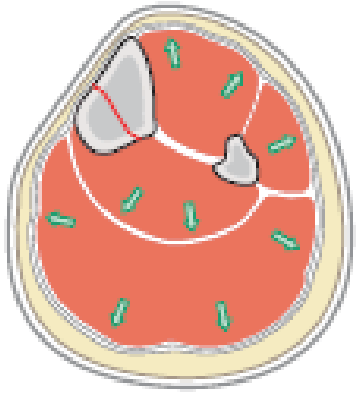


Muscle defect, tendon laceration, extensive muscle contusion

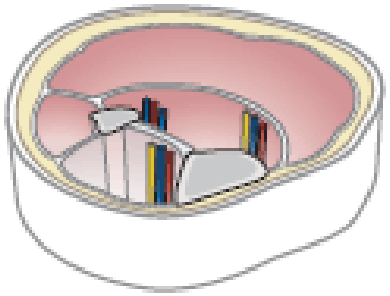
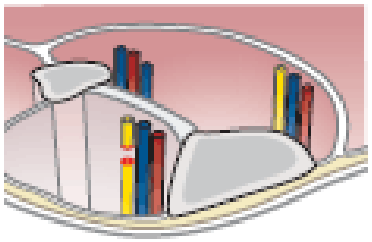
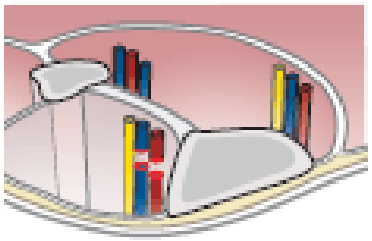
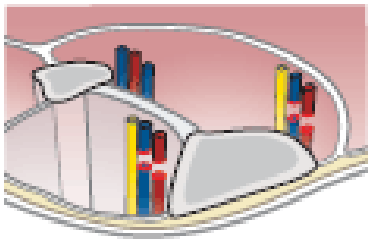
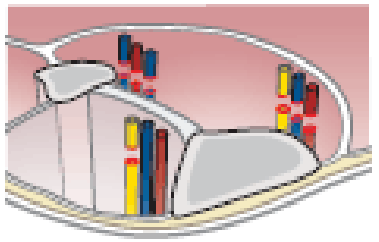
MT 5



Compartment syndrome/crush syndrome with wide injury zone



AO soft-tissue classification: NV=nerve and vessel

NV 1		No neurovascular injury
NV 2		Isolated nerve injury
NV 3		Localized vascular injury
NV 4		Extensive segmental vascular injury
NV 5		Combined neurovascular injury, including subtotal or even total amputation

42-A2/IC4-MT5-NV1

Midshaft tibial fracture - simpel oblique

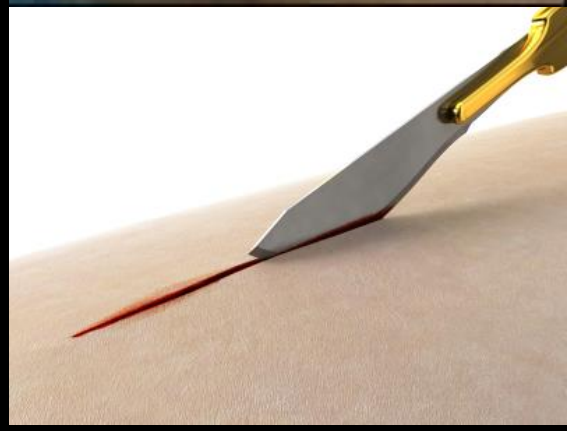
Massive soft tissue injury:

- Blisters and suspicion of extensive degloving
- Suspicion of extensive muscle contusion and compartment syndrome
- No NV-injury

Techniques for soft-tissue handling

Incisions

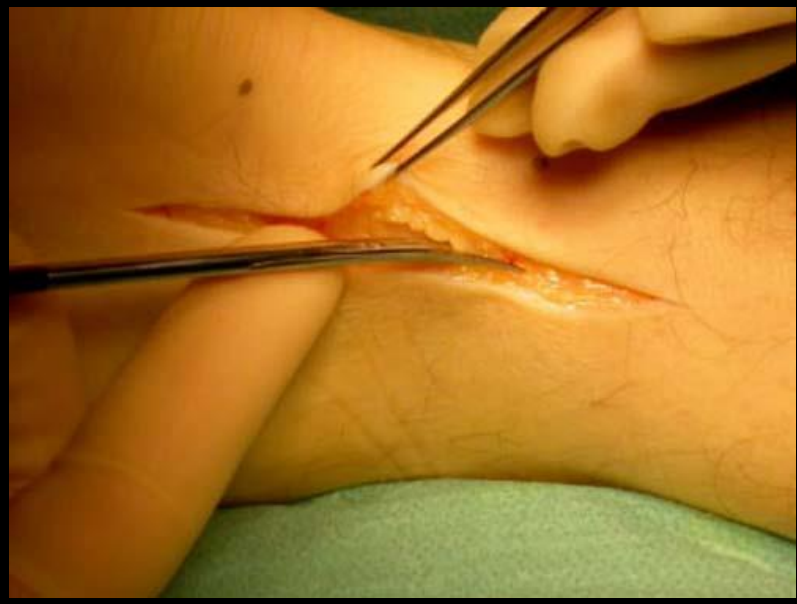
- "Minimally invasive" ≠ small incision
  - If small incision does not allow adequate visualization, excessive retraction is often used
  - Proper placement of incision is more critical when using small incisions
  - Small incisions do not ensure that the surgeon does not strip the bone
- Do not skive the skin—incise the skin perpendicular to the skin



Retraction

- Avoid retracting more than required to provide visualization
- Relax retraction whenever not needed
- Avoid self-retaining retractors when possible because they are easily set and forgotten

Forceps



- Use a very gentle touch—do not squeeze tissue
- Use as a retractor
- Avoid the use of large forceps on the skin

Dis

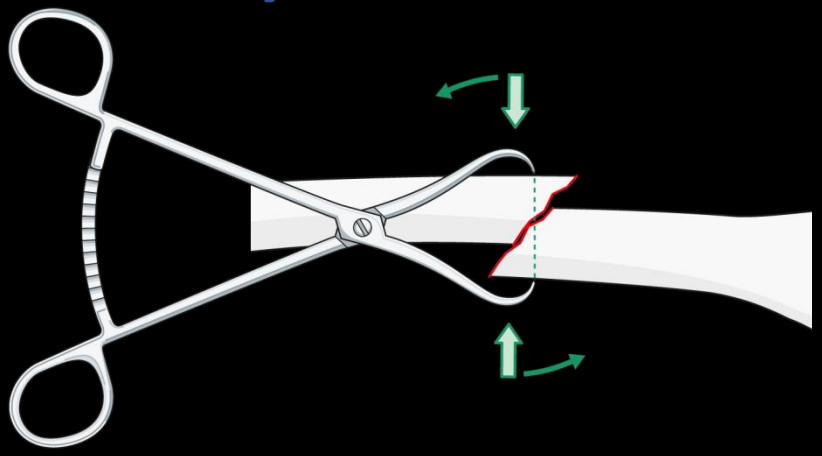
– Avoi sible
(espe d fascia)

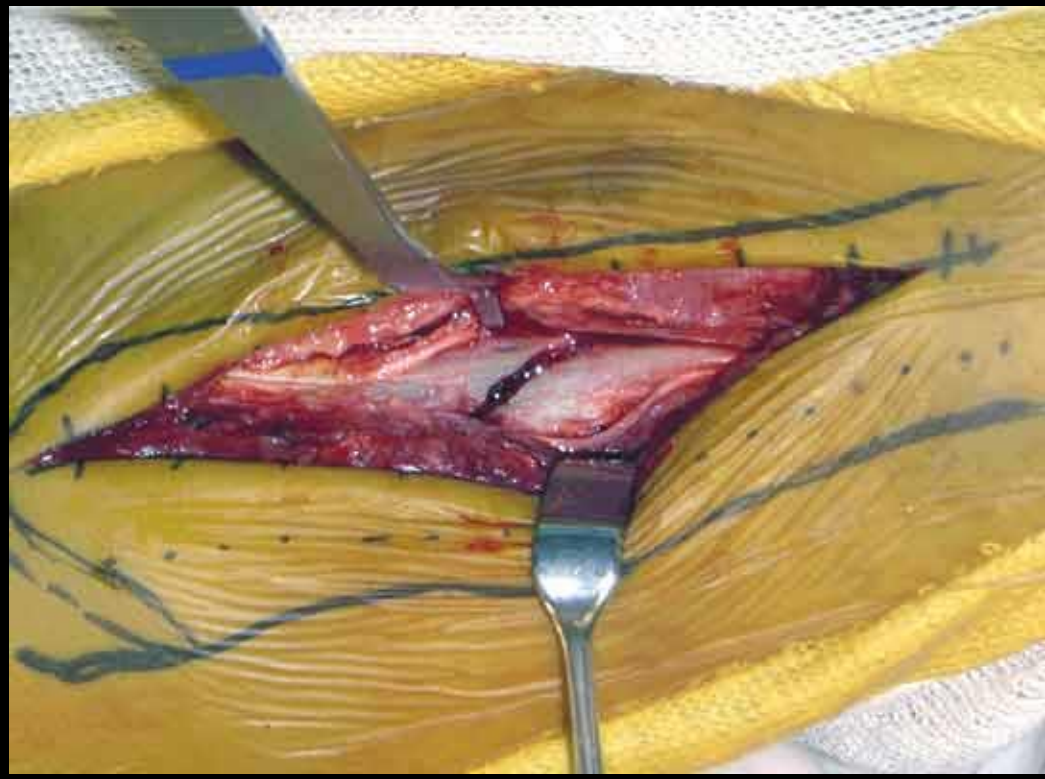
– Sharp dis when possible
(rather th nes soft tissues)

– Avoid multiple passes with scissors or scalpel through tissues

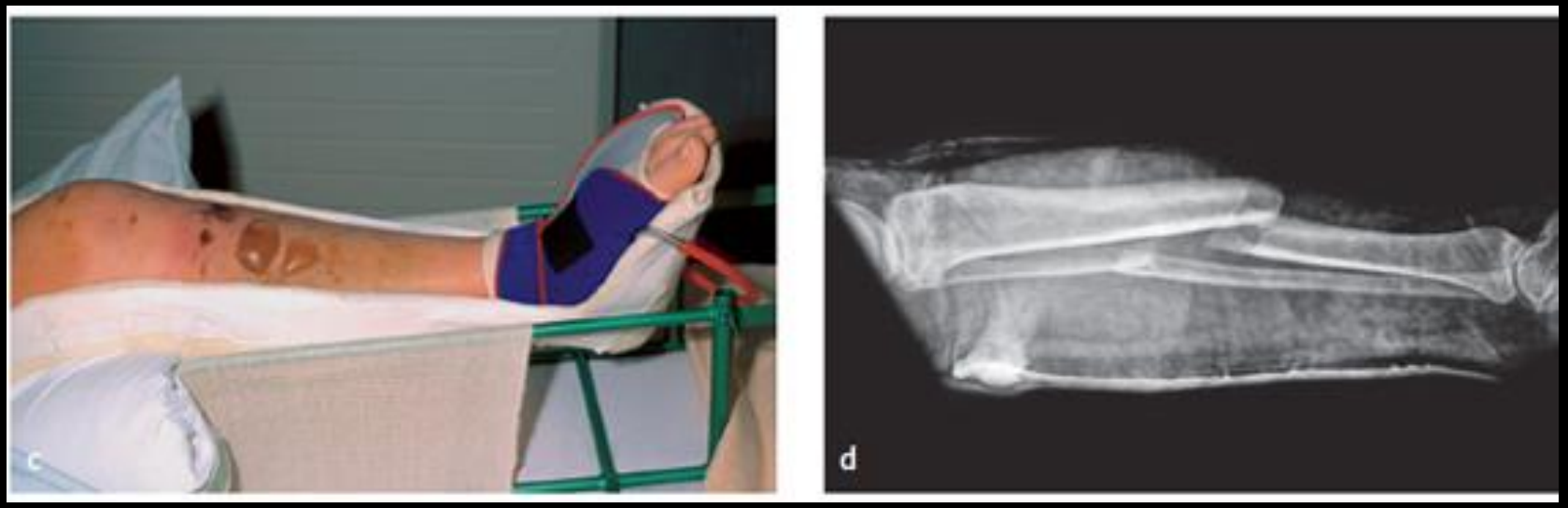
Bone exposure

- Preserve periosteum whenever possible
- Use least aggressive bone holding clamps as possible
- **Pay attention**





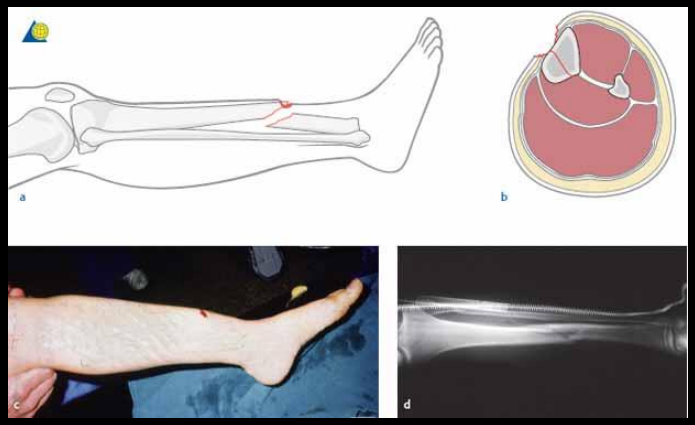
Conclusion

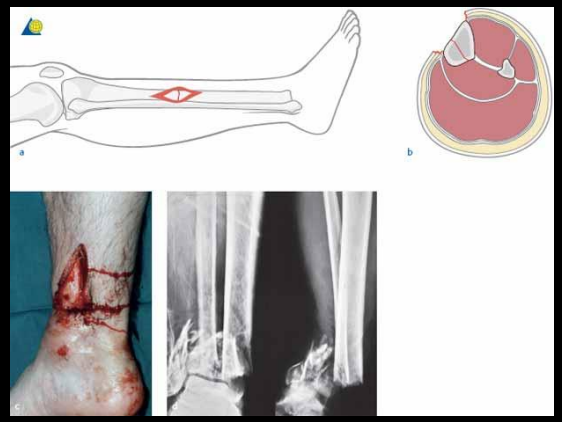


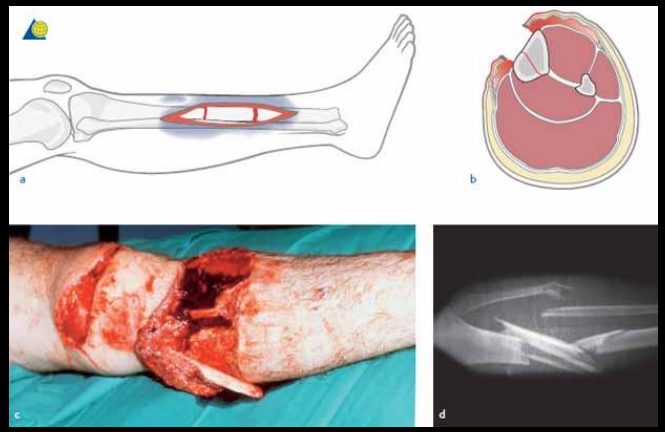
- Evaluate both the fracture and soft tissue
- Analyse damage to
  - Skin and subcutaneus fat
  - Muscle and tendon
  - Vessels and nerves

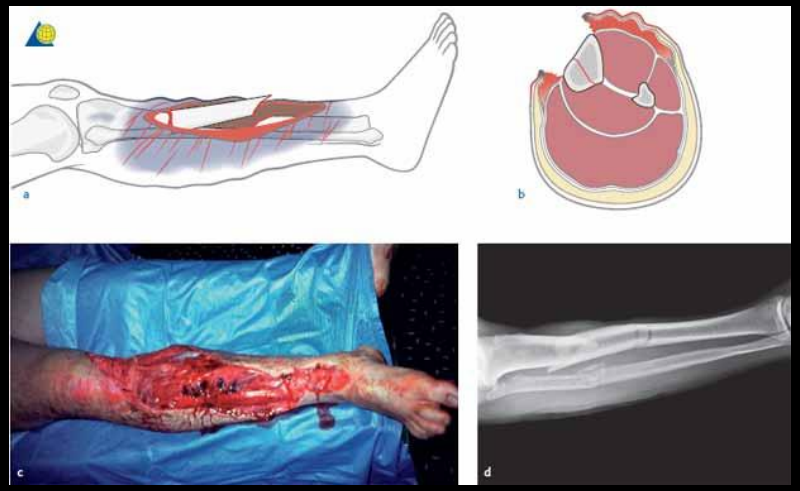
Include the condition of the soft tissue in your treatment strategy

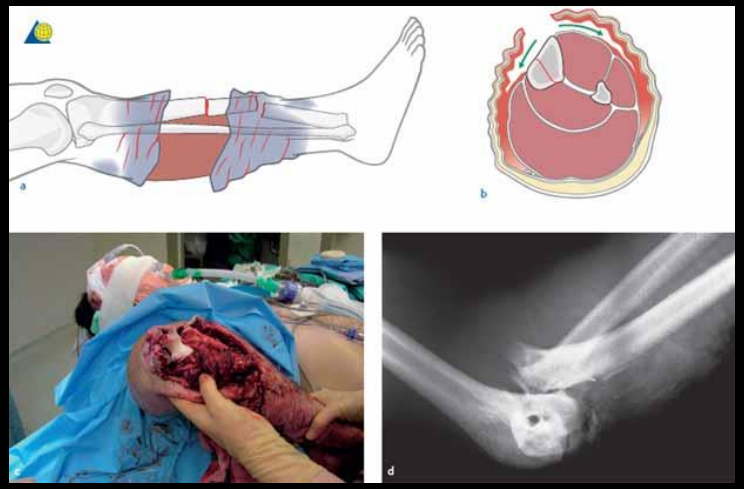
AO soft-tissue classification: open skin lesions











Fjordside case flowtron?

Coban2 Lite 40-60 mmHg

Sigvaris ulcerX compression stocking 30-40 mmHg

Randomi-
zation at the
Emergency
Room

Flowtron
before surgery

Coban2
after surgery

Compression
stocking at 2
weeks control

Compression
stocking at 6
weeks control

Elevation before surgery

Elevation after surgery

2 weeks
control.
No compres-
sion.

6 weeks
control.
No compres-
sion.

Necrosis

N=153

Necrosis	N/Total	Compression	N/Total	Elevation	P
2&6 weeks	7/82	8.5%	19/71	26.8%	0.004

AOTrauma Course—Basic Principles of Fracture Management
General principles
10 Dec 2009, Davos, Switzerland

The (soft-tissue) injury—a high priority consideration
Steffen Ruchholtz

Conclusion

- Evaluate both the fracture and the soft tissue
- Analyse damage to skin, vessels, muscles, nerves and ligaments
- Include the condition of the soft tissue in your treatment strategy

a simple, closed spiral tibial midshaft fracture from skiing with no injury of skin, muscles, tendons, nerves, or vessels

42-A1.2/IC1-MT1-NV1

Tscherne classification of closed fractures

Closed fracture grade 0 (Fr. C 0): There is no or minor soft-tissue injury with a simple fracture from indirect trauma. A typical example is the spiral fracture of the tibia in a skiing injury.

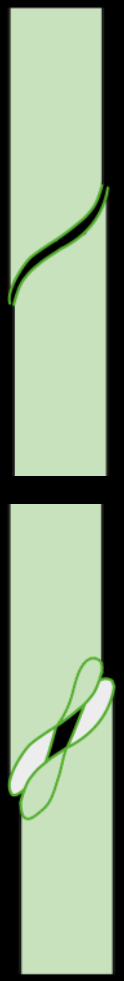
Closed fracture grade I (Fr. C 1): There is superficial abrasion or skin contusion, simple or medium severe fracture types. A typical injury is the pronation-external rotation fracture dislocation of the ankle joint: The soft-tissue damage occurs through fragment pressure at the medial malleolus.

Closed fracture grade II (Fr. C 2): There are deep contaminated abrasions and localized skin or muscle contusions resulting from direct trauma. The imminent compartment syndrome also belongs to this group. The injury results in transverse or complex fracture patterns. A typical example is the segmental fracture of the tibia from a direct blow by a car fender.

Closed fracture grade III (Fr. C 3): There is extensive skin contusion, destruction of muscle or subcutaneous tissue avulsion (closed degloving). Manifest compartment syndrome and vascular injuries are included. The fracture types are complex.

Tscherne classification of closed soft-tissue injuries

Tscherne and Oestern, 1982



C 0

- No, or no significant, soft-tissue trauma
- Simple fracture
- Indirect mechanism

Tscherne classification of closed soft-tissue injuries

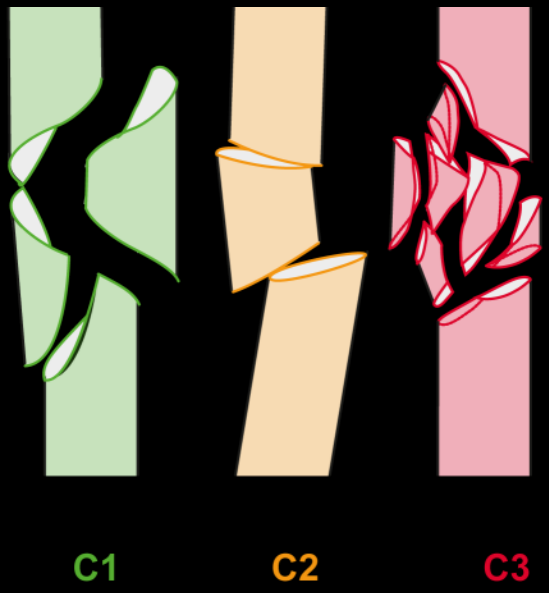
C I

- Soft-tissue contusion
- Fracture pattern usually simple

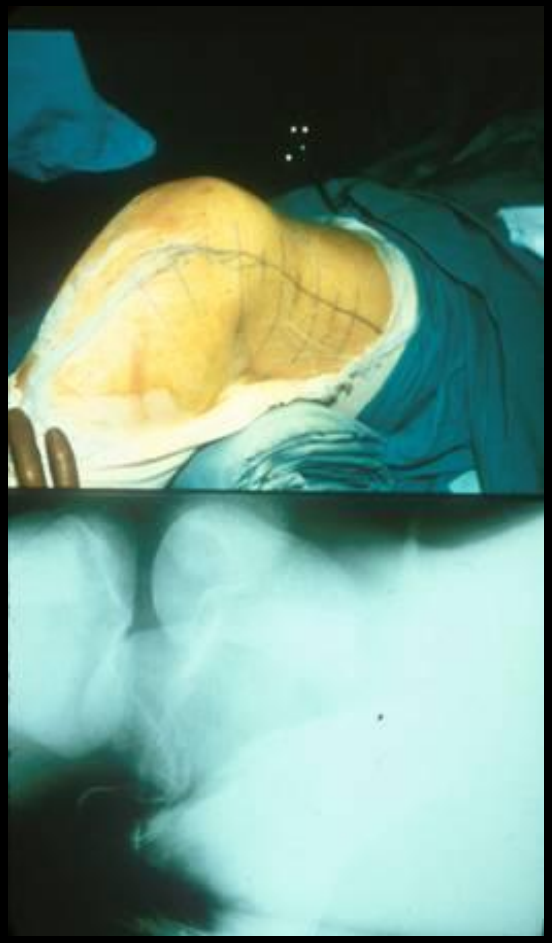
Tscherne classification of closed soft-tissue injuries

C II

- Deep abrasion
- Contusion of skin and muscle—localized
- Compartment syndrome possible
- Complex fracture (two levels)



Tscherne classification of closed soft-tissue injuries



C III

- Extensive skin contusion
- Closed degloving
- Manifestation of compartment syndrome
- Vascular injury
- Complex fracture

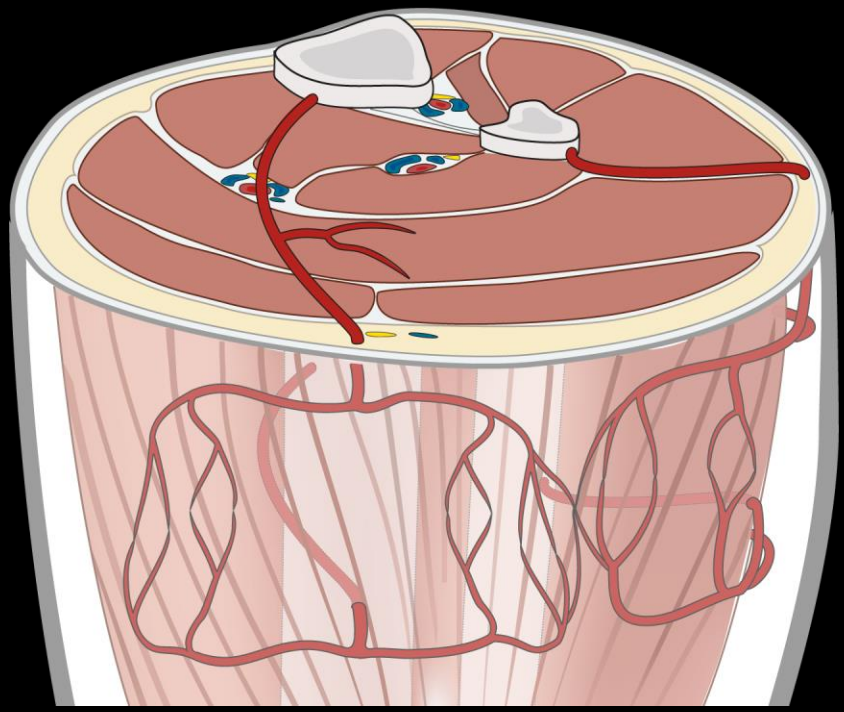
Tscherne classification of closed soft-tissue injuries

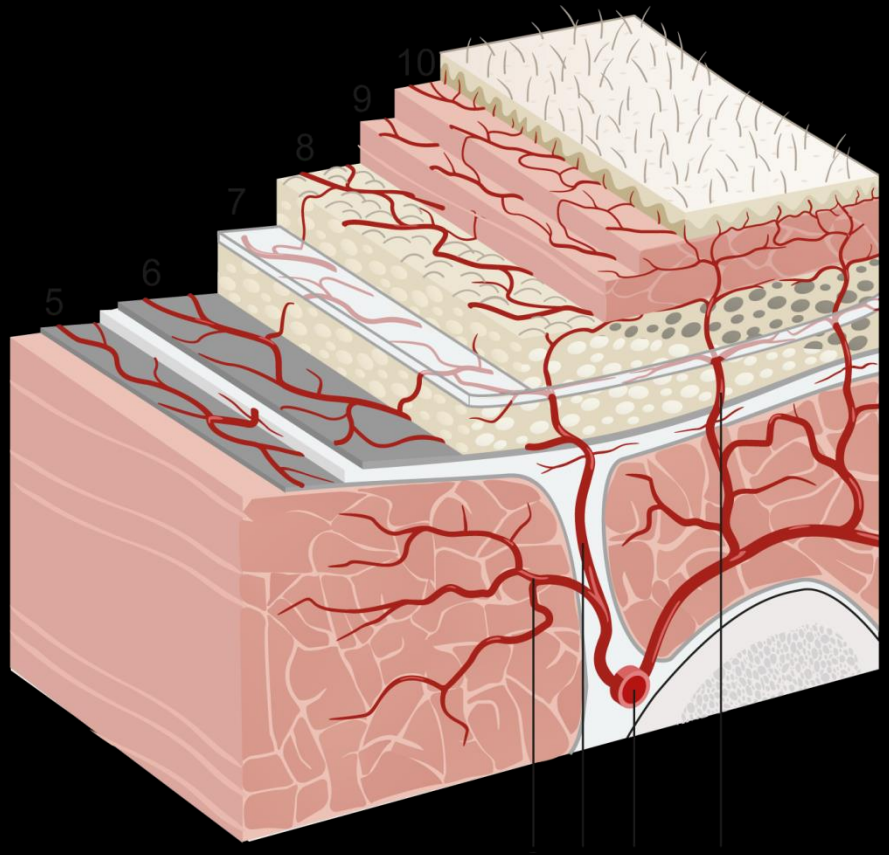
C IV

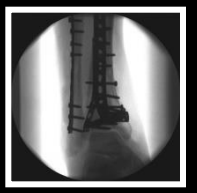
- Deep erosion
- Contamination
- Contusion
- Tangential trauma
- Shear injury
- Manifestation of compartment syndrome
- Complex fracture
- Direct mechanism
- Vascular injury with reconstruction

Vasculature of the skin

- Vascular supply to the skin
  - Directly related to perforators
  - Perforators come through muscle from named arteries





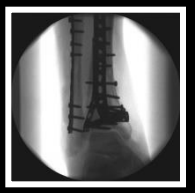


- Timing of surgery
  - Allowing for soft-tissue recovery

Schepers et al. Int Orthop 2013, Ovaska et al. JBJS Am 2013

- Timing of atb-prophylaxis
  - 20% in wrong time window
  - Decreases infections x 3 when administered properly
  - Single dose

Ovaska et al. JBJS Am 2013, Bosco III JBJS Am 2010, Olsen et al. JBJS Am 2008
Fletcher et al. JBJS Am 2007, Schmidt et al. JAAOS 2000



- Tissue handling
  - Incision planning / Additional surgical trauma

Schepers et al. Int Orthop 2013, Richards R. Injury 2006

- Shape of the implant/ Stability of ostesyntesis
  - Bulky locking plate under the skin?
  - Unstable osteosyntesis – Infection x 2

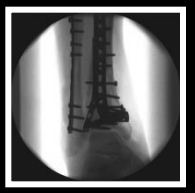
Schepers et al. Int Orthop 2013, Richards R. Injury 200
Schmidt et al. JAAOS 2000, Worlock et al. Injury 1994

- Duration of surgery/ Number of persons visiting OR

Ovaska et al. JBJS Am 2013, Bosco III et al. JBJS Am 2010

- Wound closure method
  - Staples/ Sutures?
  - Not too tight!

  Ovaska et al JBJS Am 2013



- Casting in OR?

  Ovaska et al. JBJS Am 2013

- First wound check >24h

  Bosco III et al. JBJS Am 2010

- Too early mobilixation?

  Keene et al. J Orthop Sports Phys Ther 2014, Lehtonen et al. JBJS Am 2003