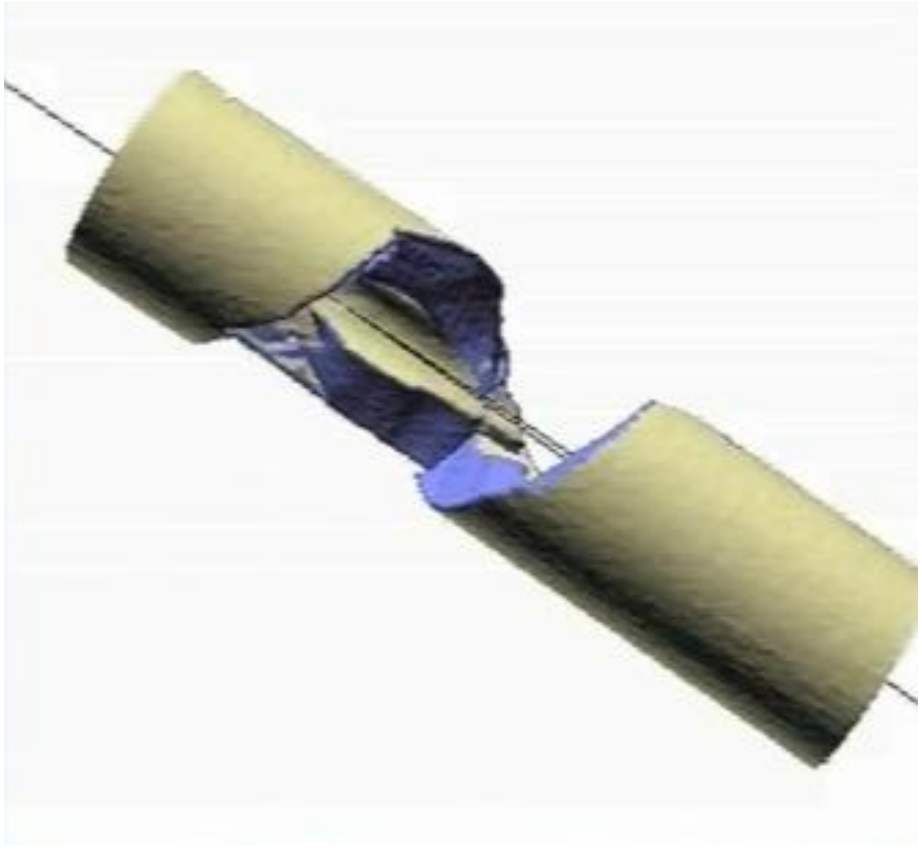
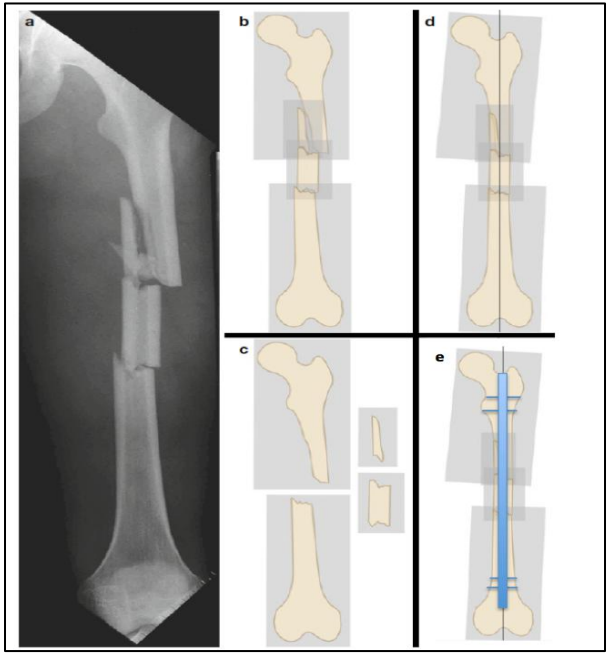
Segmental Femoral Shaft Fractures
Assesment of Length, Alignment, Rotation





32C2
intact segment

32C3
multifragmentary

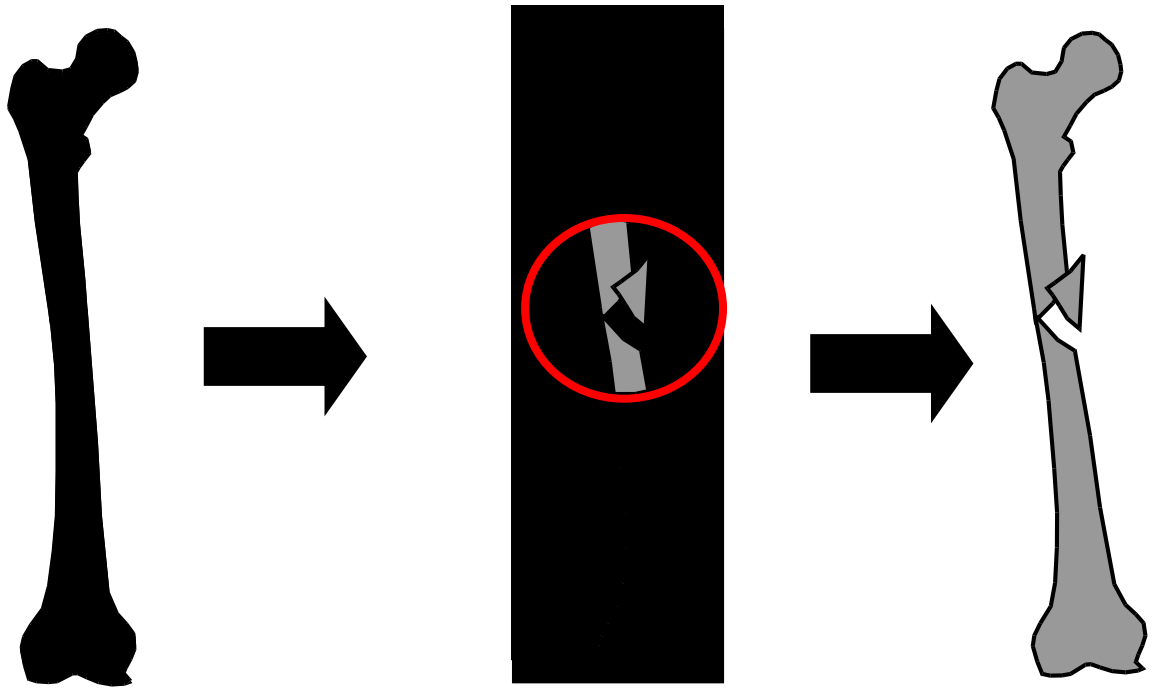
Problem

Preop
excellent image quality
large volume

Problem

Intra-op
poor image quality
small 2D window

C-arm Problem: small window



C-arm view too limited to judge alignment

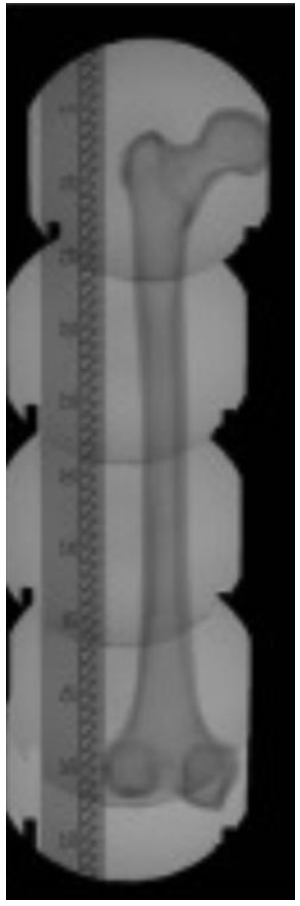
Problems

- Radiographic Limitations
  narrow radiopgraphic C-arm field …
  no ‚image-stiching technology‘ for most surgeons

- Clinical Limitations
  limited clinical Field of view
  (draping, fracture table etc.)

  Soft tissue envelope

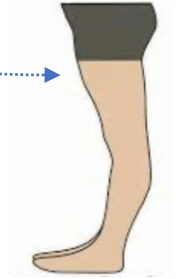
  Lack of (metric) reference



Problems in Segmental Femur Fractures

1) shortening / overdistraction
2) internal-/external rotation

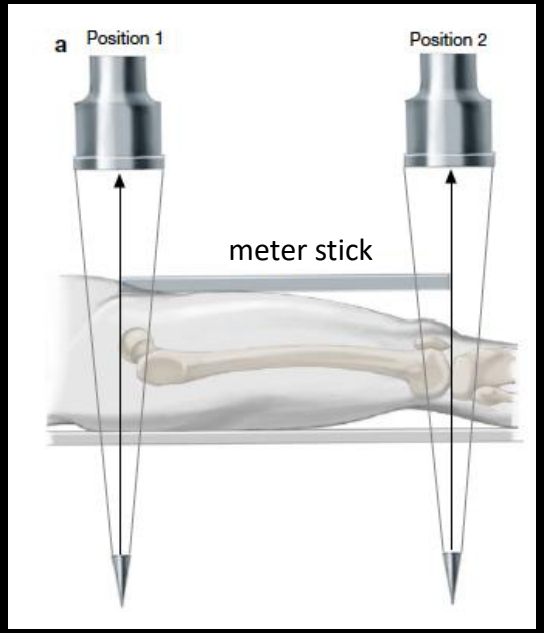
3) varus / valgus
4) ante- / recurvation



… femoral fractures: #1 in litigation in orthopaedic trauma

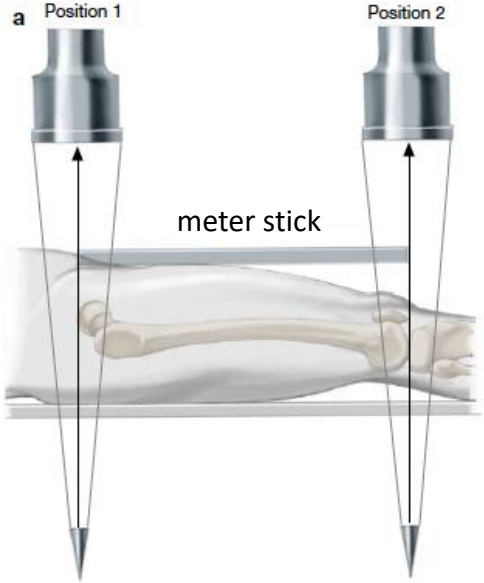
Ahmed et al. JBJS 2019 Malpractice Litigation Following Traumatic Fracture

Length
from contralat side

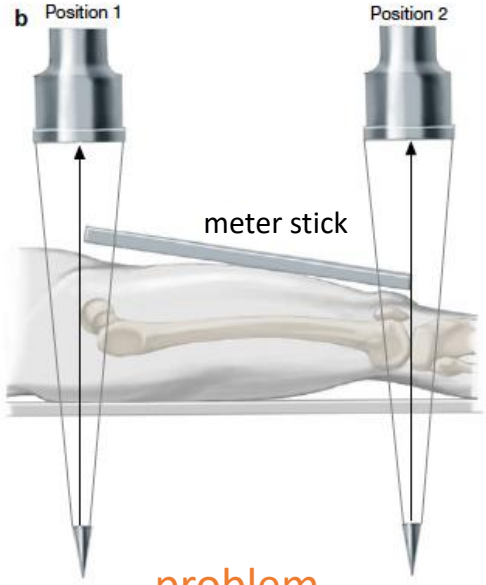


correct

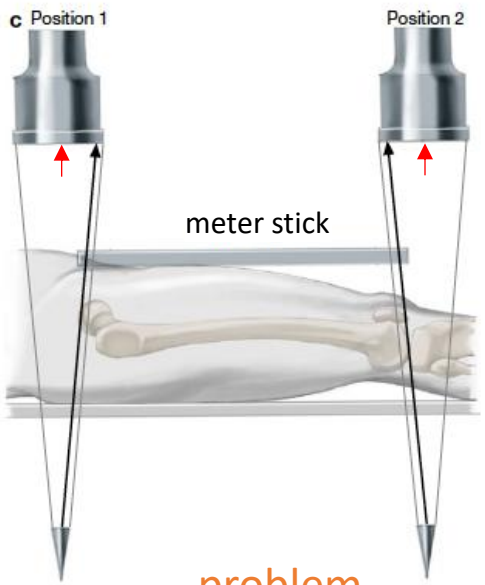
Meterstick technique
Limitations



correct



problem
meter stick oblique

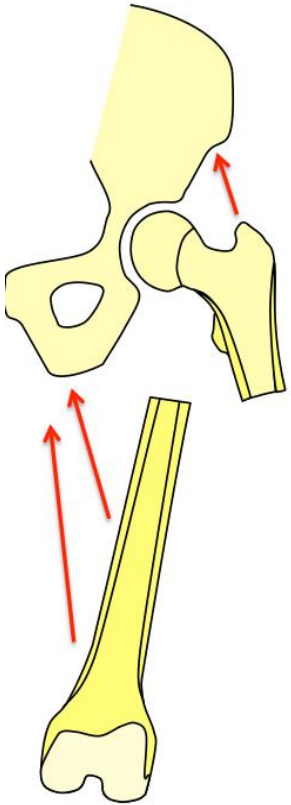


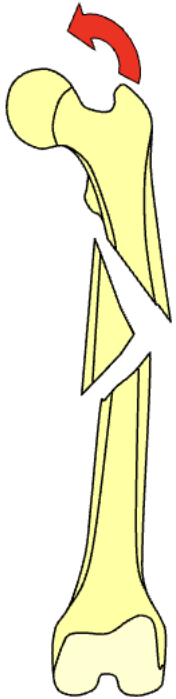
problem
meter stick not centered

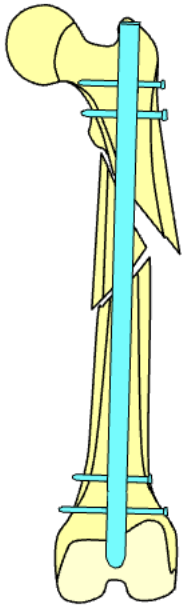
Varus-valgus: proximal

Alignment control

Starting point defines alignment



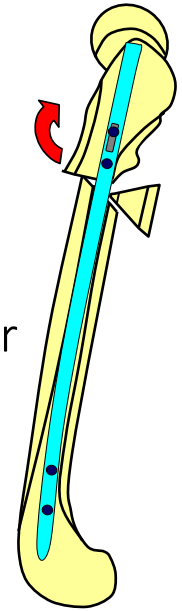




frequently proximal starting point too lateral

…

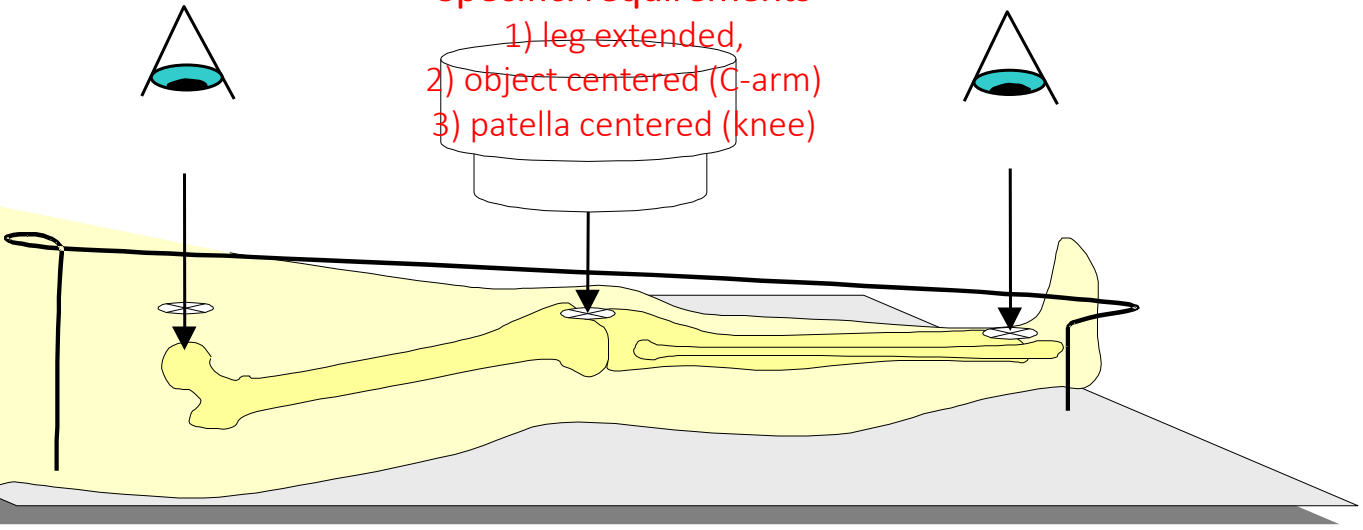
and too anterior

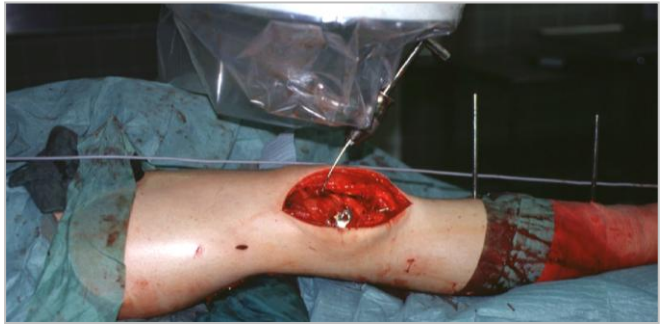


Varus-valgus midhaft:
Alignment control with Cable Technique

Specific. requirements

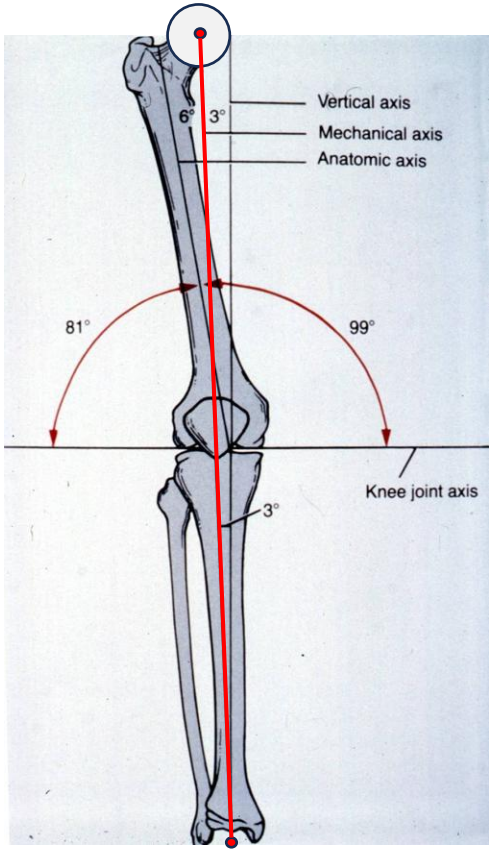
1) leg extended,
2) object centered (C-arm)
3) patella centered (knee)





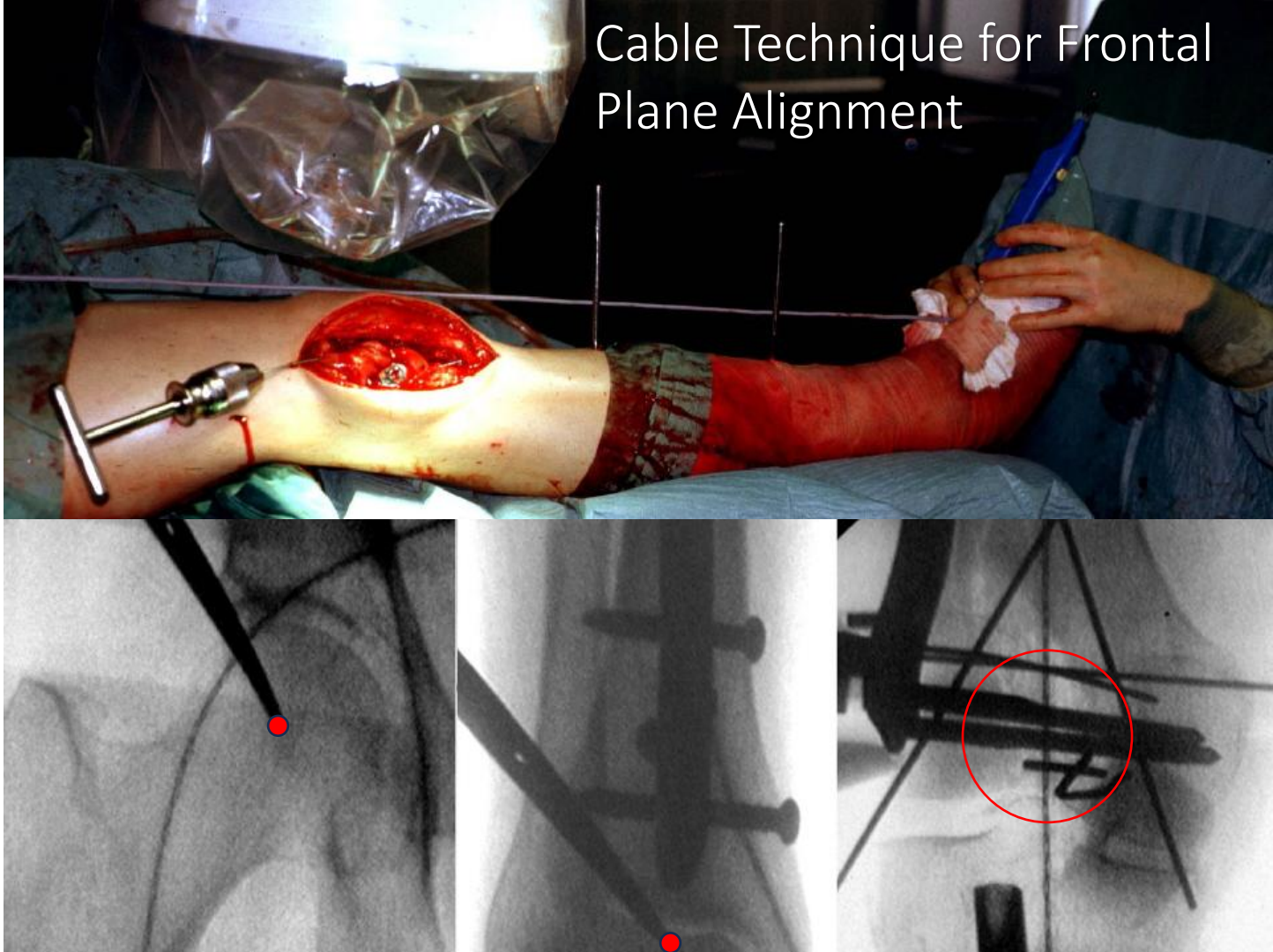
Limitation

most predictive
around the knee

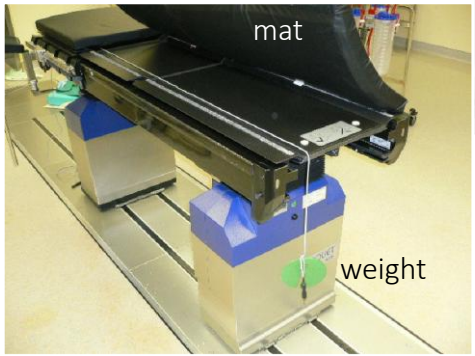


Cable technique requirements

1) leg extended,
2) patella centered in both …
image & knee



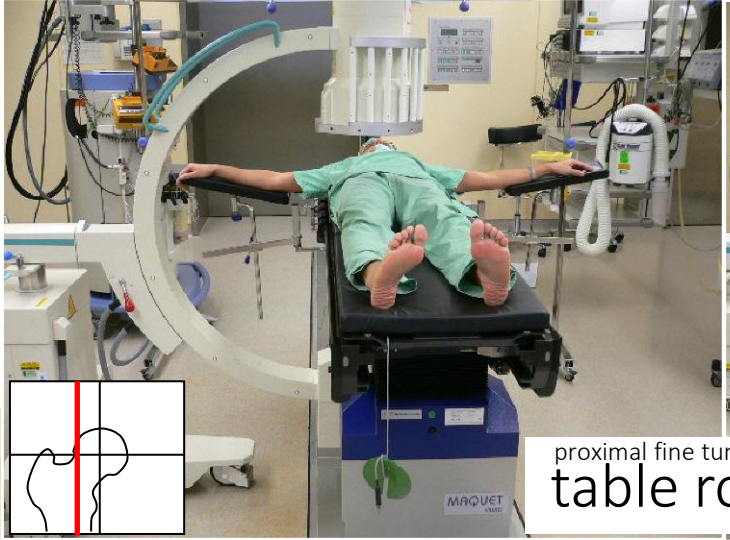
Modification: <u>posterior</u> cable technique

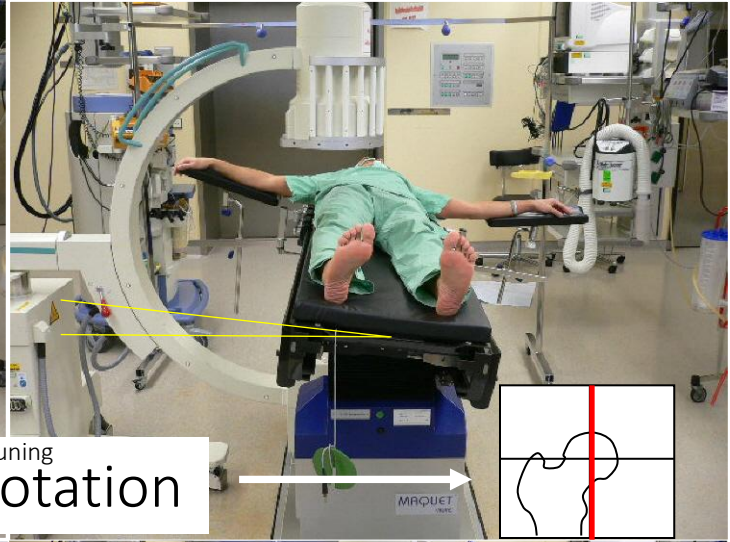


1. electro cauther cable & weight underneath bolster

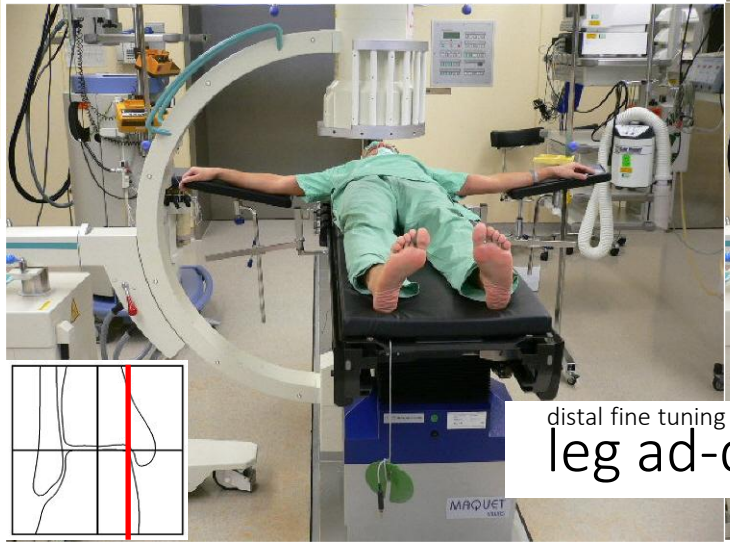
2. patient‘s hip centered above femoral head

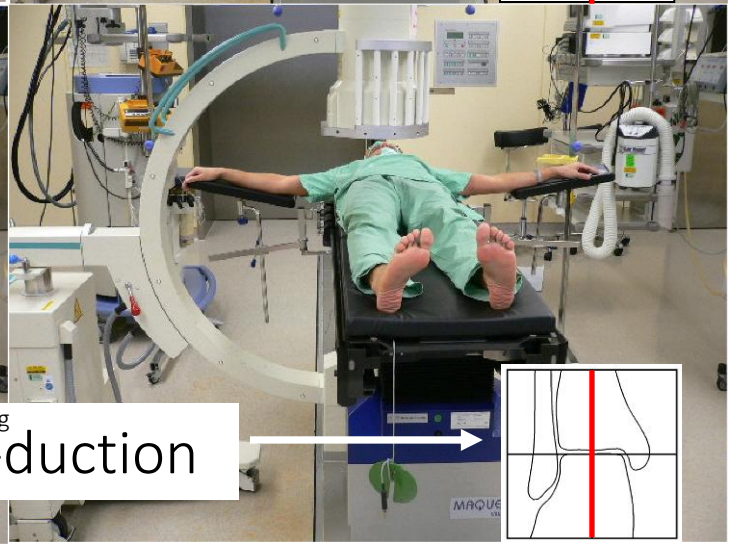
3. fine tuning with table rotation & ab-/ad-duction





proximal fine tuning
table rotation

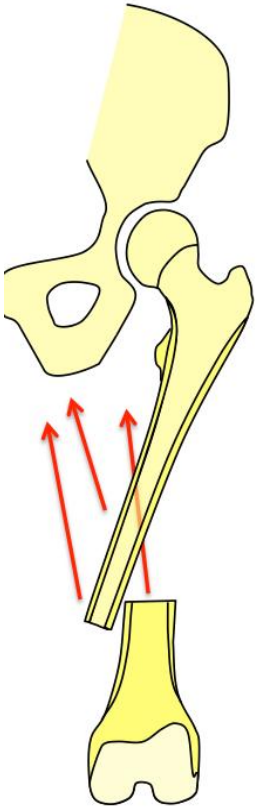


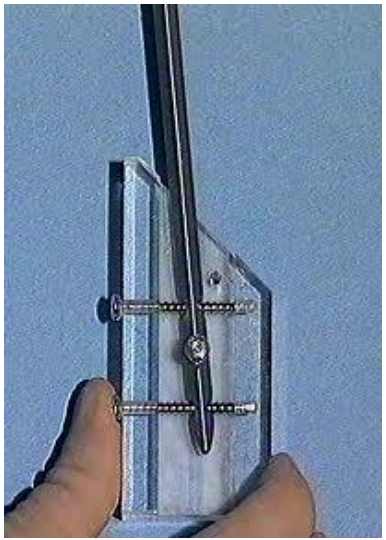


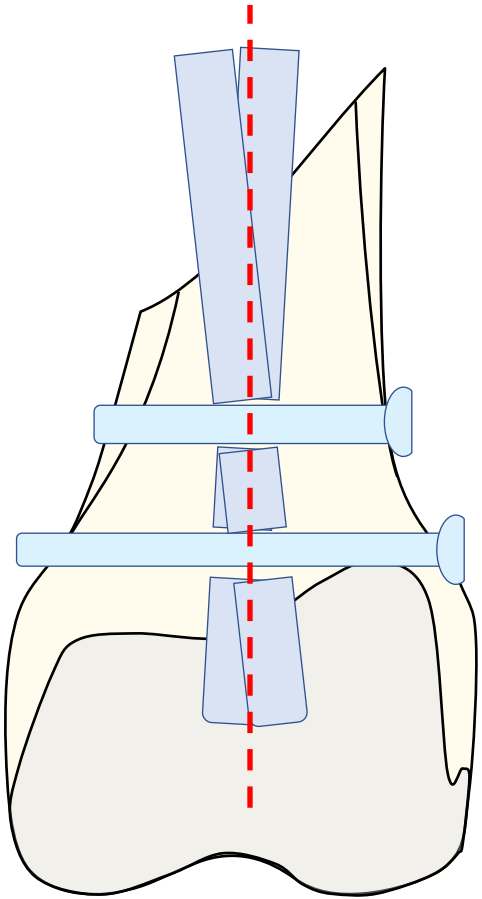
distal fine tuning
leg ad-duction

Varus-valgus distal

Understand implant toggeling



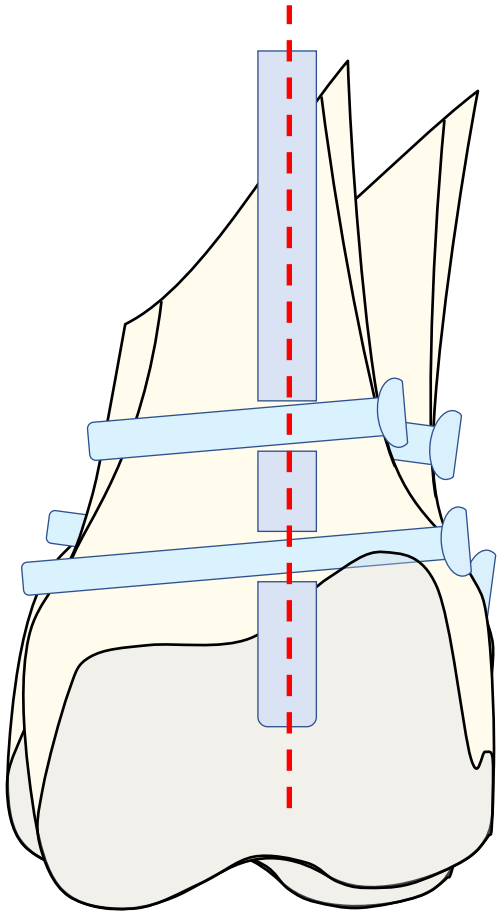




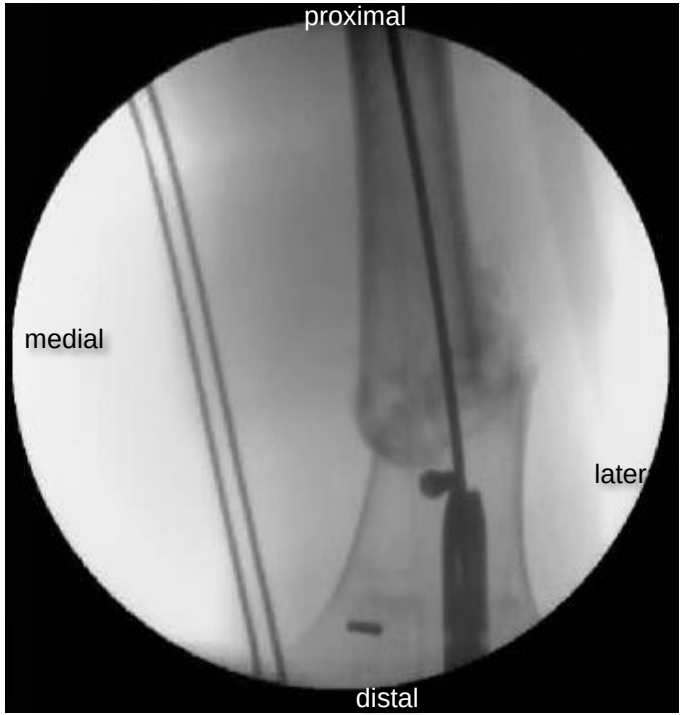
Frontal plane deformities:

mainly metaphyseal

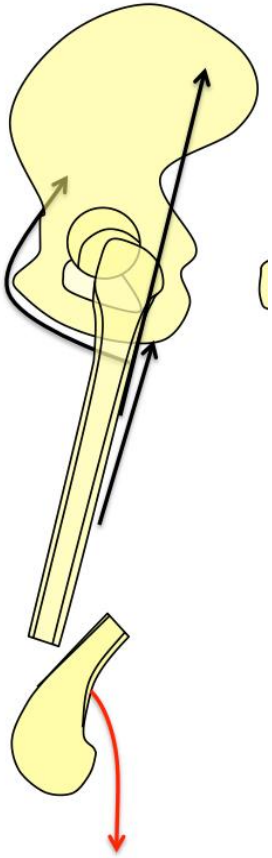
distal implant toggeling



additional support
Poller screws

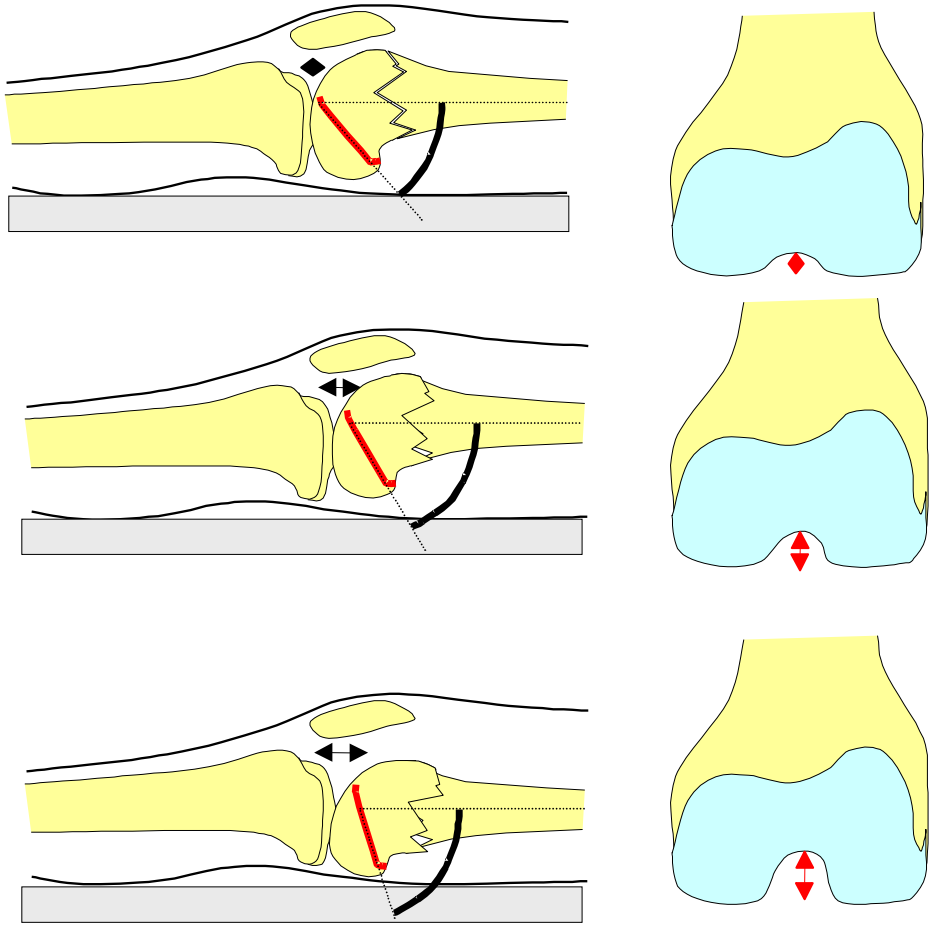


Understand your C-arm vector (notch projection)



positive notch sign

if you see a notch like this, the distal main fragment is in overextended position



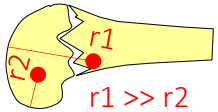
Understand your C-arm vector (95° Implants)

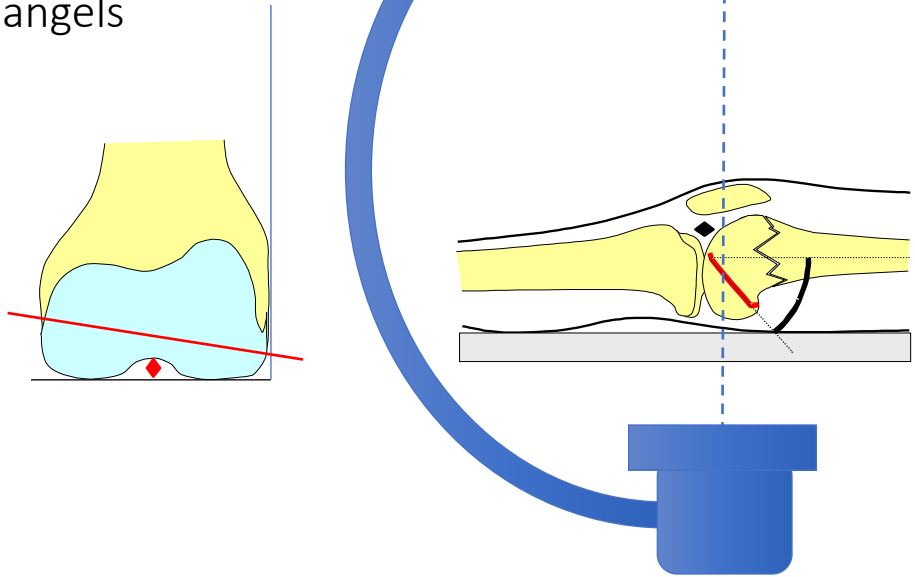
relevant for guide wire placement

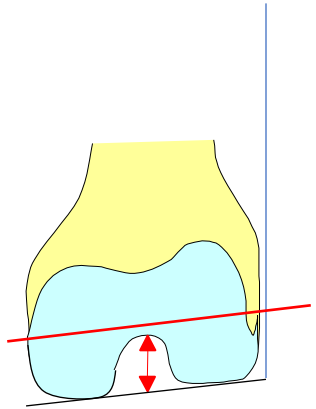
femoral condyles do not have a uniform radius

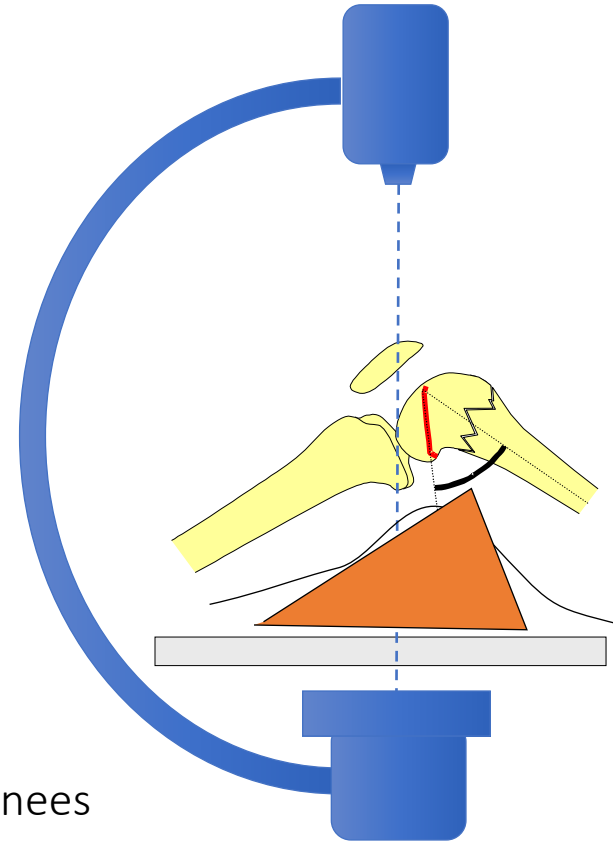
…

therefore tangent to shaft have different angels





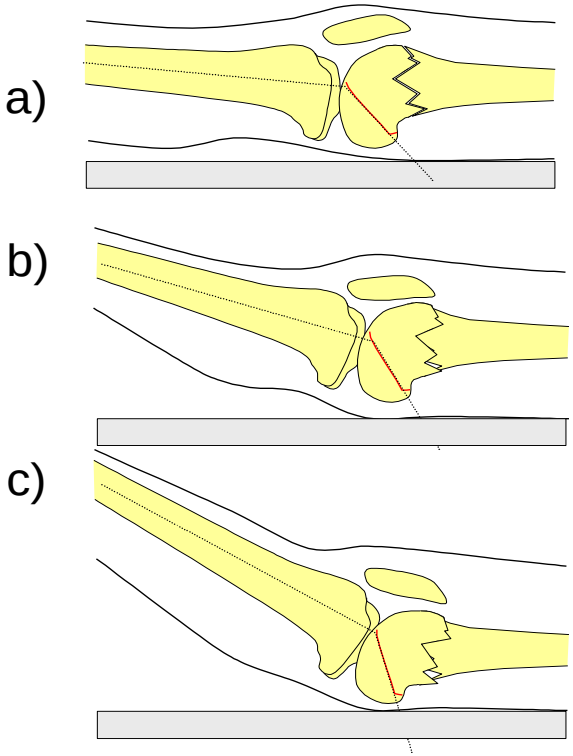




… like in flexed knees

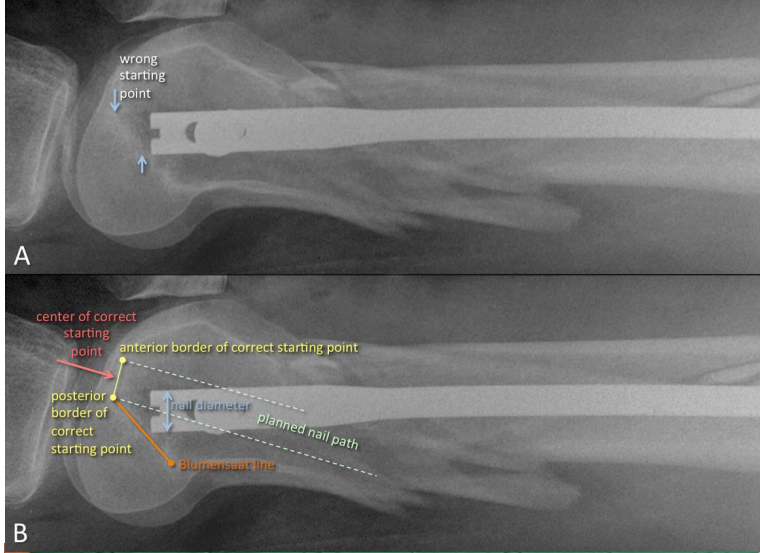
genu recurvatum

Hyperextension test



Problem:
genu recurvatum
results in knee
instability
(pseudo-laxity)

ACL tight in 25°
Hyperextension
loose in 0°
(neutral position)



Management Challenge #6 Deformity

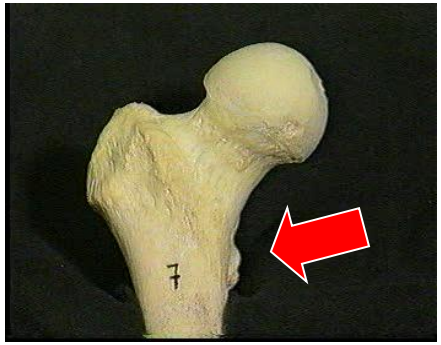
Torsion

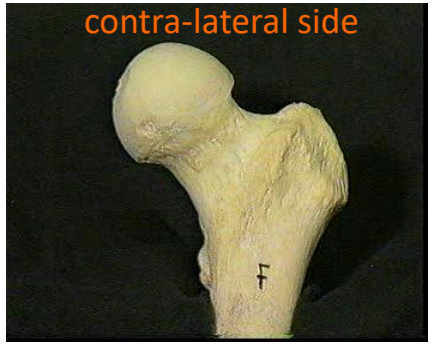
2. Sit-Test
1. Lift-off Test

Krettek, C. and T. Gösling (2015). Femoral Nailing. In; Intramedullary Nailing - A comprehensive Guide. Springer.

Torsion: Lesser trochanter shape sign

Comparison with contralateral side





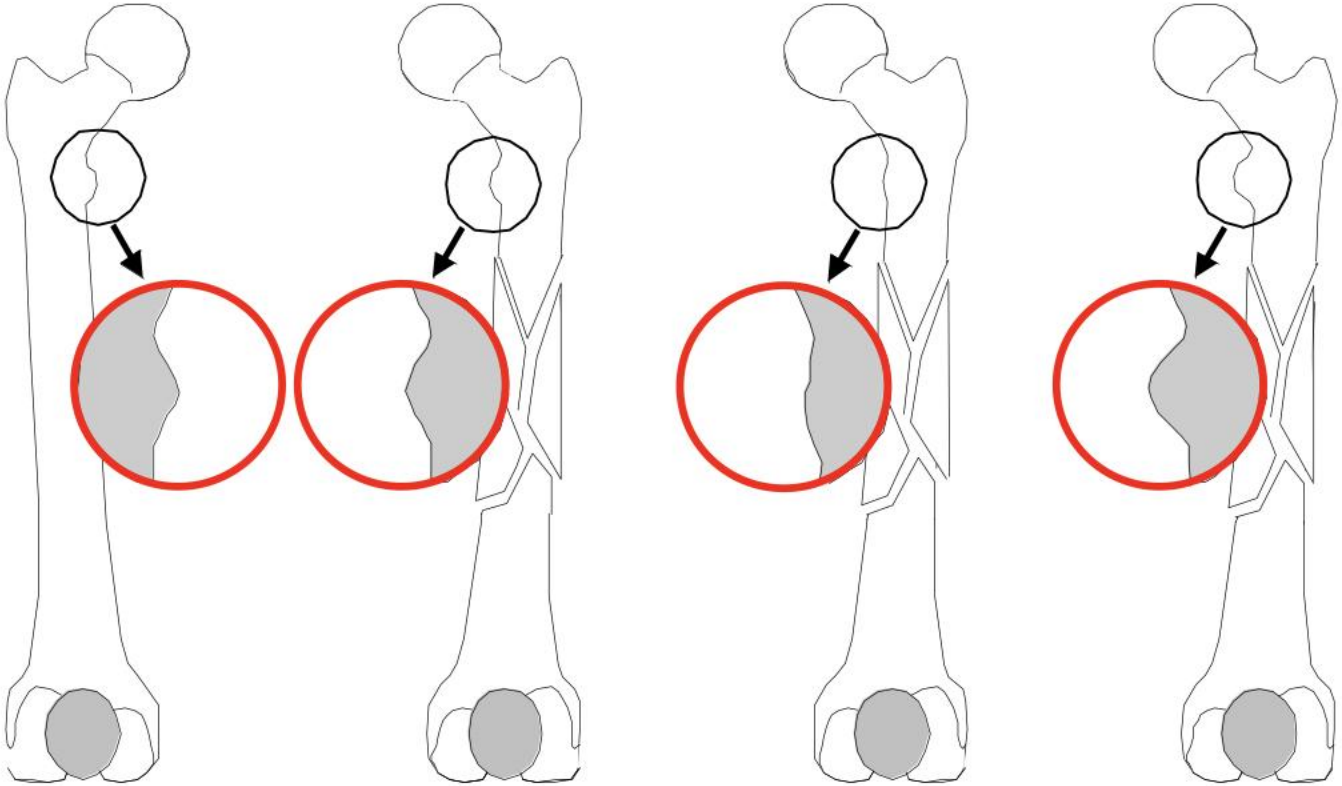
comparison with contra-lateral side

roughly
15° = 5mm
on bone surface)

Krettek et al (1999) Injury 29

Torsion: Lesser trochanter shape sign

C-arm shot of contralateral side stored



external torsion deformity

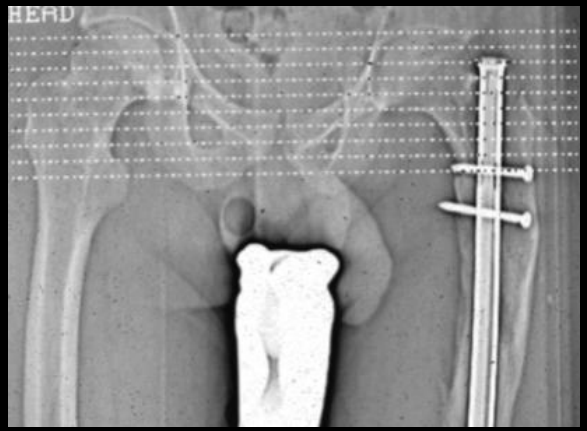
internal torsion deformity

Validity confirmed

Kim JJ, Kim E, Kim KY (2001) Predicting the rotationally neutral state of the femur by comparing the shape of the contralateral lesser trochanter. Ortho-pedics 24: 1069

Torsional Deformity Examples

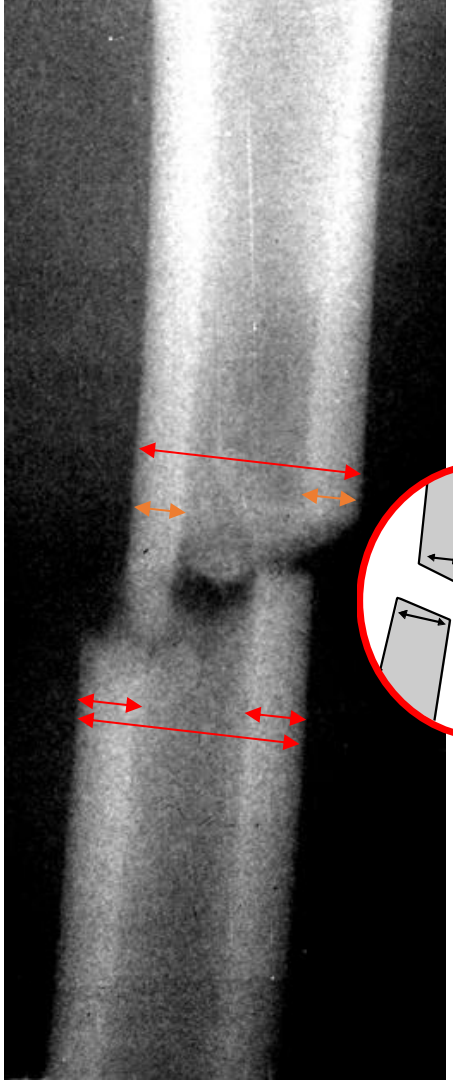
internal torsion deformity

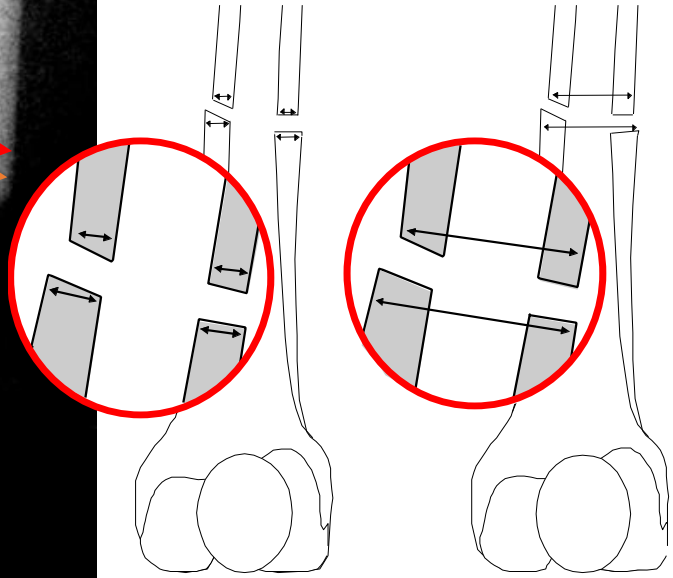


external torsion deformity

internal torsion deformity

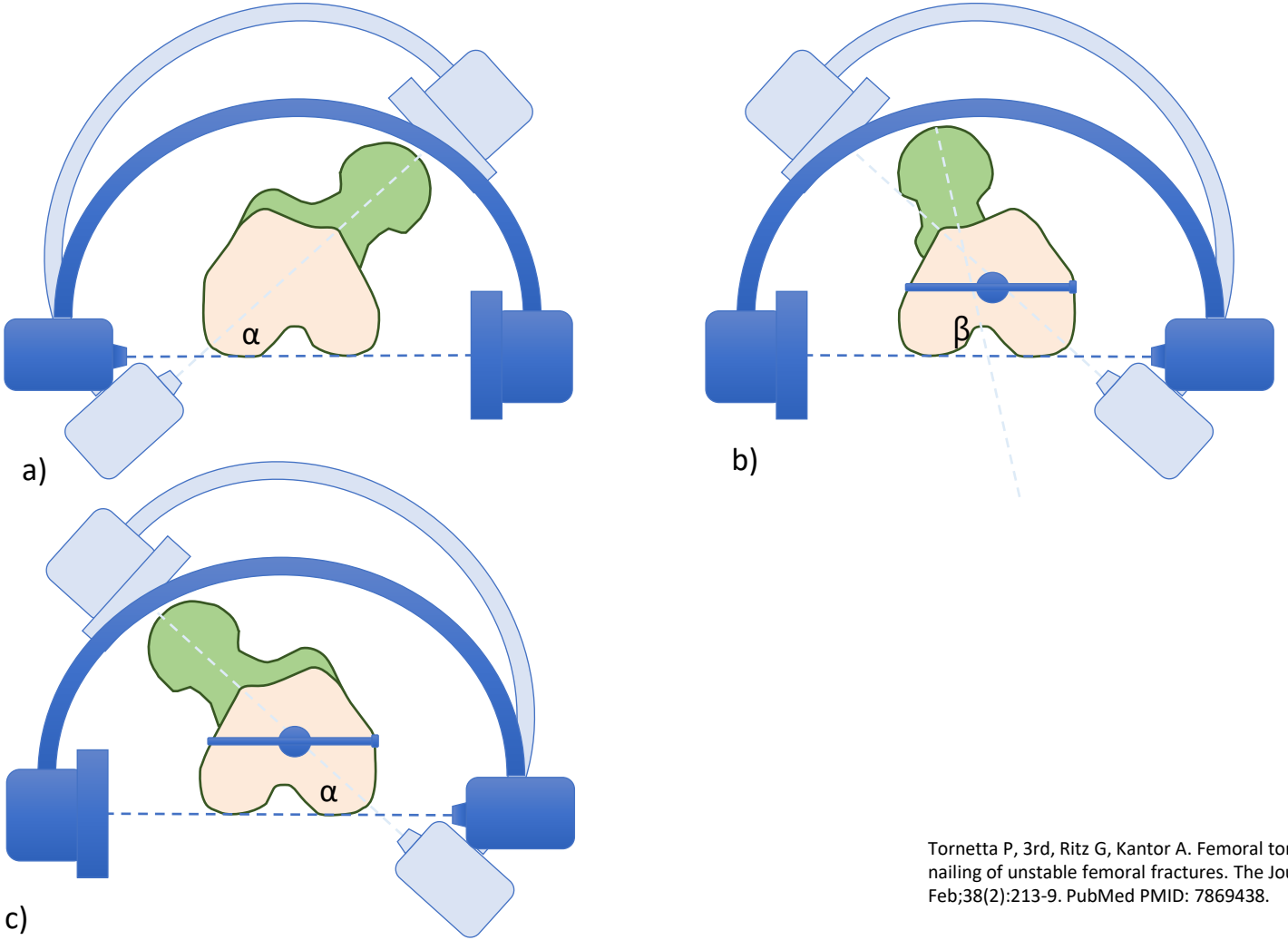
Torsion: Cortical step sign & Diameter difference sign





Krettek et al (1999) Techniques in Orthopaedics 14:247

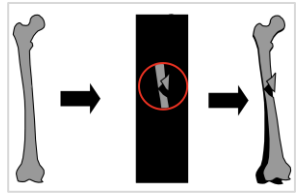
Torsion

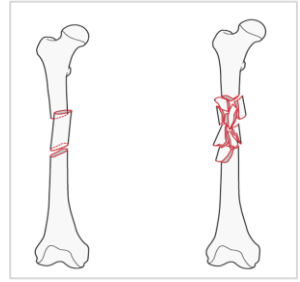
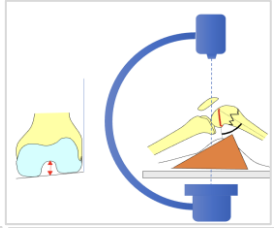
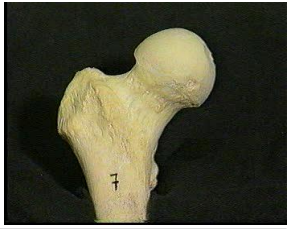


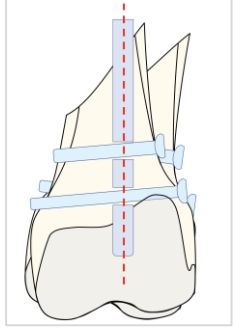
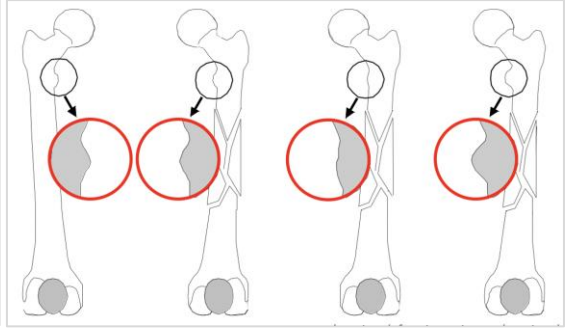
Tornetta P, 3rd, Ritz G, Kantor A. Femoral torsion after interlocked nailing of unstable femoral fractures. The Journal of trauma. 1995 Feb;38(2):213-9. PubMed PMID: 7869438.

Summary Length, Alignment & Rotation

1) Metaphyseal: starting point crucial
2) Length: meter stick technique
3) Varus-valgus: cable technique (incl. modification)
4) Distal Femur: toggeling problem /solutions
   notch sign
   condyle geometry: 95° guide wire implants
   knee stability (pseudo-laxity)
5) Torsion: sit test / lift off test
   lesser troch shape sign



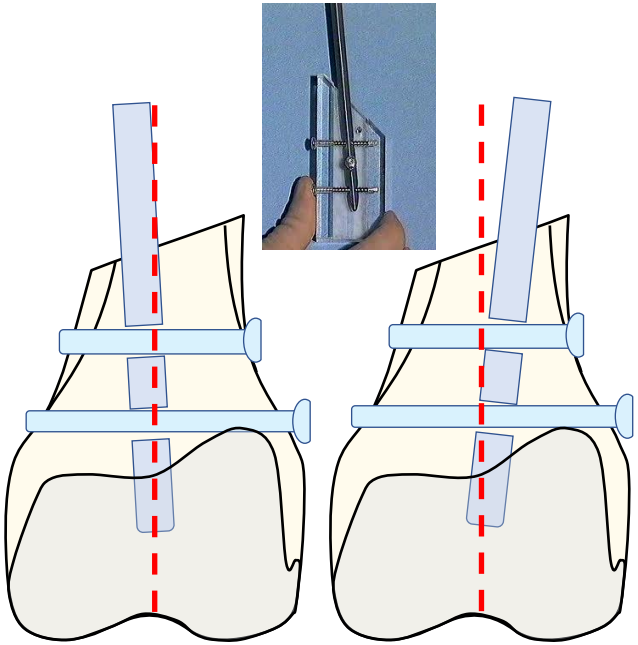
Floating knee

65 y, massively destructed, infected

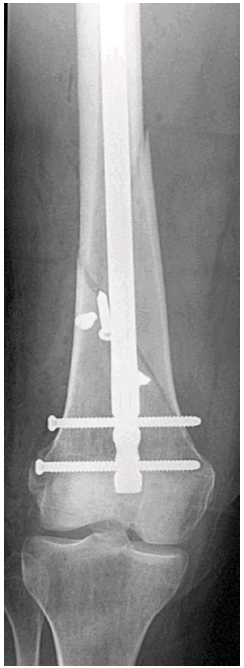
Management Challenge #7 Retrograde nail – insertion depth

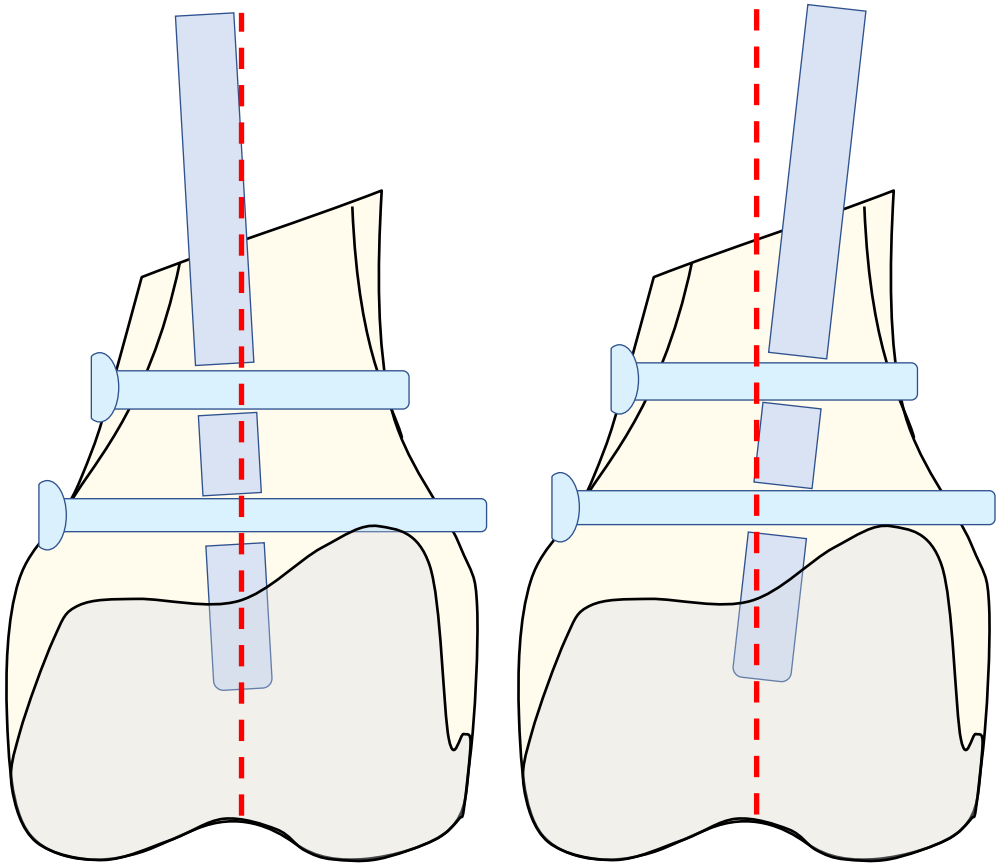
too prone
- interference with patella

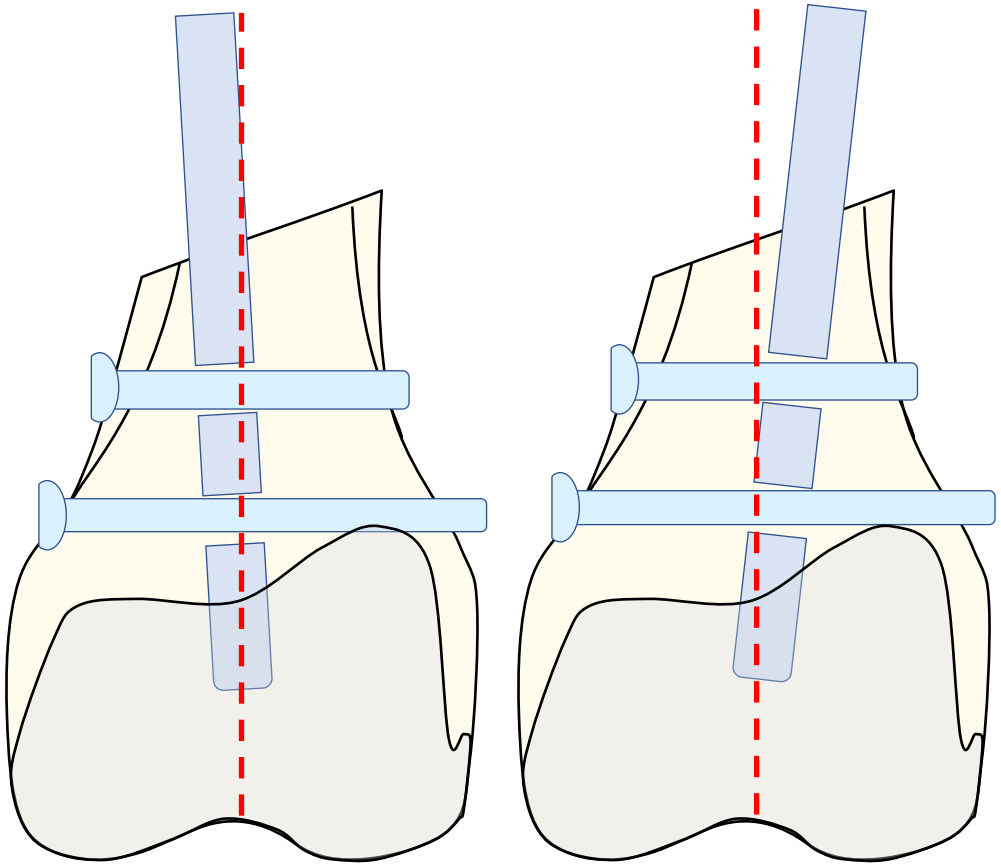
too deep
- instability



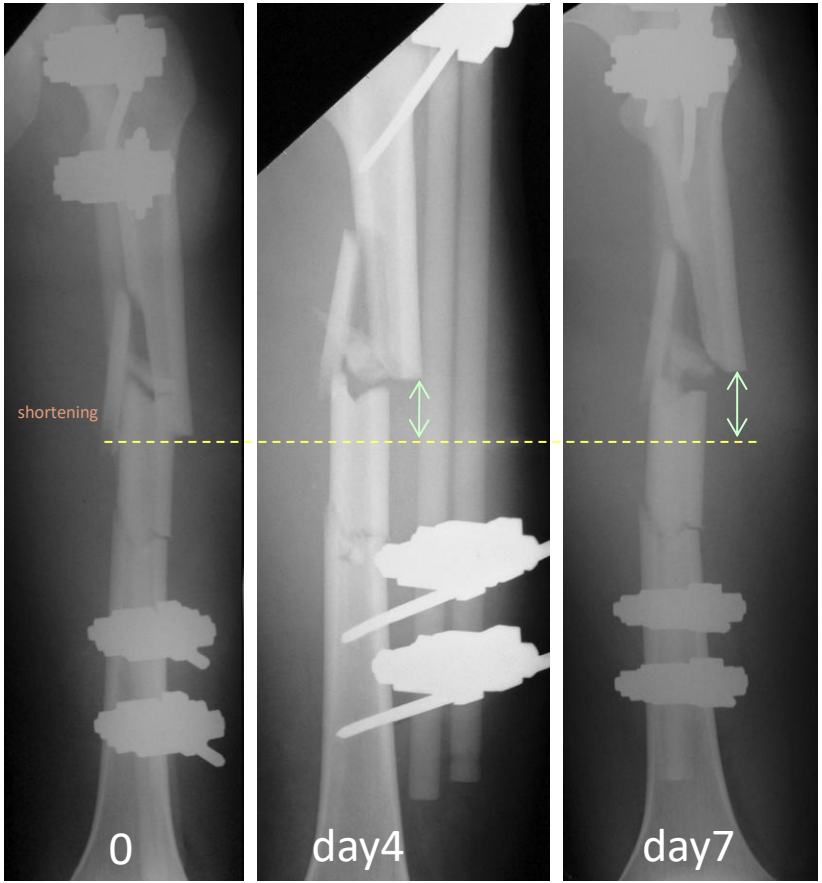
additional support
Poller screws







Post Damage Control Shortening

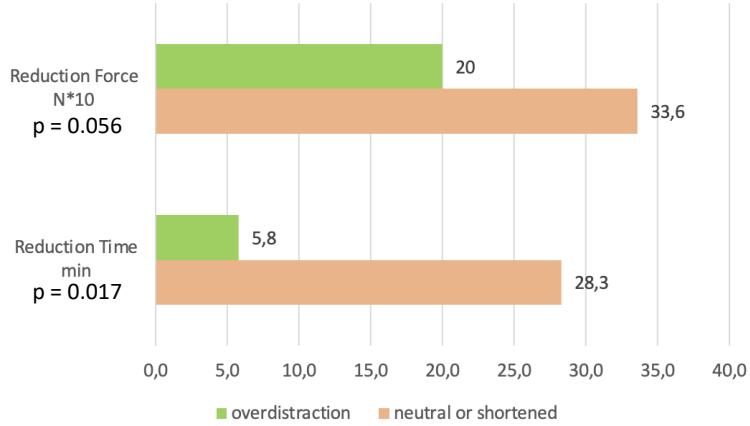


The Journal of TRAUMA 2006 Injury, Infection and Critical Care

Overdistraction of the Fracture Eases Reduction in Delayed Femoral Nailing

Results of Intraoperative Force Measurements

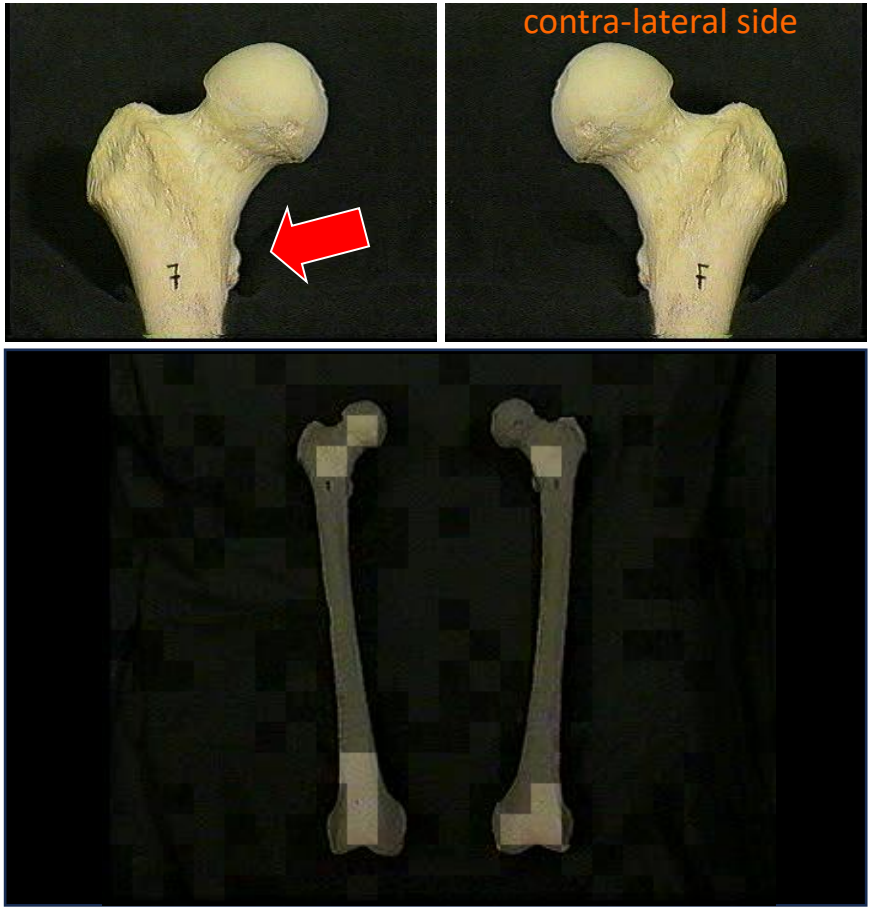
Gosling T, Hufner T, Westphal R, Faulstich J, Hankemeier S, Wahl F, Krettek, C



Conclusion

- Fracture shortening leads to higher forces & prolonged reduction time
- Overdistraction should be performed as soon as possible under careful soft-tissue monitoring

Torsion: Lesser trochanter shape sign



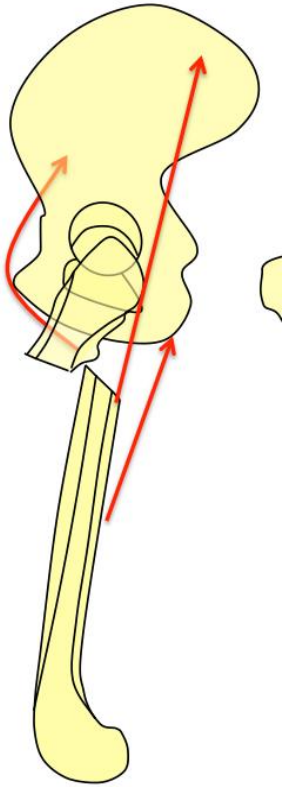
comparison with contra-lateral side

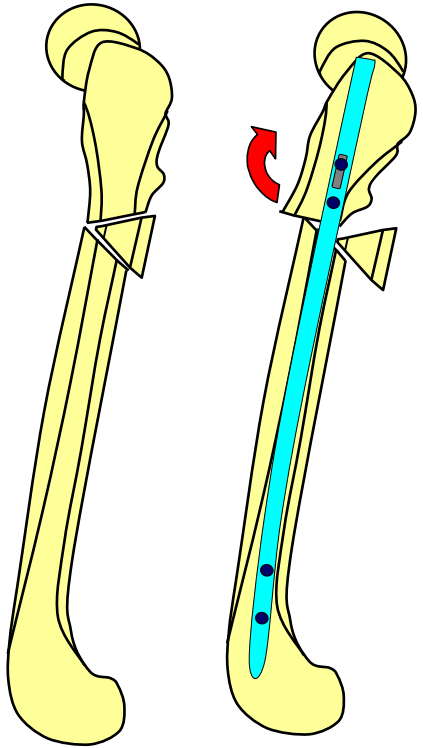
Krettek et al (1999) Injury 29

Sagittal plane deformities:

mainly metaphyseal

proximal femur

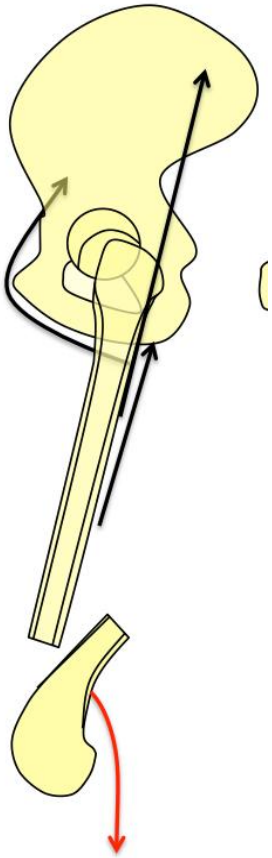




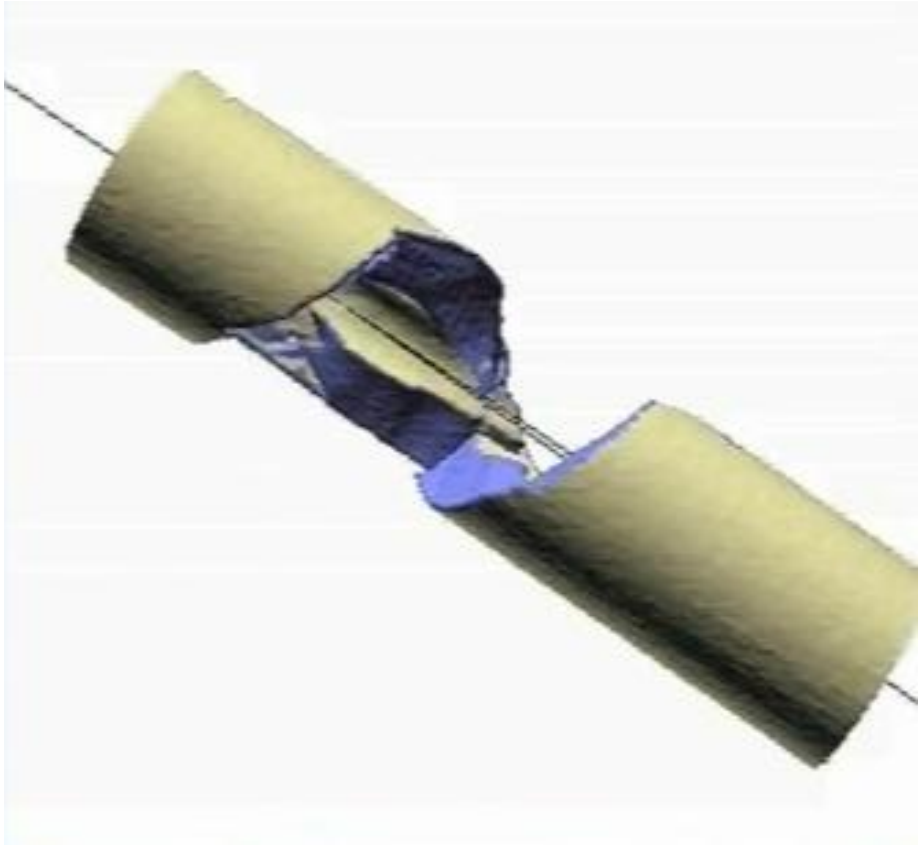
Sagittal plane deformities:

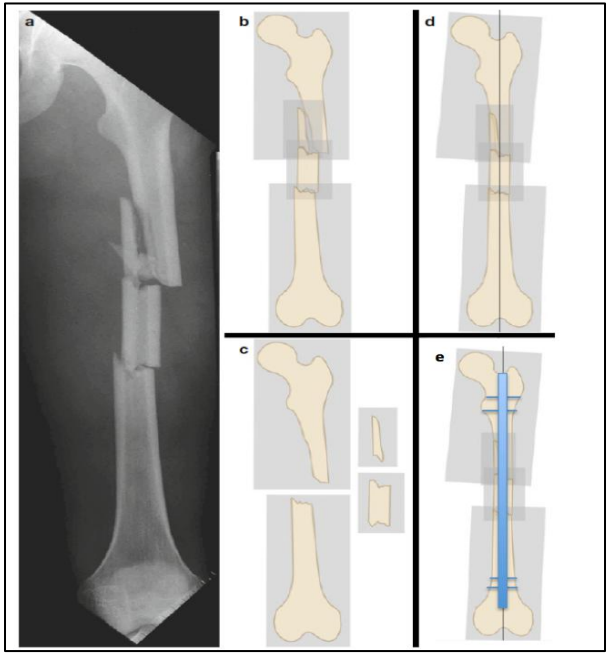
mainly metaphyseal

distal



Segmental Femur Fractures
Assesment of Length, Alignment, Rotation

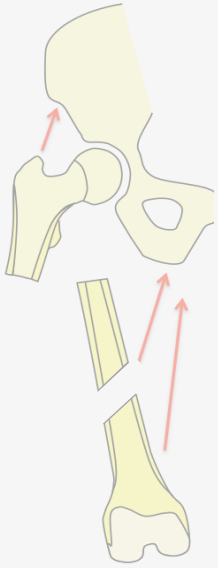


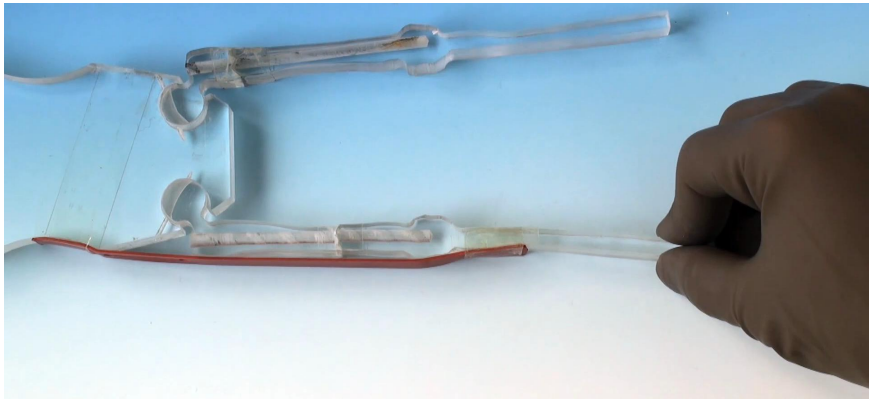


32C2
intact segment

32C3
multifragmentary

Management Challenge #1 Fx table vs simple radiolucent table





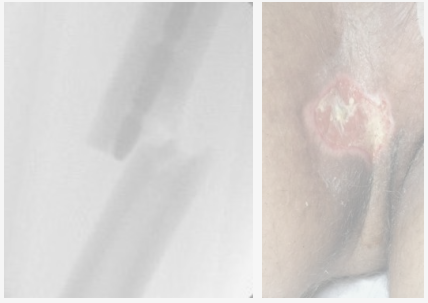
consider the role of IT band in im nailing

conflict

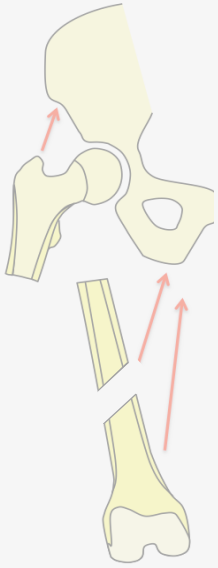
- easy acces to starting point in **ad**-duction, but ilio-tibial tract tightens
- ilio-tibial tract soft in **ab**-duction, but access difficult

Problems fx table

- Access to proximal femur easy in ad-duction
- ad-duction tightens ilio-tibial tract
- tightened ilio-tibial tract shortens fx
- shortened fx makes reduction difficult
- shortened fx requires higher reduction forces
- shortened fx leads to more reduction time



Management Challenge #1 Fx table vs simple radiolucent table



Problems fx table

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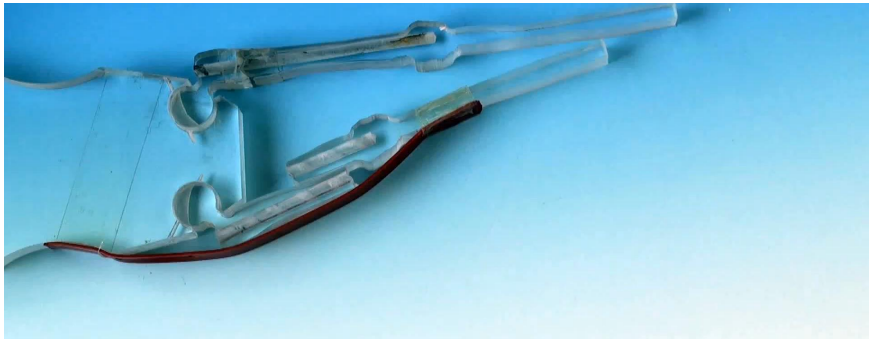
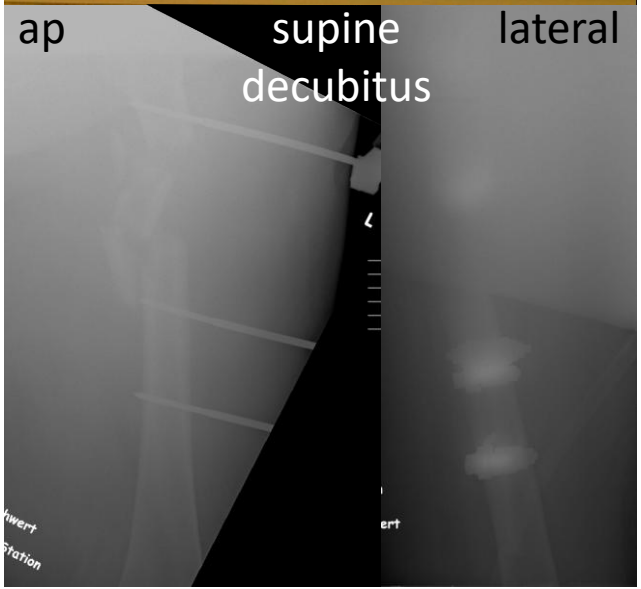


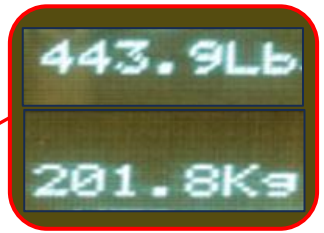
consider the role of IT band in im nailing

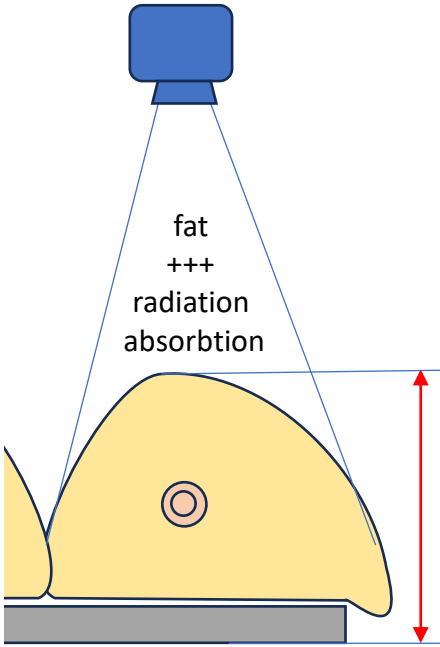
solve the conflict by splitting the process in 2 steps

1. starting point, nail insertion in **ad**-duction, then
2. proximal fragment neutral & distal fragment in **ab**-duction (relaxes iliotibial tract) & eases reduction

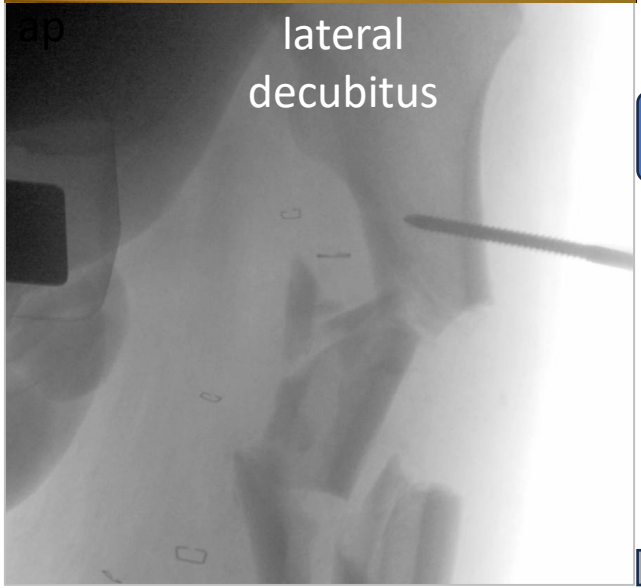
Management Challenge #2 Nailing Supine vs lateral decubitus



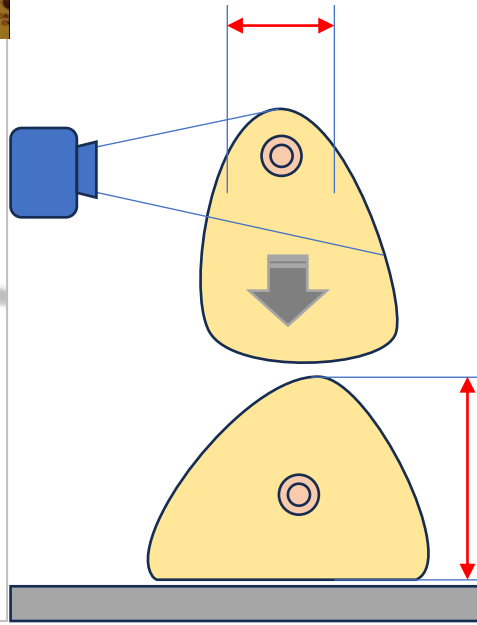




Management Challenge #2 Nailing Supine vs lateral decubitus

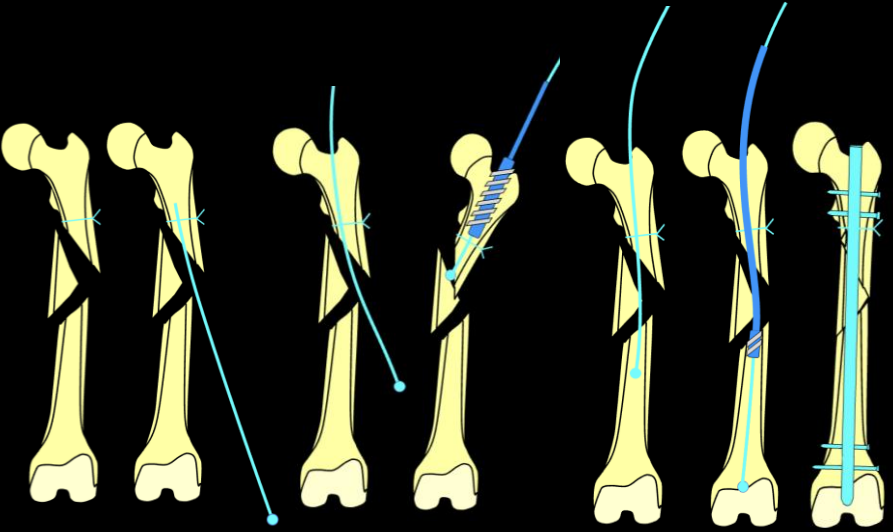


lateral decubitus &
ap projection …
soft tissues flow away
(gravity)
less volume to penetrate

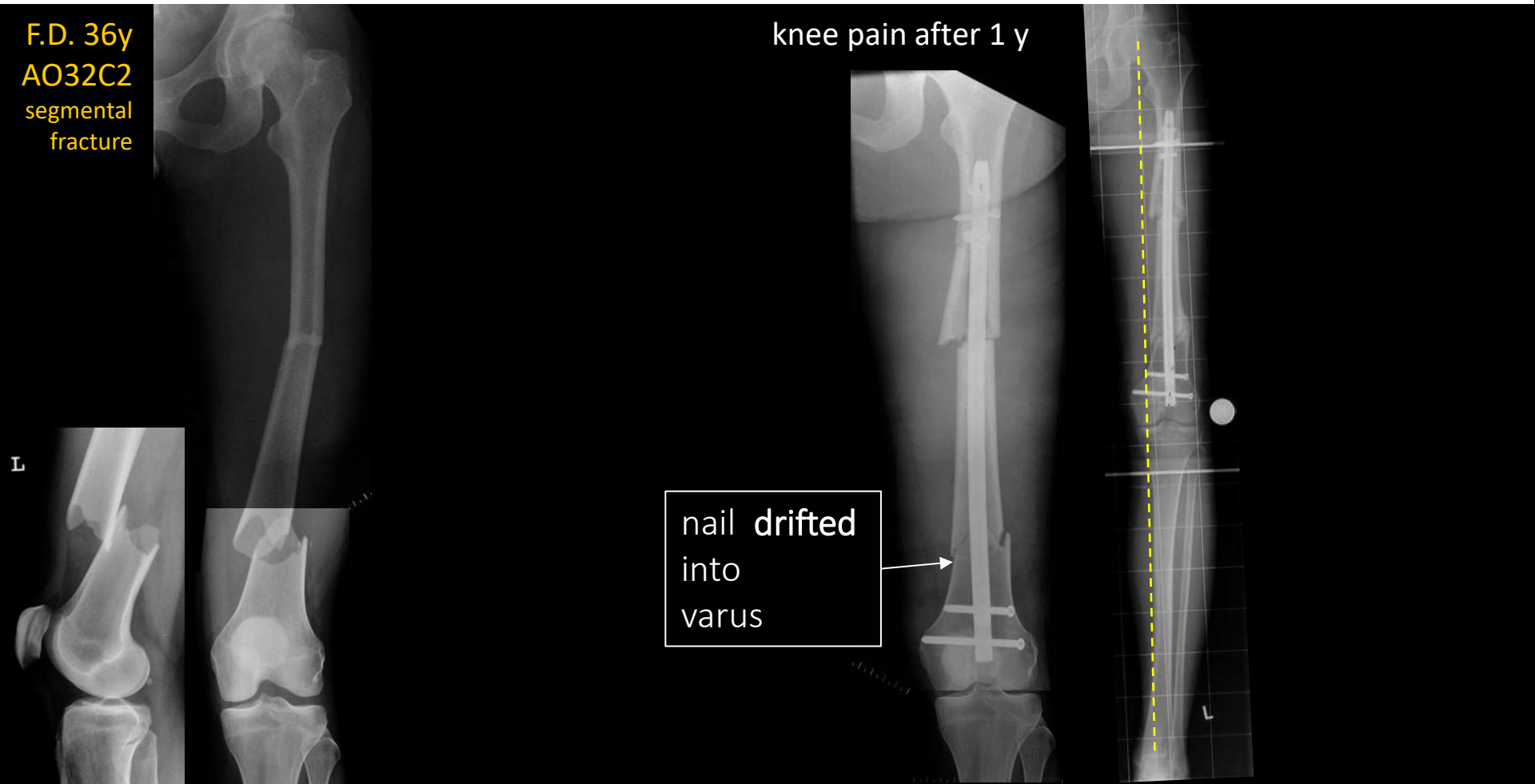


Management Challenge #3 Starting point in obese patients

retrograde starting point



Management Challenge #7 Retrograde nail – insertion depth



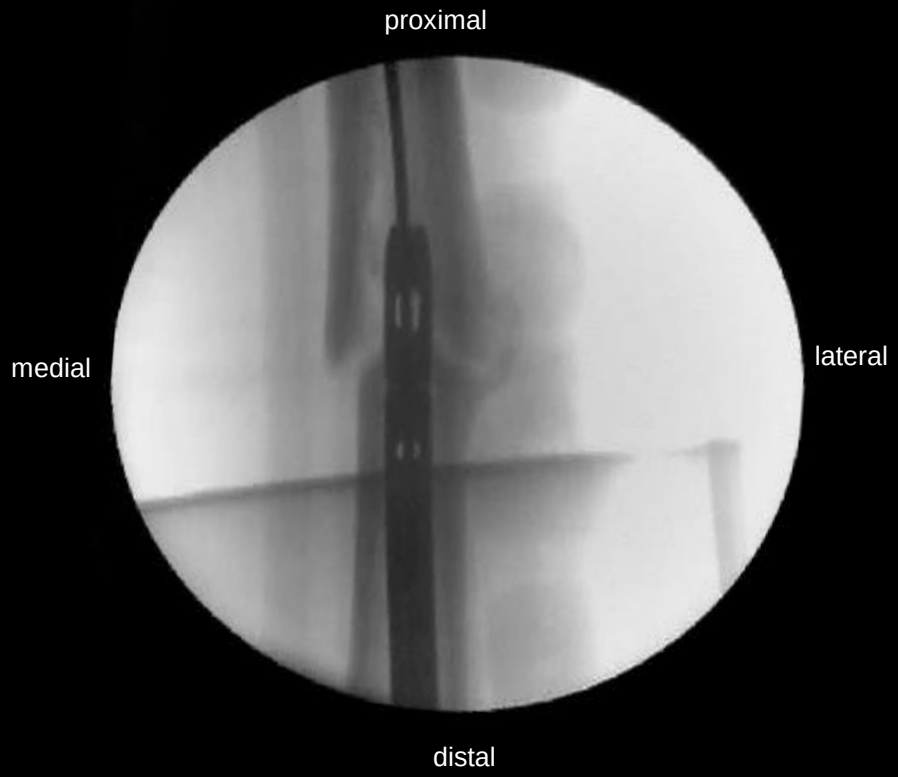
• Management Challenge #7

F.D. 36y
AO32C2
segmental
fracture

how to
prevent nail from
getting too
medial
force nail to
stay lateral

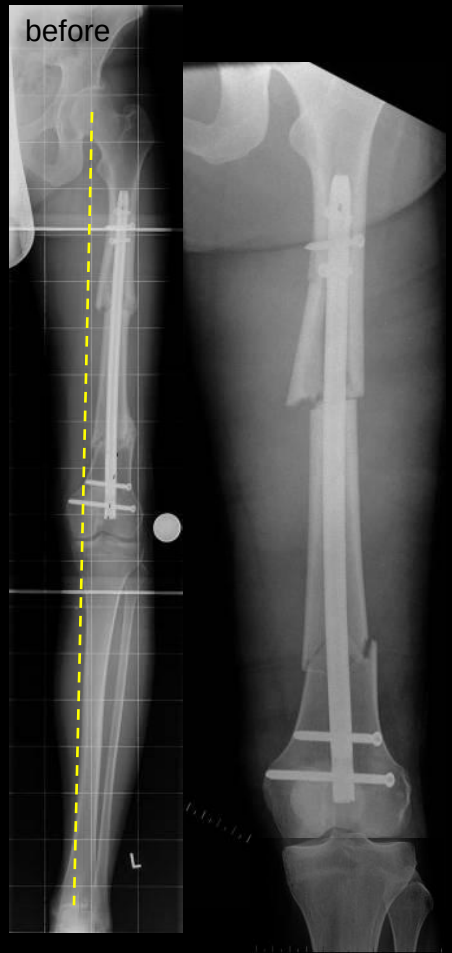
• Management Challenge #7 Alignment

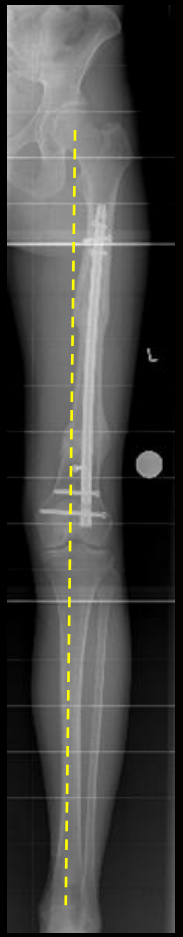
F.D. 36y
AO32C2
segmental
fracture



• Management Challenge #7 Alignment

F.D. 36y
AO32C2
segmental
fracture



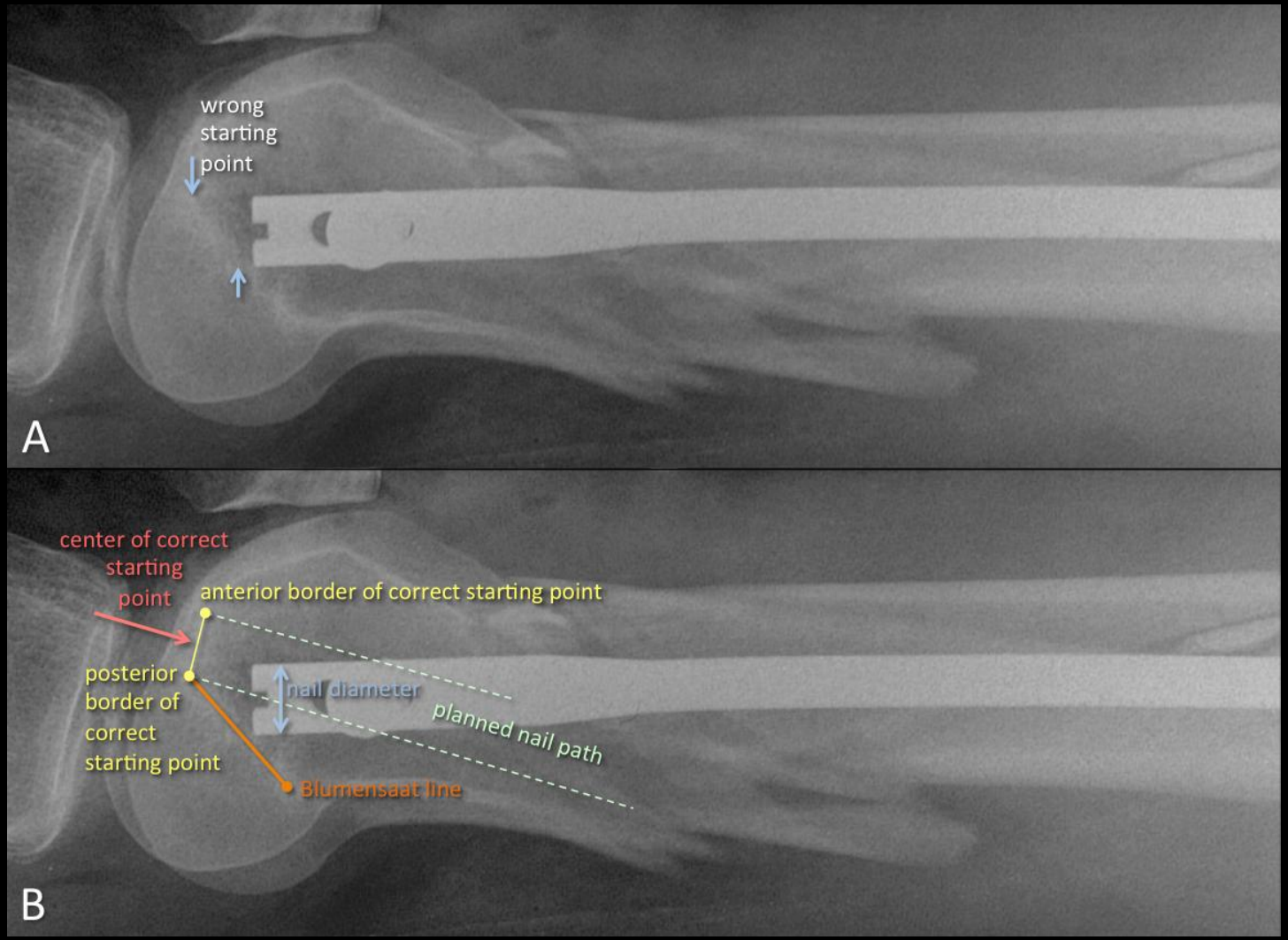


Obesity
Antegrade v Retrograde

		Obese BMI >30	Non-Obese BMI <30	
OR Time	Ante	94		
	Retro	67		
Fluoro	Ante	247	135	P<.03
	Retro	76	63	nss

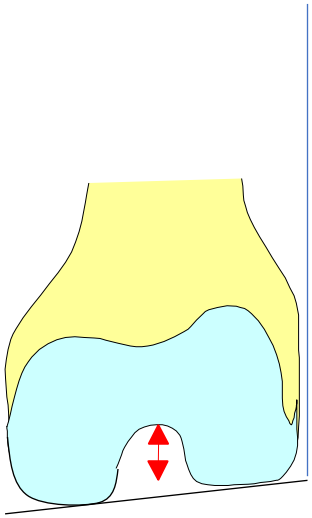
Retrograde nailing is easier in obese patients !!

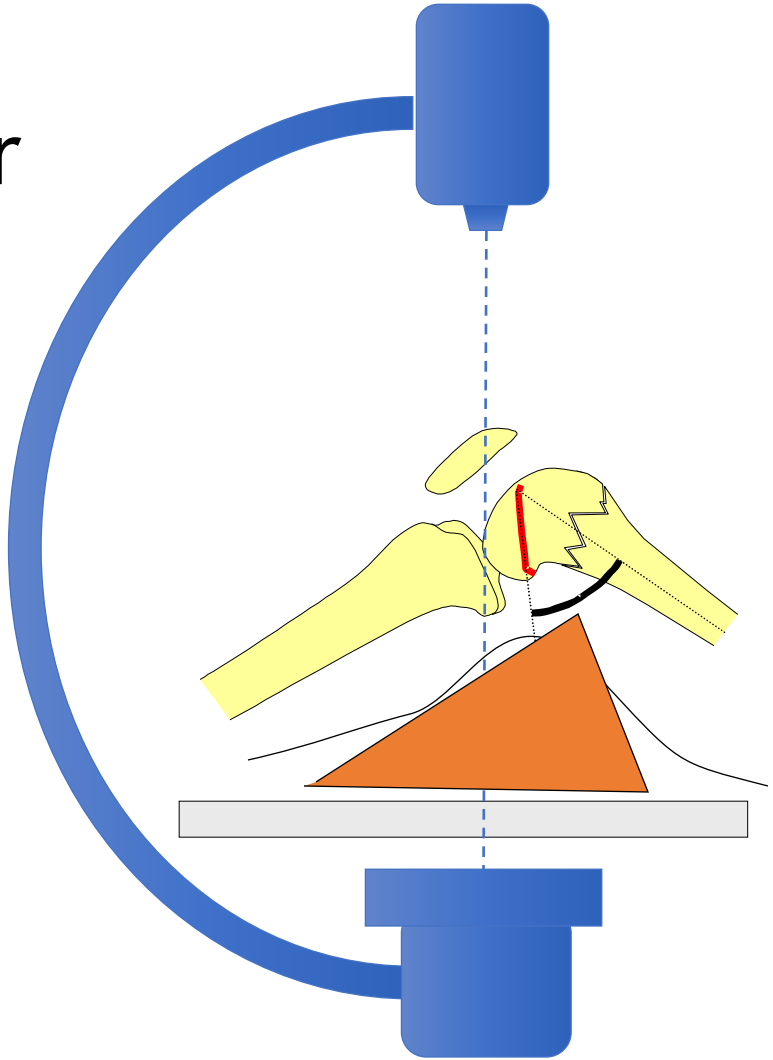
Tucker M. JOT 2007


wrong
starting
point
A
center of correct
starting
point
anterior border of correct starting point
posterior
border of
correct
starting point
nail diameter
planned nail path
Blumensaat line
B


j)

Control yo r C-arm vect or





Dream …

Intra-op 3D Info
quick and easy

Management Challenge #8 Retrograde nail

Management Challenge #1 Decision making DCO or ETC?

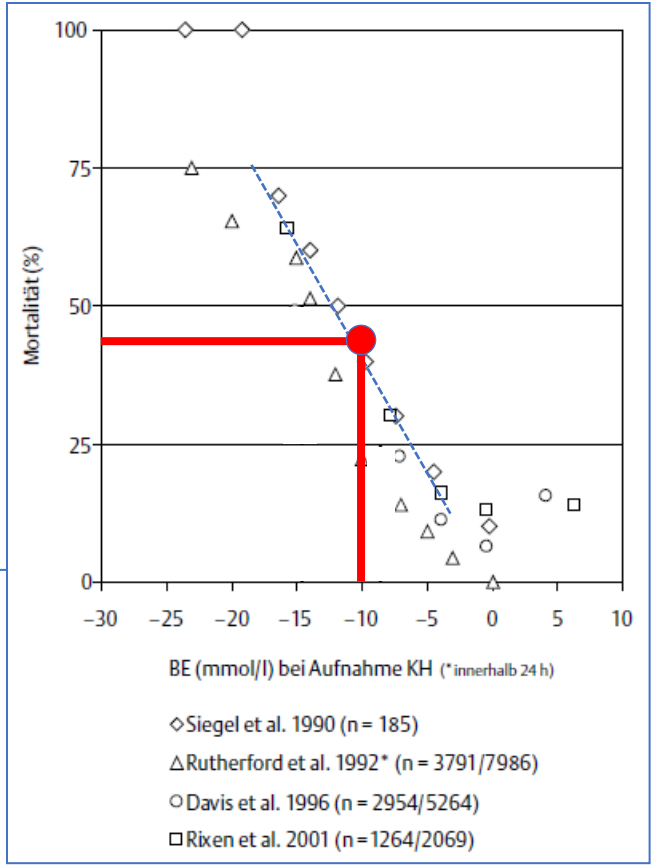
- isolated injury or polytrauma?
- TBI? chest injury?
- Patient status:
  acidosis – coagulation status – temp
  lactate?

High correlation between BE and lactate (Pearson -0.81) Caputo, Am J Emerg Med. 2015

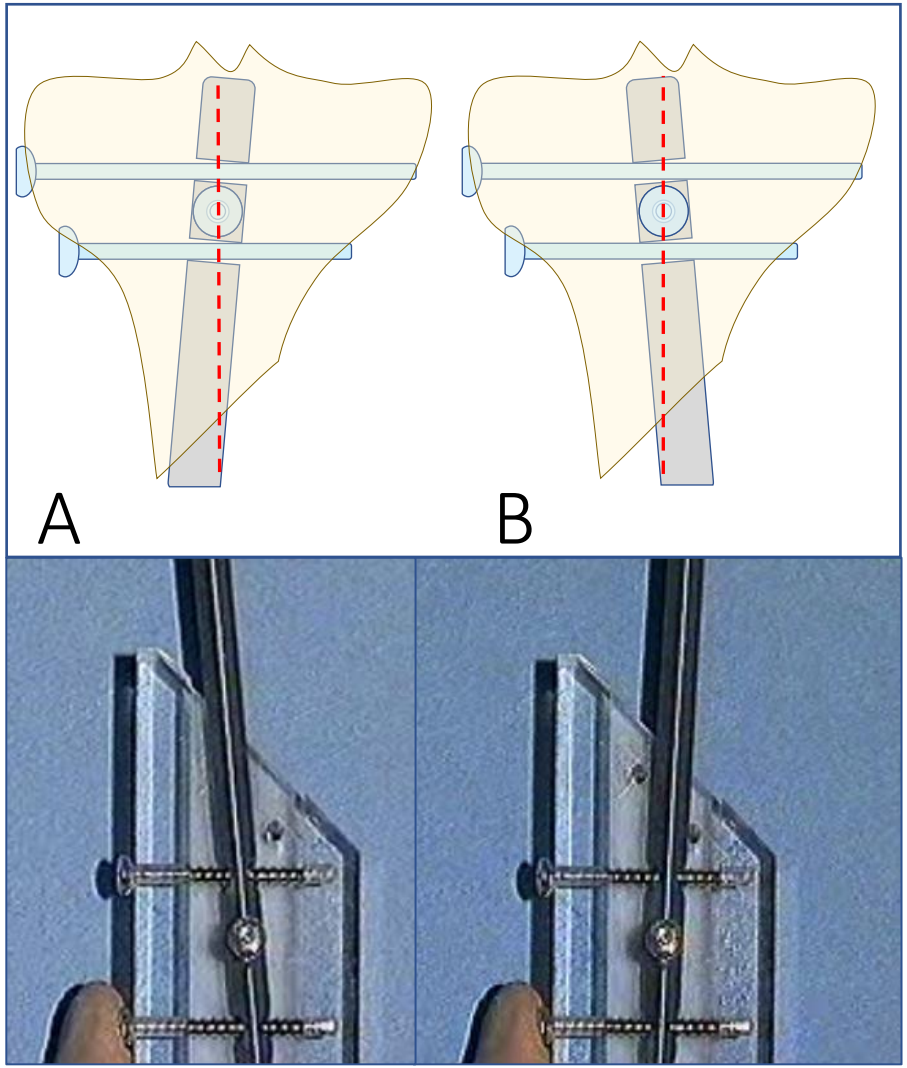
Mortality significantly increased if **> 2 mmol/L**

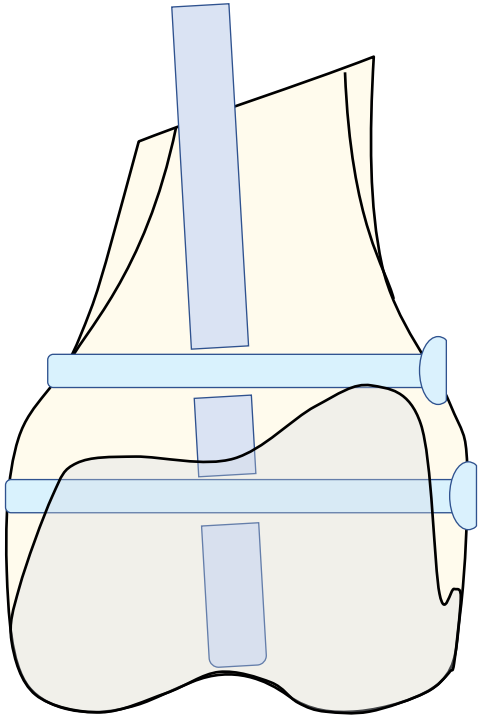
Lactate of **> 4** mmol/L mortality **> 40 %**

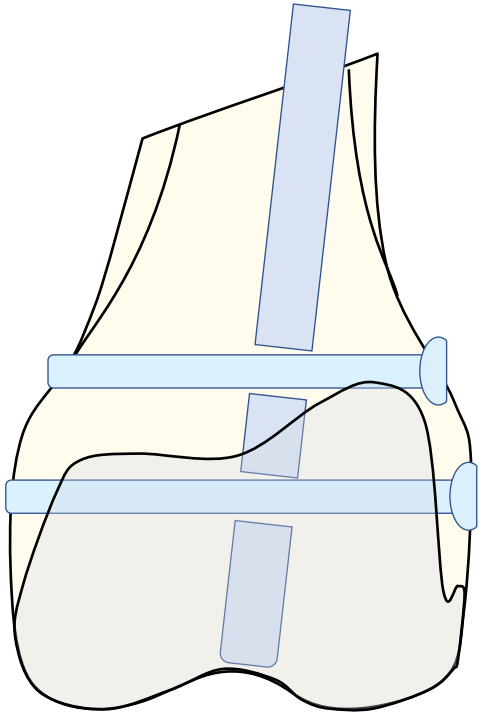
Callaway, J Trauma 2009

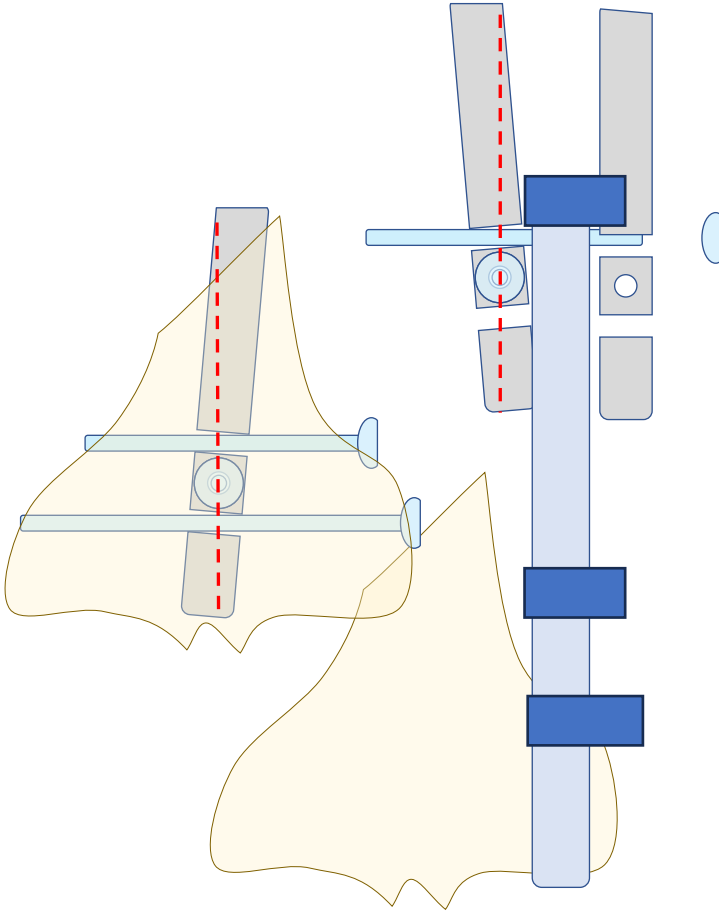


Zander, AINS, 2002

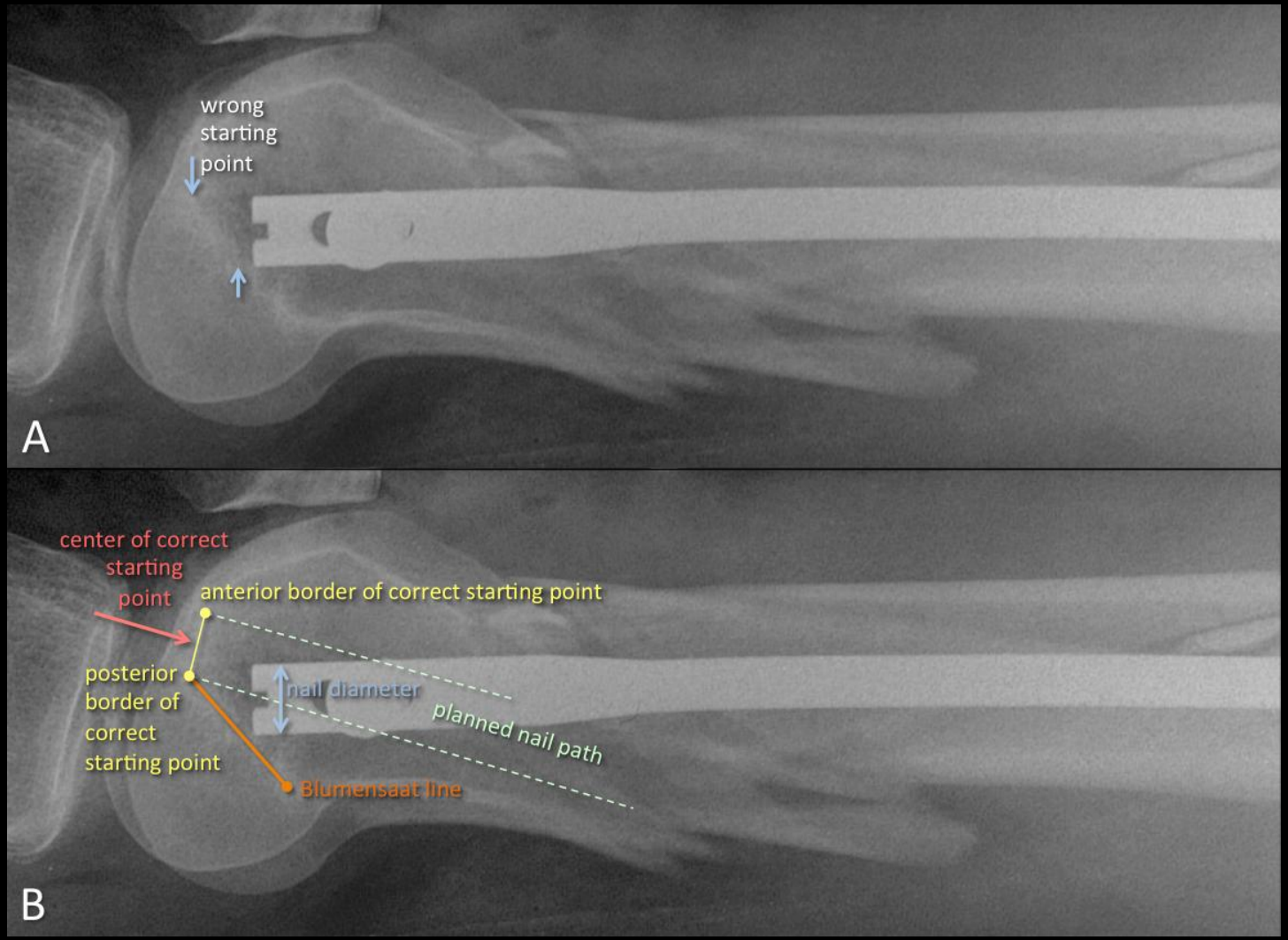

A
B

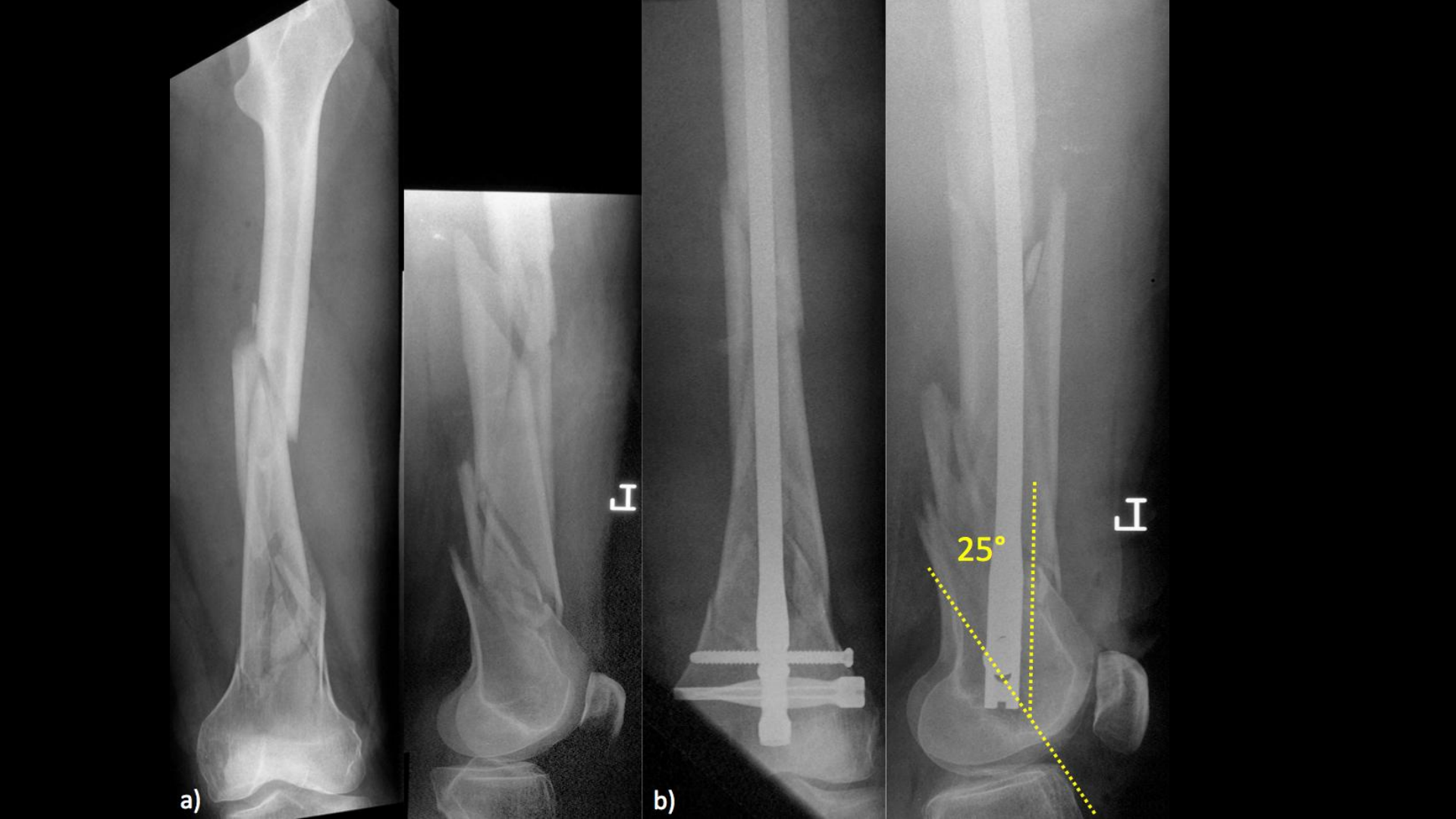


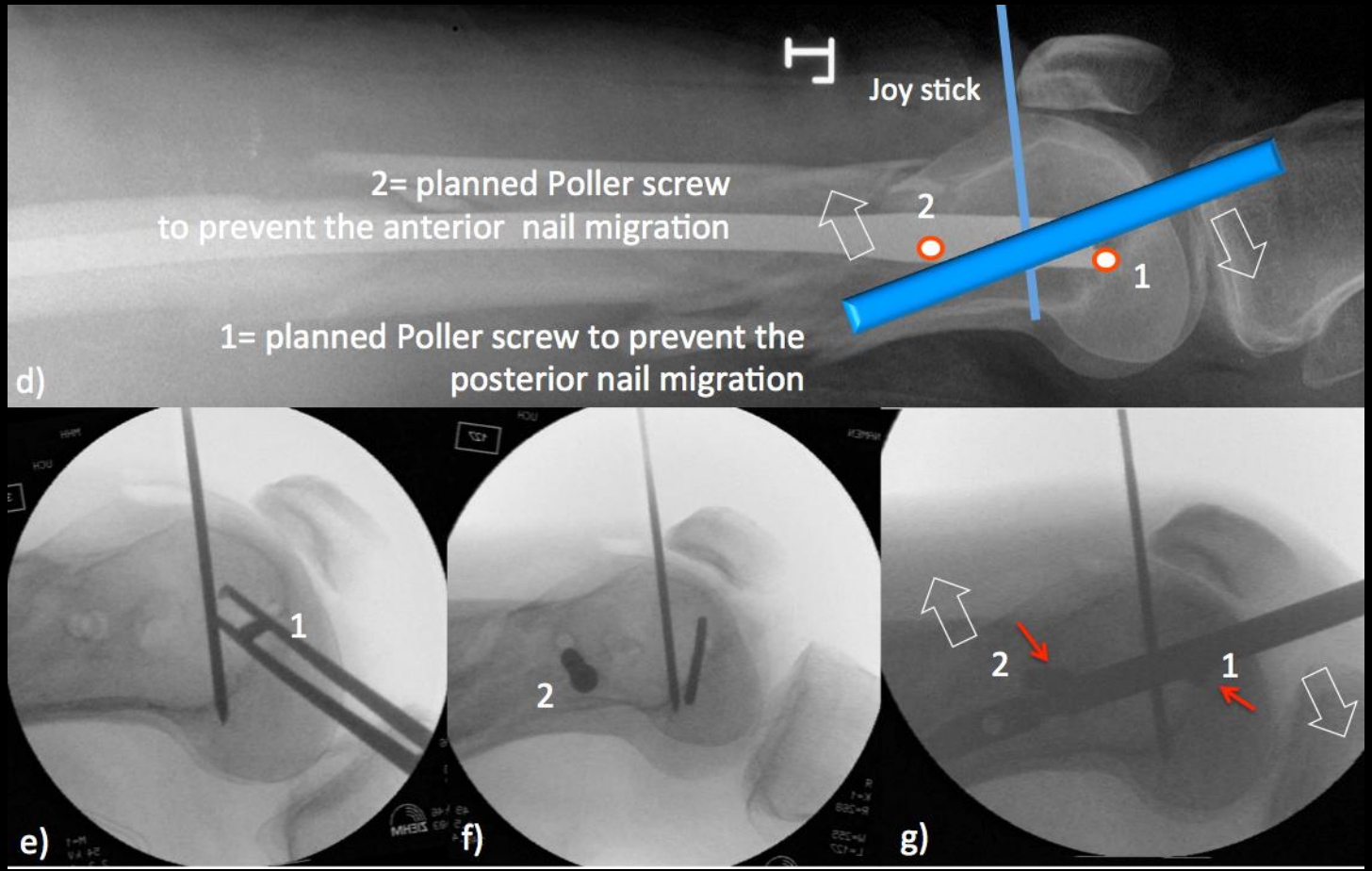


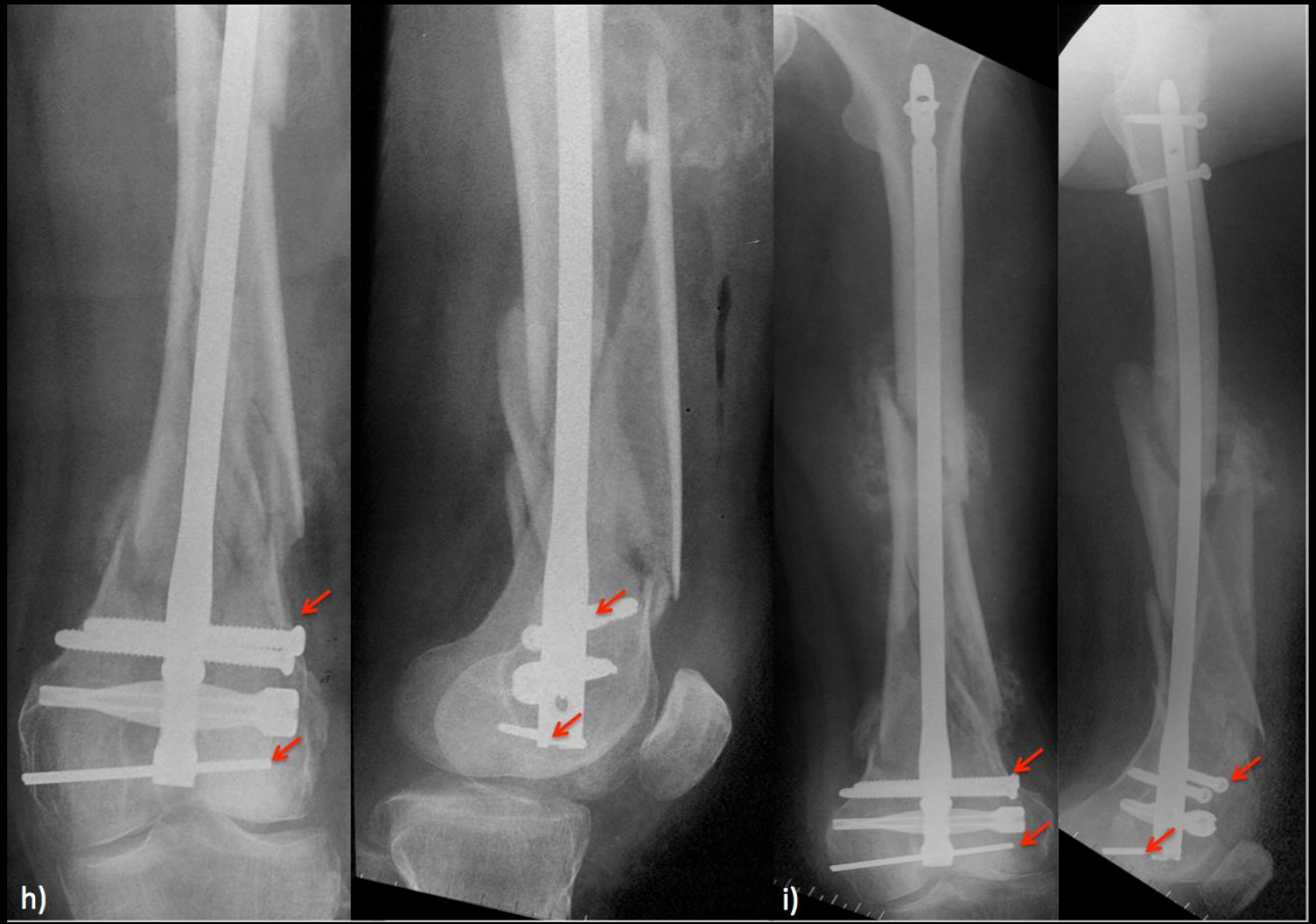



lateral
79 -83°


wrong
starting
point
A
center of correct
starting
point
anterior border of correct starting point
posterior
border of
correct
starting point
nail diameter
planned nail path
Blumensaat line
B

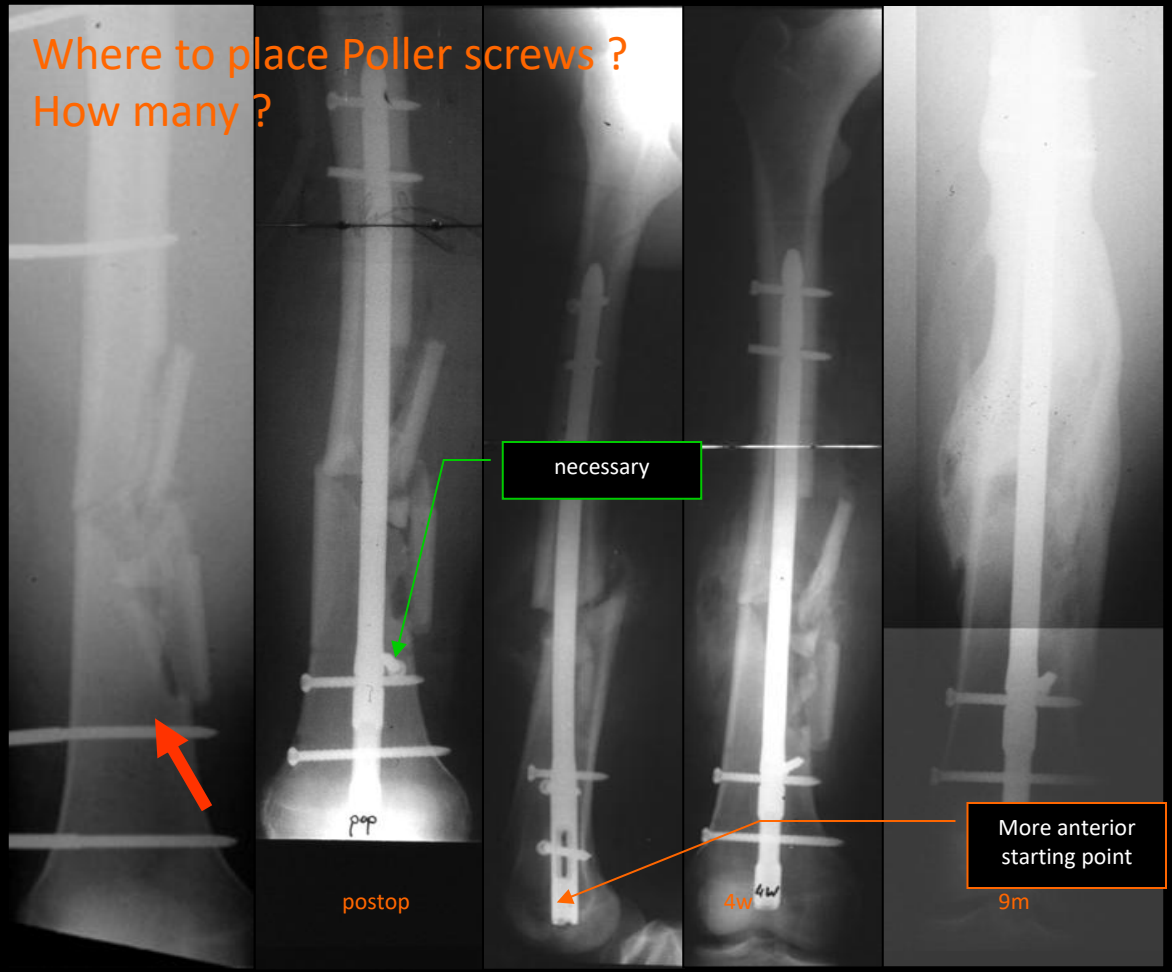

a)
b)
25°


Joy stick
2= planned Poller screw
to prevent the anterior nail migration
2
1
1= planned Poller screw to prevent the
posterior nail migration
d)
1
e)
2
f)
2
1
g)


h)
i)

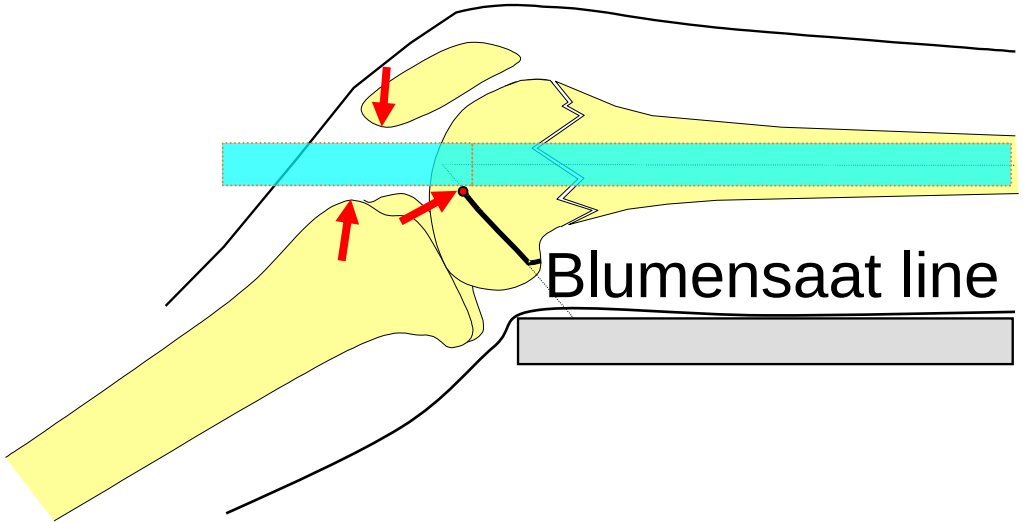

j)

Where to place Poller screws ?
How many ?




C:\Dokumente und Einstellungen\Krettek\Eigene Dateien\Publikationen\Pub 2001 Skeletal Trauma Di
Fig 51-48.jpg
File Edit Image Help
Start
Davos 2001 Adv Dist...
Microsoft Photo Edito...
ImageAccess - [UCH ...
C:\Dokumente und Ei...
Fig 51-48.jpg
07:02

Management Challenge #9 …



Management Challenge #10 ...

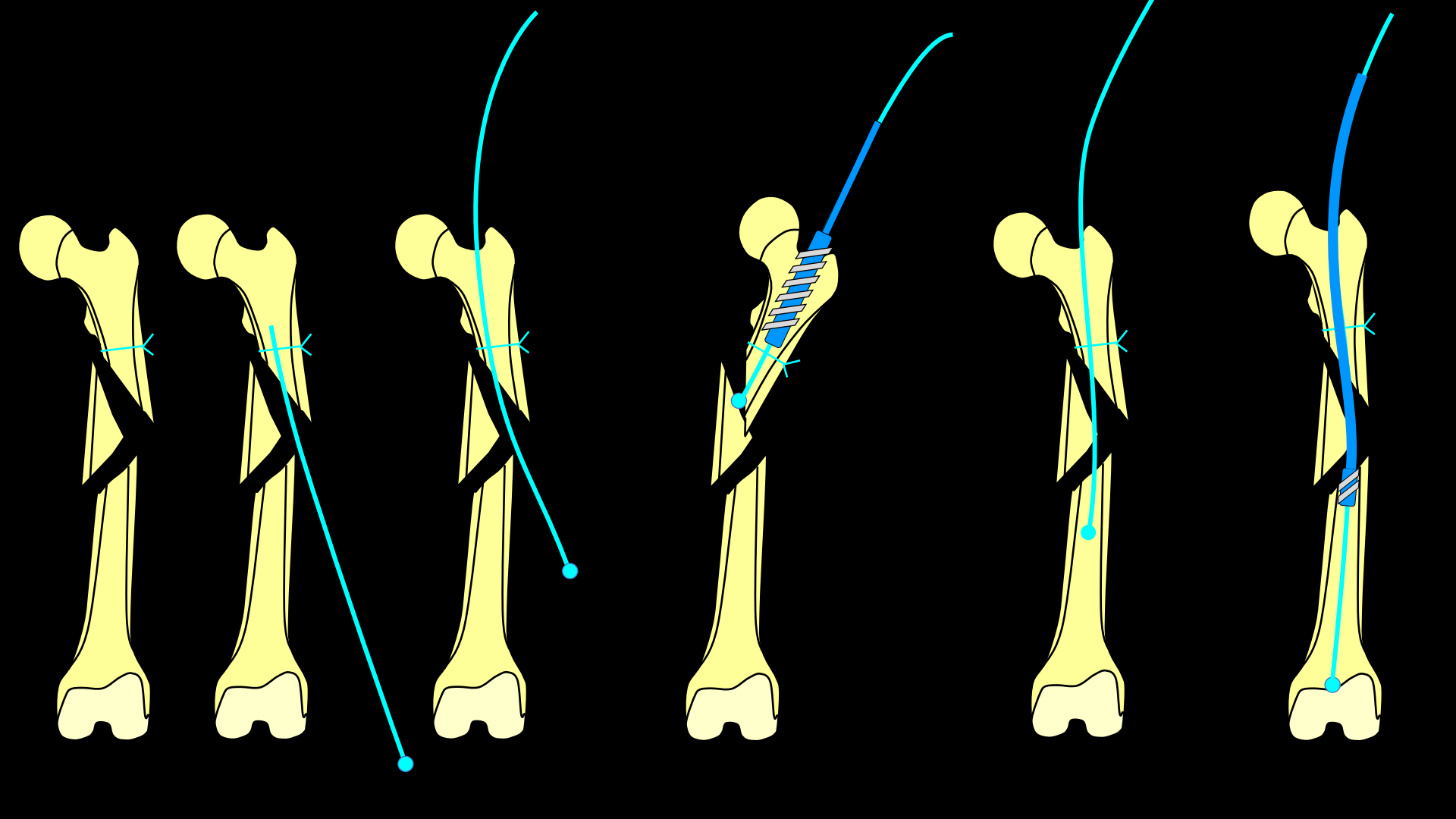
nail

plate

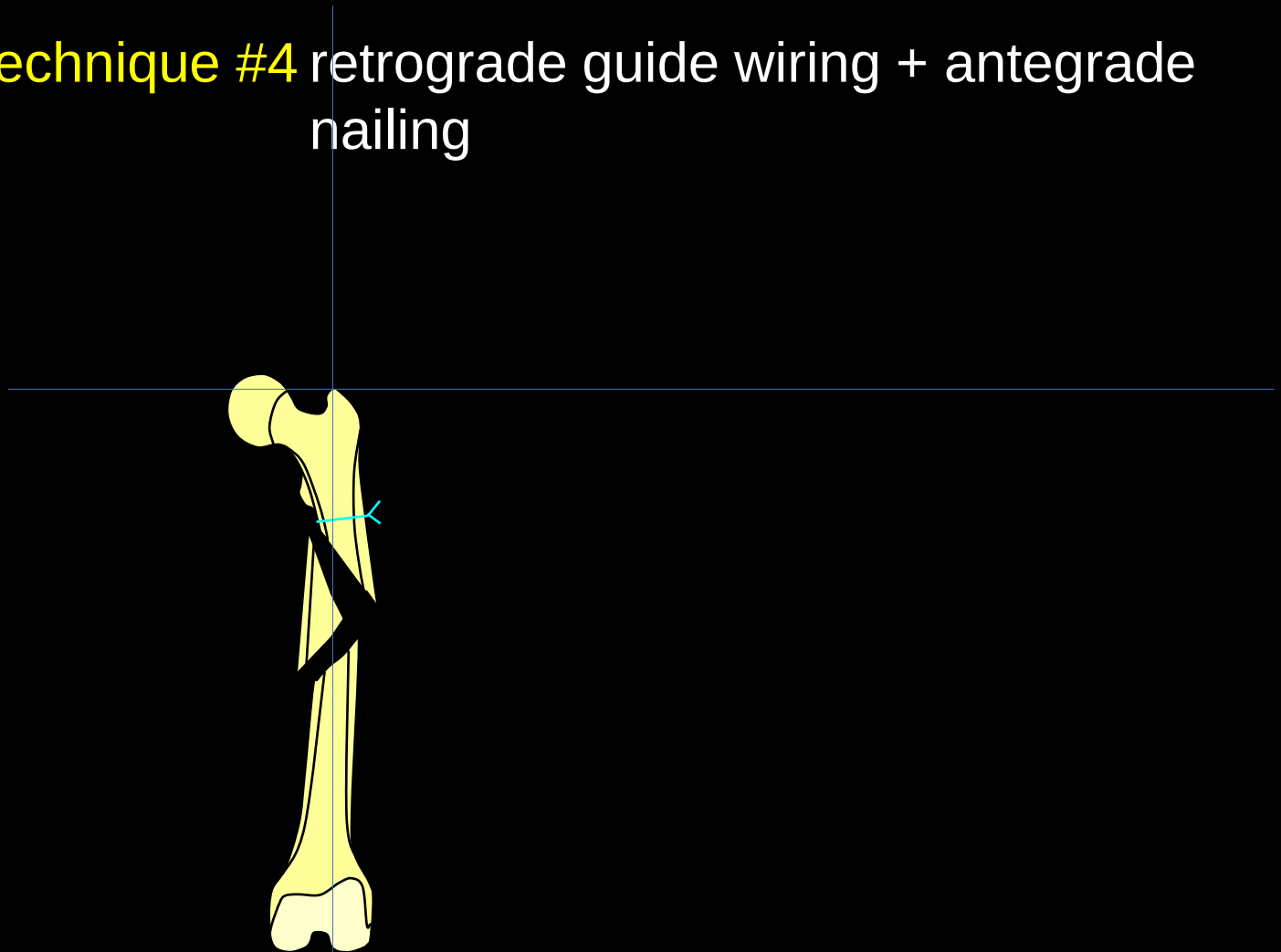
exfix

Summary Management Challenge in Segmental Femur Fractures

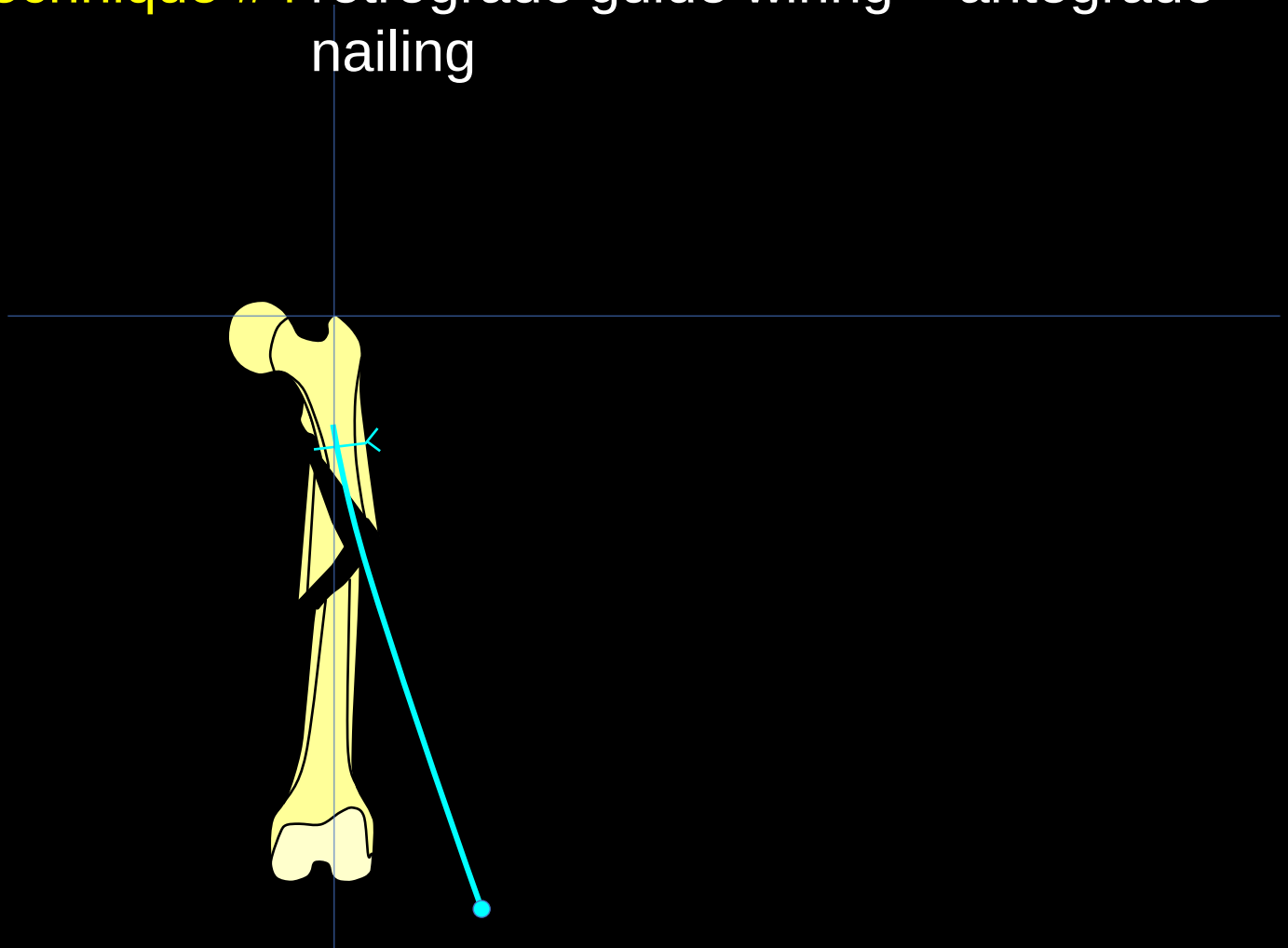
1) Decision making DCO or ETC? isolated injury, polytrauma, head injury, chest injury
2) Implant choice nail – plate – exfix
3) OR Table Fx table vs simple radiolucent table
4) Positioning Supine vs lateral decubitus
5) Insertion site antegrade-retrograde
6) Canal preparation reamed vs unreamed?
7) Reaming technique – avoid rotation of the mid segment (AO32C2)
8) Alignment
9) Open fx – vascular injuries – infection
   small open wound challenge …
10) Bone defects



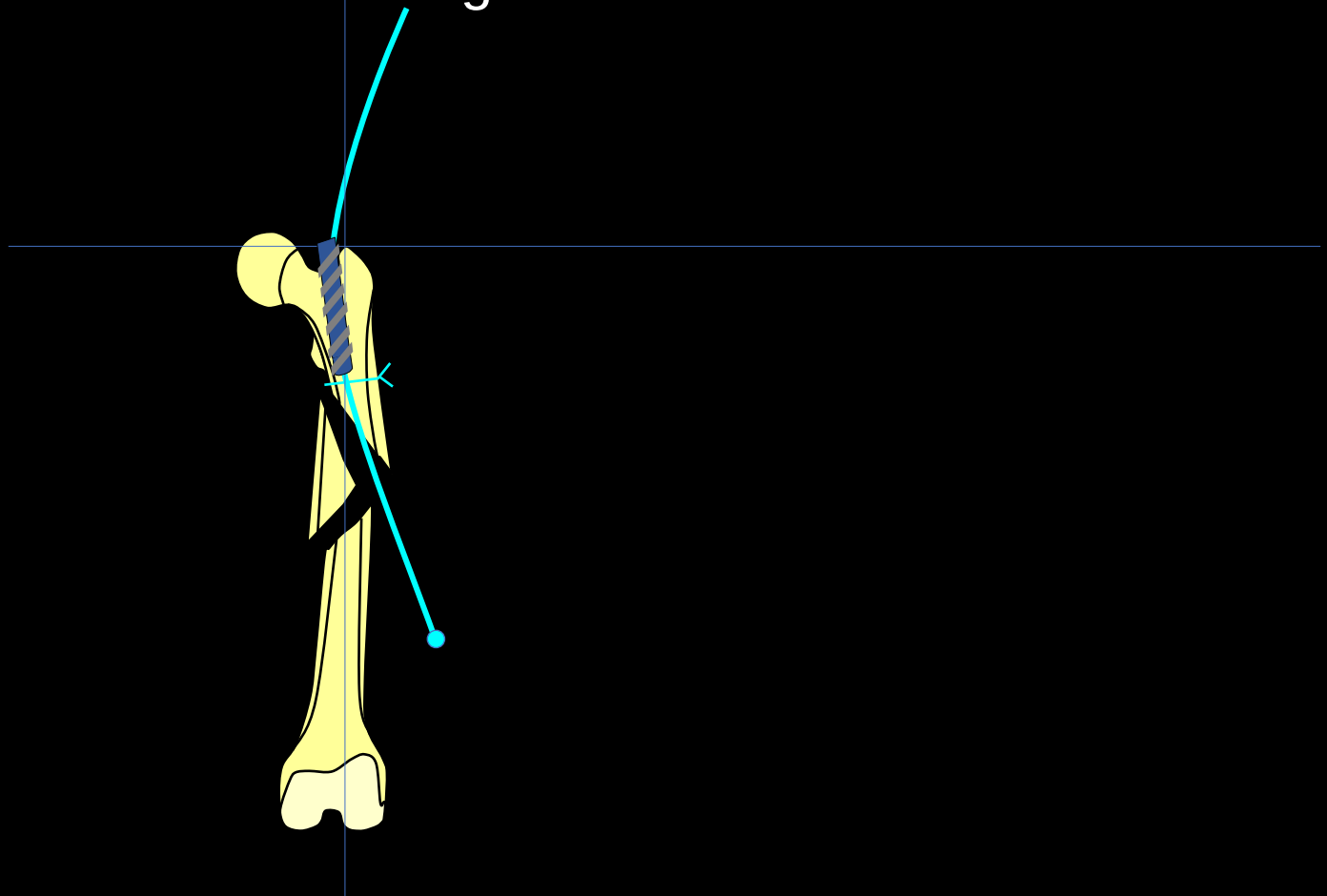
Technique #4 retrograde guide wiring + antegrade nailing



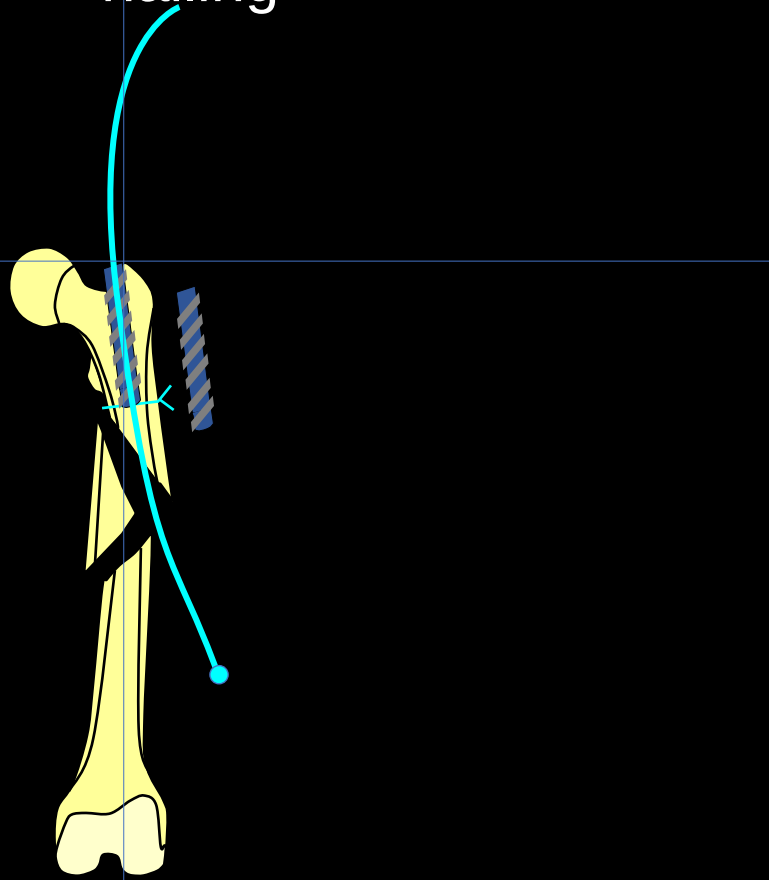
Technique #4 retrograde guide wiring + antegrade nailing



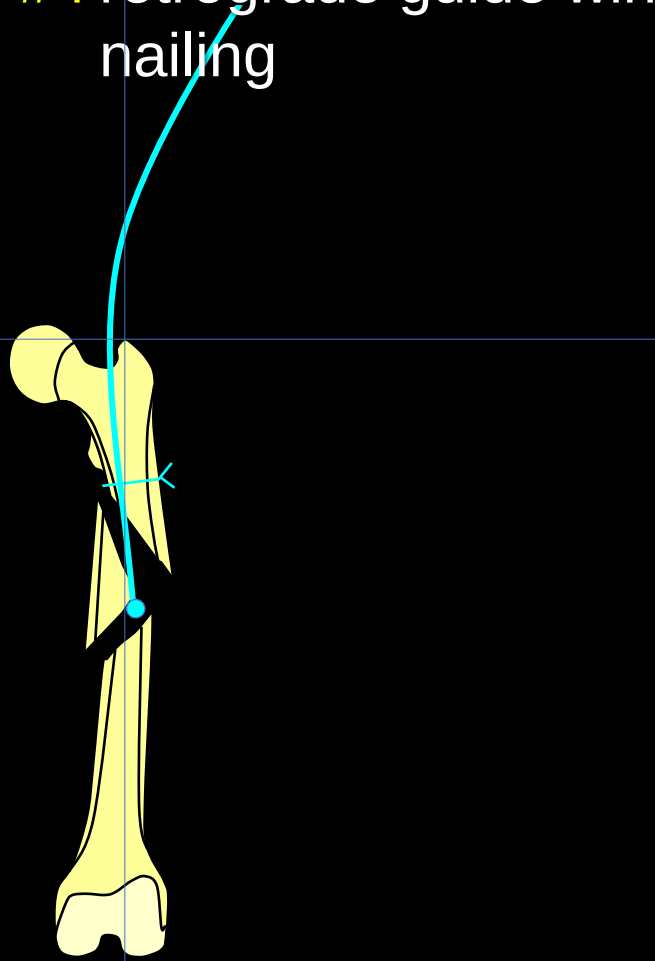
Technique #4 retrograde guide wiring + antegrade nailing



Technique #4 retrograde guide wiring + antegrade nailing

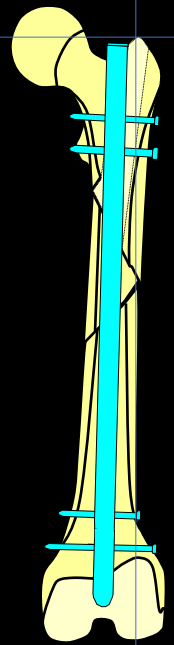


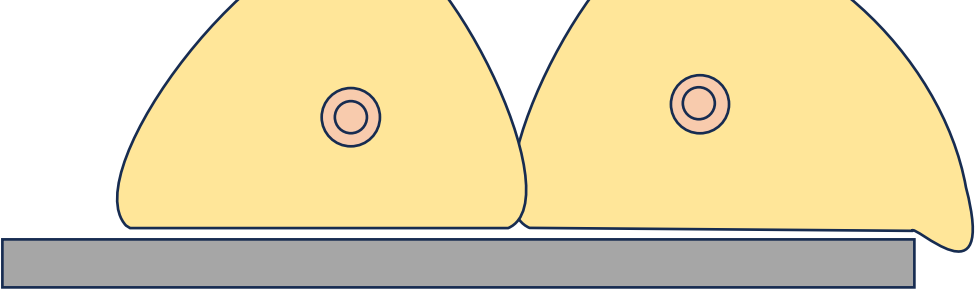
Technique #4 retrograde guide wiring + antegrade nailing

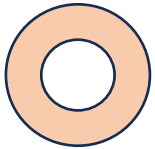


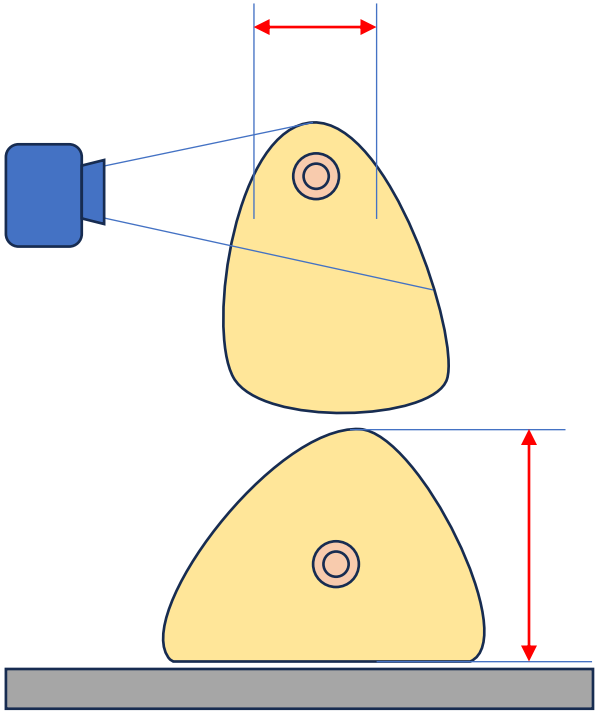
Technique #4 retrograde guide wiring + antegrade nailing

Technique #4 retrograde guide wiring + antegrade nailing





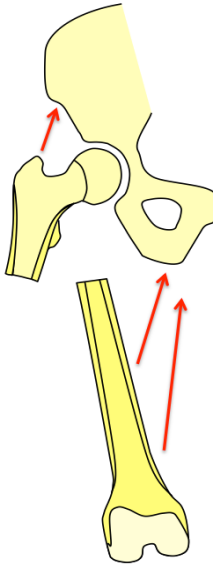




Role of IT band in femoral nailing

... brute or smart force ?

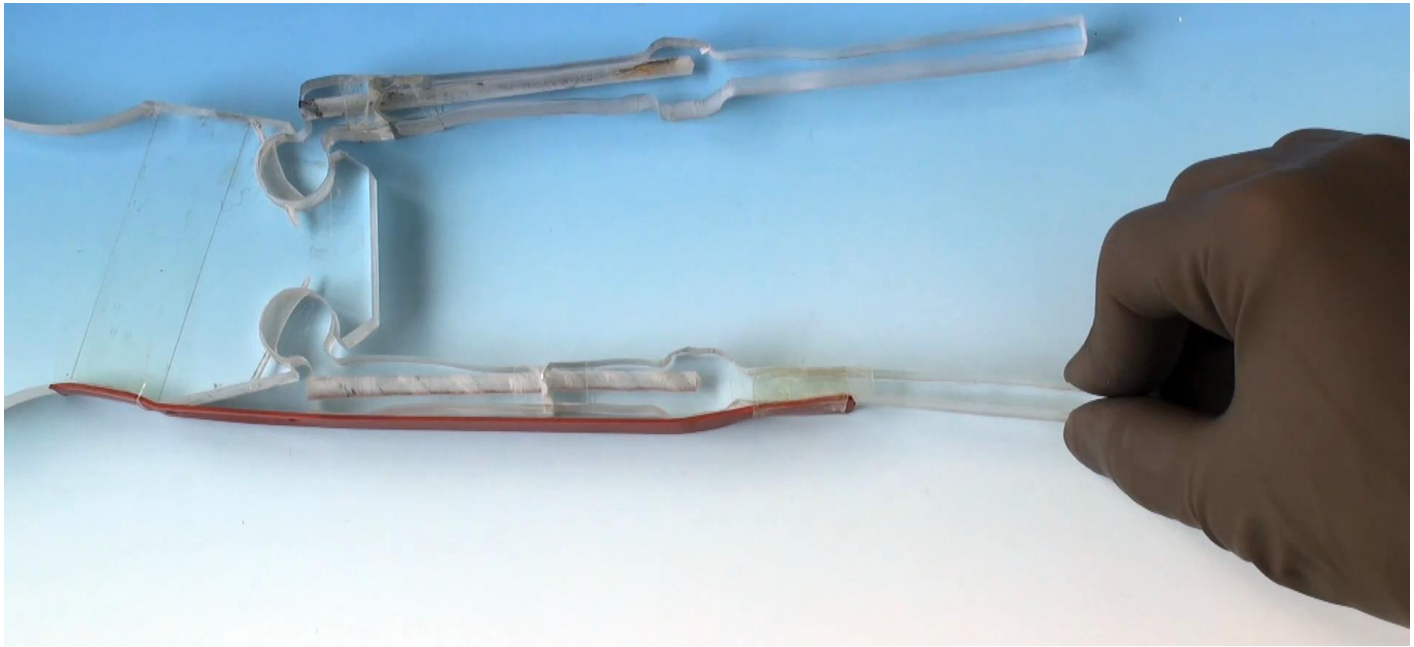
Problem chain
Access to proximal femur easy in ad-duction
ad-duction tightens ilio-tibial tract
tightened ilio-tibial tract shortens fx
shortened fx makes reduction difficult
shortened fx requires higher reduction forces
shortened fx leads to more reduction time



Role of IT band in femoral nailing

conflict

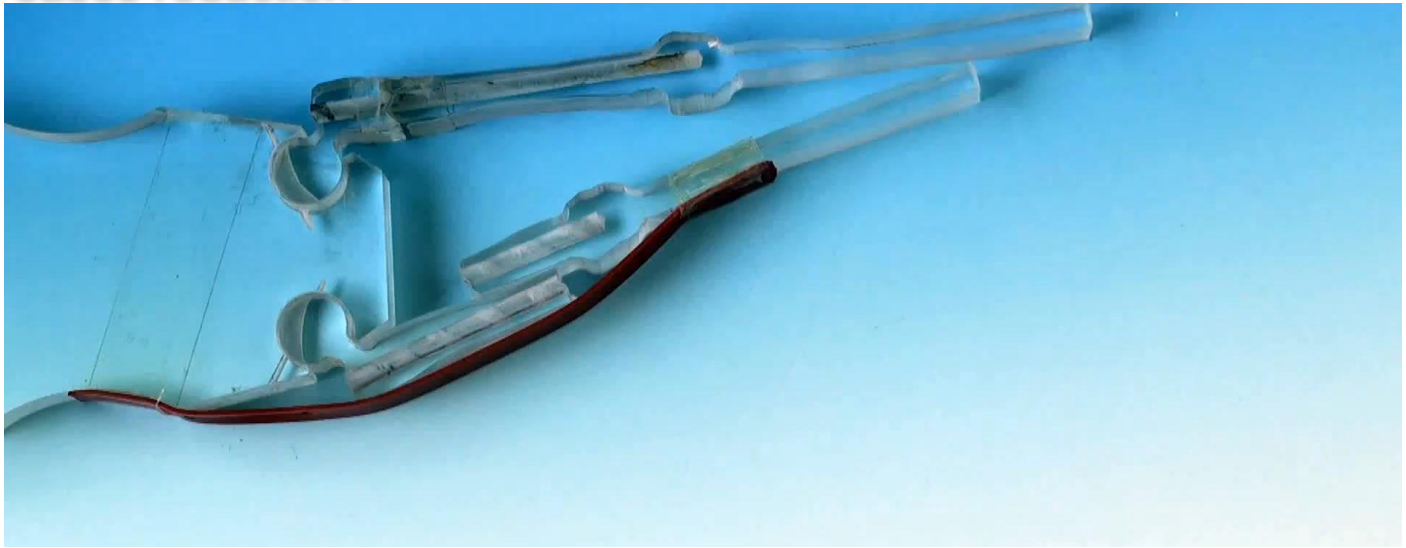
easy acces to starting point in ad-duction, but ilio-tibial tract tighters
ilio-tibial tract soft in ab-duction, but access difficult



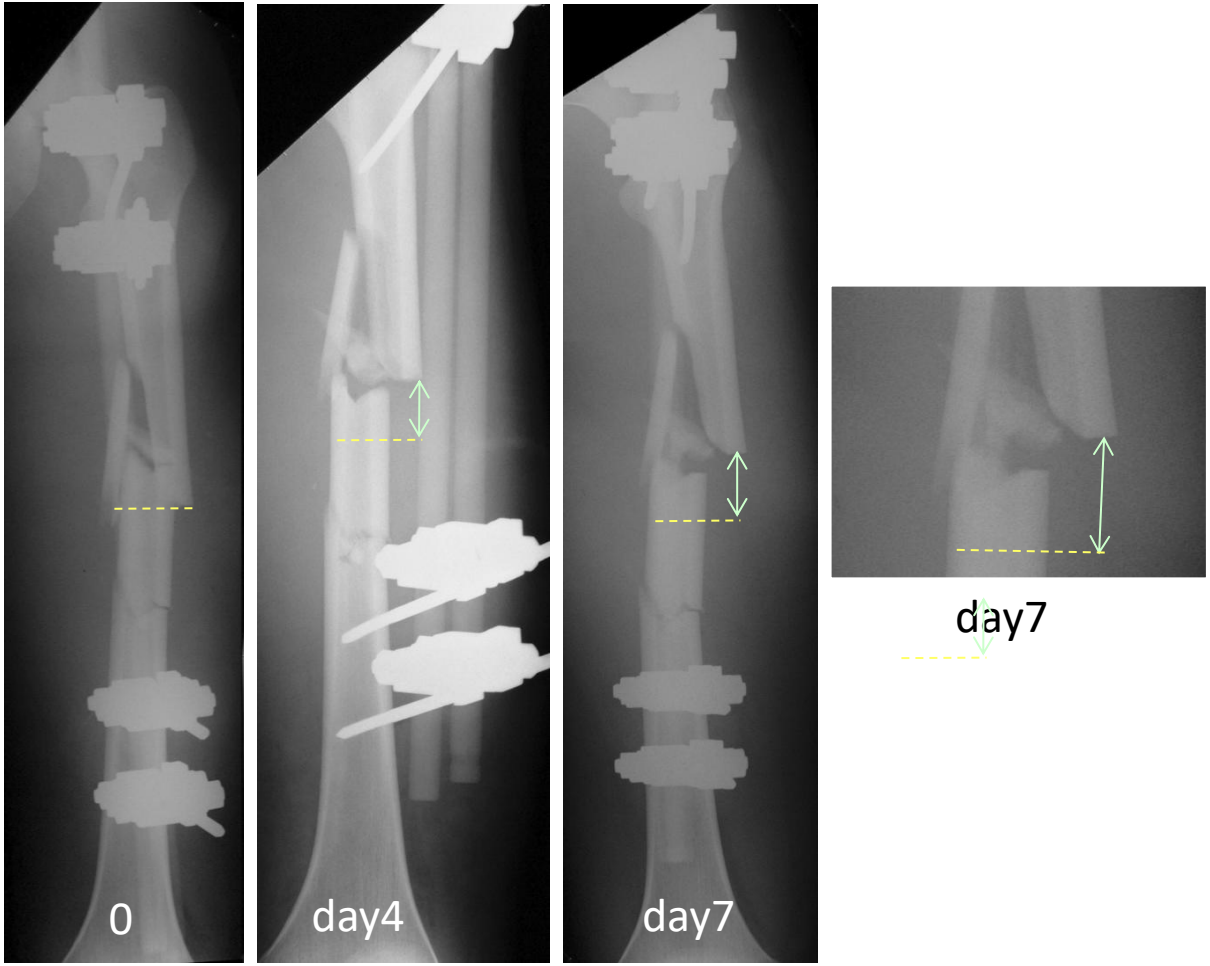
Technique #2 Role of IT band in femoral nailing

Solution split the steps

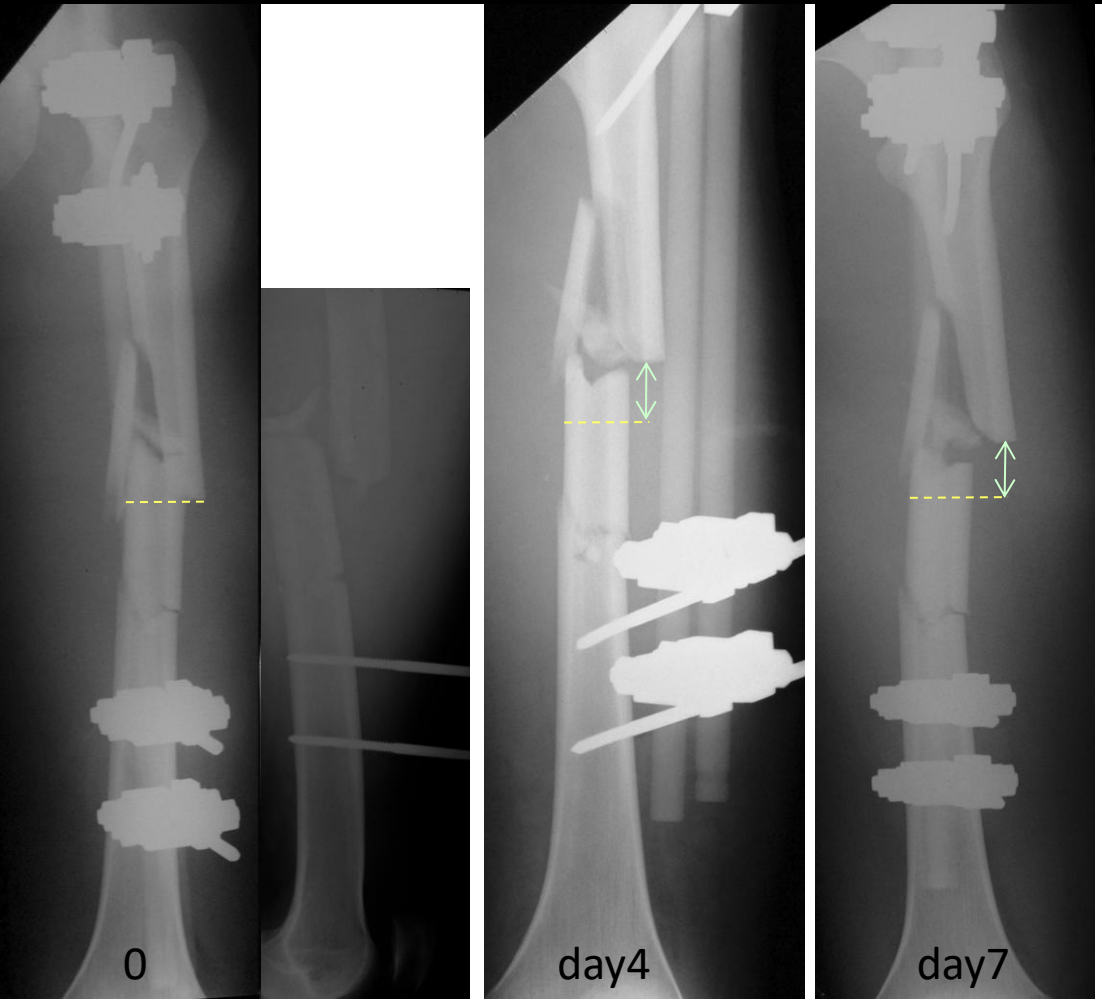
starting point, nail insertion in ad-duction
then proximal fragment neutral
distal fragment in ab-duction (relaxes iliotibial tract)
eases reduction



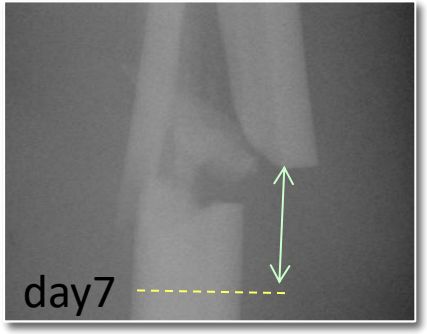
Management Challenge #5 post DCO shortening



Technique #5 Overdistraction of the Fracture Eases Reduction in Delayed Femoral Nailing



Staged distraction
without radiographic control
clinical parameters only



Technique #5 Overdistraction of the Fracture Eases Reduction in Delayed Femoral Nailing

Overdistraction of the Fracture Eases Reduction in Delayed Femoral Nailing

Results of Intraoperative Force Measurements

Gosling T, Hufner T, Westphal R, Faulstich J, Hankemeier S, Wahl F, Krettek, C

Question: does ExFix + overdistraction reduce reduction forces & shorten reduction time in IM nailing ?

Methods: experimental study, 7 pts / 8 femur fxs.
Measured amount of shortening/distraction, distraction forces (load cell), time for reduction

Results:

Group A	Group B	
ExFix neutral or shortening	over- distraction	
maximal force was 336 N (±51.9 N)	200 N (±43.1 N)	p = 0.017
reduction time 28.3 min (±21.8 min)	5.8 min (±4.0 min)	p = 0.056

Conclusion: Fracture shortening leads to higher restraining forces & prolonged reduction time Overdistraction should be performed as soon as possible under careful soft-tissue monitoring

The Journal of TRAUMA Injury, Infection and Critical Care
2006

Femur Fractures

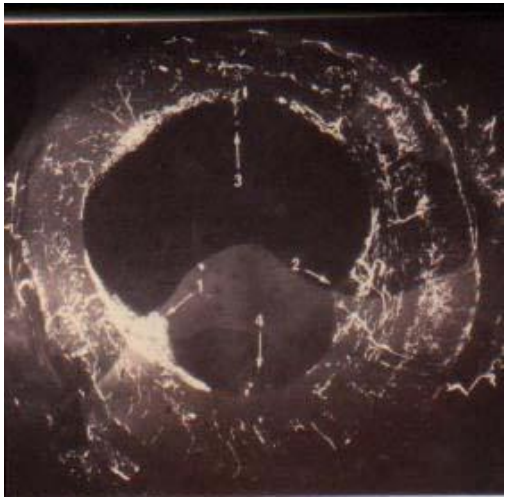
- Common injury due to major violent trauma
- 1 femur fracture/ 10,000 people
- More common in people < 25 yo or >65 yo
- Femur fracture leads to reduced activity for 107 days, the average length of hospital stay is 25 days
- Motor vehicle, motorcycle, auto-pedestrian, aircraft, and gunshot wound accidents are most frequent causes

Anatomy

- Long tubular bone, anterior bow, flair at femoral condyles
- Blood supply
  - Metaphyseal vessels
  - Single nutrient artery in diaphysis enters through the linea aspera
  - Nutrient artery communicates with medullary arteries in intramedullary canal
  - Medullary arteries supply 2/3 of endosteal blood supply

Blood Supply

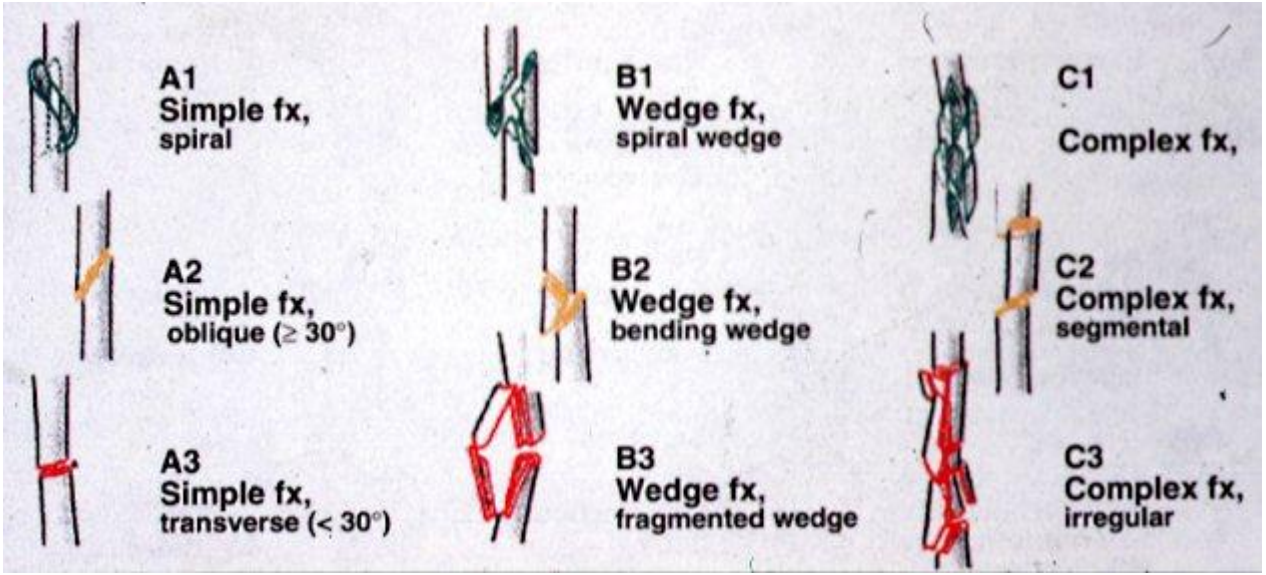
- Reaming destroys intramedullary endosteal blood supply
- Periosteal blood flow increases
- Medullary blood supply is re-established over 8-12 weeks if spaces left in canal by implant



- Unreamed intramedullary nailing decreases blood flow less; restoration of endosteal blood flow earlier but equal to reamed canal at 12 weeks

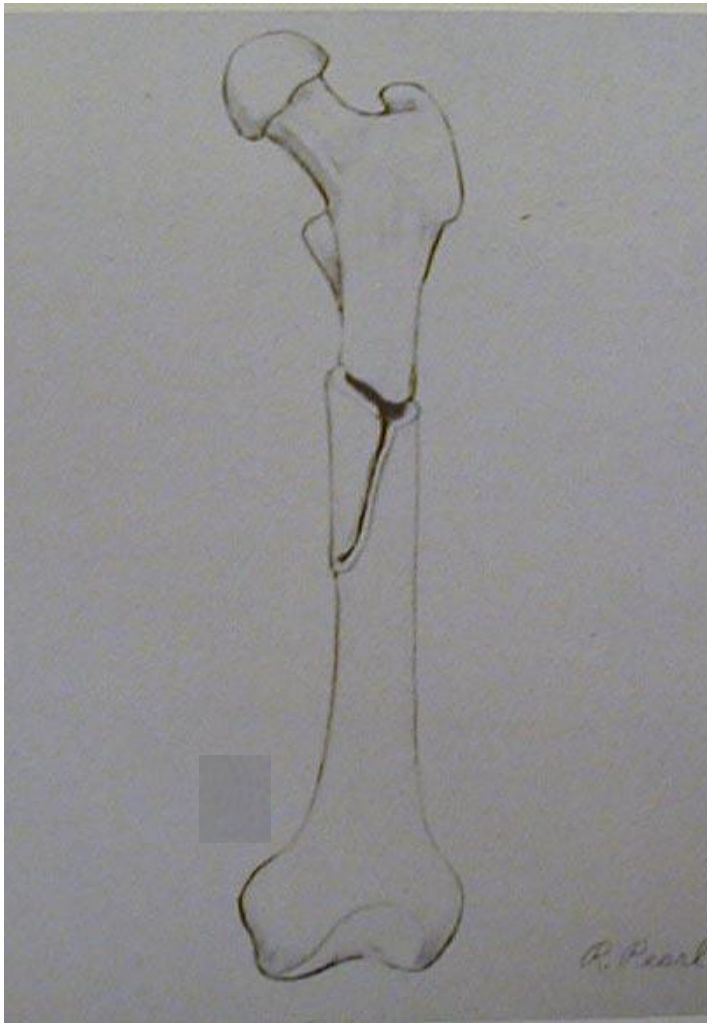
Femur Fracture Classification

AO/OTA Femur Diaphysis - Bone segment 32



Femur Fracture Classification

- Type 0 - No comminution
- Type 1 - Insignificant butterfly fragment with transverse or short oblique fracture
- Type 2 - Large butterfly of less than 50% of the bony width, > 50% of cortex intact
- Type 3 - Larger butterfly leaving less than 50% of the cortex in contact
- Type 4 - Segmental comminution
    - Winquist and Hansen 66A, 1984



Femur Fracture Management

- Piriformis fossa intact, lesser trochanter intact
- Can you nail this ?
- Should you nail this ?

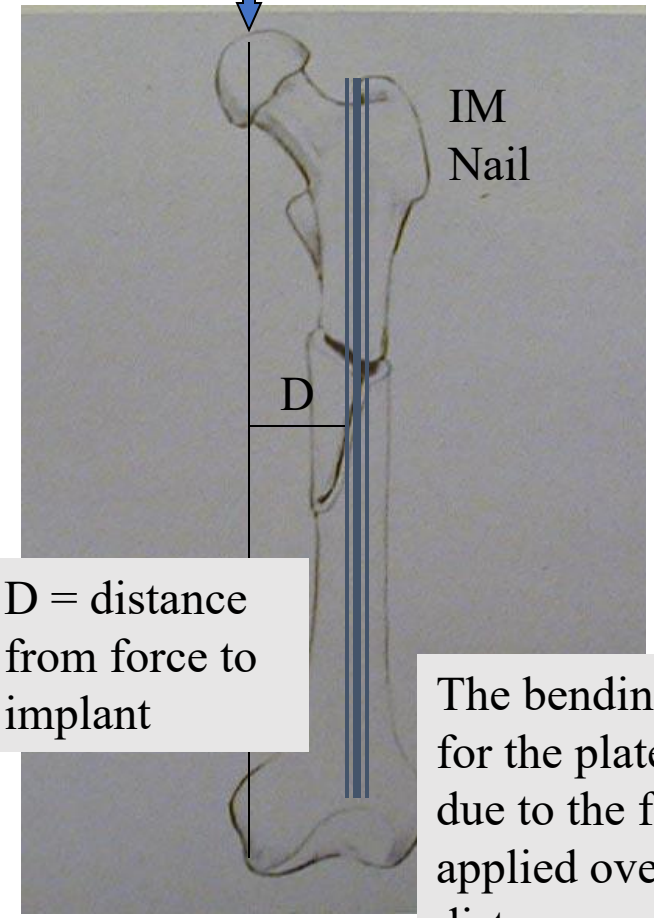
Femur Fracture Management

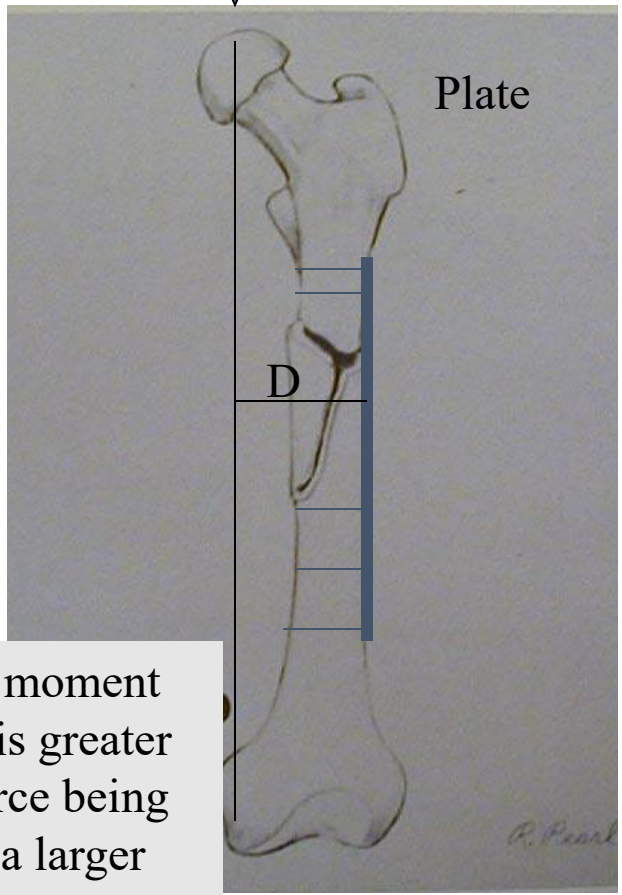
- Initial traction with portable traction splint or transosseous pin and balanced suspension
- Evaluation of knee to determine pin placement
- Timing of surgery is dependent on:
  - Resuscitation of patient
  - Other injuries - abdomen, chest, brain
  - Isolated femur fracture

F = Force

Bending moment = F x D

F = Force





D = distance from force to implant

The bending moment for the plate is greater due to the force being applied over a larger distance

Femur Fracture Management

- Diaphyseal fractures are managed by intramedullary nailing through an antegrade or retrograde insertion site
- Proximal or distal 1/3 fractures MAY be managed best with a plate or an intramedullary nail depending on the location and morphology of the fracture

Hare traction splint for initial reduction of femur fractures prior to OR or skeletal traction

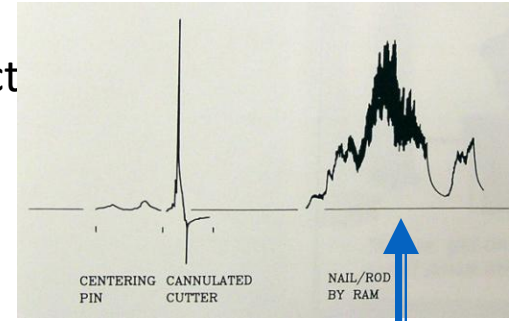
Femoral IM Nailing
To Ream ?

Hypothesis:

Femoral reaming increases fatty emboli to the lungs and potentially increases pulmonary complications

Femur Fracture
Reaming

- Reaming advantages:
  - Nail will not get incarcerated
  - Higher union rates
  - More durable fracture/nail construct
  - Earlier weight bearing



- Unreamed nails - still generate fat embolism with opening of piriformis fossa and probably higher pressure with unreamed nail insertion

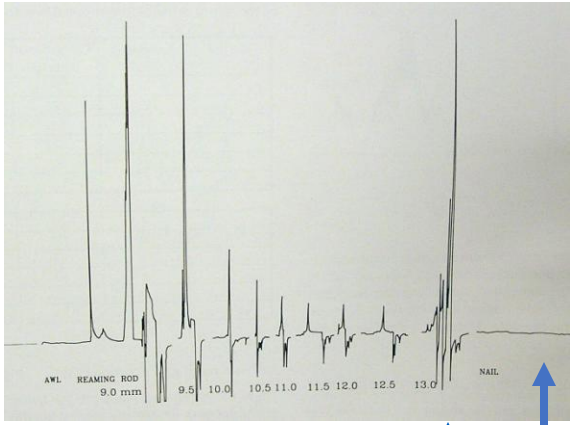
Femur Fracture
Reaming

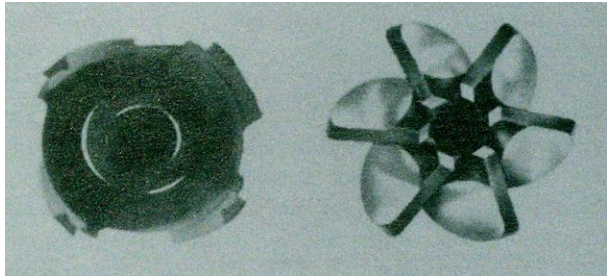
- Reaming of the femoral shaft fracture
  - Multiple studies demonstrate that the thoracic injury is the major determinant of pulmonary complications, NOT the use of a reamed IM nail
    - Charash J Trauma 1994
    - Van Os J Trauma 1994
    - Ziran J Trauma 1997
    - Bone Clin Orthop 1998
    - Bosse JBJS 79A 1997

Femur Fracture Reaming

- Reaming of the femoral shaft fracture
  - Only Pape (J Trauma 1993) has shown a deleterious pulmonary effect to immediate reamed intramedullary nailing in acute femur fracture patients with pulmonary trauma
  - In both a retrospective analysis and multiple animal studies (Pape , J Trauma 1992)
  - However, other animal studies refute these results
    - Wolinsky, J Orthop Tr 1998
    - Duwelius, JBJS 79A 1997

Femur Fracture Reaming Pressures





No difference in pressures generated by head design

- Muller, Injury 1993

awl

9.5mm first reamer

9mm reaming guide pin

NO increase pressure with nail insertion

13mm reamer with larger shaft

Injury + Patient

POLYTRAUMA

- Early stabilization beneficial
  - **Seibel Ann Surg 1985**
  - **Bone, JBJS 1989**
  - **Goris , J Trauma 1982**
  - **Johnson, J Trauma 1985**
  - **Behrman, J Trauma 1990**
  - **Bone, J Trauma 1994**

Johnson KJ, et al :Incidence of ARDS in patients with multiple musculoskeletal injuries: effect of early operative stabilization of fractures. J Trauma 1985

1. **Incidence of ARDS increased with increased ISS and delay in fracture stabilization**
2. **The more severe the injury, the more significant fracture stabilization was in preventing ARDS**
3. **Pts with ISS > 40 had an increased mortality assoc with a delay in fracture stabilization**

Damage Control Orthopaedics

Select group of critically injured or “borderline” patients may not tolerate extensive procedures or blood loss

External Fixator for Femoral Shaft Fracture

Exchange Nailing in the femur is safe and yields high union and low infection rates

Nowotarski JBJS 2000

Injury + Patient

Practice management guidelines

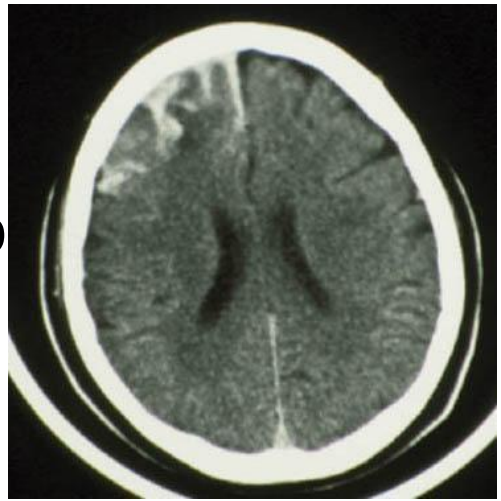
Recommendations-Polytrauma

- Level II-no improvement in survival
  - some patients fewer complications
  - no detrimental effect of early fixation
  - early fixation preferable

Dunham J Trauma 2001

Head Injury + Femur Fx

- Early fixation of long bone fractures does NOT promote secondary brain injury which may increase mortality, BUT hypoxia, hypotension, and increased ICP DO



Poole J Trauma 1992
Schmeling CORR 1995
McKee J Trauma 1997
Velmahos Am J Surg 1998
Scalea J Trauma 1999

Chest Injury + Femur Fx

CHEST INJURY

Thoracic trauma ITSELF is the major determinant of morbidity and mortality, NOT IM NAILING

Bone CORR 1995

Bosse JBJS 1997

Timing of femur fracture fixation: effect on outcome in patients with thoracic and head injuries
Brundage SI, J Trauma 2002

Data showed that early femur fracture fixation (< 24 hours) is associated with an improved outcome, even in patients with coexistent head and/or chest trauma. Fixation of femur fractures at 2 to 5 days was associated with a significant increase in pulmonary complications, particularly with concomitant head or chest trauma, and length of stay. **Chest and head trauma are not contraindications to early fixation with reamed intramedullary nailing.**

Femur Fractures Reduces Mortality

- 3069 patients, ISS≥ 15
- serious abdominal injury (AIS >3) had most benefit from resuscitation
- delay > 12 hours DECREASED mortality by 50% in multisystem trauma patients

  - Morshed, JBJS 2009

Comparison of Reamed vs Unreamed IM Nails
224 patients multiply injured patients
Risk of nonunion was 5x greater in unreamed group
80% of nonunions could have been prevented by reaming

NO increase in ARDS with reaming !!

Conclusion:

REAM

Powell and COA, JOT 2006

Femoral Nailing
Course # 101

1. Femoral Nail Design
2. Ream vs Unreamed
3. Nails available, treatment options

Technik der Marknagelung, 1945

RAIN AHEAD!

TIME

THE WEEKLY NEWSMAGAZINE

MARCH 12, 1945

MEDICINE

Amazing Thighbone

Bachelors of Mars

Spinster Scurvy

Penicillin by Mouth

ROD IN FEMUR (TWO VIEWS)

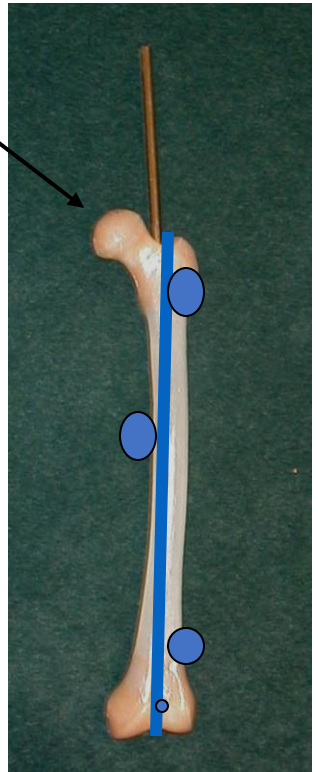
ITROSE

ORROSION

THE NITROSE CO., Inc.

Straight nail with 3 point fixation

First IM nailing but not locking



Klemm K, Schellman WD:
Veriegelung des marnagels, 1972

Locking IM nails in the 1980's

Kempf I, Grosse A: Closed Interlocking Intramedullary Nailing. Its Application to Comminuted fractures of the femur, 1985

IM Nail Variables

- Stainless steel vs Titanium
- Wall Thickness
- Cannulation
- Slotted vs Non-slotted
- Radius of Curvature
- ? To Ream

Stiffness

Modulus of Elasticity

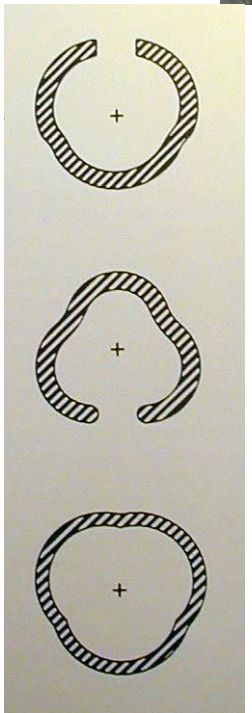
X 10^8 PSI

Metallurgy less important than other parameters for stiffness of IM Nail

Wall Thickness

Large determinant of stiffness

Slotted vs Non-slotted

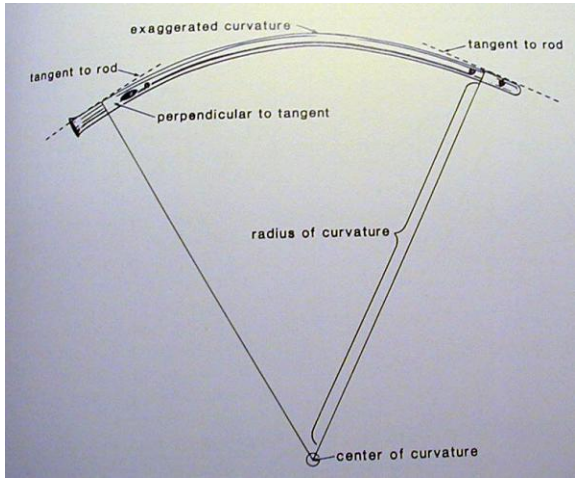


Anterior slot - improved flexibility

Posterior slot - increased bending strength

Non-slotted - increased torsional stiffness, increased strength in smaller sizes, ? comminution

Radius of Curvature of femur averages 120 cm

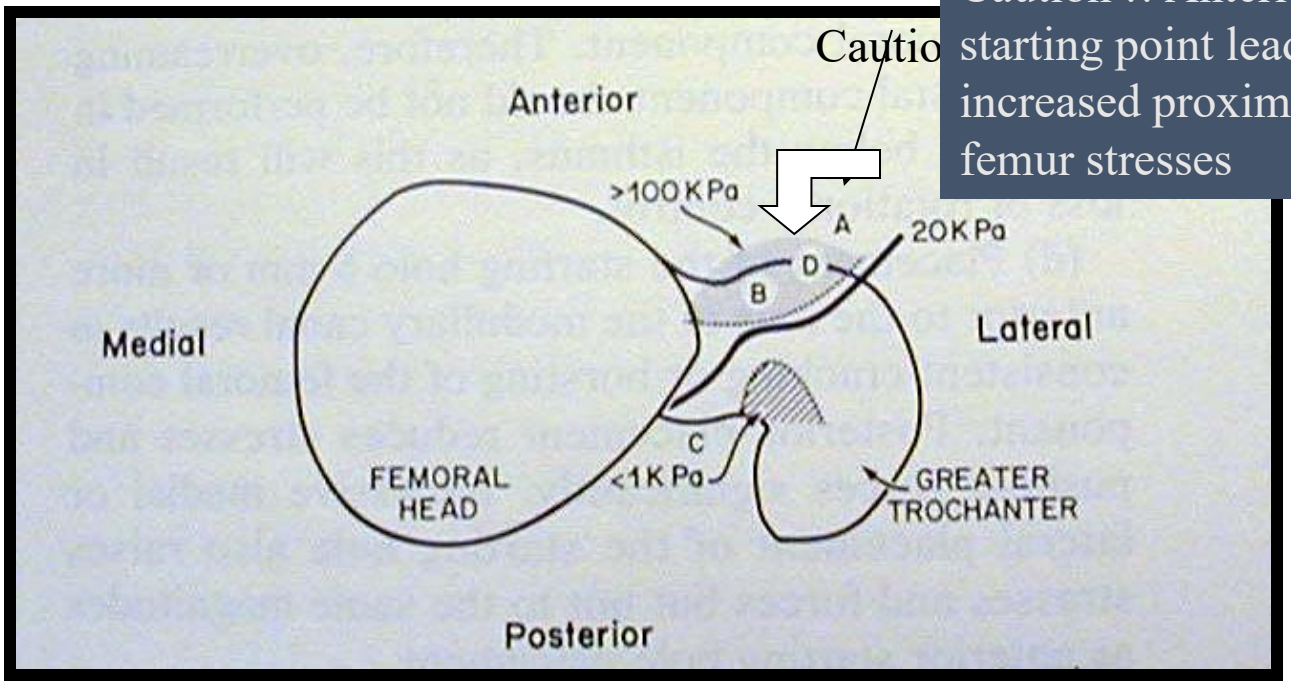


- Current femoral nails radius of curvature ranges from 150-300 cm
- IM nails are straighter (larger radius) than the femoral canal

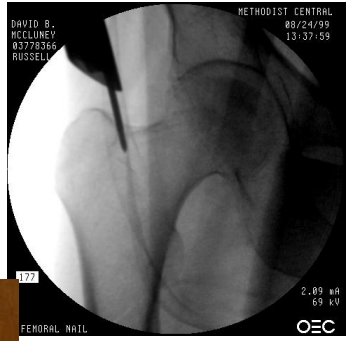
Femur Fracture Management

- Antegrade nailing is still the gold standard
  - Highest union rates with reamed nails
  - Extraarticular starting point
  - Refined technique
- Antegrade nailing problems:
  - Varus alignment of proximal fractures
  - Trendelenburg gait
  - Can be difficult with obese or multiply injured patients

Antegrade Femoral Nailing: piriformis fossa starting point



Minimally Invasive Nail Insertion Technique (MINIT)



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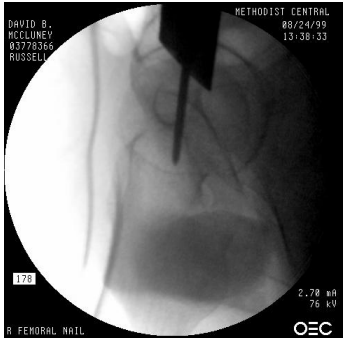

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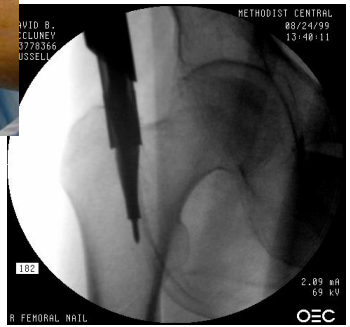

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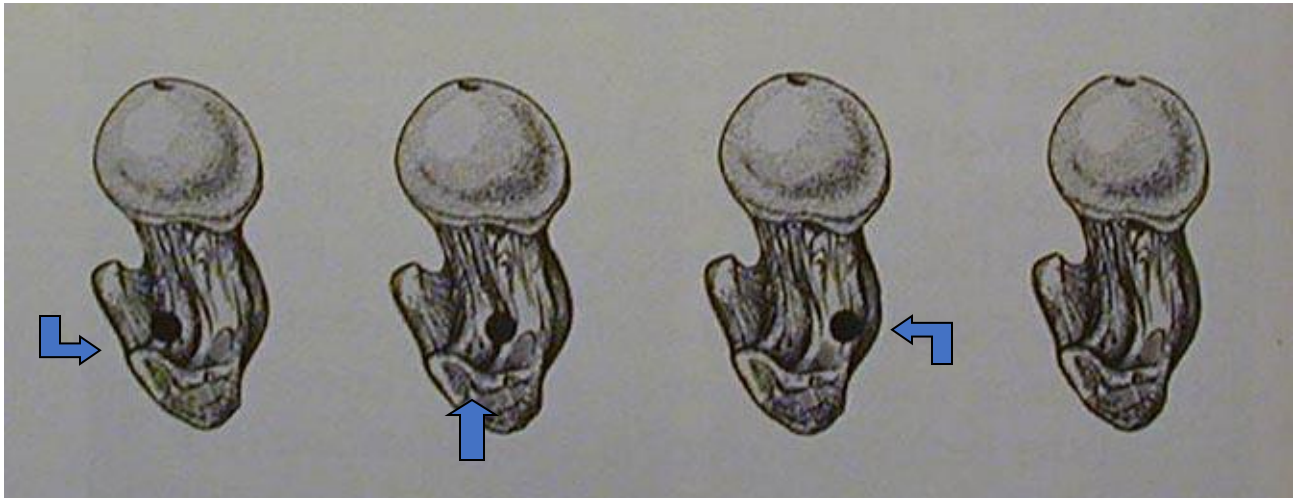
Courtesy T.A. Russell, M.D.

Antegrade Femoral Nailing

starting point

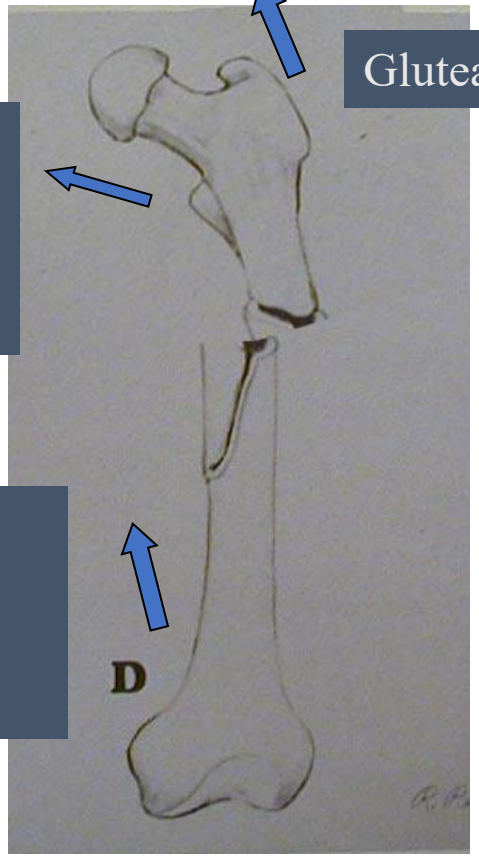


Posterior - loss of proximal fixation

Piriformis fossa- proper starting point

Anterior - generates huge forces, can lead to bursting of proximal femur

Femur Fractures



Gluteal muscles

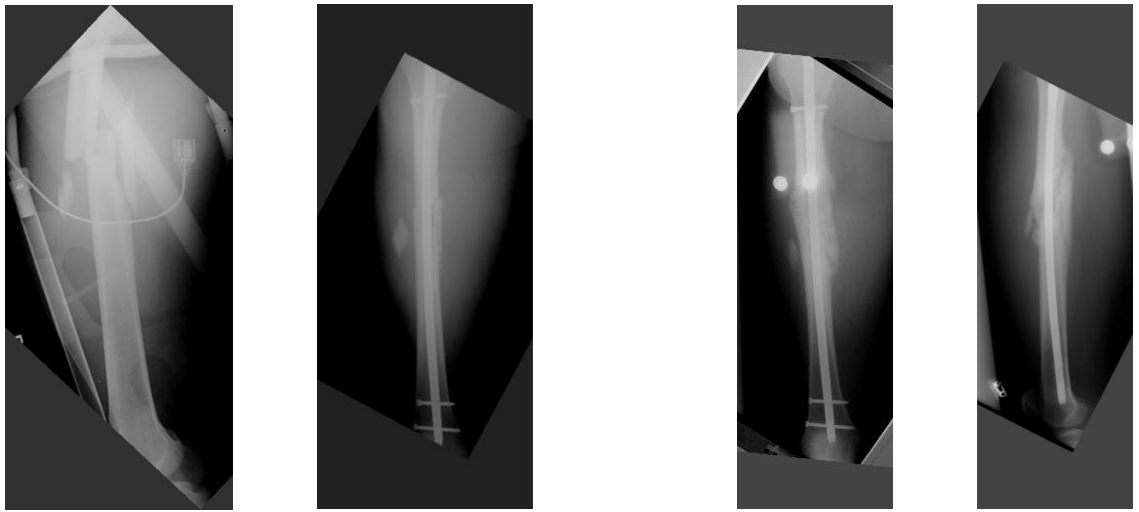
Iliopsoas leads to flexion of the proximal fragment

Adductor muscles shorten the femur

These muscle forces must be overcome to reduce and intramedullary nail the femur

Static Locking of All Femoral IM Nails !!!

- Brumback- 1988
  - 98% union with Statically Locked Rod



Immediate Weight Bearing

- Mythical 70 Kg Man
  - Axial Load to Failure 300%
    - 75% Stiffness in Bending
    - 50% Stiffness in torsion
  - Withstand 500,000 cycle at loads of 3X body
  - 28 Winquist type 4 fractures
    - 27 Healed primarily
    - No Locking Bolt or Rod Fatigue
      - Brumback JBJS 1999

Antegrade Nailing
Fracture Table or Not ?

Supine - better for multiply injured patients, tough starting point

Lateral - easier piriformis fossa starting point, difficult set up, ? rotation

Without a fracture table, length, distal lock first and slap nail

Femur Fracture Management

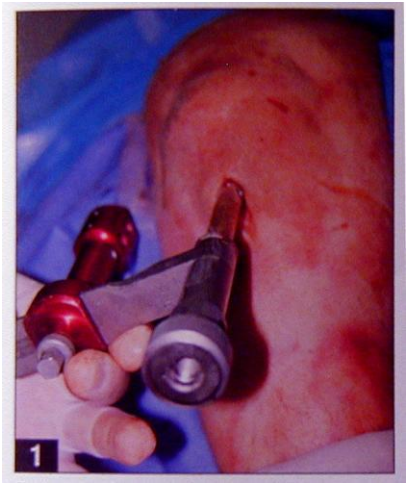
- Retrograde nailing has advantages
  - Easier in large patients to find starting point
  - Better for combined fracture patterns (ipsilateral femoral neck, tibia,acetabulum)
  - Union approaching antegrade nails when reamed
- Retrograde nailing has its problems:
  - Union rates are slightly lower, more dynamizing with small diameter nails
  - Intra-articular starting point

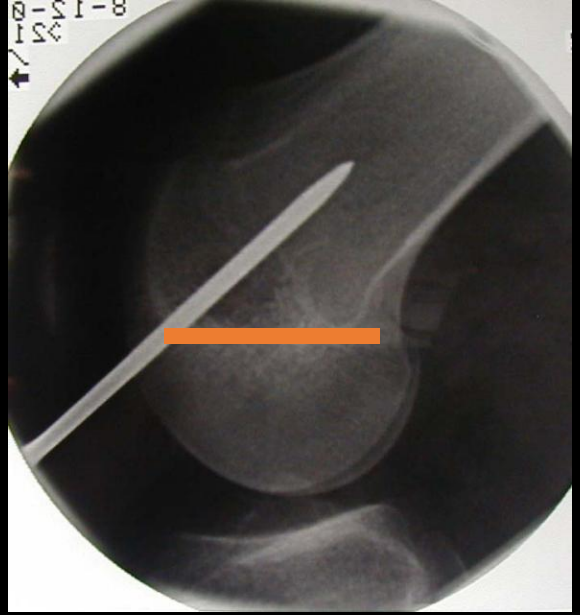
Femur Fracture Technique

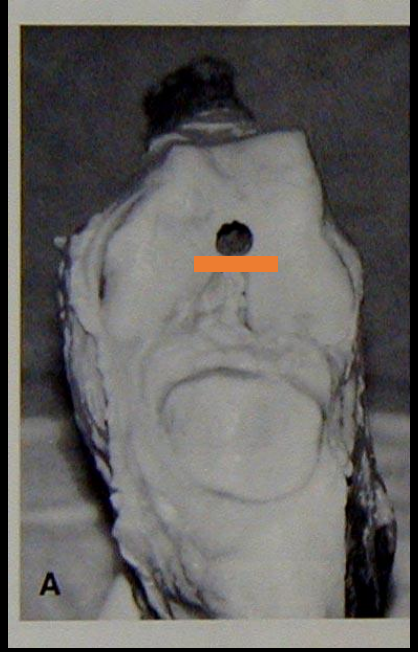
- Retrograde Intramedullary Nailing
  - Supine - flex the knee 50° to allow access to Blumensaat's line

Percutaneous with fluoro OR

Limited open technique







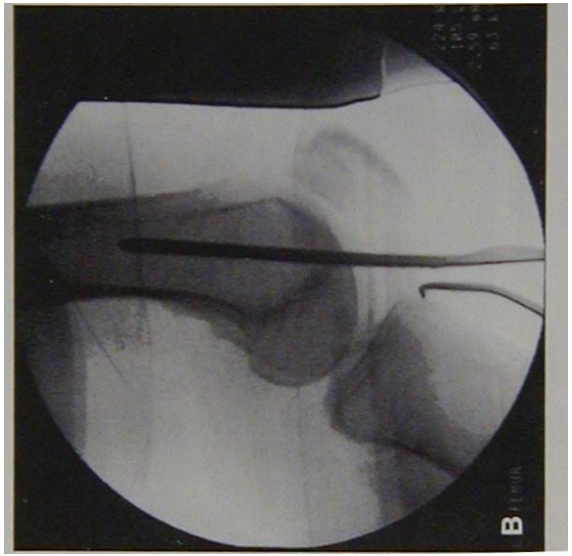
Center guide pin on AP and Lateral

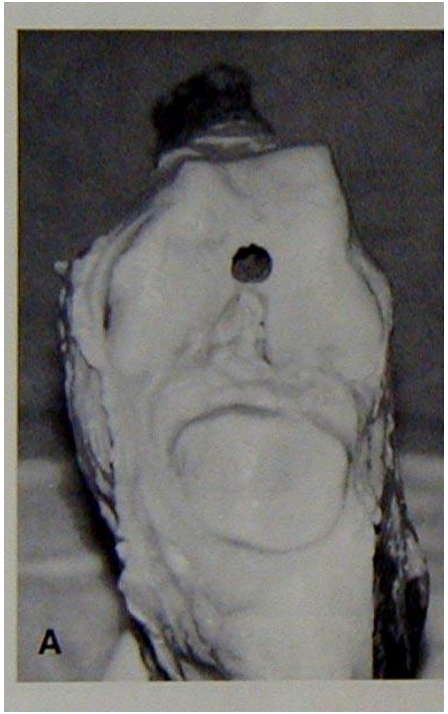
Especially important for distal 1/3 fractures

Above Blumensaat's Line

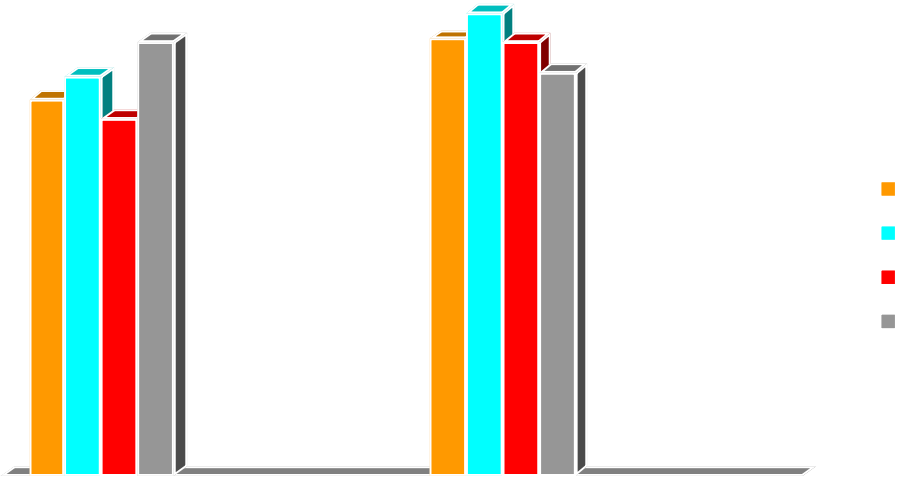
Retrograde Femoral Nailing

Starting Point

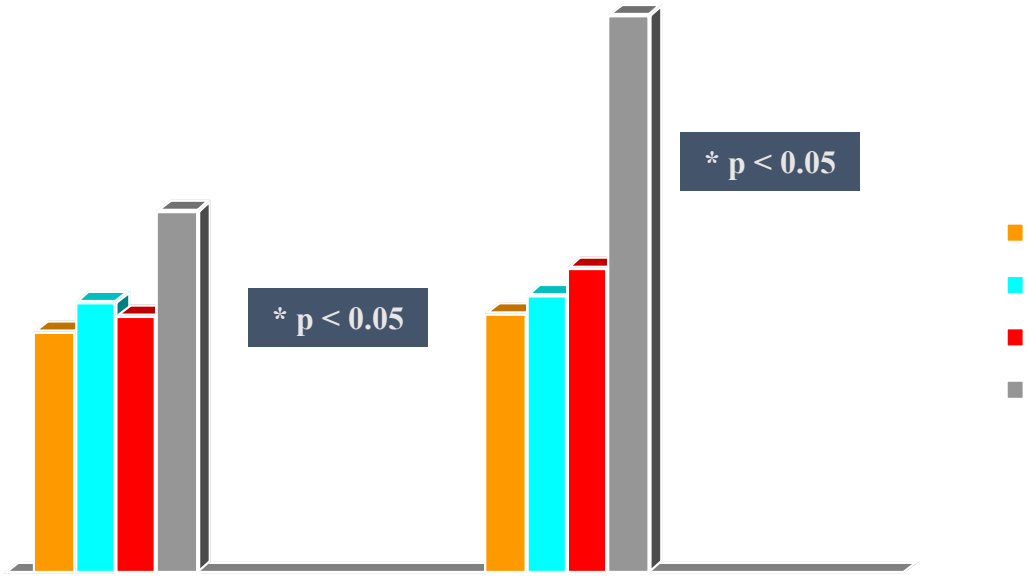




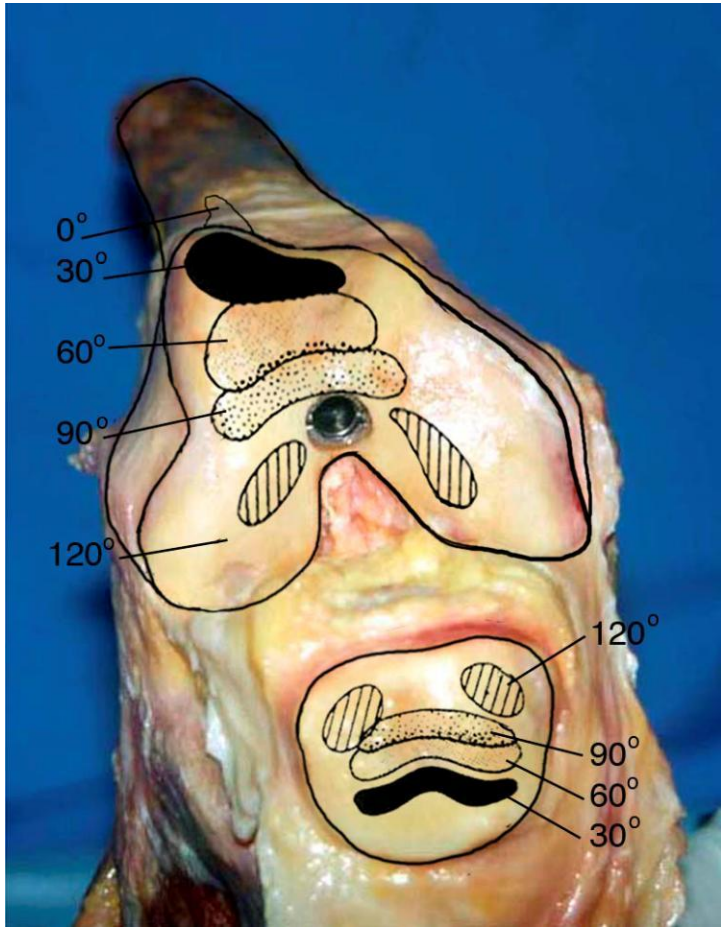
Mean Contact Area



Maximum Pressure



Only with the nail 1 mm prominent were the patellofemoral pressures increased


0°
30°
60°
90°
120°
120°
90°
60°
30°

Retrograde Femoral Nailing

- A cadaveric study using Fuji film demonstrated NO deleterious effects on the patello-femoral joint with a properly inserted retrograde IM nail
- The orthopaedic literature does NOT support decreased knee motion or increase knee pain with a retrograde nail

1

2

Bilateral femur fractures nailed retrograde

Less comminuted fracture nailed first to assess length for segmental fracture

- 42 yo male C2 femur, Gr 2 open ipsilateral tibia fx

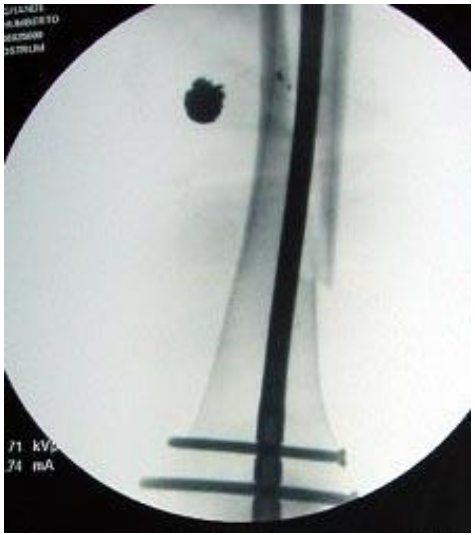
- Immediate post-op with treatment through a limited 4cm knee incision

Femur Fracture Management

- Retrograde Nailing
  - Union rates lower with unreamed nails
  - Higher dynamization with non canal sized nails
  - Better union rates equal to antegrade with reamed canal sized nails
    - Moed JBJS 1995, J Orthop Trauma 1998
    - Ostrum J Orthop Trauma 1998, 2000
  - Advantages for ipsilateral acetabulum or femoral neck and shaft fracture, floating knees, obese patients, supracondylar fractures including those around total knee replacements

Retrograde Nailing is Beneficial for Floating Knee Injuries

Shortening after Retrograde Nail Insertion



Backslap after distal locking

Retrograde Nail:
Long or Short ?

- 9 human matched cadaver femurs, gap model
- 36 cm vs 20 cm
- Coronal and sagittal testing
- 75 Newtons applied in 3 point bending
- Locked with 1 or 2 proximal screws

Retrograde Nail:
Long or Short ?

	20cm	36cm
2 prox,sagittal	7.2*	1.8*
2 prox,coronal	6.3	4.3
1 prox,sagittal	7.6*	2.2*
1 prox,coronal	13.6*	4.4*

Longer nails provide improved stability !!!

* statistically significant at $p<0.05$

Femur Fracture
Technique

- Antegrade Intramedullary Nailing
  - Supine - better for multiply injured patients
  - Lateral - easier piriformis fossa starting point, difficult set up, rotation concerns
  - Without a fracture table
- Retrograde Intramedullary Nailing
  - Supine - flex the knee 50° to allow access to Blumensaat’s line

Antegrade v Retrograde Comparisons

Equal union rates

Tornetta, JBJS (B), 2000
Ricci, JOT, 2001
Ostrum, JOT, 2000

- ANTEGRADE
  - More hip and proximal thigh pain
  - Greater incidence of Trendelenburg gait
- RETROGRADE
  - More symptomatic distal hardware
  - Higher dynamization rates with small diameter nails

Obesity
Antegrade v Retrograde

	Obese BMI >30	Non-Obese BMI <30	
Ante OR Time	94		
Retro OR Time	67		
Ante Fluoro	247	135	P<.03
Retro Fluoro	76	63	nss

Retrograde nailing is easier in obese patients !!

Tucker M. JOT 2007

Comparison of Knee function after Antegrade and Retrograde IM Nailing with Isokinetic Evaluation

No differences in :

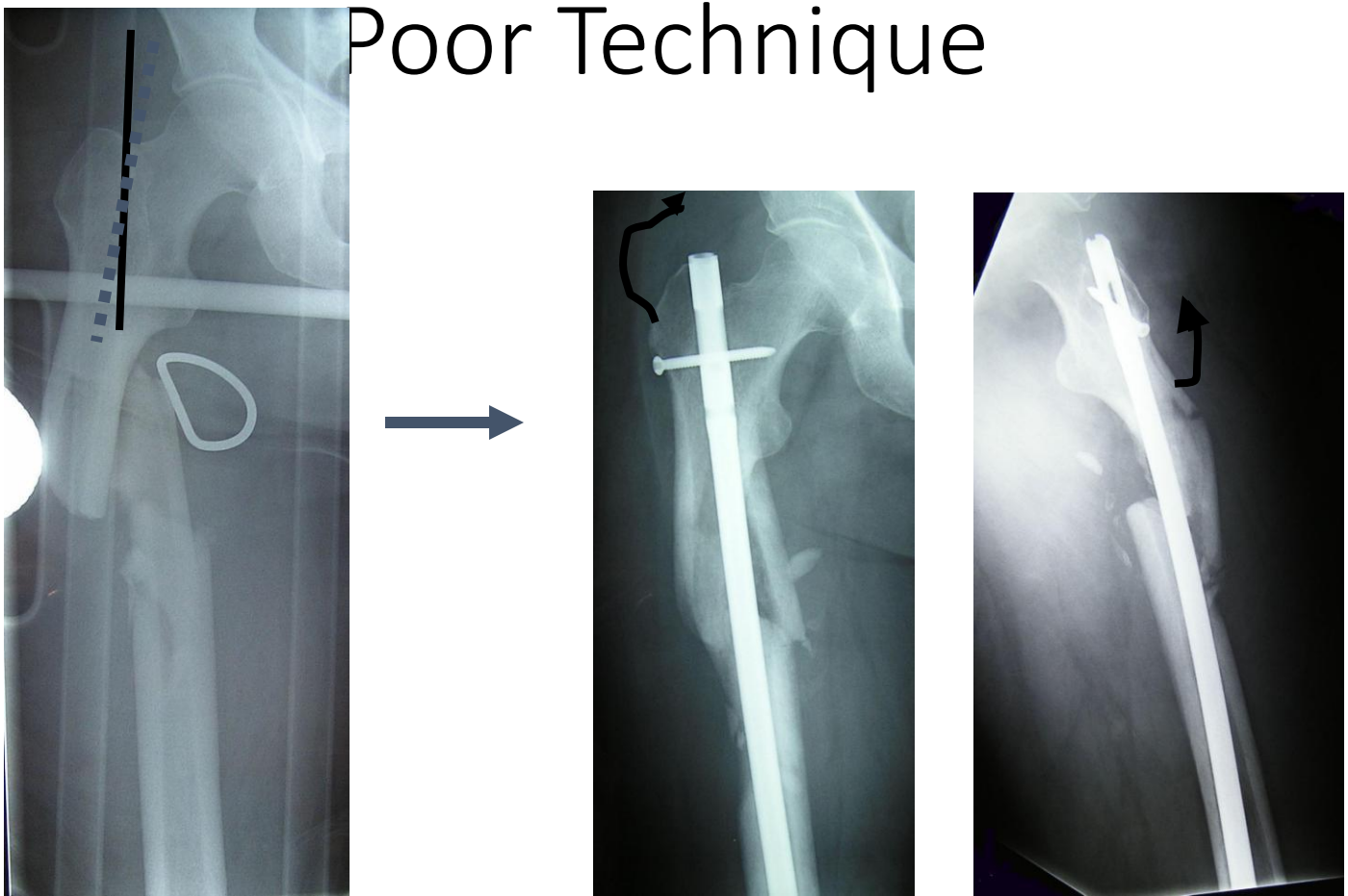
- knee range of motion
- Lysholm Scores
- isokinetic knee evaluation
- time to union
- secondary surgeries (including hardware removal)

- Daglar, JOT 2009

Antegrade Femoral Nailing: Piriformis vs Trochanteric

- Reduction and starting point are still the keys !!
- Problems arise with subtrochanteric fractures
- Inappropriate starting point leads to malreduction

Piriformis Nail: Poor Technique



Piriformis Nail: Poor T

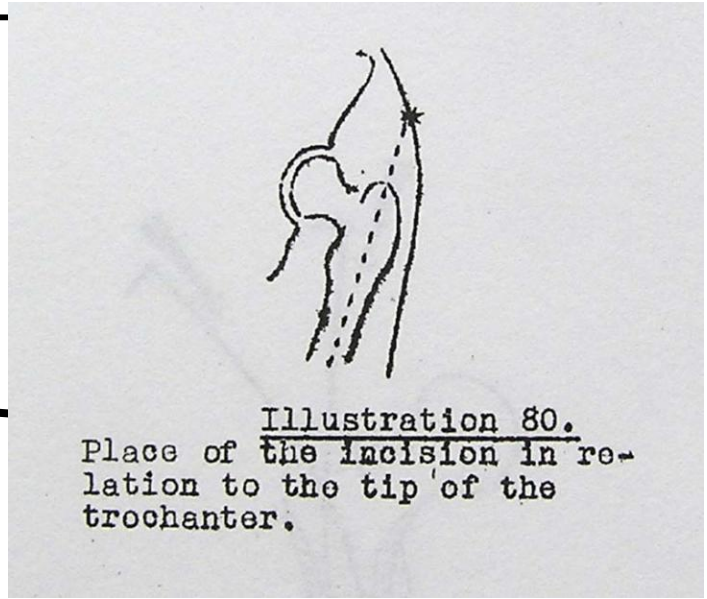
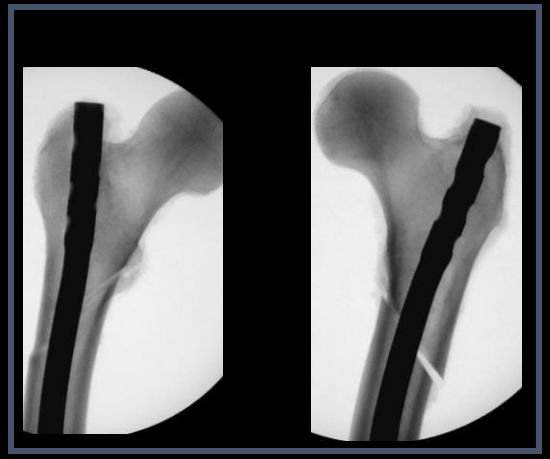


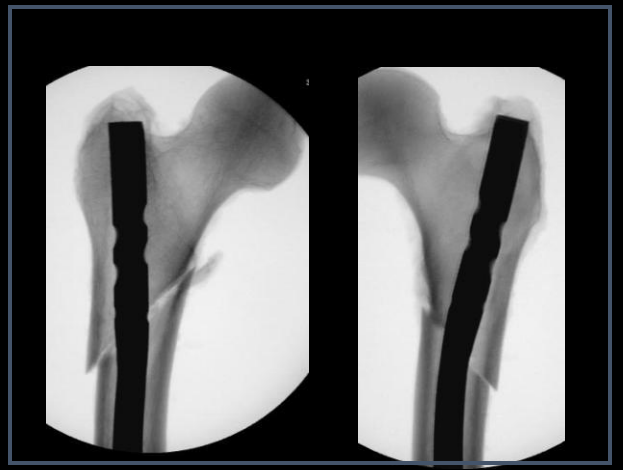
Illustration 80.
Place of the incision in relation to the tip of the trochanter.

Tip of Trochanter

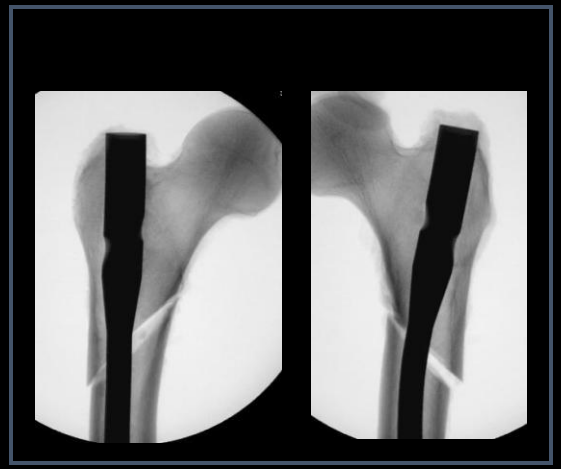
2-3 mm medial to tip

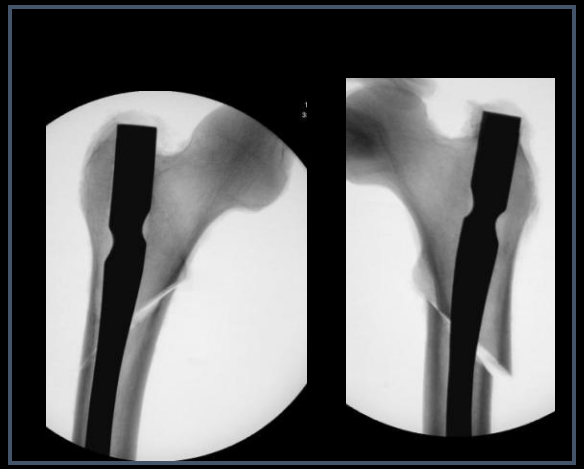
2-3 mm lateral to tip





Femur # 9



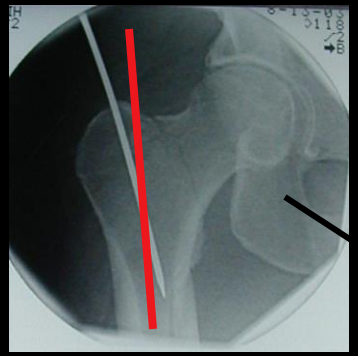


Recommendations

The tip of the trochanter or slightly medial is the entry site of choice for antegrade trochanteric nailing of subtrochanteric fractures

The lateral starting point, even 2-3 mms from the tip of the trochanter, is to be avoided

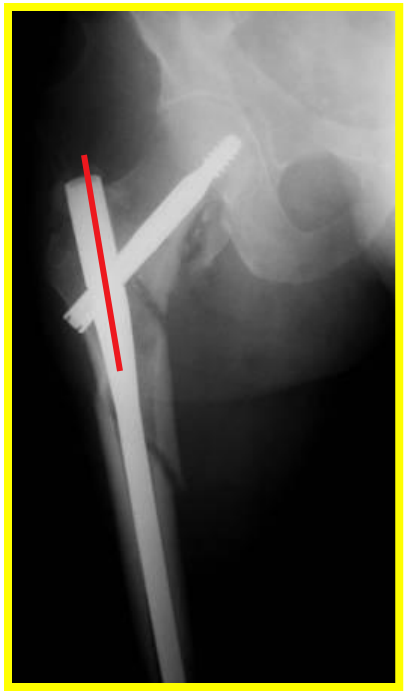
Ostrum R, JOT 2005

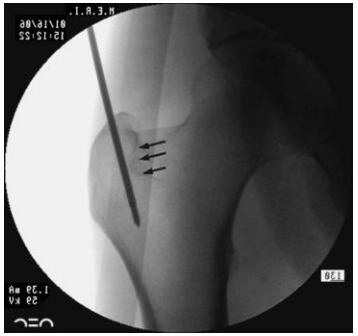


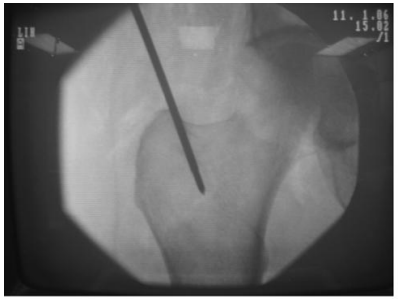
Lateral to tip of GT is OK for shaft fractures

Medial to the tip of the GT for subtrochanteric fractures

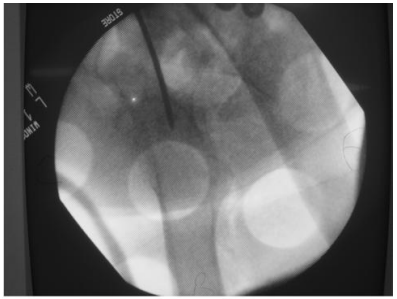
Reduction with medial tip starting point





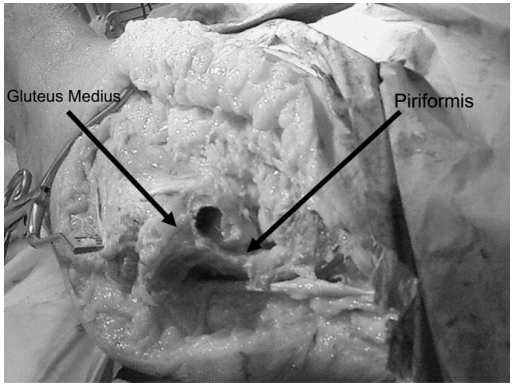


AP

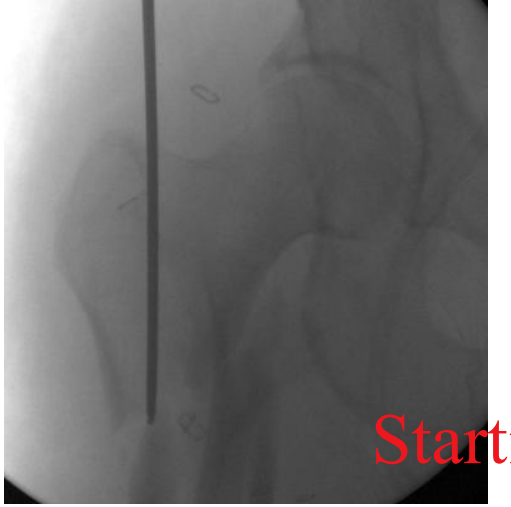


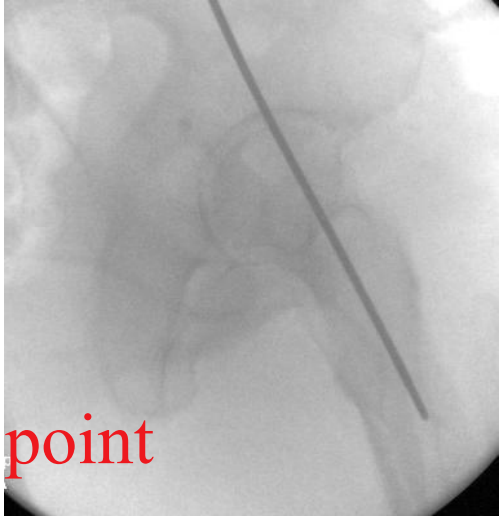
Lateral

Medial Trochanteric Portal

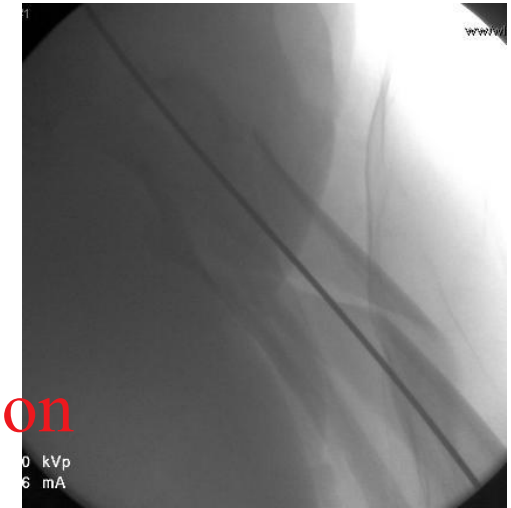


Perez E, Russell TA. JOT 2007



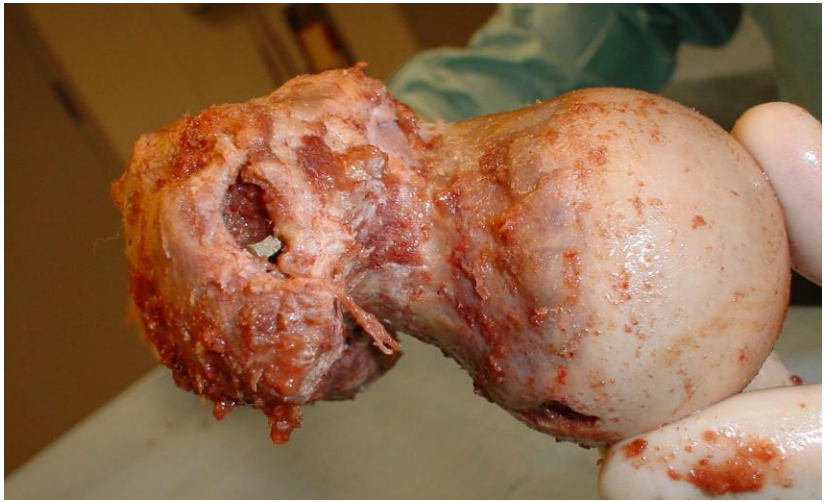


Starting point



Reduction

- Assessing rotation in the lateral position
- Without changing rotation of the C-arm
- A true AP of the hip and knee



- 17 mm entry hole in trochanter
- 15-50% disruption of gluteus medius tendon
- ? Functional sequelae

    - McConnell T, Clin Orthop 2003

A prospective, randomized comparison of trochanteric vs piriformis fossa entry portal for high energy proximal femur fractures

- NO difference in : Hip Scores, RTW, Ambulation, Hip/Knee ROM

- Varus $\geq$ 5 degrees
  - Recon = 2
  - Gamma = 4

- BMI significantly linked to duration of OR and length of incision, NOT EBL

Starr AJ, J Orthop Trauma 2006

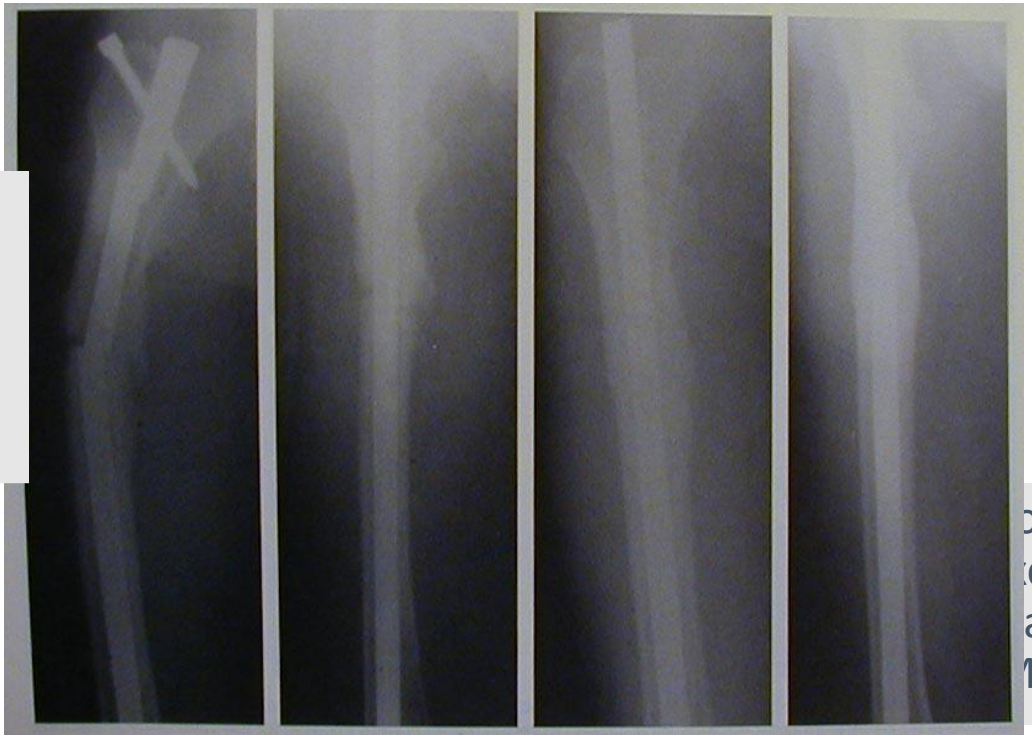
Femur Fracture
Complications

- Hardware failure
- Nonunion - less than 1-2%
- Malunion - shortening, malrotation, angulation
- Infection
- Neurologic, vascular injury
- Heterotopic ossification

Femur Fracture

Nonunion

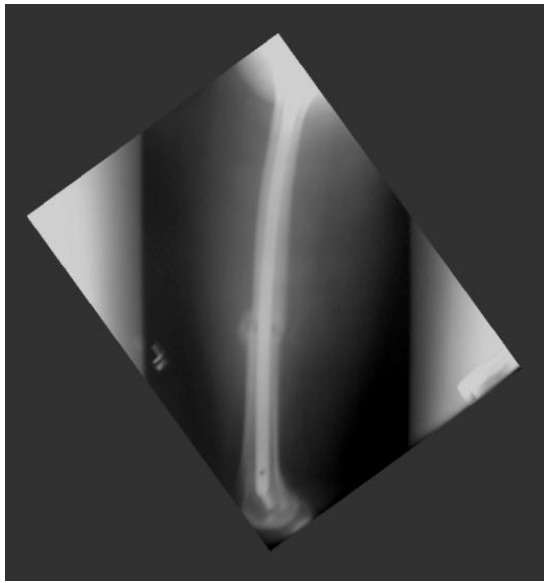
Femoral nonunion with broken IM Nail

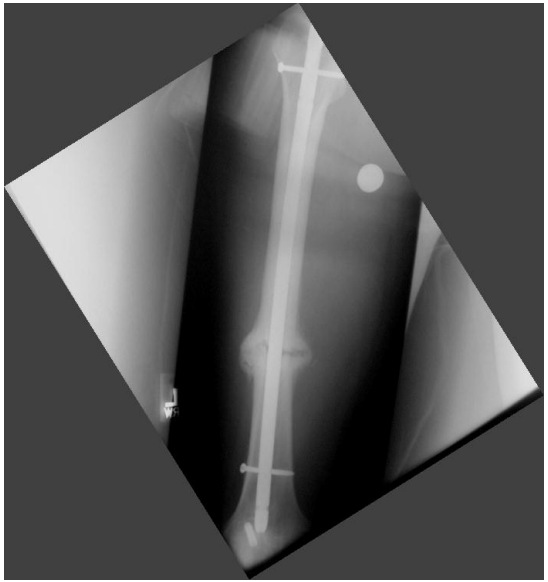


on after
change,
amed
M nail

Hypertrophic Nonunion

- Problem with smaller diameter nails
- Don’t Dynamize → ~~EXC~~HANGE !!
- Has a blood supply, WANTS MORE STABILITY





Plating of femoral nonunions after IM Nail

- 23 pts, nonunion of femur after IM nail
- nail removal, PLATING, soft tissue preservation
- 21/23 healed, avg 12 weeks
- avg OR time 164 minutes (120-240)
- avg EBL = 340 ml (200-700)

•Bellabarba, JOT 2001

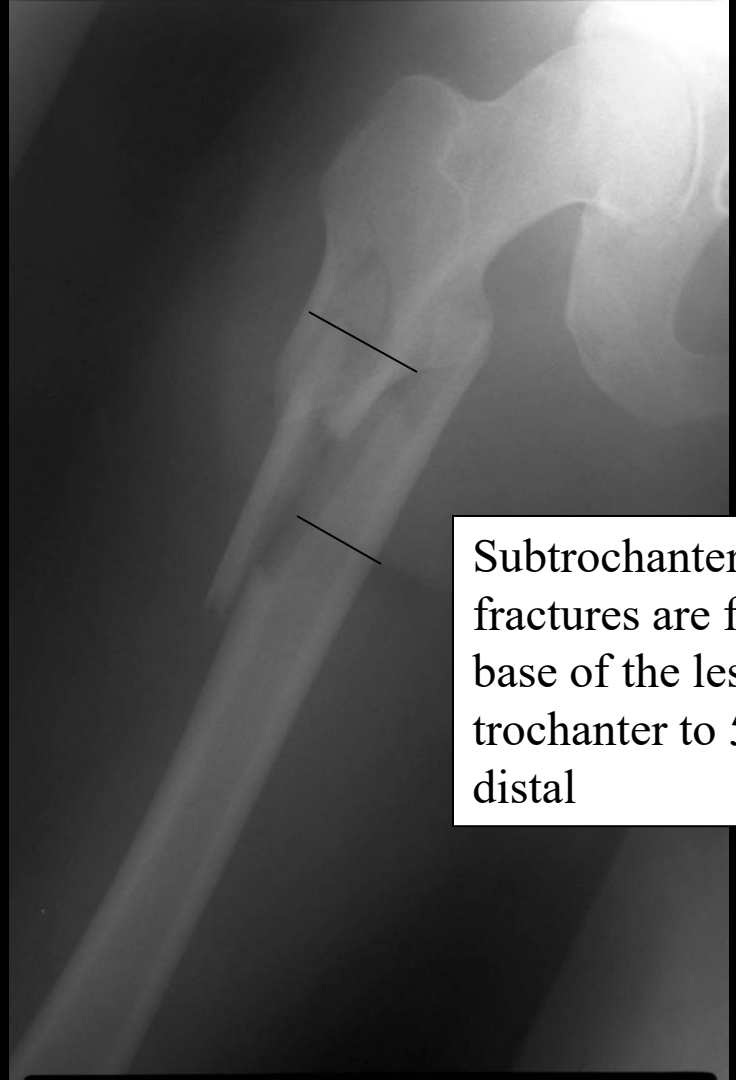
Exchange Nailing of femoral Nounions

- 42 pts, closed exchange nailing
- 7 posititve cultures
- 36 (86%) healed, avg 4 mos after OR
- Lack of immediate weight bearing, open fractures assoc with nonunion after 1st OR
- Atrophic/oligotrophic nonunions, and infection were associated with treatment failure after exchange nail
- A second nail larger by 2 mm or more than the original nail was associated with a higher success rate
    - Shroeder, JOT 2009

Femur Fracture

Subtrochanteric Fracture Management

- Possible to perform intramedullary nail if the piriformis fossa is intact
- Choice of nail type depends on if the lesser trochanter is intact
- Varus seen with proximal femur intramedullary nailing
- Plating is also an option with/without an intact starting point

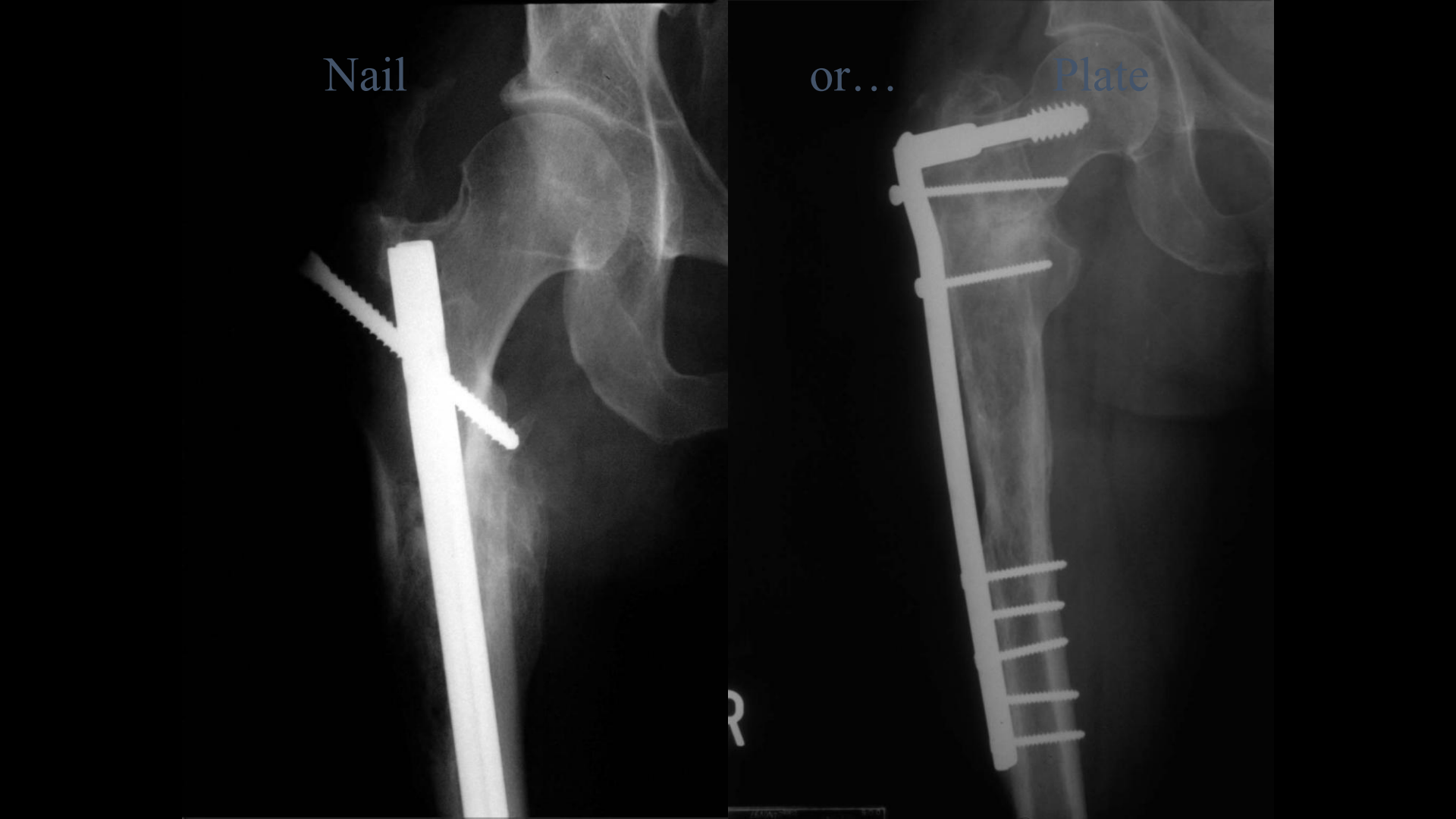


Subtrochanteric fractures are from the base of the lesser trochanter to 5 cm distal

Low Subtroch Fx's

Most low subtrochanteric fractures with an intact piriformis fossa can be treated with a 1st gen IM Nail

When piriformis fossa is not involved and the lesser trochanter is fractured, a 2nd generation nail may be used

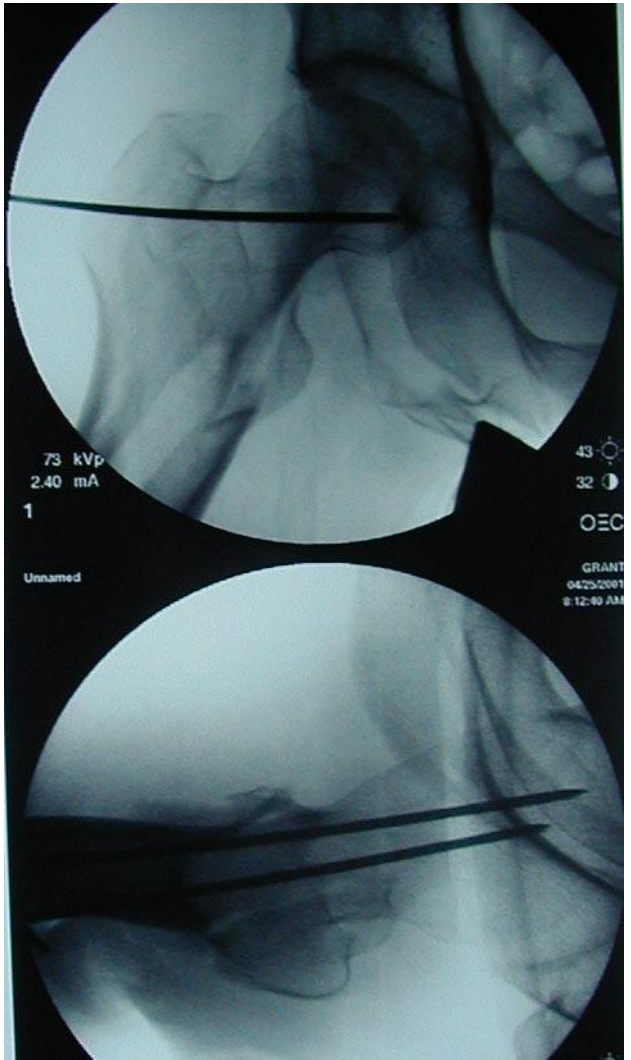

Nail
or…
Plate

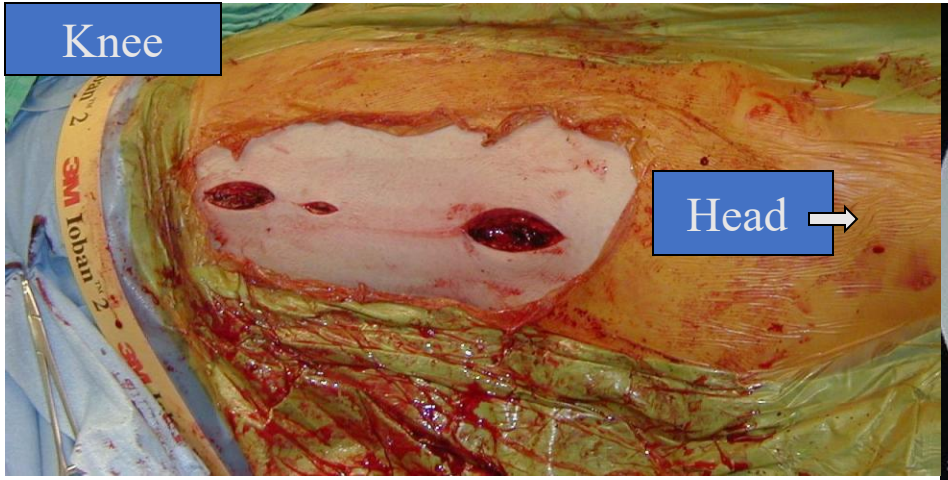
Indirect Reduction: Technique

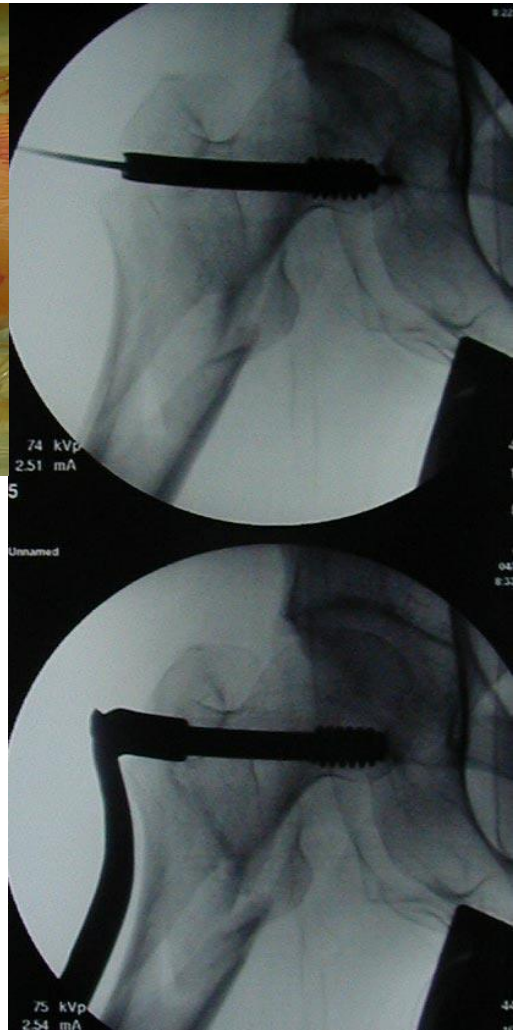
Indirect Reduction

Step 1- Approximate closed reduction with fracture table in BOTH planes

Step 2 - Percutaneous insertion of guide pins







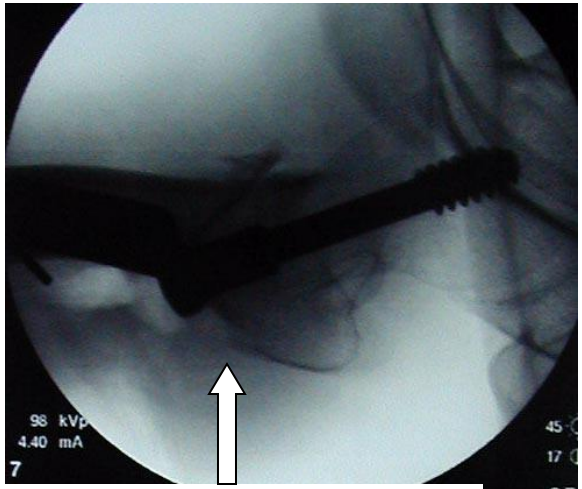
Step 3 - Placement of

lag screw and percutaneous plate placement

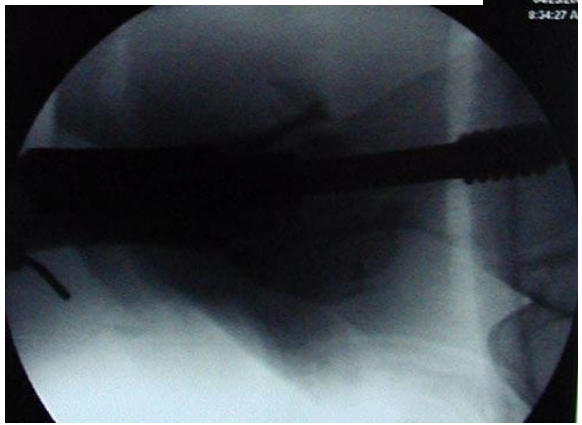
Indirect Reduction

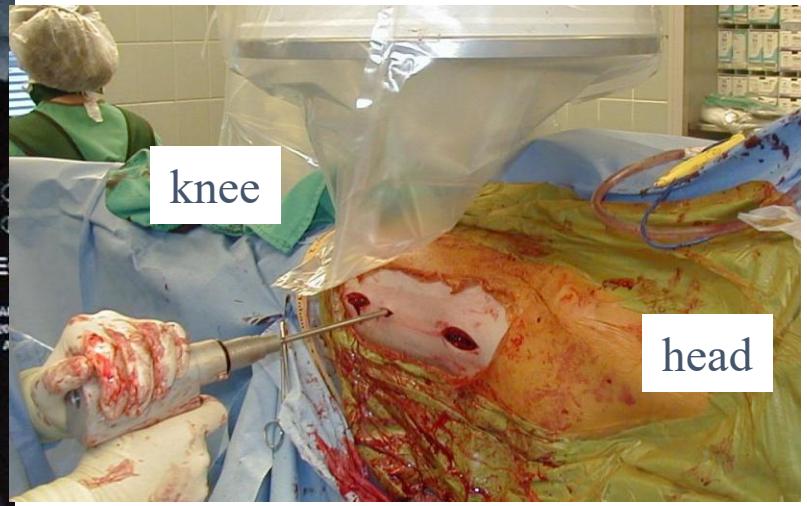
Step 4 - Final reduction with

percutaneous screw placement



Push up to prevent sag





Screw Placement

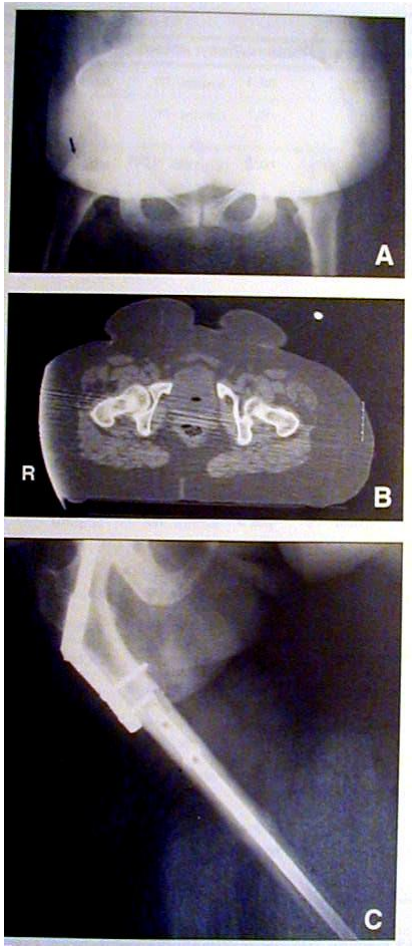
Indirect Reduction

Ipsilateral Femoral Neck & Shaft Fractures

- Optimum fixation of the femoral neck should be the goal
- Varus malunion of the femoral neck is not uncommon, osteotomies can lead to poor results
- Vertical femoral neck fracture seen in 26-59% of cases (Pauwel's angle > 70°)
- Rate of avascular necrosis is low, 3%, even when missed

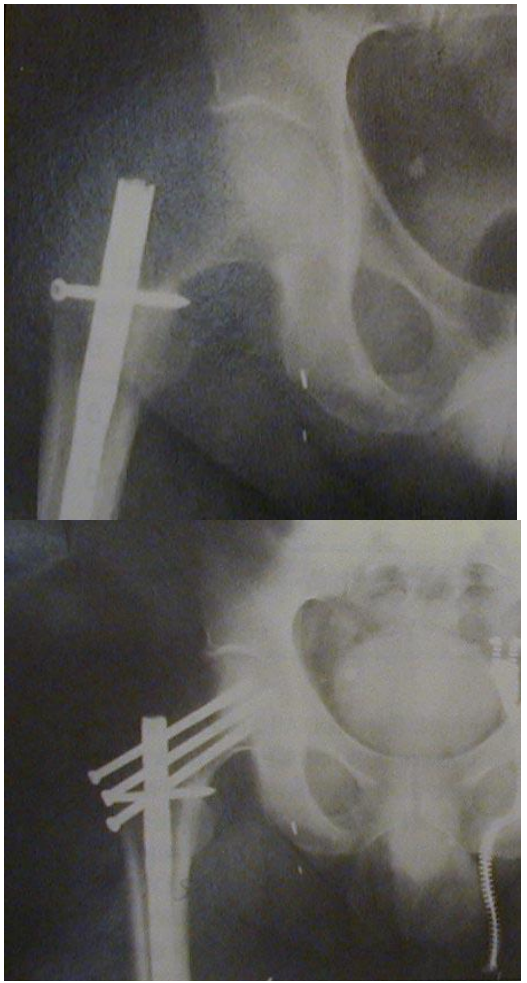
Ipsilateral Femoral Neck & Shaft Fractures

- Type 1 - nondisplaced femoral neck/hip fractures
- When found prior to nailing can be treated with screws or a sliding hip screw then retrograde or antegrade nail



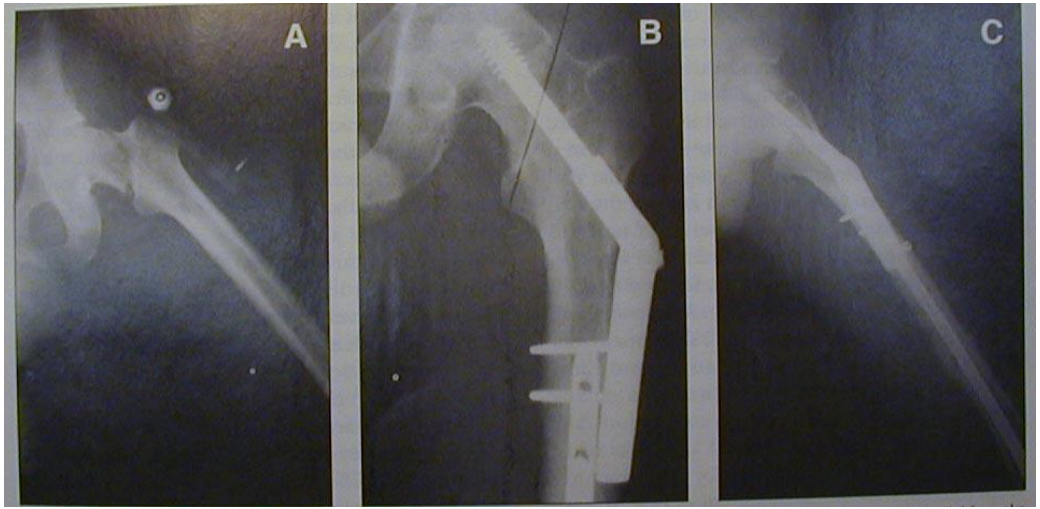
Ipsilateral Femoral Neck & Shaft Fractures

- Type 2 - missed femoral neck fracture
- Insertion of screws around the nail
- Low AVN rate even when missed
- Vertical fractures not iatrogenic



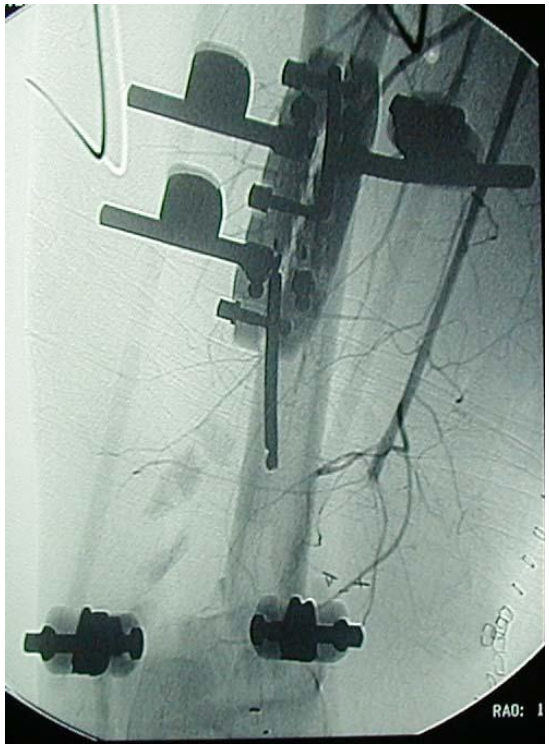
Ipsilateral Femoral Neck & Shaft Fractures

- Type 3 - displaced femoral neck fractures
- Treat with implant appropriate for neck fracture FIRST
- Treat femoral shaft fracture with retrograde nail



Femoral Shaft Fracture with Vascular Injury

- Quick external fixation with restoration of length
- Fasciotomies



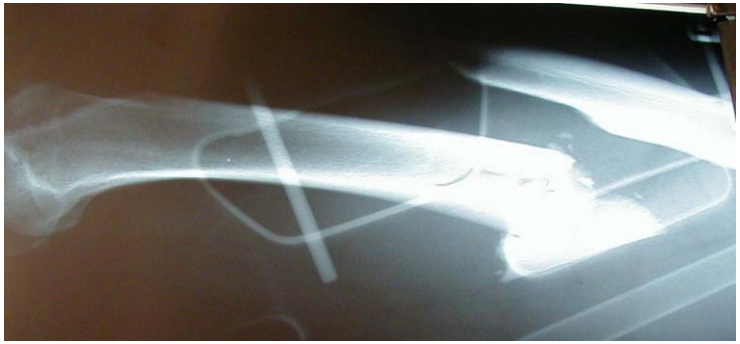
Femoral Shaft Fracture with Vascular Injury

- Exchange femoral nail either in same setting or in a few days
- When found early plating or rodding of femur is rarely possible first
- Do NOT perform IM nailing after arterial repair without initial length restoration

Open Femur Fracture
Antegrade IM Nail is Safe

- Reamed , Antegrade Intramedullary Nailing has been shown to be effective
- A high union rate, low complications
- Perhaps stage Grade 3B fractures after debridement and skeletal traction
  - Brumback, JBJS 71A, 1989
  - Lhowe, Hansen JBJS 70A, 198

Open Femur Fracture
Antegrade IM Nail is Safe



IM Nailing of the Femoral Shaft

- Choice *TO* nail depends on fracture configuration, especially at proximal and distal ends
- Choice *OF* nail depends on fracture location, associated musculoskeletal injuries, obesity
- *Think* before IM Nailing of femur

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E-mail OTA about Questions/Comments

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OTA Return to index