principles of open fracture treatment



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definition

an open fracture is a fracture that communicates with the outside environment







a (open) fracture is a soft-tissue injury which also involves the bone



open fractures ISTP e round 9/23

open fracture management

aim	problems
prevent infection	infection
soft tissue and bone healing without complications	delayed and non union soft tissue problems
restoration of function	loss of / non functional extremity

the problem:

open fx incidence 30/100 000/yr

open tibia 11% of all open fx

infection risk 30-50%

complication rate 50%



extreme mental distress, high morbidity, high costs

Where Are We in 2022? A Summary of 11,000 Open Tibia Fractures Over 4 Decades

Isaac A. Castillo, MD,[a] Jacob A. Heiner, MD,[b] Ramzy I. Meremikwu, MD,[c] James Kellam, MD,[b] and Stephen J. Warner, MD, PhD[b]

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….little has changed over 40 years regarding our ability to lower the infection and nonunion rate.

…efforts to minimize complications with open tibia fractures need to continue.

classification

gustilo-anderson

open fractures ISTP e round 9/23

gustilo classification 1976/1984



reflection of amount of energy imparted

some prognostic implications

1. skin wound size
2. level of contamination
3. extent of soft tissue injury/ periosteal stripping
4. fracture configuration

classification must be done *AFTER* debridement

type I

wound < 1cm
minimal soft tissue injury
inside-out
clean wound
minimal contamination
minimal contusion
minimal energy
simple fracture
no crush mechanism





type II

wound > 1 cm

moderate soft tissue injury

moderate crush

no extensive soft tissue damage, flaps or avulsions

simple fracture

minimal comminution





type III – high energy

open segmental / comminuted fracture
severe soft tissue damage
severe crush injury
severe contamination

traumatic amputation
gunshot injuries
farm injury
open fracture with vascular injury

type III

additions to original classification

type III divided into A B C

Gustillo, Mendoza, Williams (1984)

injuries > 8 hours are type III

Gustillo, Gruniger, Davis (1987)

type III A

extensive soft tissue injury

outside – in

segmental / comminuted

NOT dependant on wound size





does NOT require flap

primary closure possible

skin graft OK

type III B

severe periosteal stripping and bone exposure

severe contamination

severe comminution

REQUIRES free or local flap





type III C

ANY open fracture with vascular injury that needs repair

1 major artery intact = III A/B

independent of soft tissue injury

impaired blood supply:
- higher infection risk
- delayed healing

if vascular repair not possible = amputation



most widely used

communication / research tool

prognostic importance – complication rate type III ⬆

interobserver agreement 60%

definition not uniform

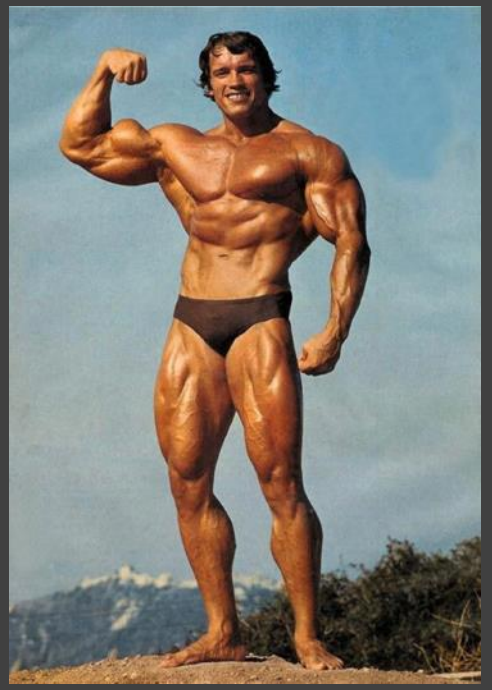
does not look at skin/bone/muscle separately

does not address salvage - GHOIS

prognostic factors - patient

- age
- obesity
- malnutrition
- habits
  - smoking / drugs
- immune compromise
  - diabetes/HIV





the bad news

injury and patient factors are not in your control

the good news

your treatment can make prognosis better

antibiotics
debridement
bone stabilisation
dead space management
soft tissue coverage



ED treatment

primary / secondary survey
antibiotics / tetanus
examine wound once
remove gross contamination
sterile dressing / betadine
splint the limb
reduce, but
skin tension beats bony reduction



ED treatment

take photos

neuro and vascular status

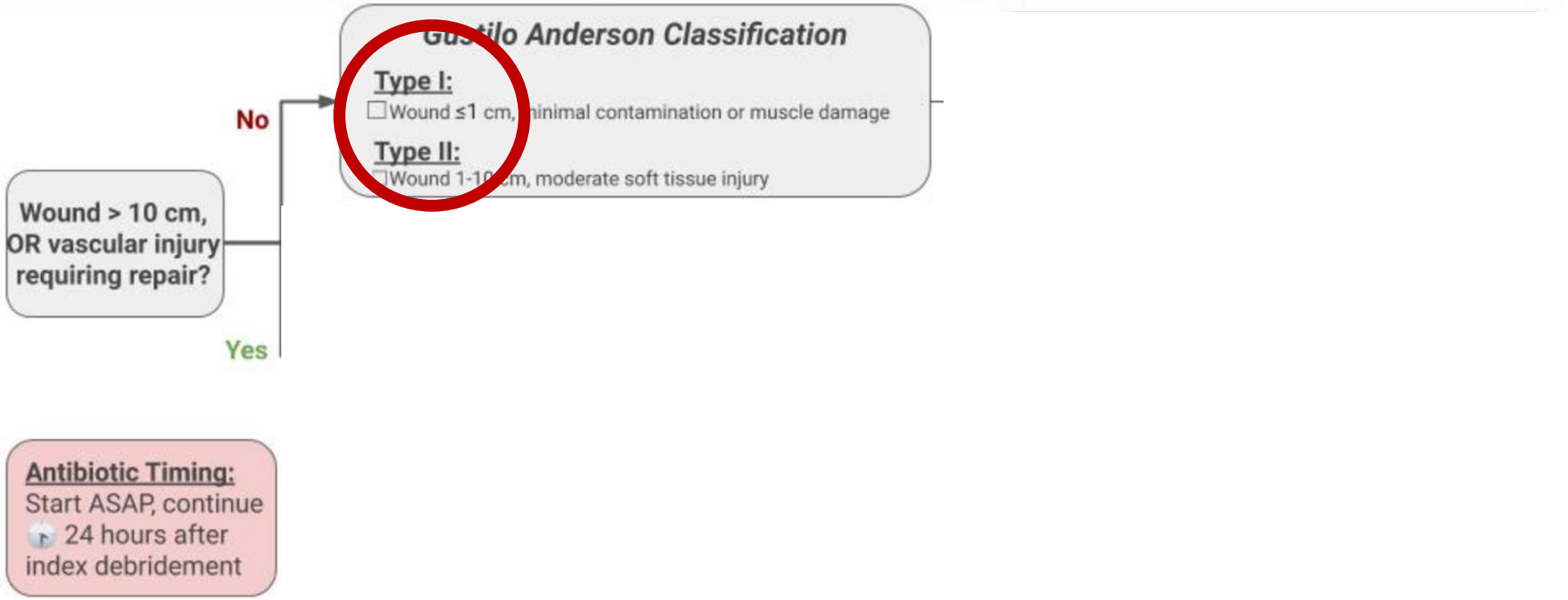
compartments

bleeding – the finger is mightier than the clamp

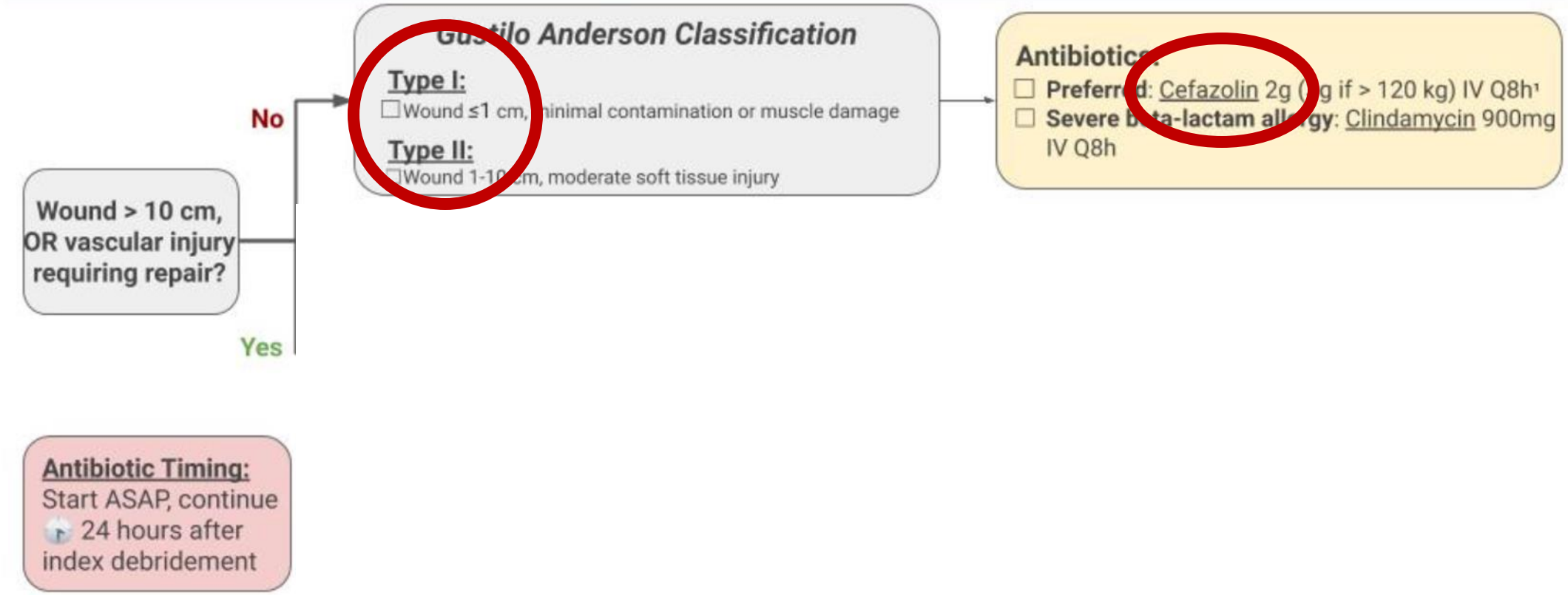


antibiotics

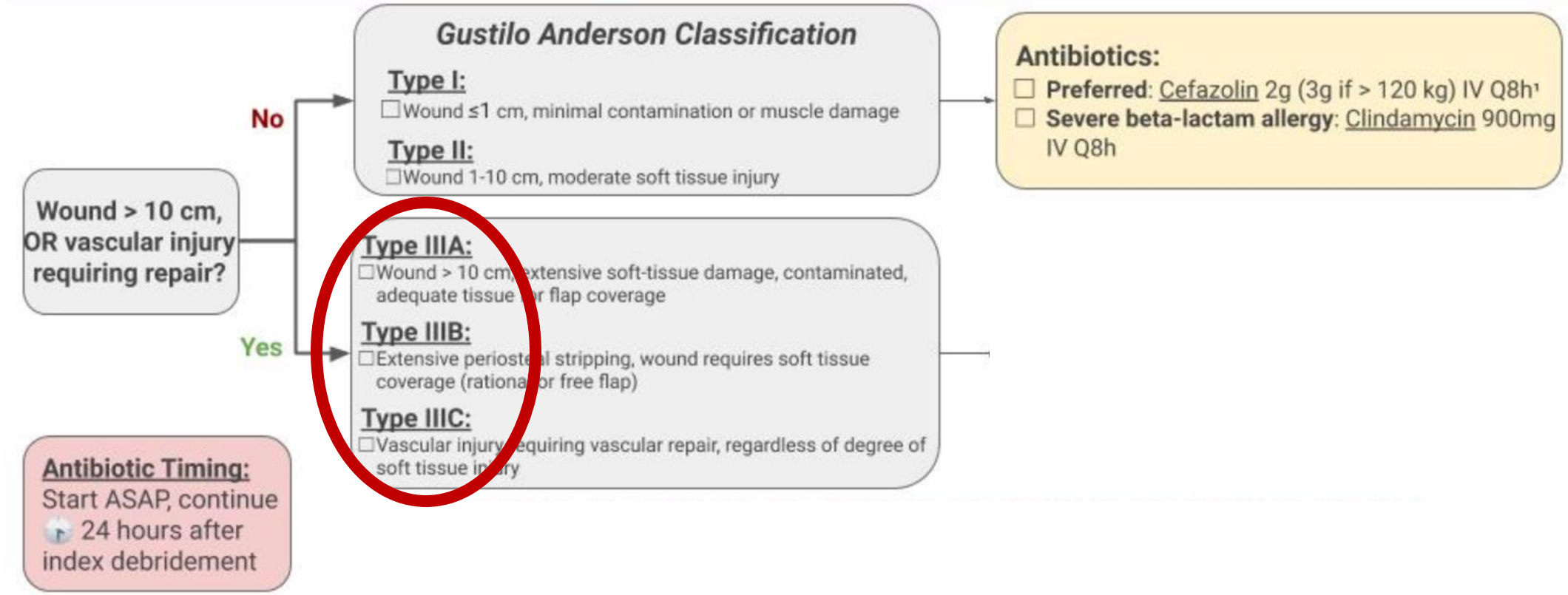
Open Fracture Antibiotic Protocol



Open Fracture Antibiotic Protocol



Open Fracture Antibiotic Protocol



Open Fracture Antibiotic Protocol

Wound > 10 cm, OR vascular injury requiring repair?

No

Yes

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 > 10 cm, extensive soft-tissue damage, contaminated, adequate tissue or flap coverage

Type IIIB:
☐ Extensive periosteal stripping, wound requires soft tissue coverage (rational or free flap)

Type IIIC:
☐ Vascular injury requiring vascular repair, regardless of degree of soft tissue injury

Antibiotics:
- ☐ **Preferred**: Cefazolin 2g (3g if > 120 kg) IV Q8h[1]
- ☐ **Severe beta-lactam allergy**: Clindamycin 900mg IV Q8h

Antibiotics:
- ☐ **Preferred**: Ceftriaxone 2g IV Q24h
- ☐ **Severe beta-lactam allergy**: Clindamycin 900mg IV Q8h + levofloxacin 500 mg IV Q24h[1]

Antibiotic Timing:
Start ASAP, continue 24 hours after index debridement

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Exceptional Cases
- ☐ **Soil or Fecal Contamination**: Vancomycin 15 mg/kg IV q8-24h[2] + Ertapenem 1g IV Q24h[1]
- ☐ **Standing Water Contamination**: Piperacillin/Tazobactam (Zosyn) 4.5g IV Q6h[1,3]
- ☐ **Known MRSA Colonization**: Add Vancomycin 15 mg/kg IV Q8-24h[2]

antibiotics

administer as soon as possible – Patzakis 1974 / Lack 2015

time to AB more important than time to OT

duration:
max 72 hours or max 24 hours after wound closure

evidence for gram negative coverage weak

ADJUNCT only

most important: follow your hospital's protocol

antibiotics



wound cultures at first debridement

do not use for antibiotic guidance – does not correlate

most infections nosocomial

cultures at closure – correlate with development of infection

antibiotics

local antibiotics

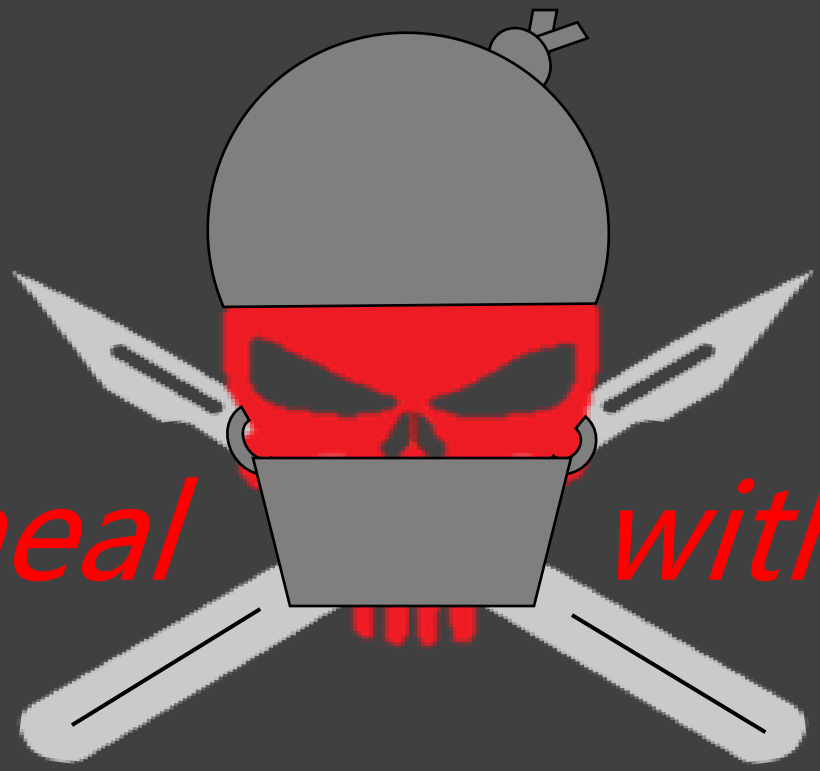
growing evidence that effective

why did you rob the bank?



vancomycin powder
vanco/genta cement / beads
continuous local antibiotic perfusion – CLAP
iSAP / iMAP

the best antibiotic is surgical steel



debridement

prior to irrigation

turn into surgical wound

tourniquet - put on, don't inflate

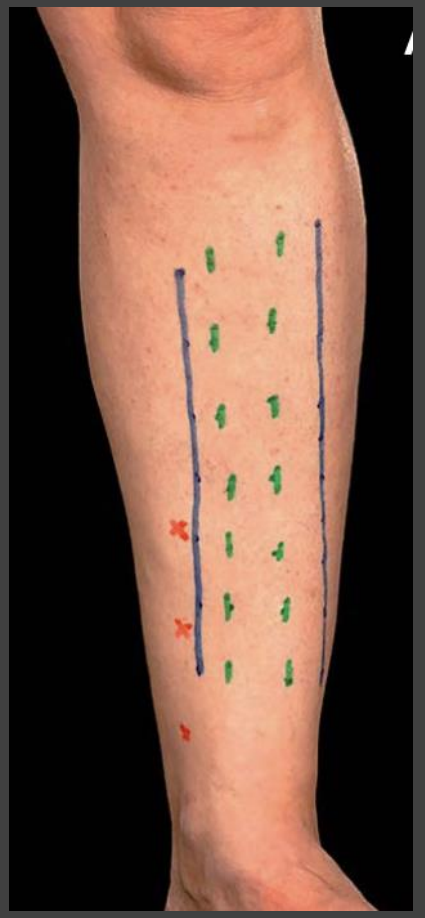
requires wound extension

- longitudinal

systematic fashion

- skin – fat – fascia – muscle - bone





PHOTOS

debridement - skin

extend the wound

must see entire zone of injury – longitudinal

keep skin excision kept to a minimum

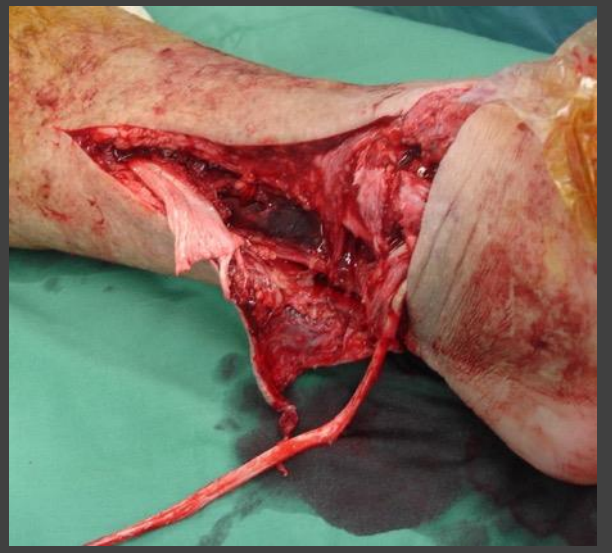
especially subcutaneous tibia border

skin can recover and functions as dressing

consider future flaps

excise dead fat and dirty fascia



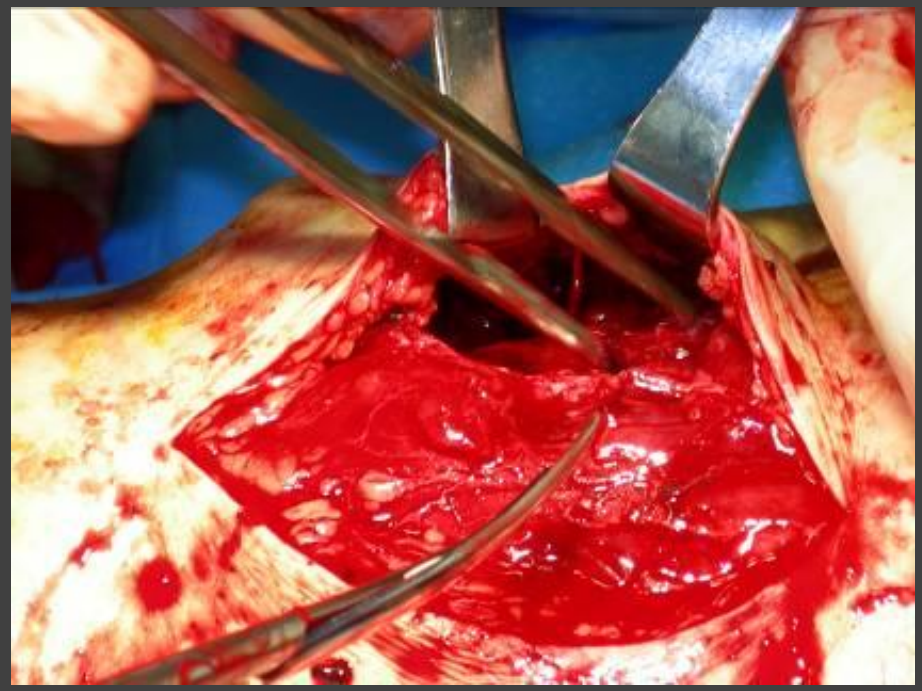


debridement - muscle

open compartments
to see extent of injury

remove dead / necrotic muscle

colour
consistency
contractility
capacity to bleed



debridement - bone

tug test

no bleeding / no attachments: out

keep large articular fragments

consider fixing at initial debridement





debridement – ideal timing (BOAST 4)

immediately if highly contaminated

< 12 hours IIIA / IIIB not contaminated

< 24 hours for all other fractures

debridement

think like a tumour surgeon: radical removal of dead tissue

the biggest mistake is if your incision is too small



more than two debridements =
independent predictor for infection

SHARP dissection, don't use blunt instruments to spread tissue
destroys horizontal layers – creates bigger traumatic wound

debridement contd…

if good debridement and closure: change instruments

in doubt bring a friend

photos before and after

VERY good documentation – text, drawings

documentation helps with audits and research

it's an art, not a science, you will get better with experience

lavage

important adjunct

FLOW trial

(very) low pressure saline

lots of it



coverage

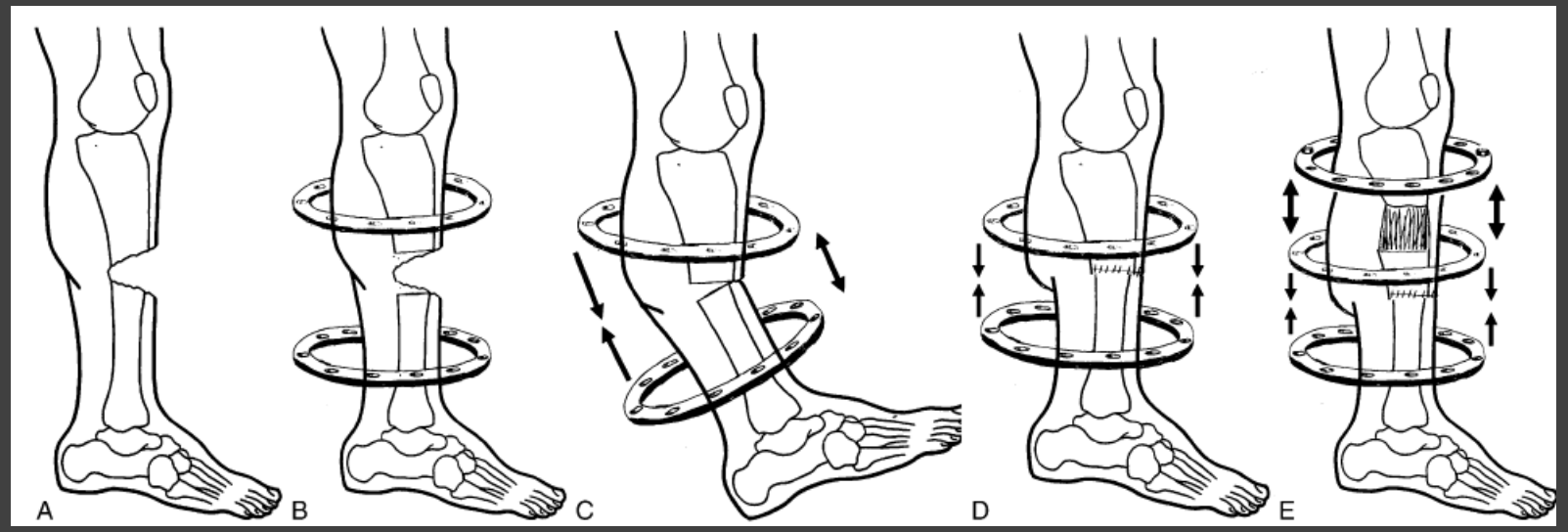
type I and II primary closure

must be tension free!

type III within 72 hours
dpc, regional or free flaps

infection rates increase after 7 days





can also shorten







NPWT

closed suction system – clean, comfortable

reduces number of dressing changes

reduces swelling / bacterial count

enhances granulation tissue

NOT substitute for primary closure

NOT for infected wounds

NOT the magic solution



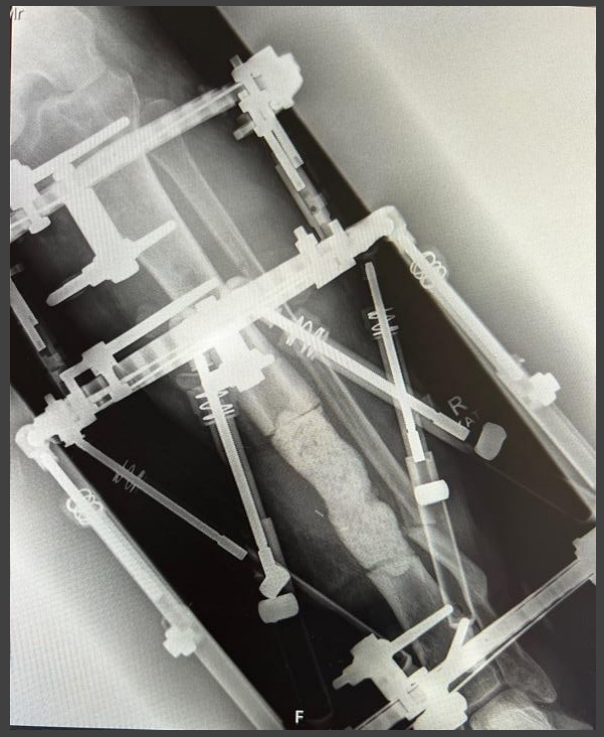




dead space management

dead space = infection. MUST avoid

shortening
drains
vacuum dressing
muscle
bone cement
ab beads
syringes





bone stabilisation

in an ideal world:





GA I and II – IF or EF no difference

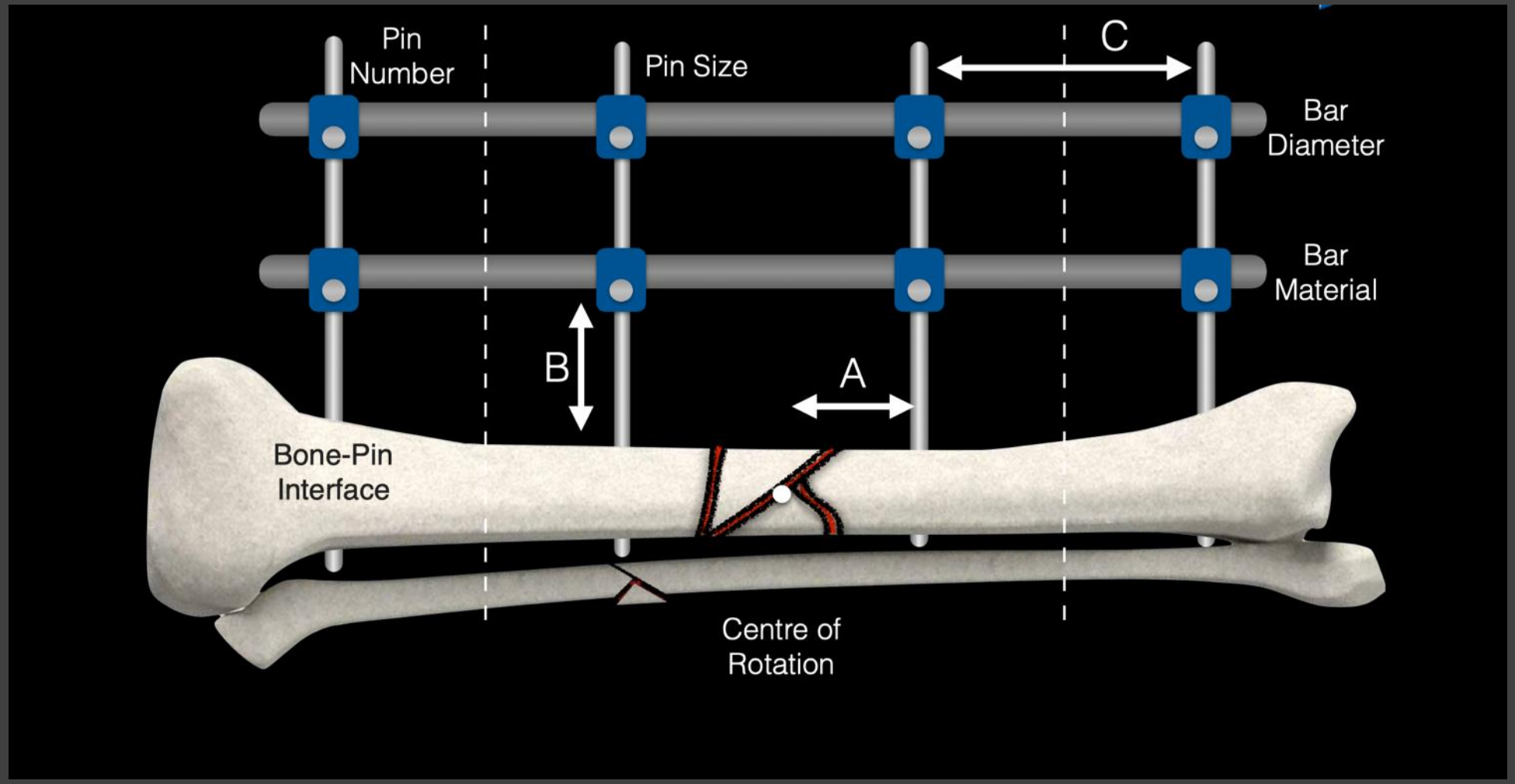
GA III A and B - circular fix or nail

GA III C - best results with circular fixation

however,…

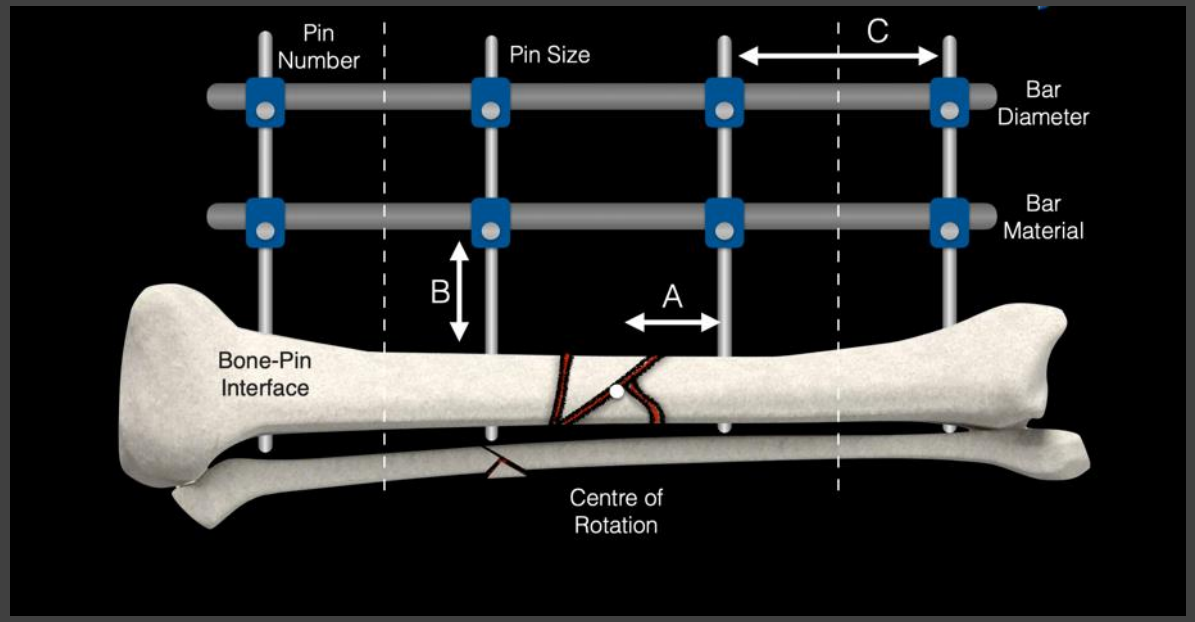


we need to get it right



we need to get it right

pin placement
pin number
pin diameter
rod placement
rod material
rod number



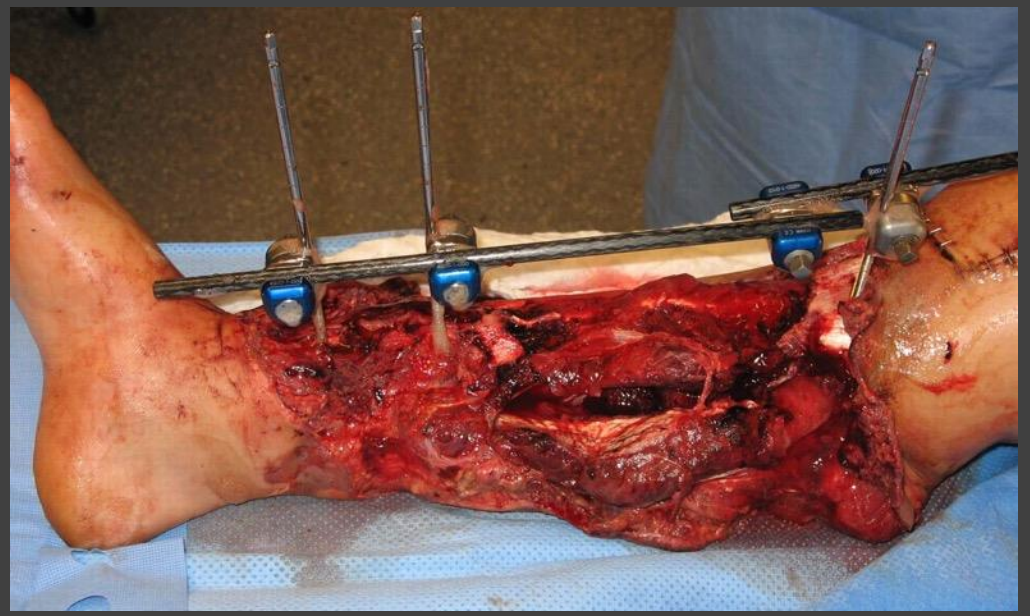
it's all about biomechanics



beware of the ornamental ex fix - do not over or under-build

it's all about biomechanics





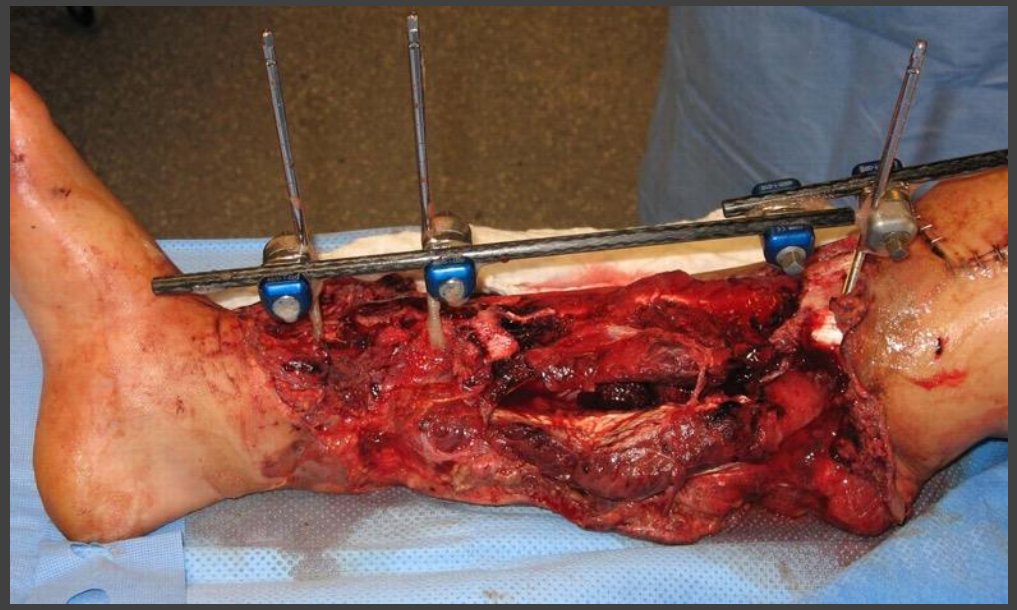
beware of the ornamental ex fix - do not over or under-build

too rigid

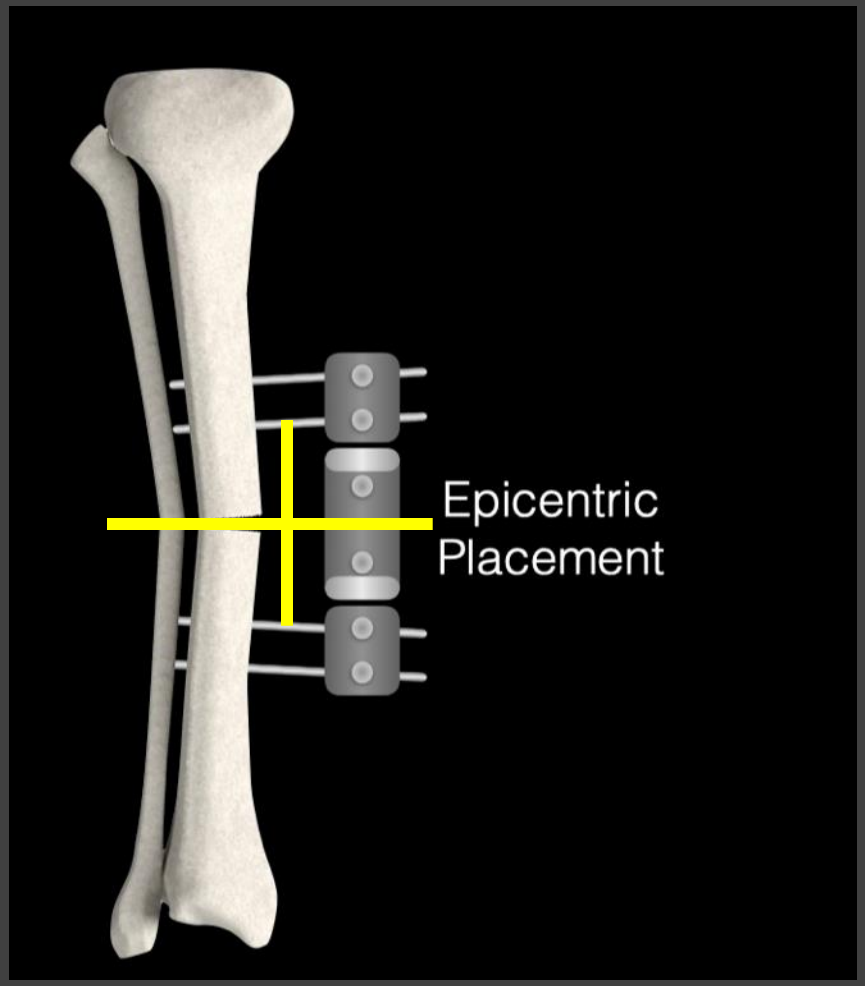
non and delayed union
disuse osteoporosis

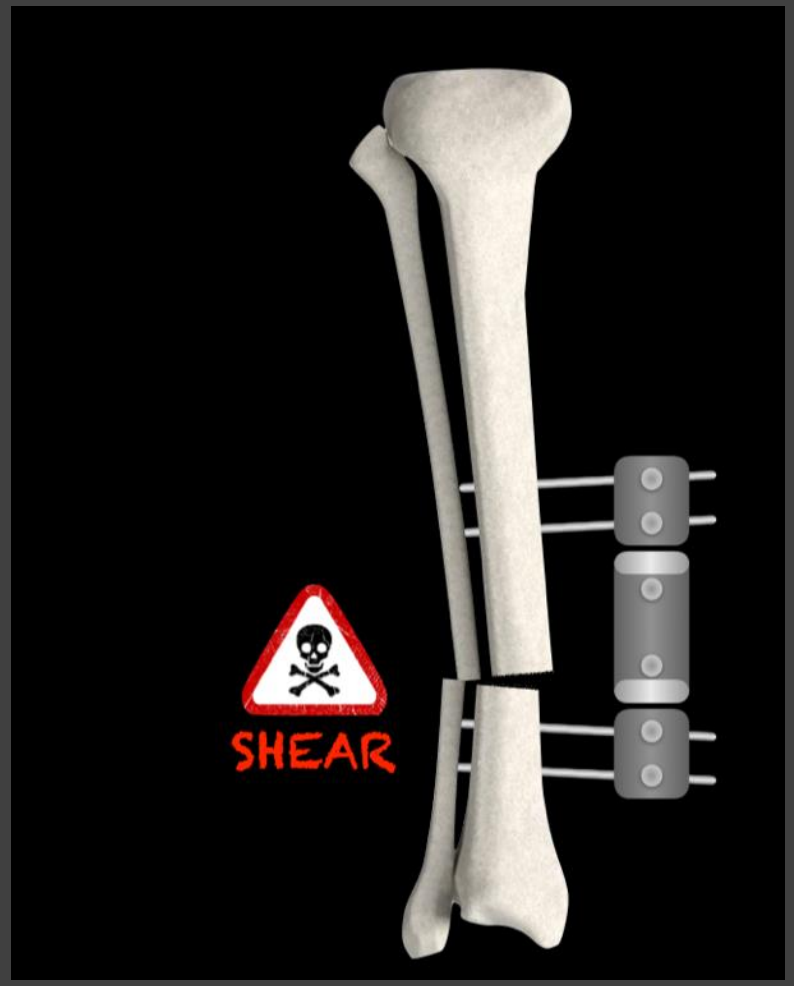
too flexible

mal and nonunion
infection
pin problems



we need to get it right





pin diameter ≤ 1/3 bone diameter

perpendicular to each other

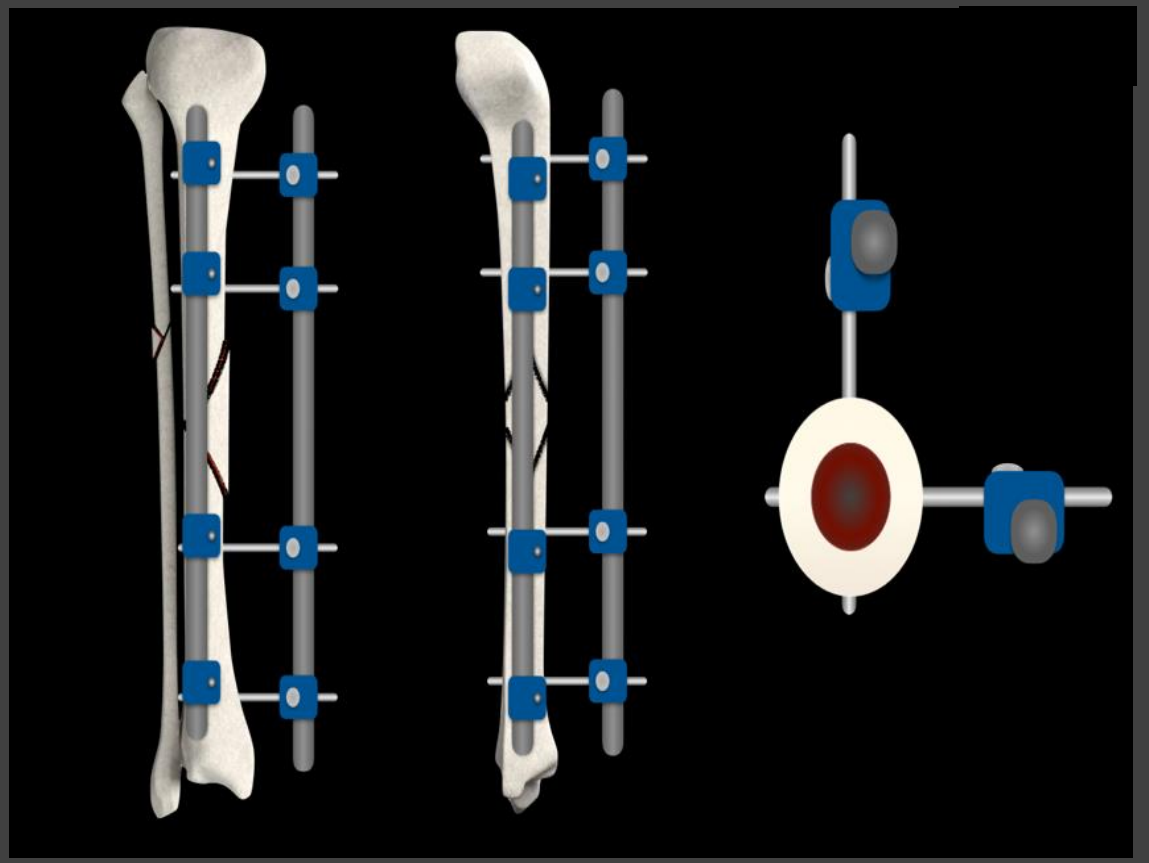
rod in line with load axis

not in the fracture

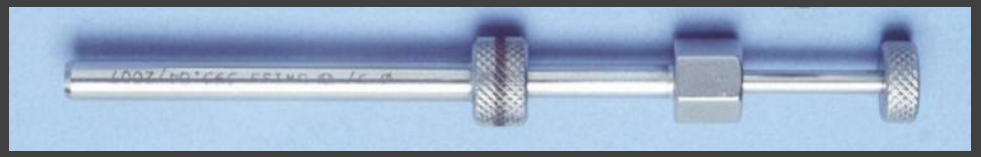
in doubt put more pins

2 rods stiffer

carbon rods stiffer



pin insertion technique



incise skin

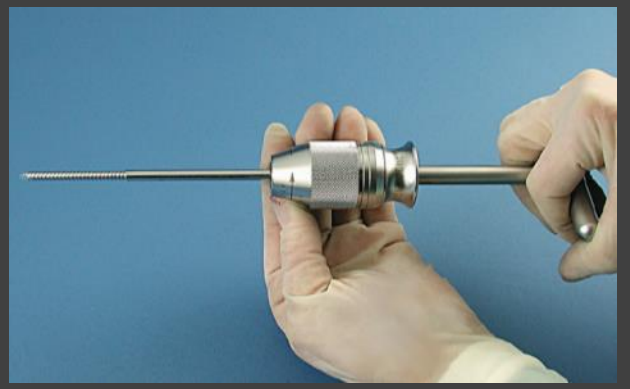
spread soft tissues to bone

use sharp drill with sleeve

irrigate while drilling

place pin with sleeve



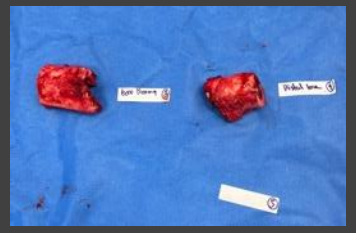


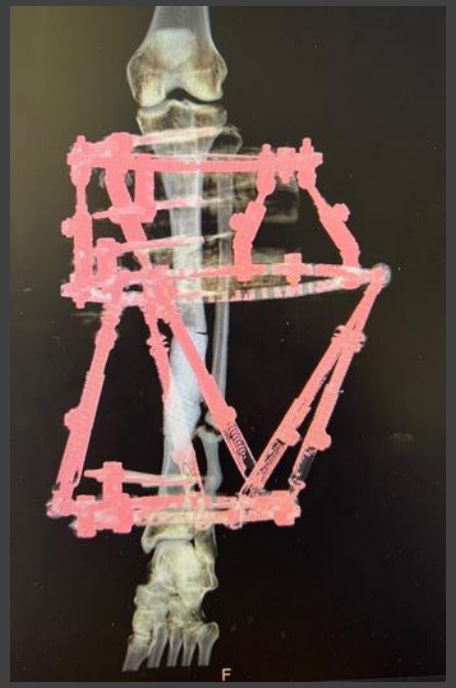
avoid soft tissue damage and bone heat necrosis

think of:

safe insertion sides
future flaps
easy access to wounds
future internal fixation







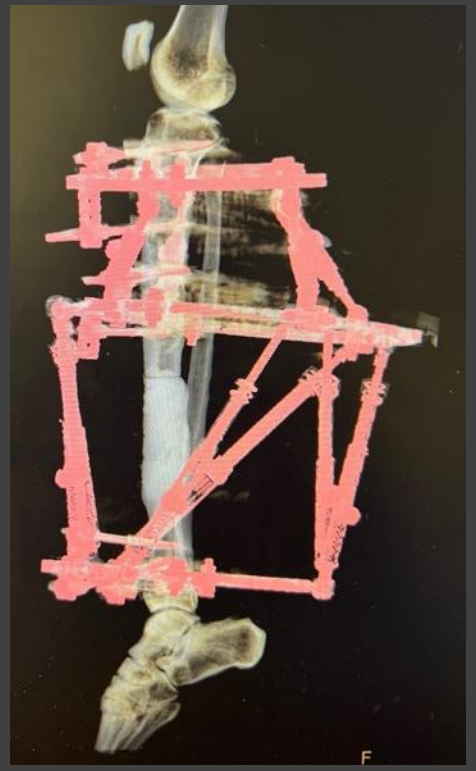






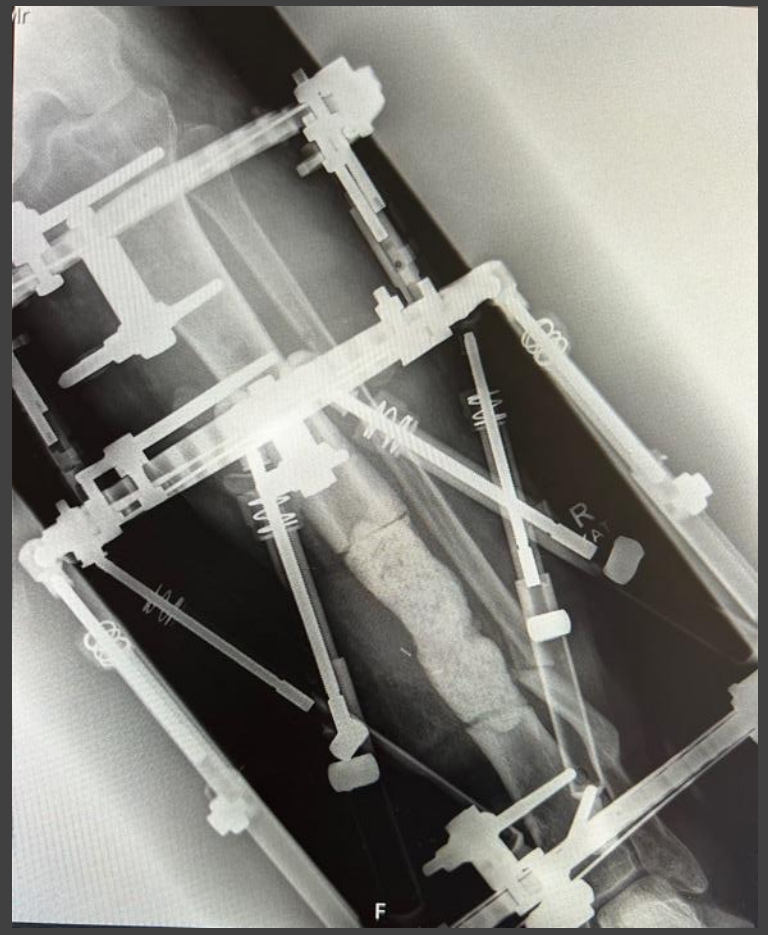
Figure 7. *Professor Ilizarov smoking while on break in the operating room (photo courtesy of RISC).*

ring fixator most versatile
lengthening/correction/transport

needs some training

uncomfortable for the patient but very comfortable for the bone

for long time application
for large bone defects



the other, VERY important stuff

physiotherapy

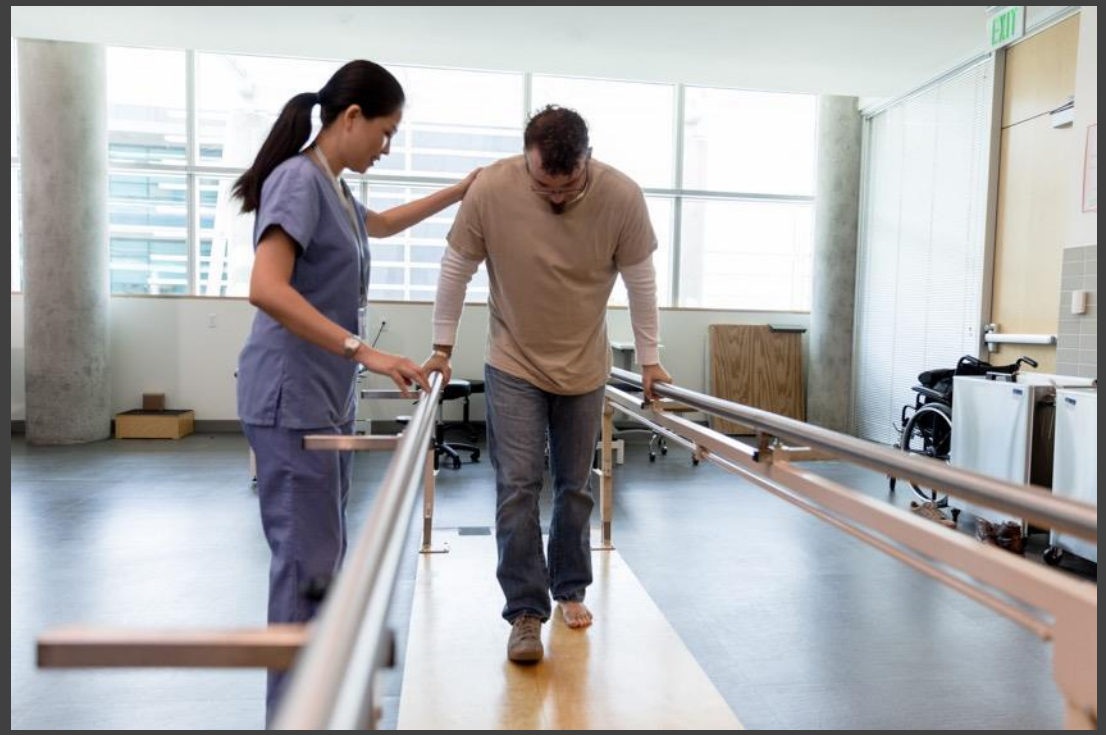
dietician

labarotory

dressing protocol

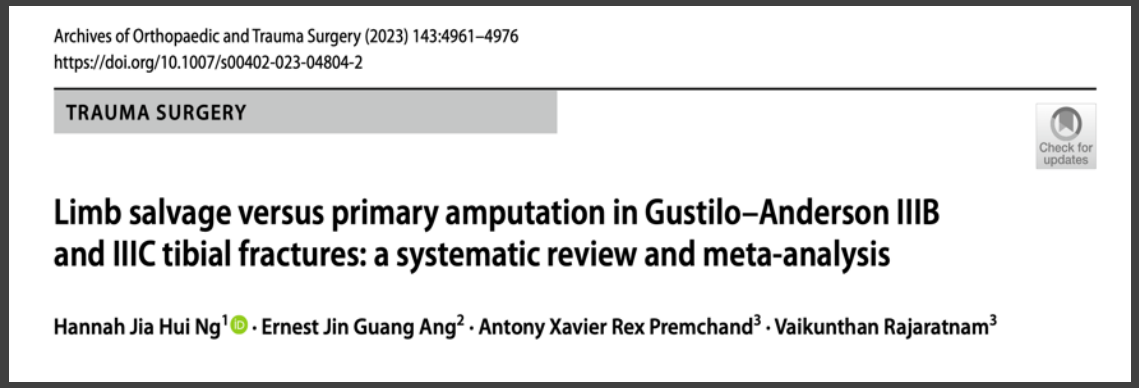
flap care protocols

pin site protocols



multidisciplinary team sport

amputation vs salvage



Archives of Orthopaedic and Trauma Surgery (2023) 143:4961–4976
https://doi.org/10.1007/s00402-023-04804-2

TRAUMA SURGERY

Check for updates

Limb salvage versus primary amputation in Gustilo–Anderson IIIB and IIIC tibial fractures: a systematic review and meta-analysis

Hannah Jia Hui Ng[1] · Ernest Jin Guang Ang[2] · Antony Xavier Rex Premchand[3] · Vaikunthan Rajaratnam[3]

most studies on GA III C tibia fractures

LEAP study 1987 – amputation better

all other studies no difference:

patient reported outcomes
function
return to work / sport
quality of life

but:



poor quality studies, retrospective

different patient collective to MSF

severe ankle fractures w flaps: BKA better outcomes

what do we know?

outcomes are the same

scoring systems don't work

plantar sensation not predictive

amputation more expensive

salvage more complications





amputation vs salvage



should we save the limb?

can we save the limb?

what is the cost of our decision?
money + psychological

what is the predictable functional outcome?

bottom line

do I have the skills to save AND the resources the patient needs to save their limb?

YES



continue assessment / treatment

NO



refer if possible

amputate

take home message

soft tissues are most important

good debridement is mandatory

the best antibiotic is surgical steel

your cut cannot be too large

mechanical stability is key

get help from a friend

involve the patient at every step

be ready for complications



references:

you can download all papers and this presentation here:

https://drive.google.com/drive/folders/1-BwduvXnP-Hty1kuxNuBqByhz7XTWNdh?usp=sharing



thank you

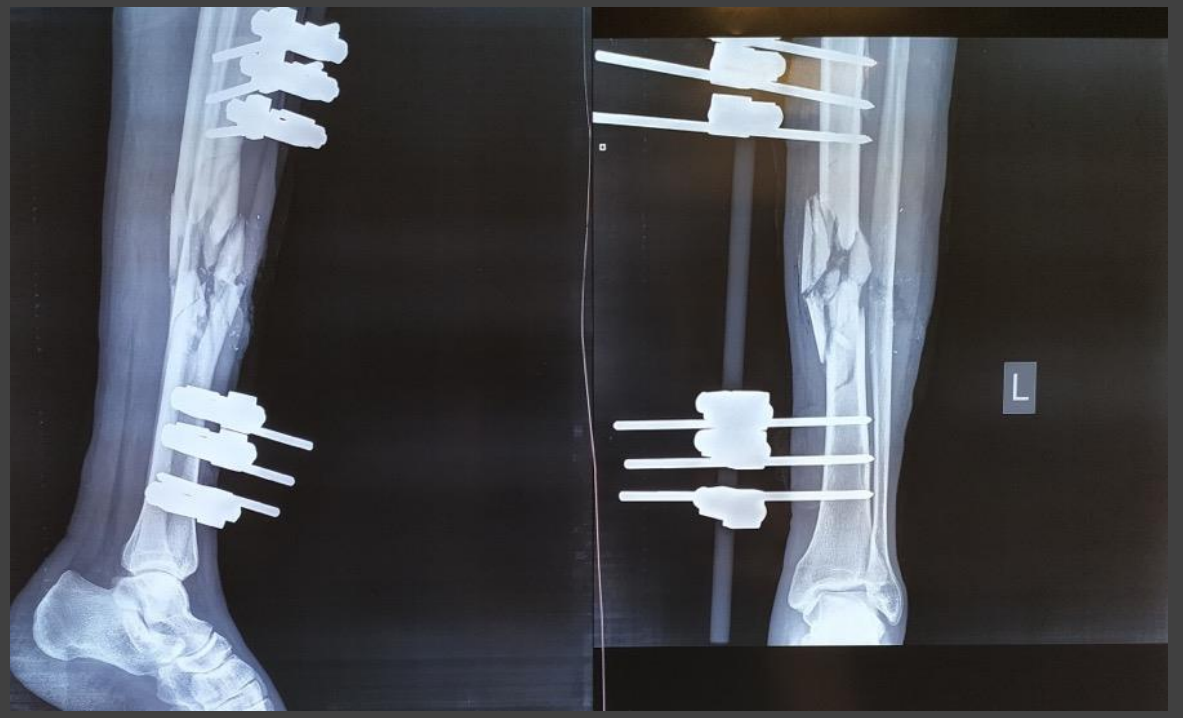
cases

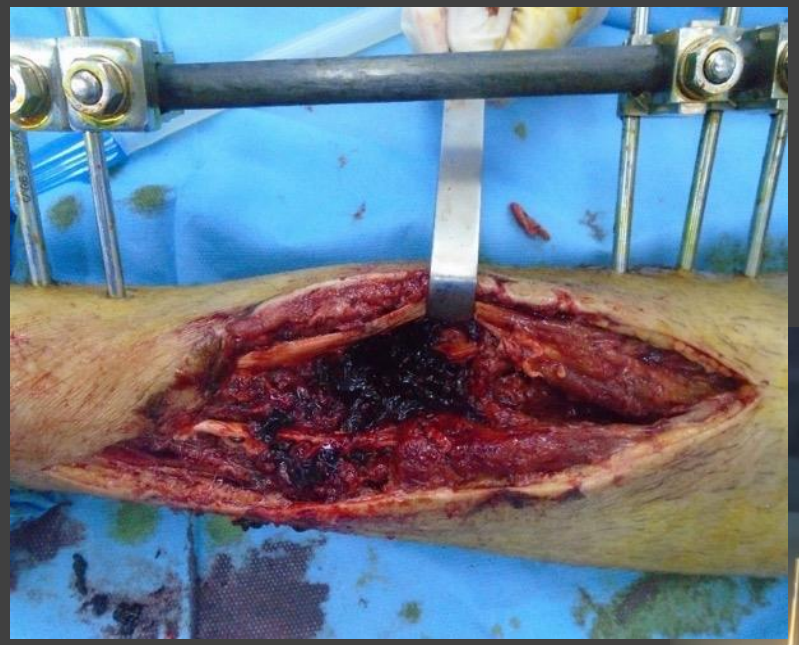
open fractures ISTP e round 9/23

01 GSW

open fractures ISTP e round 9/23

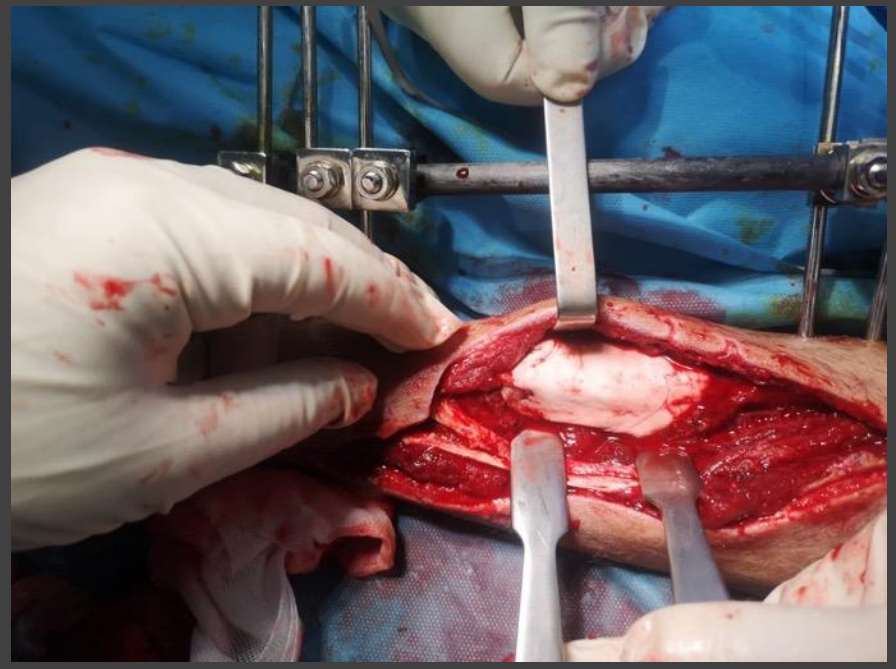



L












L










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02 MVA

open fractures ISTP e round 9/23

JF 69 yo f, car vs tree 80 km/h

- lower limbs trapped by dashboard 1 hr
- LBH 8 pm
- BMI > 35, apixaban, HTN
- hypotensive? 2 PRBC; hypoxic, GCS 14
- mainly lower limb injuries

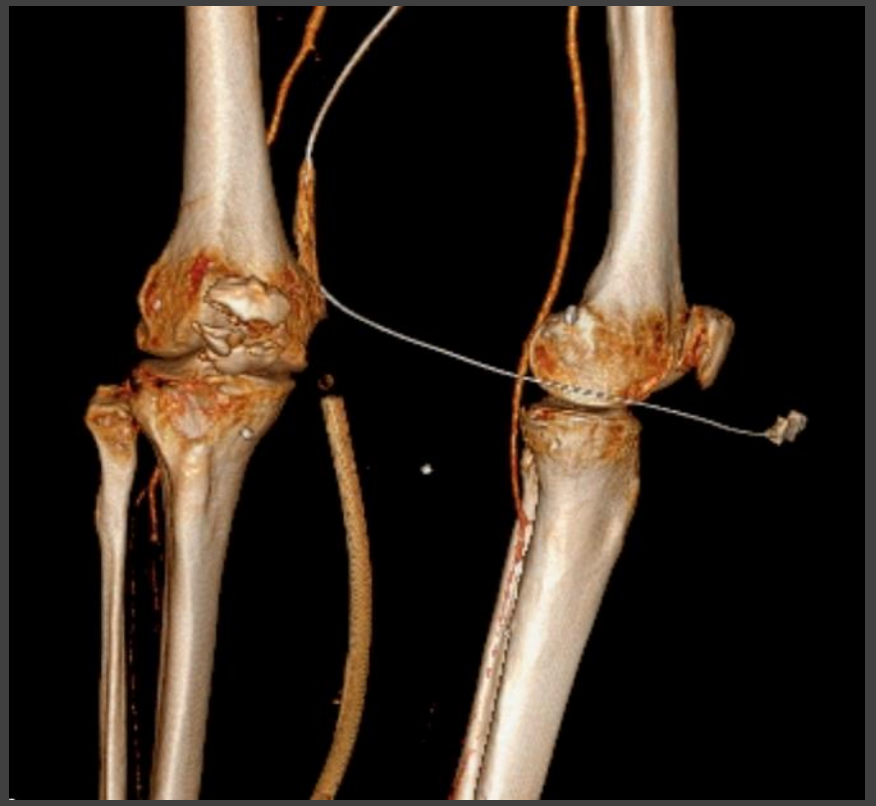
- large lacerations over both knees
- open patella fracture right
- dislocated open ankle fracture left
- femur fracture right
- C7 ; L1 L2 fractures
- right 10th rib








L
F
5



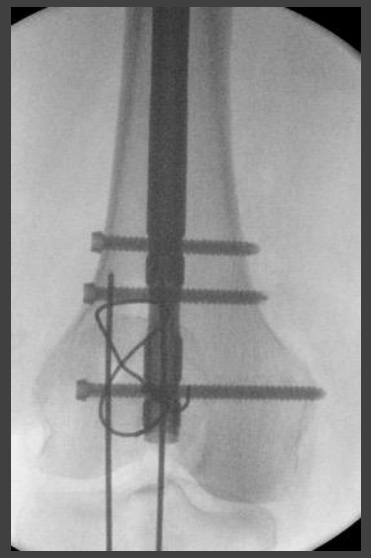



JD
BL



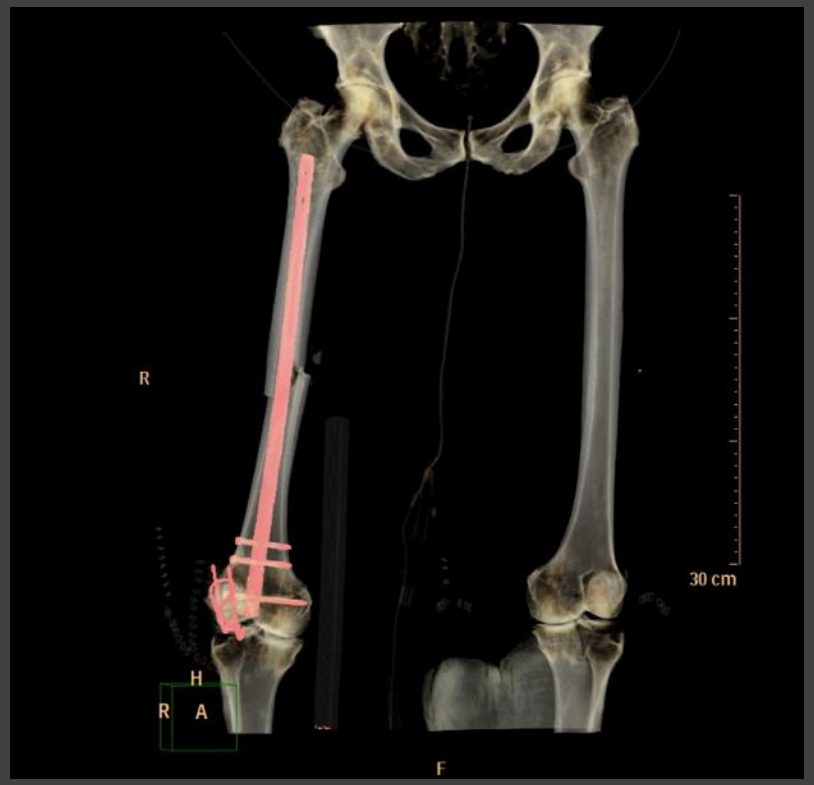


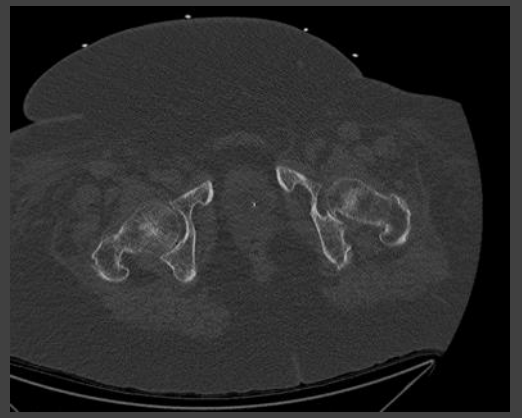


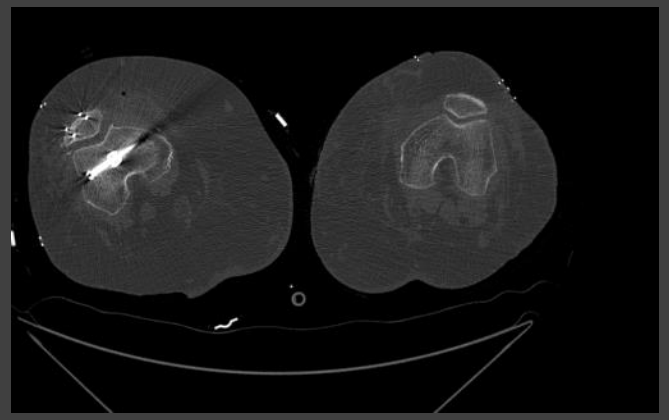







R
30 cm
H
R A
F

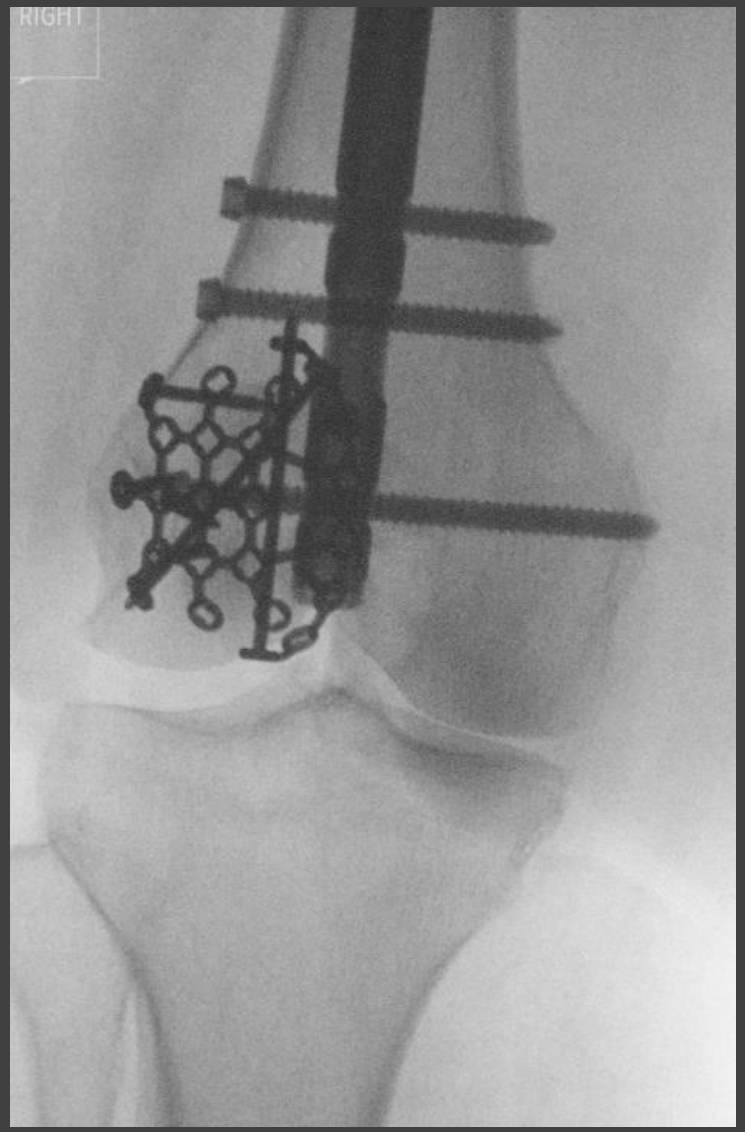


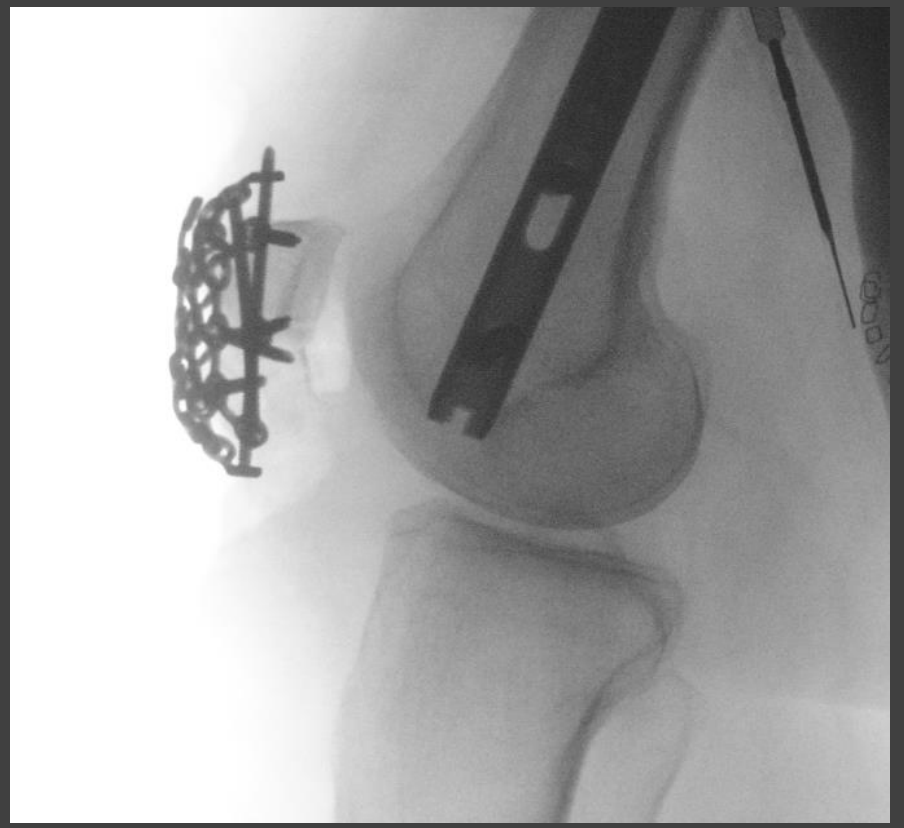



103 (14:14)
1






RIGHT

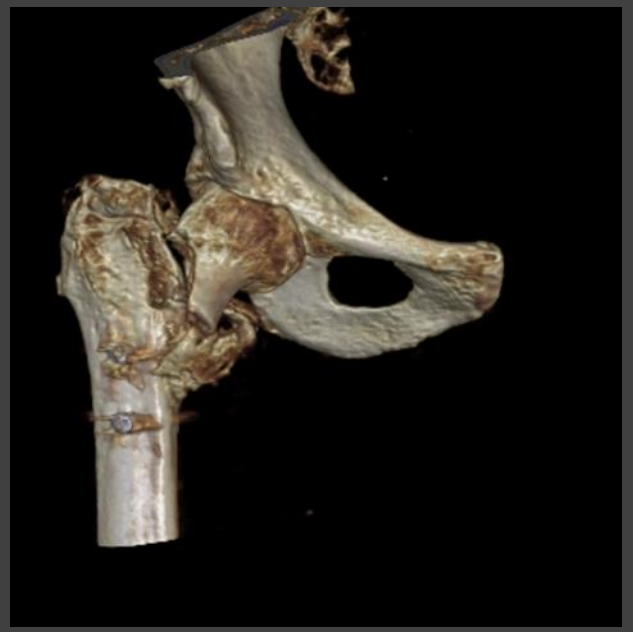






the saga continues





the saga continues

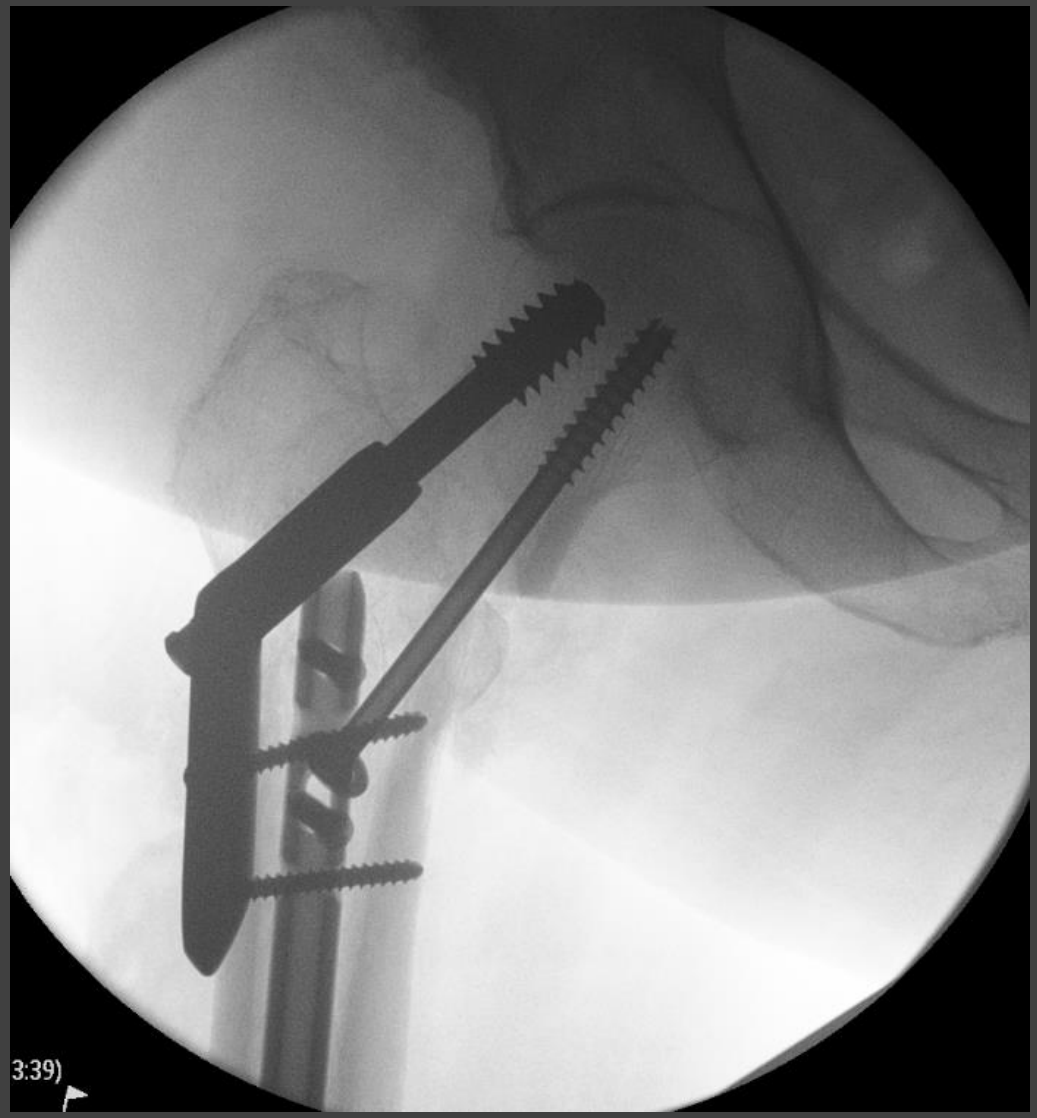
- T2 RF sats 80 % bipap
- infective component
- confused
- CCF

dexmedetomine infusion
IV furosemide, hydrocortisone, magnesium, piperacillin/tazobactam
PO tapentadol, paracetamol, spironolactone
PRN docusate, ipratropium, ondansetron, oxycodone, salbutamol

stabilisation NOF 14 8

effing difficult

not the end of it


3:39)

03 MBA

open fractures ISTP e round 9/23

45-year-old man motorcycle vs car

open 3A distal femoral fracture R

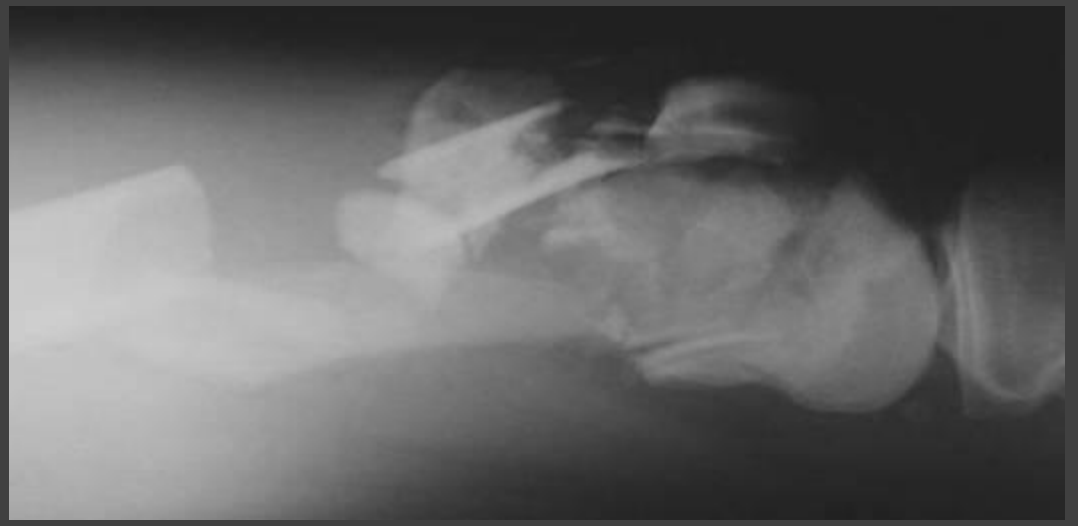
closed mid-tibial fracture on right side

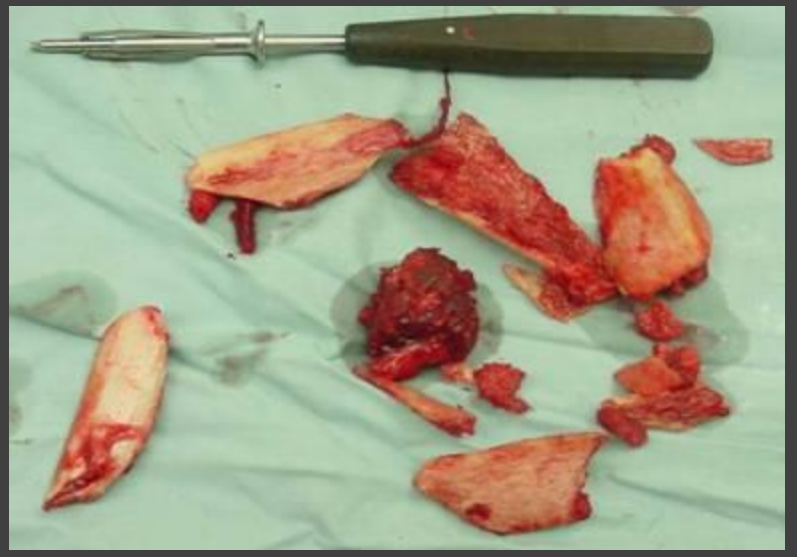
groin laceration on left side

Hemodynamically stable











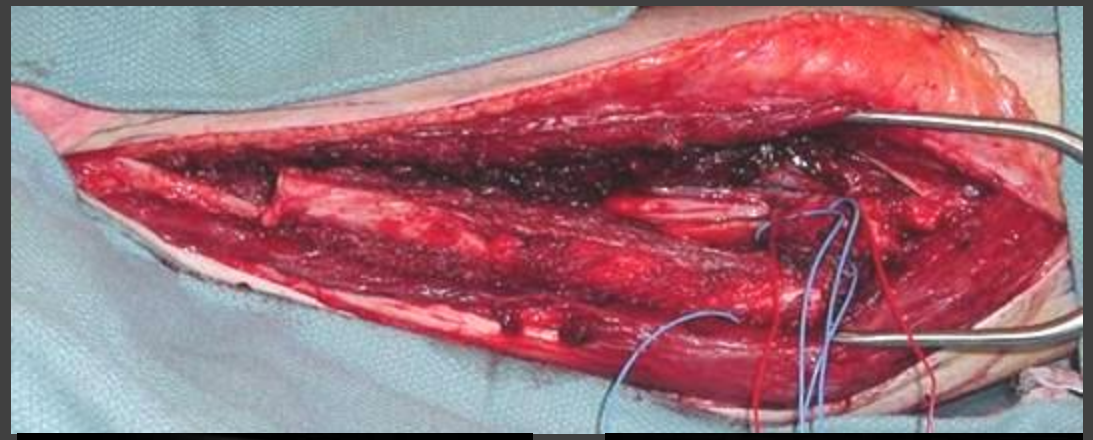




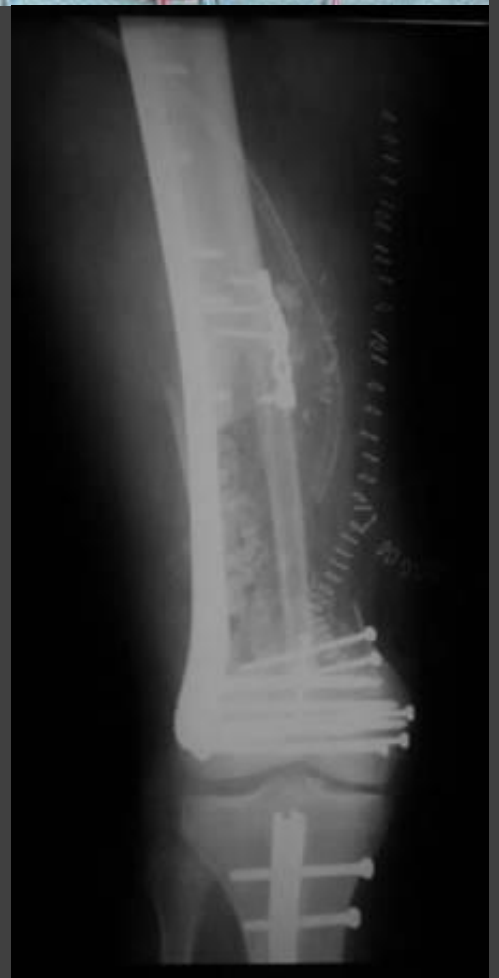




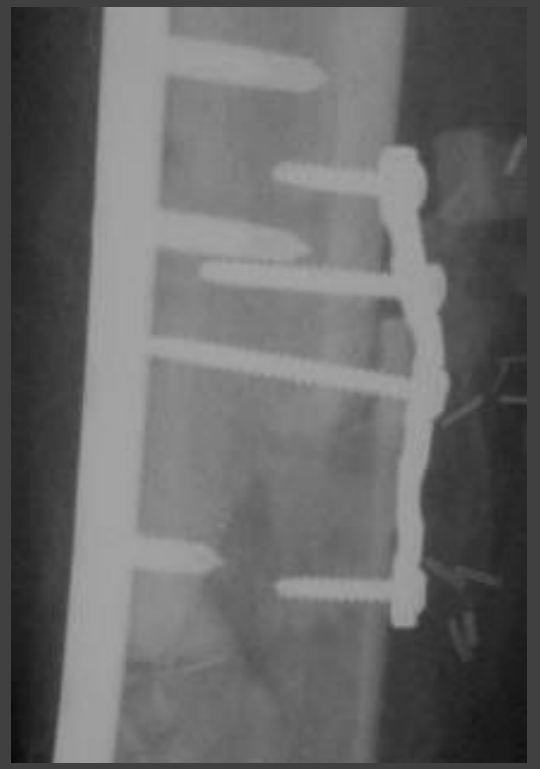













04 GSW

open fractures ISTP e round 9/23

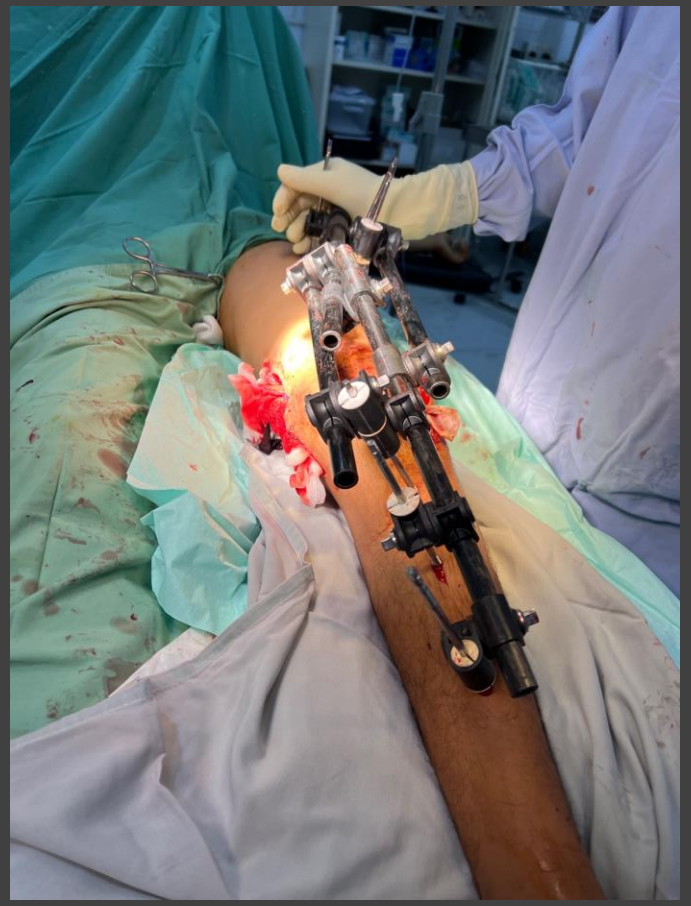







.09.19]<CURRENT>
Sex: M
SIZES ARE







05 MVA

open fractures ISTP e round 9/23

35-year-old man, high-speed MVA

type 3B open tibial fracture

diaphyseal wound

no other injuries

good pulses, sensation normal, can move toes



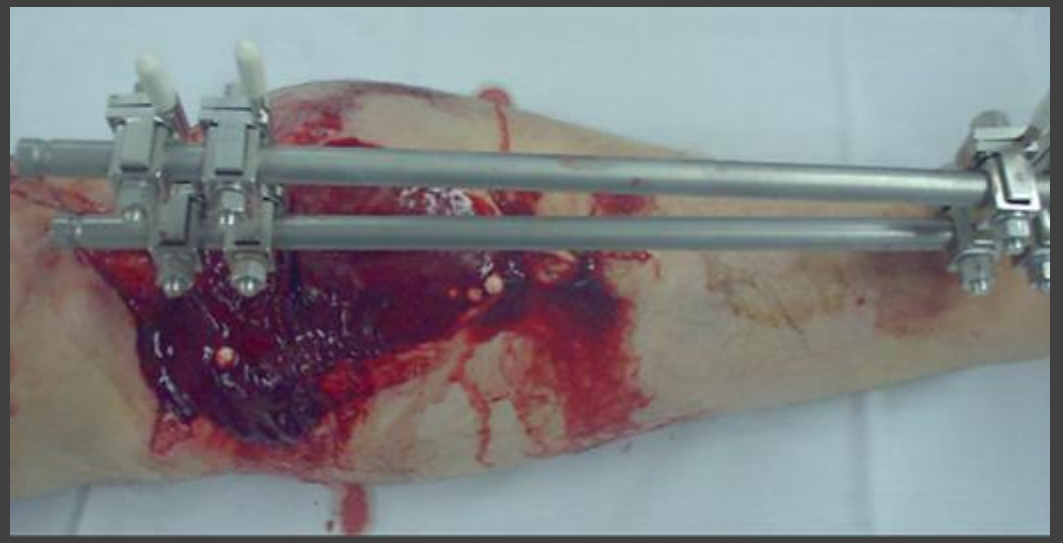


wound debrided

external fixation

antibiotic beads

re-debrided—clean



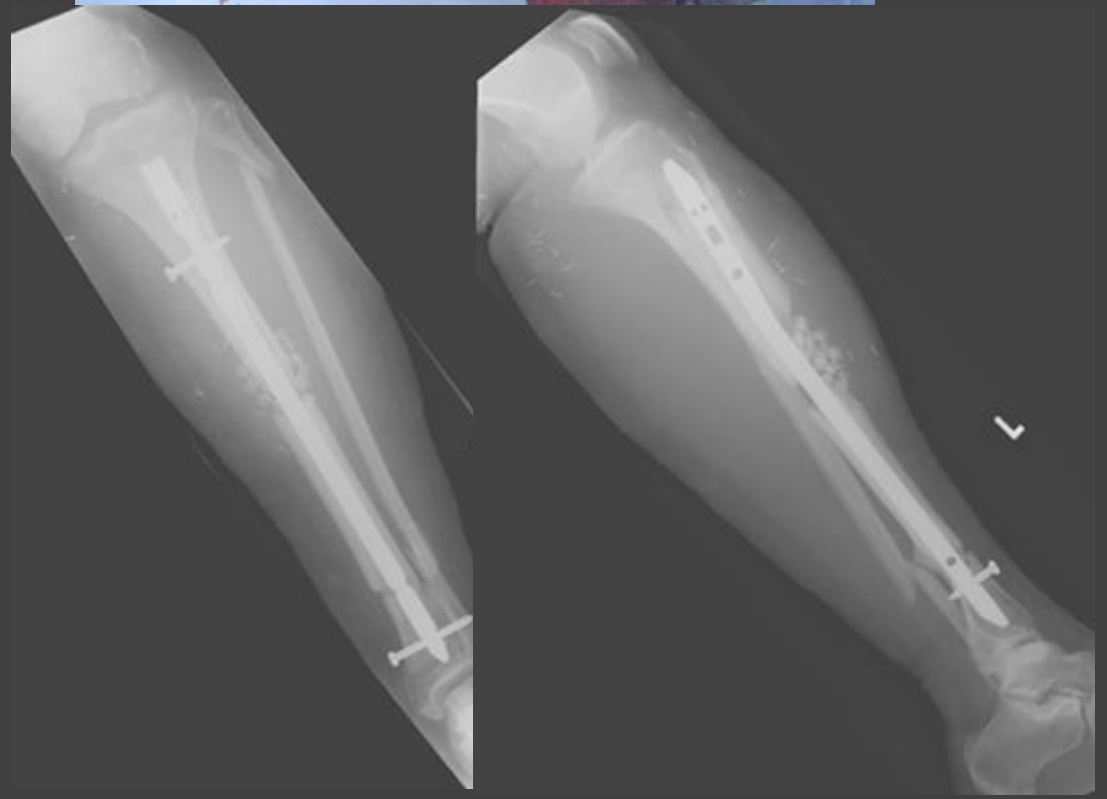


all pieces of bone have blood supply but one

shortened primarily 3 cm by removing one segmental piece that had no blood supply

IM nail, unreamed





X-rays after 2 months





6 months







1-year follow-up









06 fall

open fractures ISTP e round 9/23

33-year-old man, 2 m fall from ladder

isolated injury

small wound oozing
at back of foot

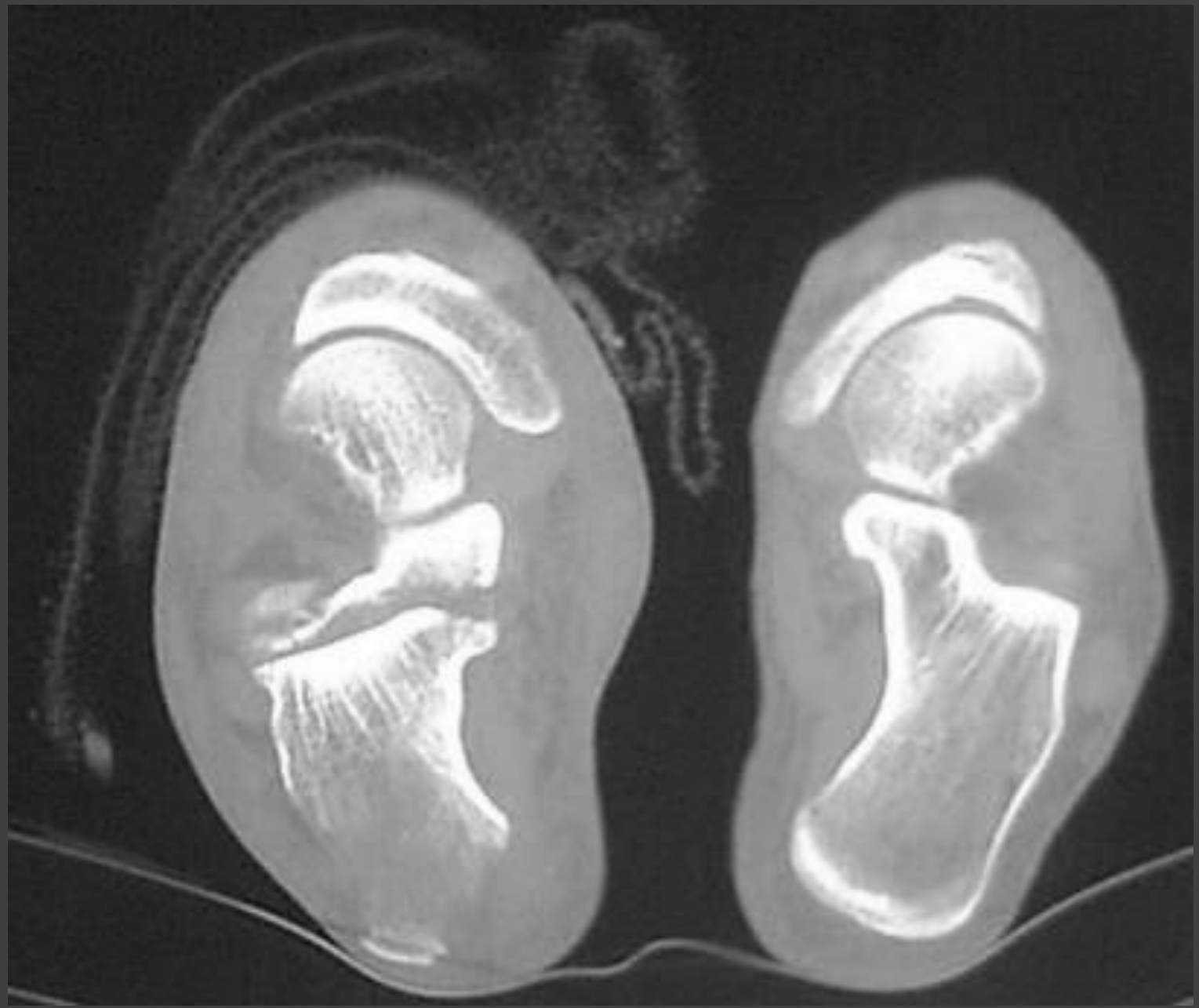
smoker

neurovascular status normal















3 months postoperative



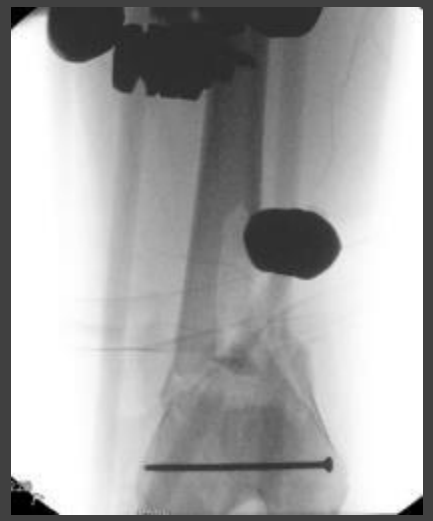
07 MBA

open fractures ISTP e round 9/23


L


[A]
L
Horizontal Beam









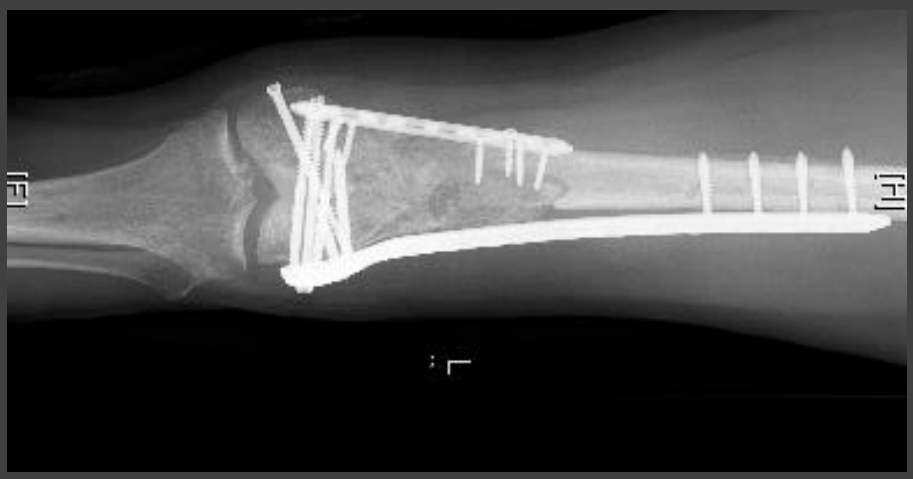



Study
Image Time
DO




[F]
[H]


Proc ID: 2744075
Se:1
Horizontal Beam
Im:1
L
DOB:20/06/19
MRN:1930
Study Date:6/04/20
Image Time: 10:12:23 A
Sex
kV: 73
mAs: 6
Exp Index: 1428
Femur L

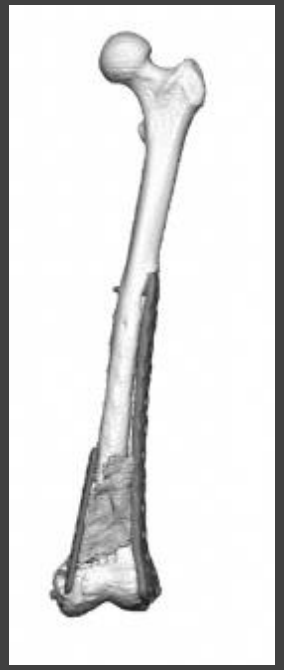



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DOB:20/06/19
MRN:193
Study Date:29/07/20
Image Time: 9:22:28
Se
Horizontal Beam
dex: 219






[F]
































L
[H]
L
cc
[F]


L
cc
[F]



08 GSW

open fractures ISTP e round 9/23




NING: MAY NOT BE USED FOR DIAGNOSTIC PURP









09 GSW

open fractures ISTP e round 9/23





open fractures ISTP e round 9/23





open fractures ISTP e round 9/23

10 MBA

open fractures ISTP e round 9/23







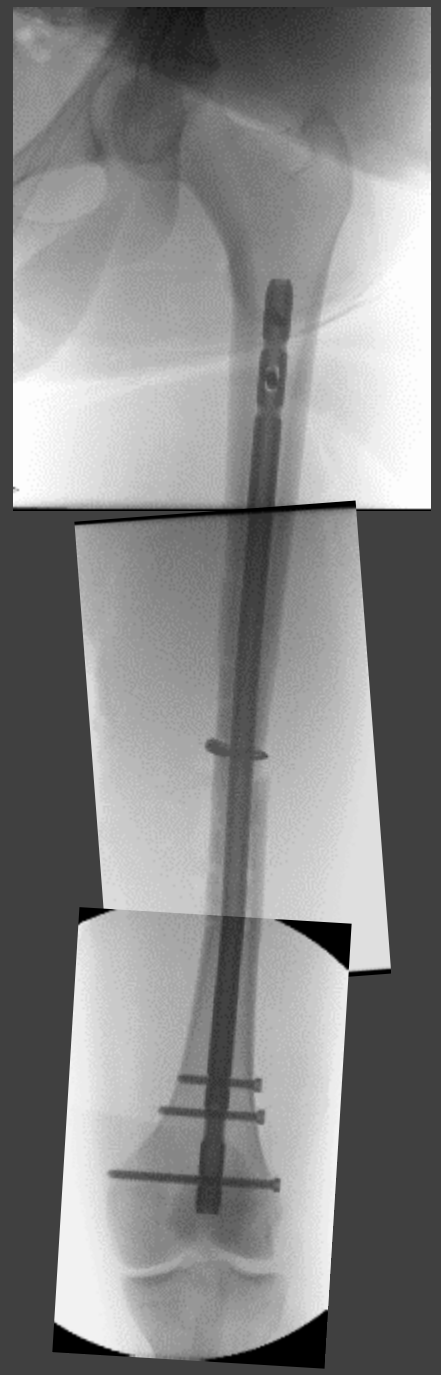









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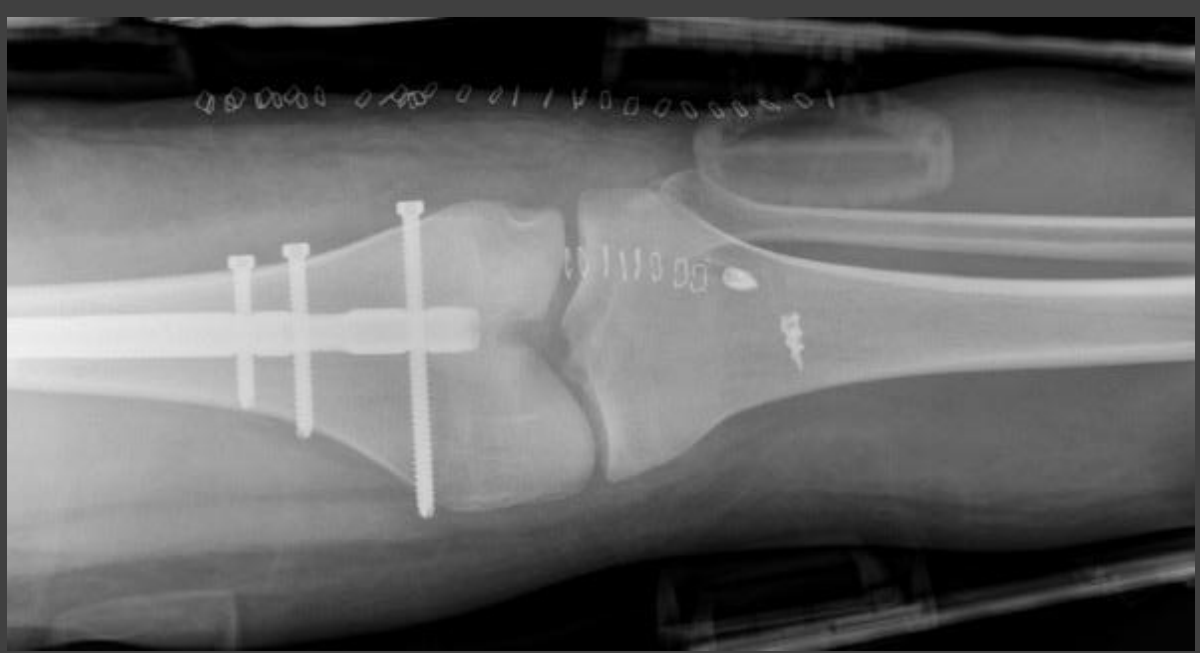



L


L





















I I MBA

open fractures ISTP e round 9/23















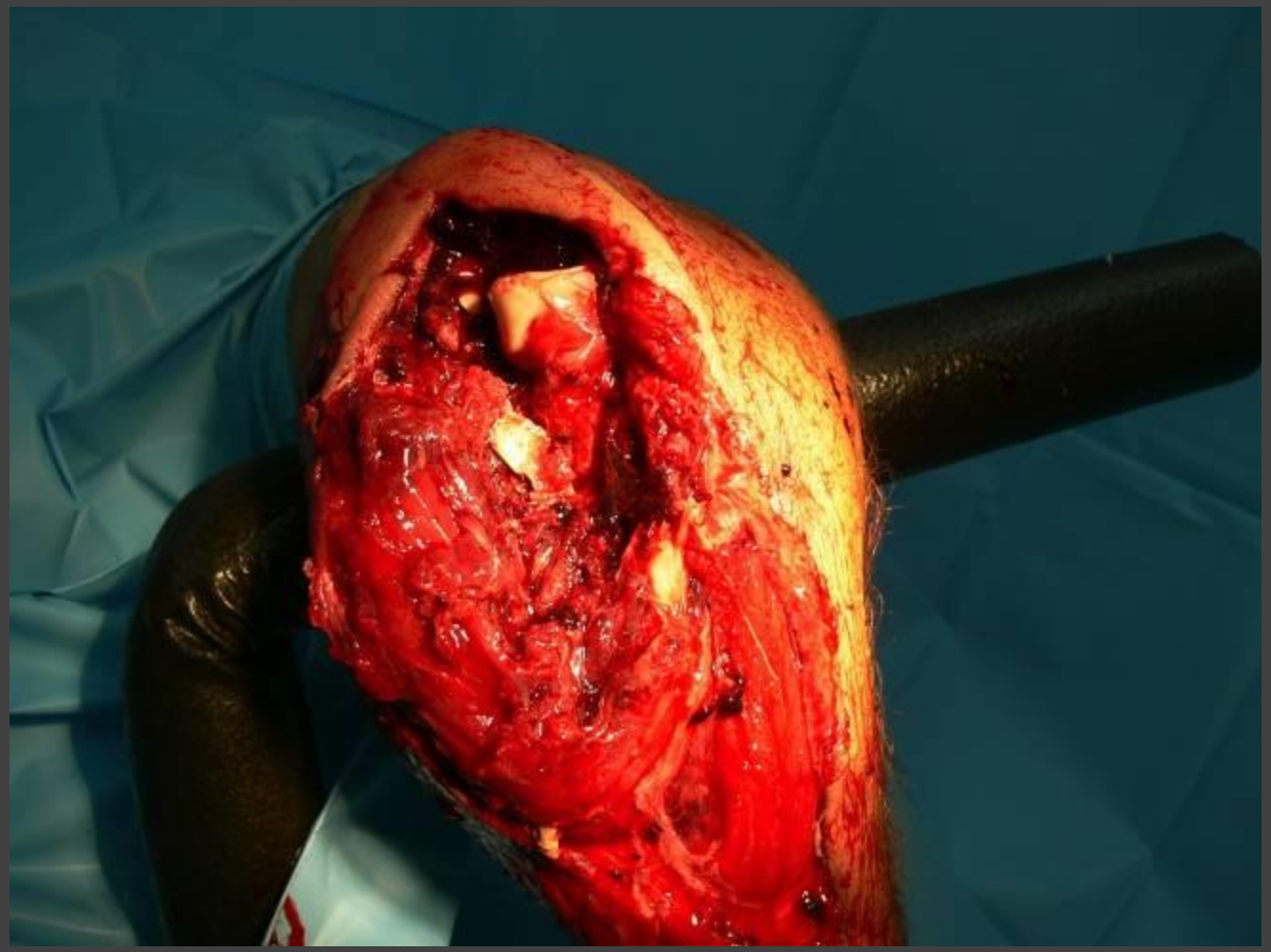


12 MVA

open fractures ISTP e round 9/23


R
AH







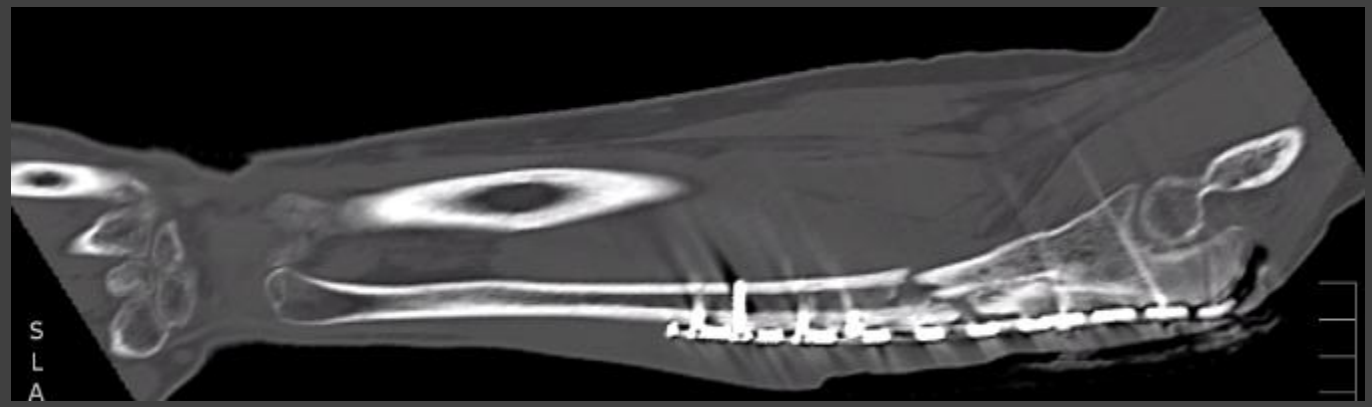







R
KP




S
L
A


R
KG


R


328




AW

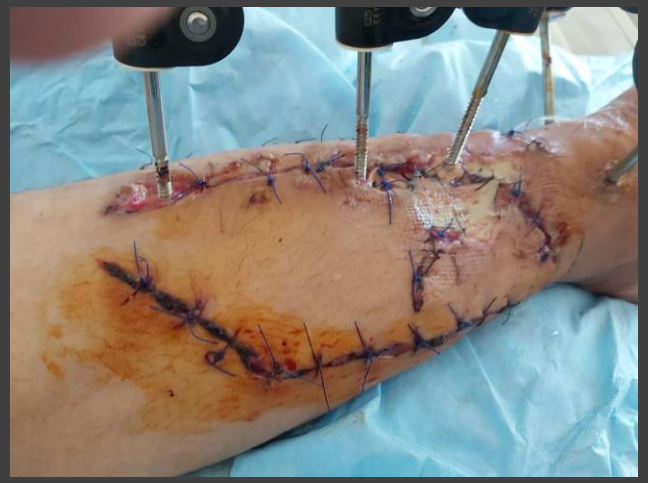
13 fall

open fractures ISTP e round 9/23





open fractures ISTP e round 9/23







open fractures ISTP e round 9/23



open fractures ISTP e round 9/23

open fractures ISTP e round 9/23

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