



Fixation of Periprosthetic TKR Fx's: What to look for, What to consider, What to do...

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Disclosure



- Design Team
 - Depuy / Synthes
 - Biomet
- Educational Consultant
 - Depuy
 - Biomet

Etiology



- 0.3 to 2.5% TKR's
- Risk Factors
 - Osteopenia
 - Osteolysis
 - Having a TKR
 - Decreased BMD 6-12 mo post-TKR
 - ? Benefits of alendronate (Wang CJ, et al: JBJS 2003)
 - Notching? (0.5-52% TKR's)
 - 1.5% of notched femurs (Gujarathi N, et al: Acta Orthop 2009)
- Low vs High Energy Mechanisms

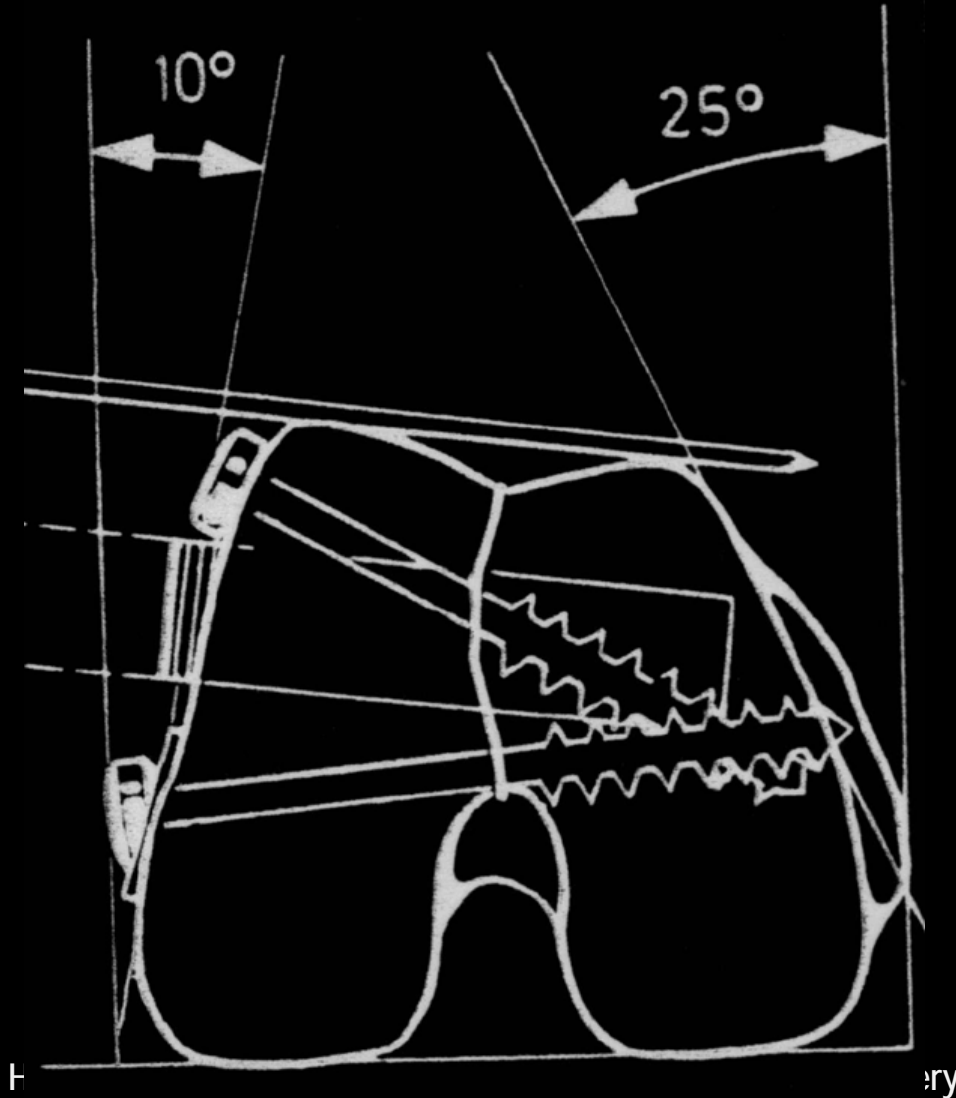
Considerations



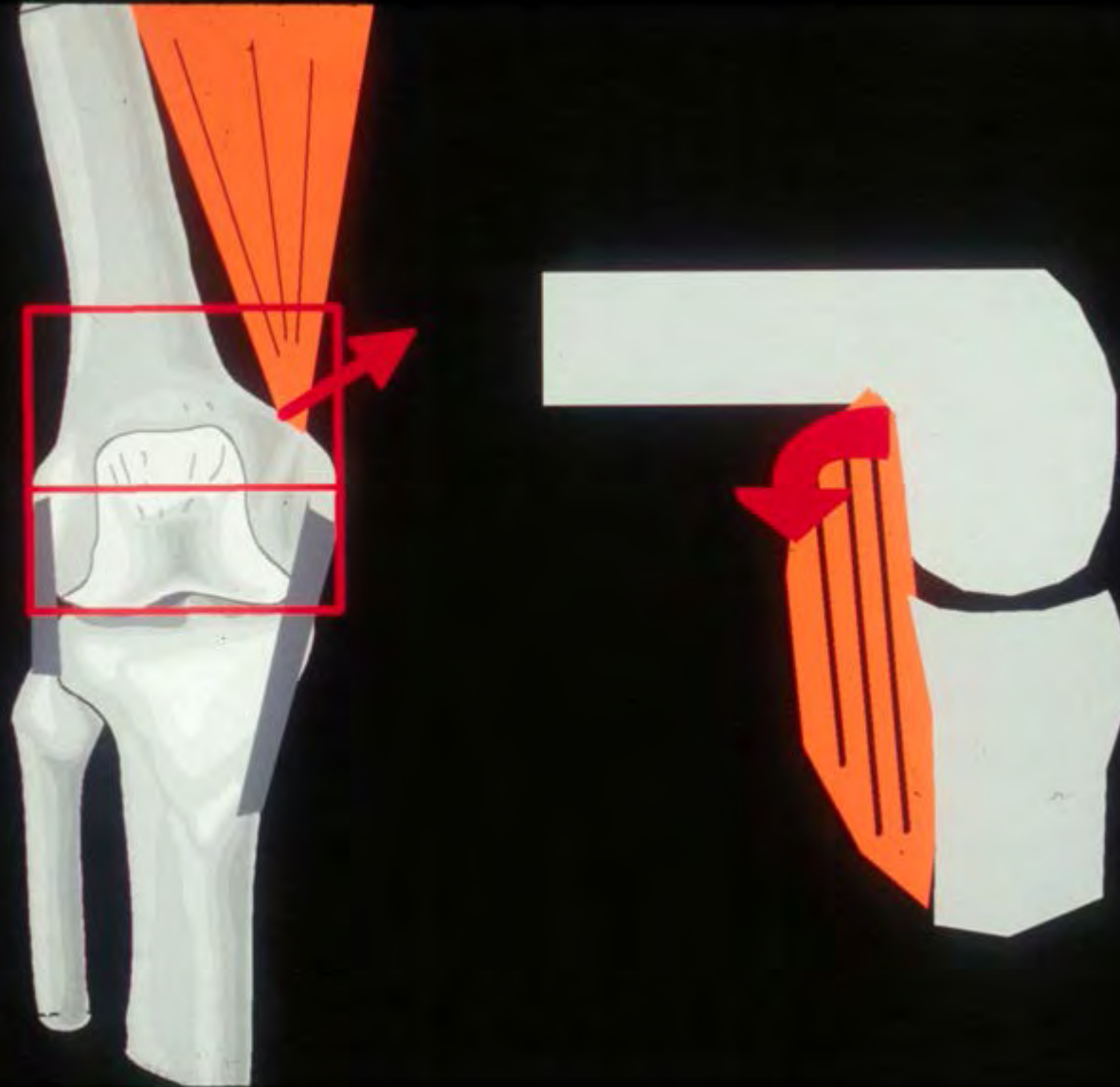
- Fracture location
- Implant stability
- Bone quality

Anatomy

Trapezoid cross section



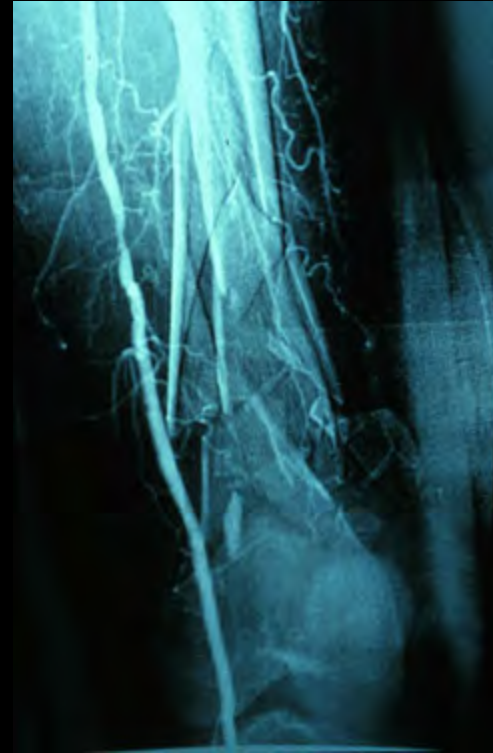
Deforming Forces



Radiographic Evaluation



- Good Quality AP and Lateral
- CT scan
- Angiography
 - Asymmetric pulses
 - ABI <0.9



In 2017...



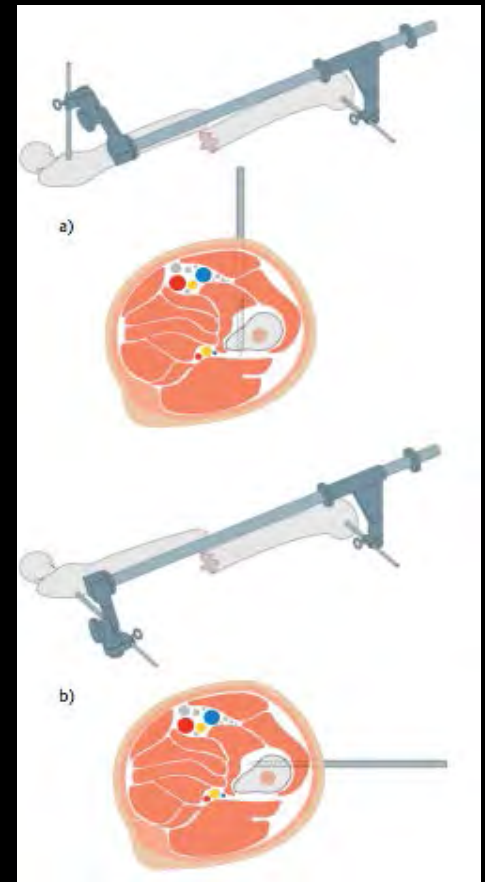
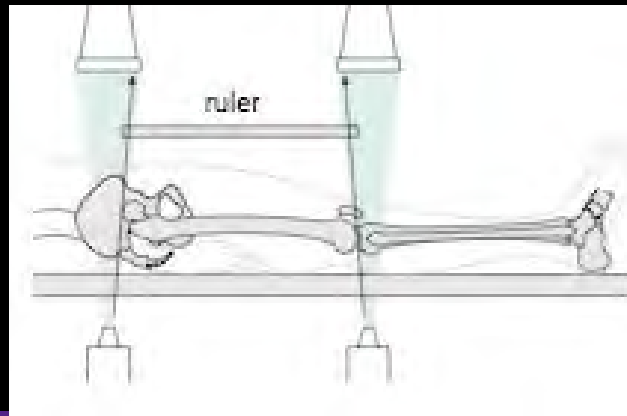
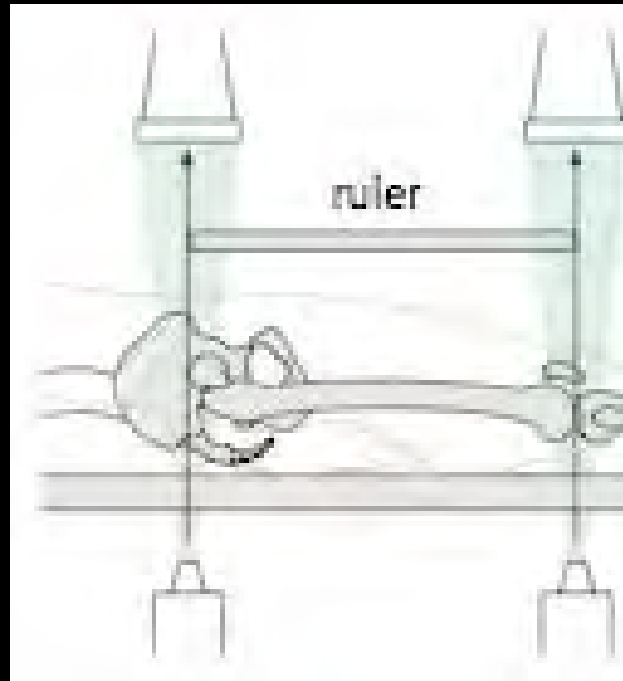
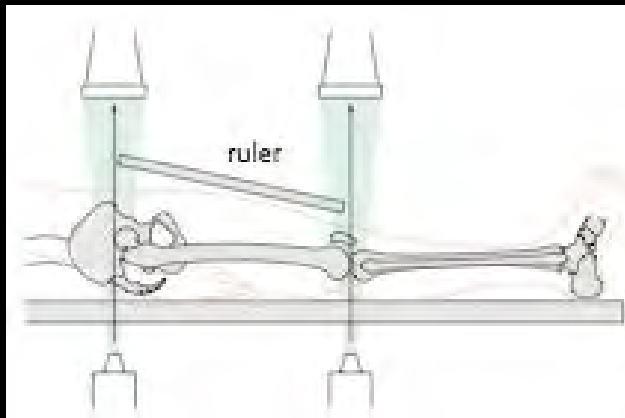
- WE SHOULD OPERATE unless:
 - Patient too medically unfit
 - Completely undisplaced fracture?

Goals of Treatment

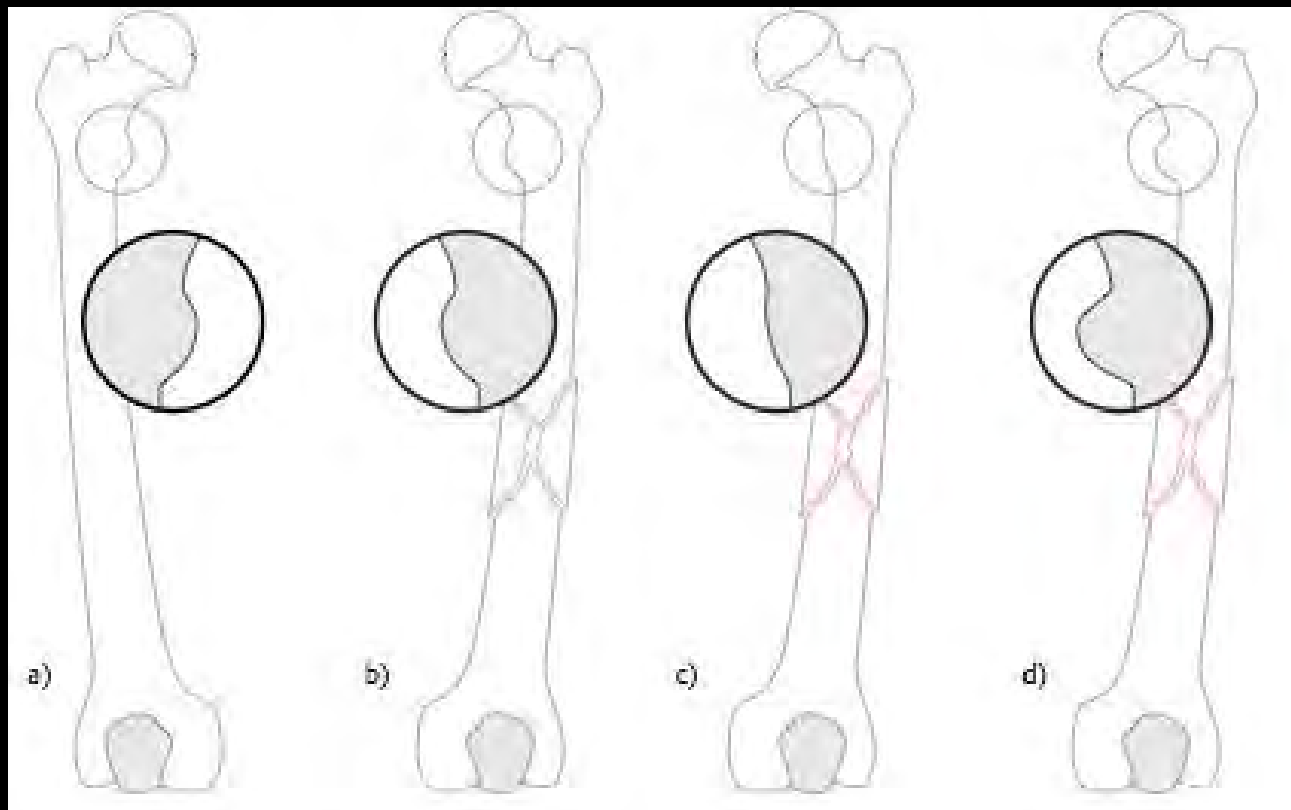


- ***Stable fixation*** of the meta-diaphyseal fracture
- ***Avoid complications***: malunion, nonunion, infection, arthrofibrosis
- ***Allow early movement*** and rehabilitation
 - Minimize disability and maximize return to function

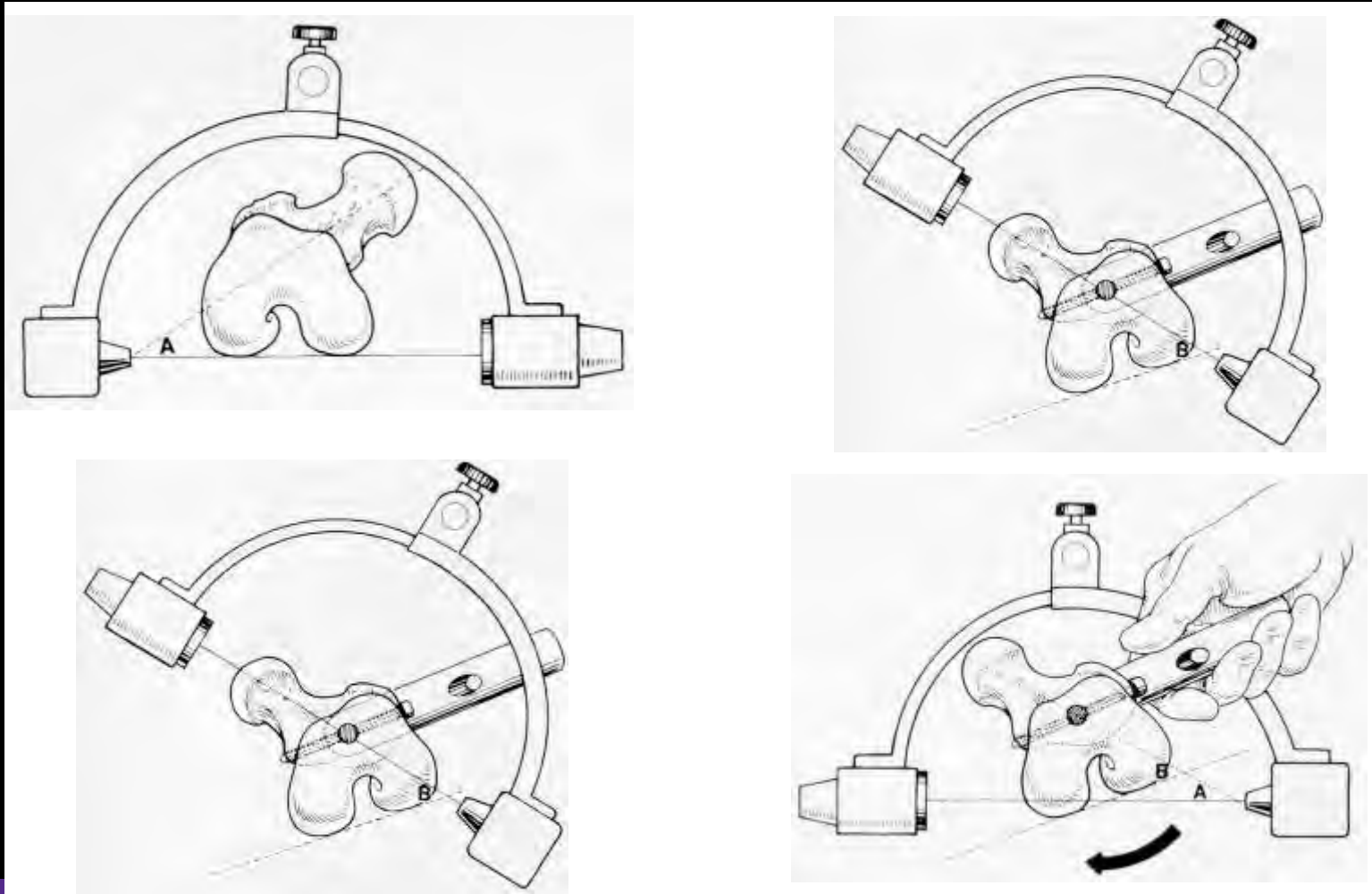
Achieving goals



Achieving goals



Achieving goals



TKA Classification

Rothman Institute 2006



Type I : Good Bone Stock, Well Fixed Component

IA non displaced-potential nonoperative (Rorabeck I)

IB Displaced fx- operative (Rorabeck II)

Type II: Good Bone stock but loose or poorly positioned component

-Revision with long stem components

Type III: Good or Poor bone stock with loose component

--Revision TKA (Rorabeck III)

➤ Kim, et al. CORR,446. 2006

➤ Rorabeck, Taylor. Orthop Clin North Am, 30. 1999.

Decision Matrix



<u>Bone Stock</u> Implant	Good	Bad
Good	Nail vs. Plate	Revise vs. ORIF/Augment
Bad*	Revise	Revise with long stem

Options



- IMN
- ORIF
- Supplements
 - CaPhos
 - Allograft
 - BG substitutes
- Revision TKR



Options



- What's best to decrease r.r. nonunion?
 - IMN
 - Locked implants
 - Conventional plating / struts
 - Non-op

415 case meta-analysis

- IMN
- Locked implants
 - Herrera DA, et al: Acta Orthop 2008

LISS vs Blade Plate



Higgins TF et al (JOT 2007)

- LISS
 - Less subsidence
 - Greater resistance to failure
 - Findings regardless of BMD
- LISS w/ multiple fixed angle devices that are multiplanar

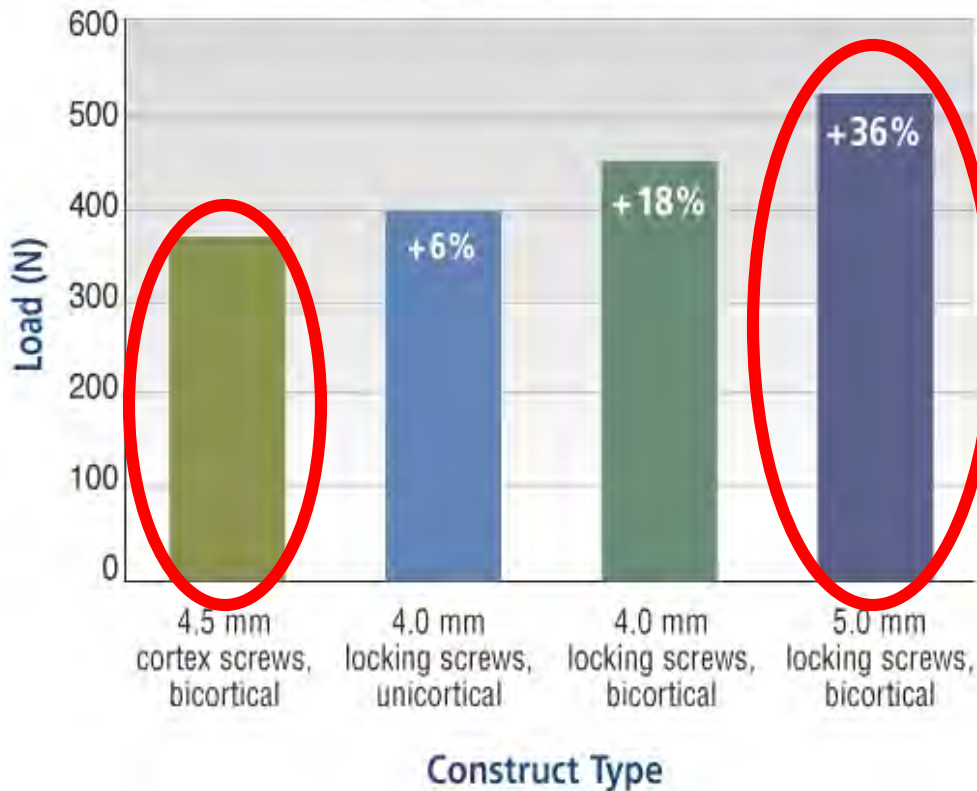


Uni vs Bicortical screws... Locking implants...



Simulation of Normal Cortical Bone**

Axial load required to displace selected plate/screw constructs by 0.5 mm

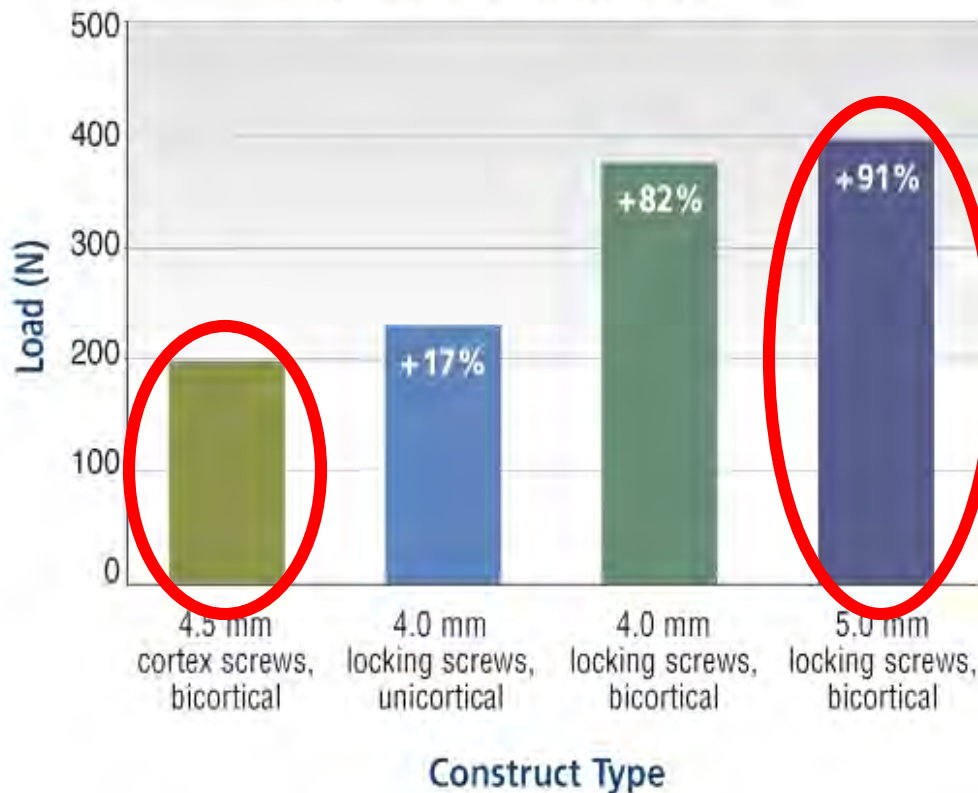


** Simulation of normal cortical bone performed with 40 lb/ft³ foam

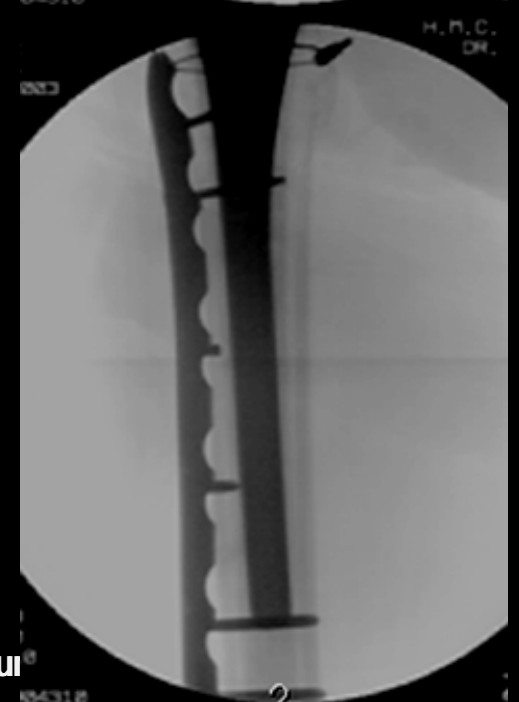
Osteoporotic Bone

Simulation of Osteopenic Bone*

Axial load required to displace selected plate/screw constructs by 0.5 mm



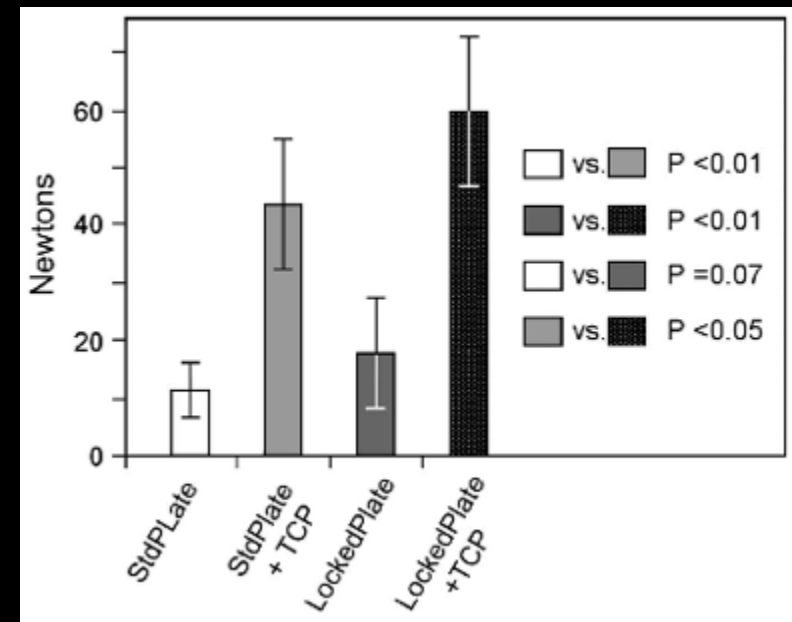
* Simulation of osteopenic bone performed with 15 lb/ft³ foam



Options



- Can we increase pull-out strength w/ ORIF and osteopenia?
- PMMA or TCP w/ locking screws
- 5x increased pull-out strength to conventional plating



Collinge et al: JOT 2007

Patient NC



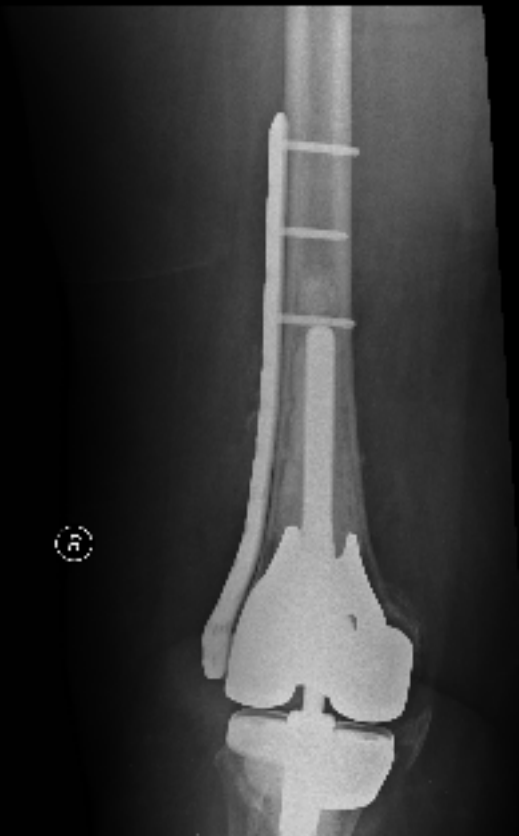
artr

Patient NC



epartr

NC – F/U



Should 90-90 strut-plate be standard?



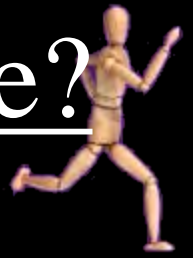
Biomechanical Evaluation of Periprosthetic Femoral Fracture Fixation

By Rad Zdero, PhD, Richard Walker, MD, James P. Waddell, MD, FRCS(C), and Emil H. Schemitsch, MD, FRCS(C)

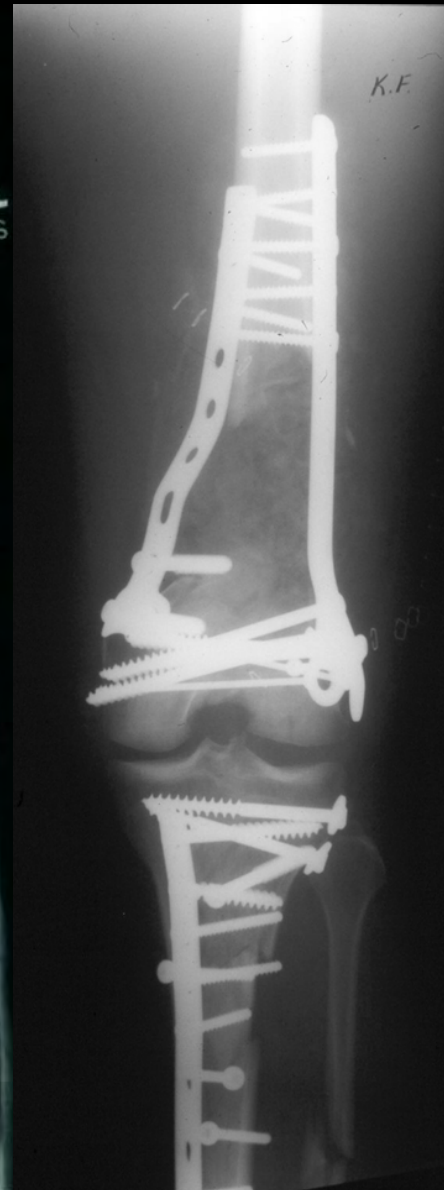
COPYRIGHT © 2008 BY THE JOURNAL OF BONE AND JOINT SURGERY, INCORPORATED

- 90-90 strut / plate stronger than
 - Conventional plate
 - Locked plate \pm cables
- Biomechanical study with THR's
- **WHAT ABOUT THE BLOOD SUPPLY???**

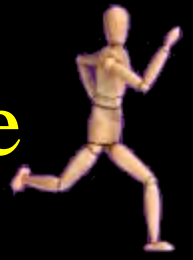
Problem – Should we double plate?



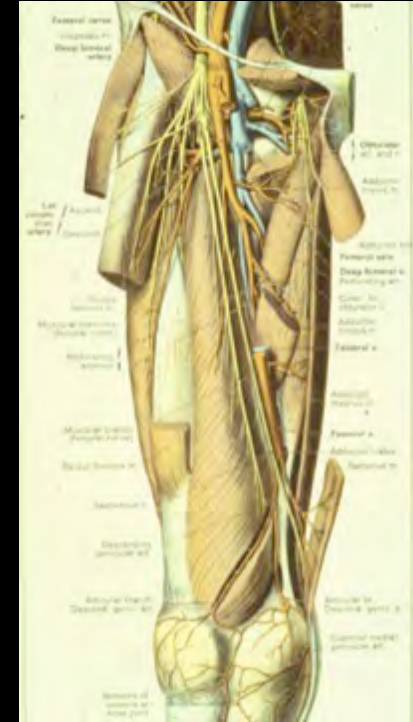
Varus
Collapse
and
shortening



Double-Plating of Comminuted, Unstable Fractures of the Distal Part of the Femur

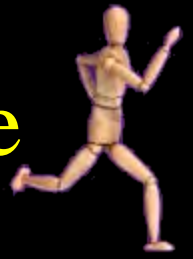


- Sanders et al. J. Bone and Joint Surg. 1991
 - 9 patients
 - Functional outcomes
 - 5 good results
 - 4 fair results
 - 1 patient with $> 100^{\circ}$ knee flexion
 - Neurovascular concerns medially

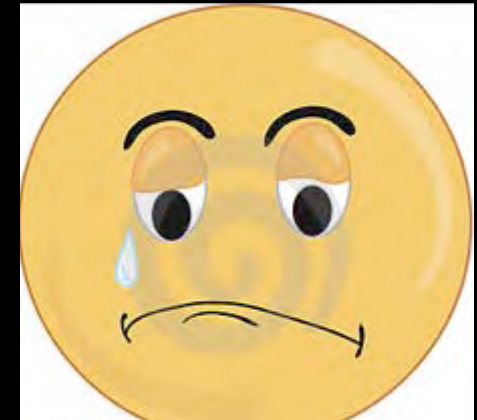


- **WHAT ABOUT THE BLOOD SUPPLY???**

Double-Plating of Comminuted, Unstable Fractures of the Distal Part of the Femur



- Sanders et al. J. Bone and Joint Surg. 1991
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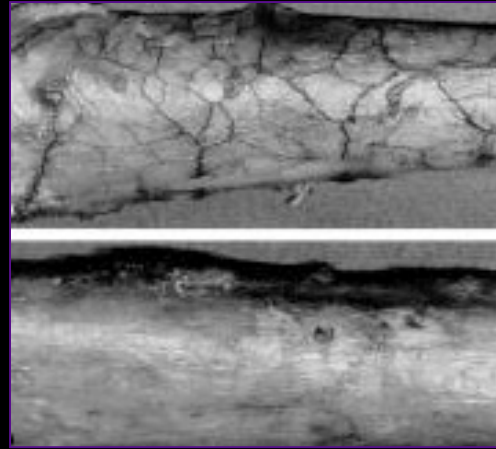


• **WHAT ABOUT THE BLOOD SUPPLY???**

Saving the Blood Supply

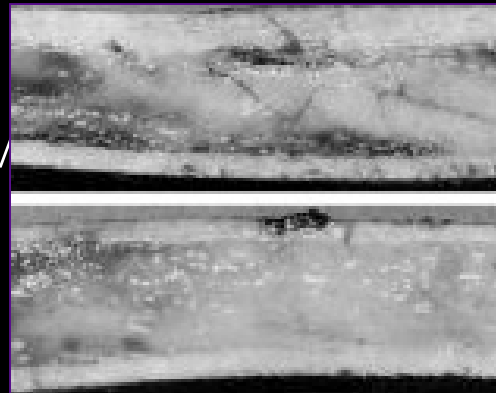


- 10 cadaveric femurs
- CPO vs MIPPO
 - 16 hole LC-DCP
- Dye injection
- ALL MIPPO specimens w/
intact nutrient and
perforating arteries



MIPPO - peri

CPO - peri

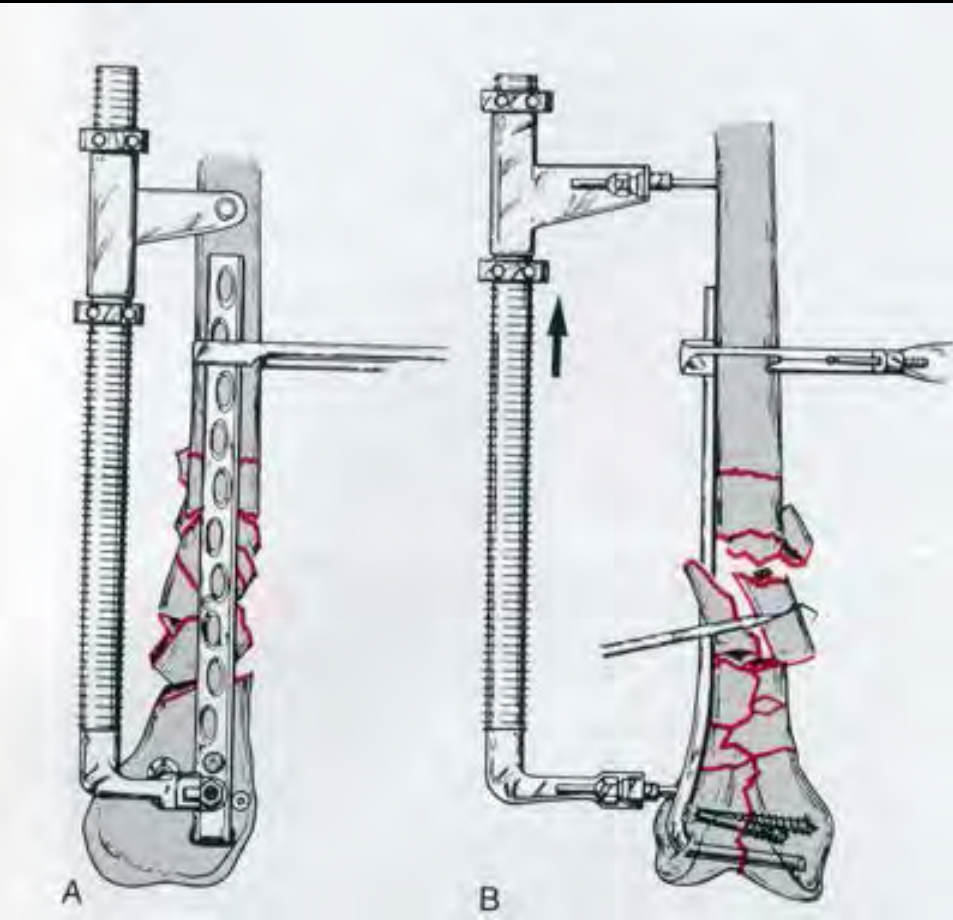


MIPPO - IM

CPO - IM

(Farouk & Krettek, JOT, 1999; Injury 1997)

Indirect Reduction of Metaphyseal Component



Effect of Keeping Periosteum



- Maintenance of b.s.
- Higher union rates
- Lower complications
- Less bone grafting

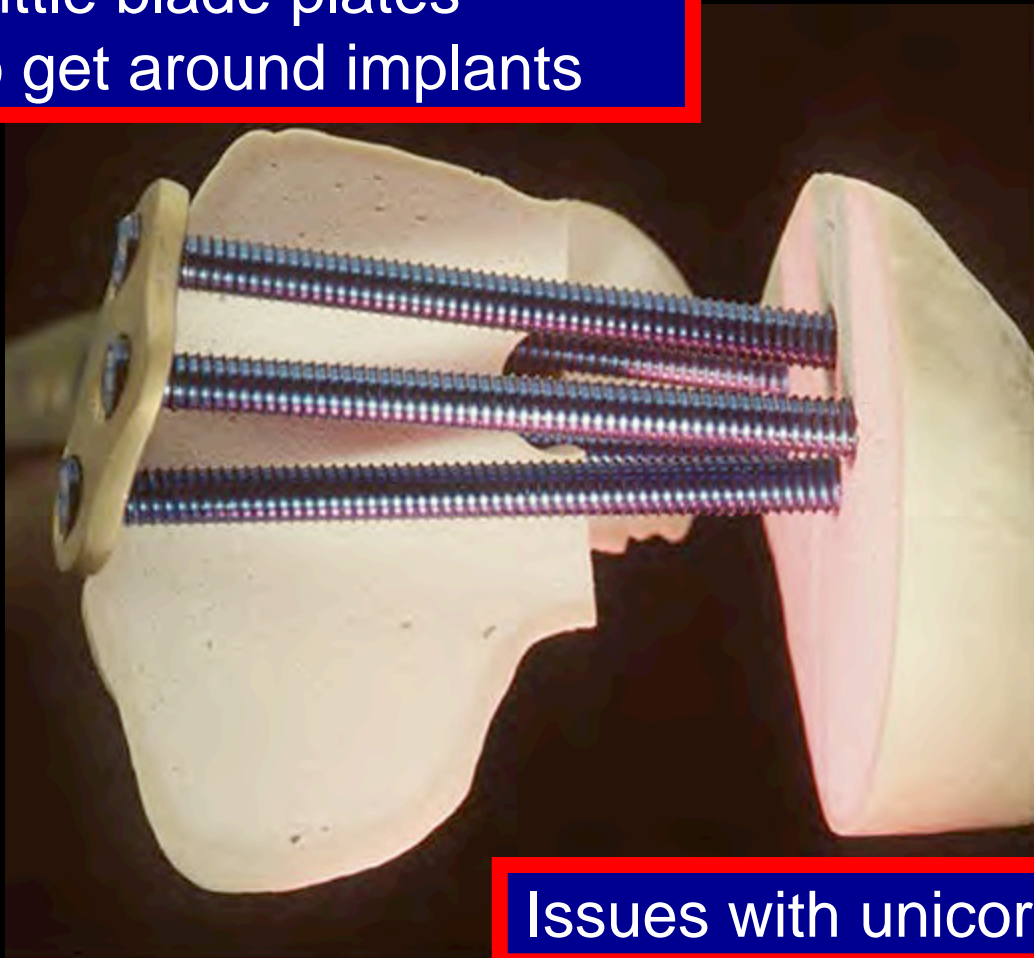
(Wenda, Injury, 1997; Krettek, Injury 1997;
Krettek, Unfallchirurg, 1996; Bolhofner JOT 1996
Kinast & Bolhofner, Clin Orthop, 1989)



DF Implants



- Multiple “little blade plates”
- Difficult to get around implants



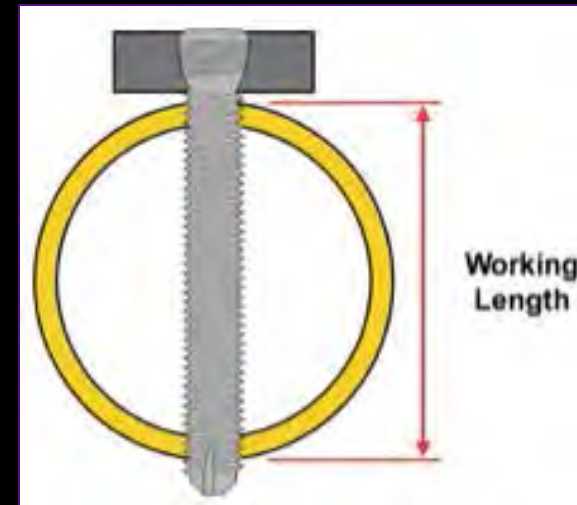
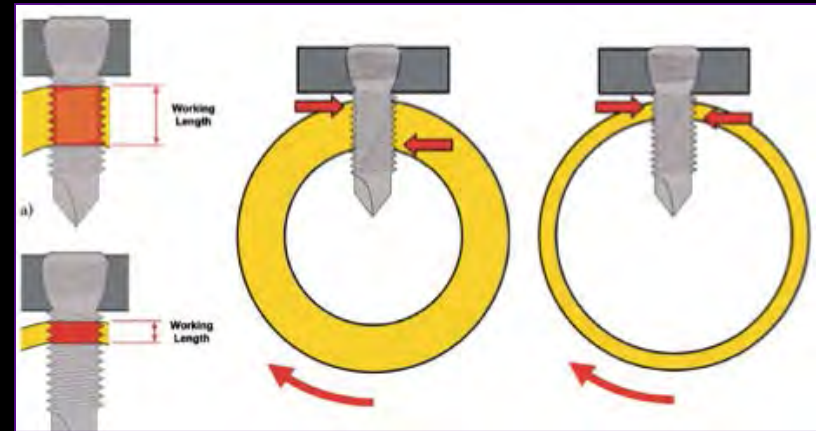
Issues with unicortical shaft screws

Locked Screws & Osteoporosis

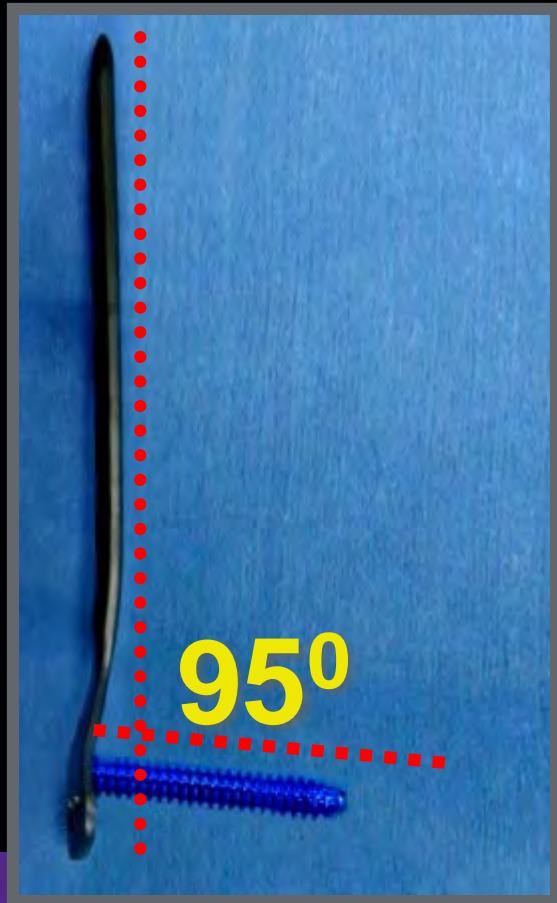


- Cortical thickness
- Canal dilatation
- Working Length
 - Screw
- Bi-cortical Lock

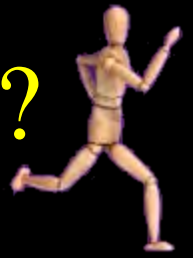
(Gautier, Injury, 2003)



Fixed angle device with angular options???



Is polyaxial locking strong enough???



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Results of Polyaxial Locked-Plate Fixation of Periarticular Fractures of the Knee

By George Haidukewych, MD, Stephen A. Sems, MD, David Huebner, MD, Daniel Horwitz, MD, and Bruce Levy, MD

- 56 peri-articular knee fractures
- 12 open
- All treated w/ POLY-AX plate

- *94% union*
- *No varus progression*
- *No screw or plate failures*





What about the tibia?

Tibia TKR fx's



- Intra-op
 - Metaphyseal
 - Tubercle osteotomy
- Post-op
 - Non-displaced
 - Displaced

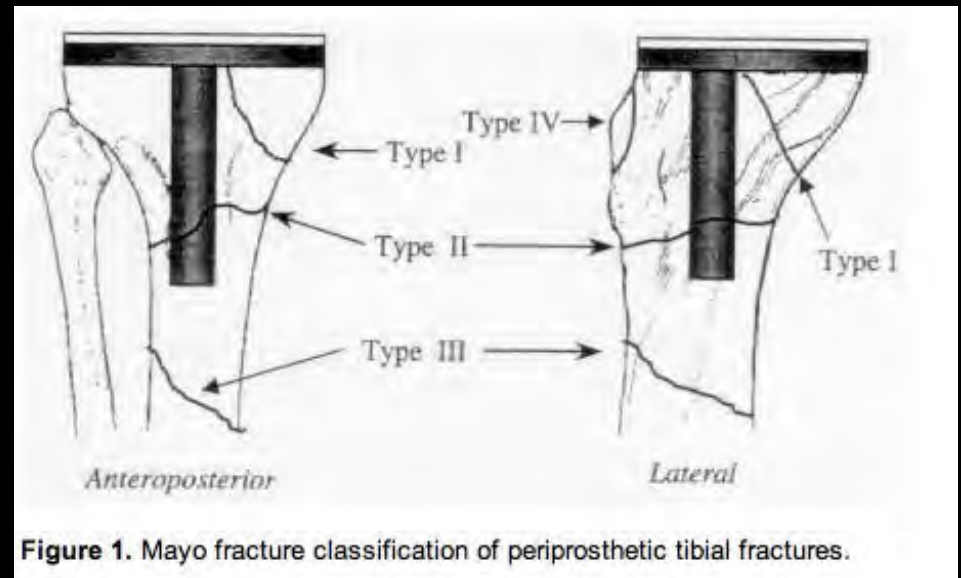


Figure 1. Mayo fracture classification of periprosthetic tibial fractures.

Tibia TKR fx's



- Intra-op
 - Metaphyseal
 - Tubercle osteotomy
- Post-op
 - Non-displaced
 - Displaced

TABLE 2. Classification of Postoperative Periprosthetic Tibial Fractures

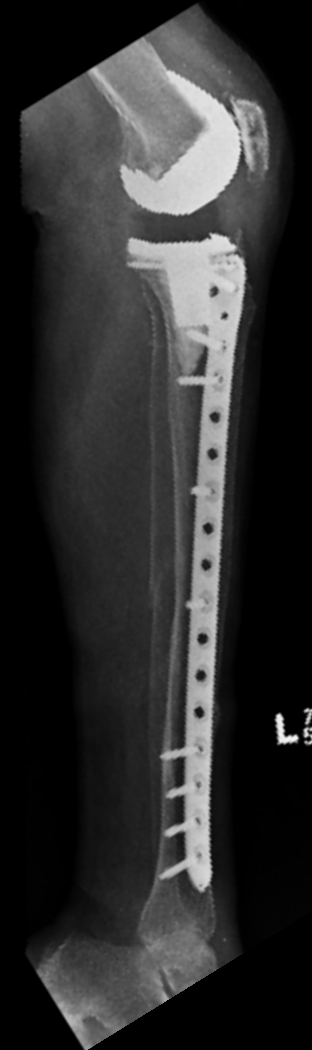
Major Anatomic Pattern	Subcategory
I. Tibial plateau	A. Well fixed prosthesis
II. Adjacent to stem	B. Loose prosthesis
III. Distal to prosthesis	C. Intraoperative
IV. Tibial tubercle	

Reproduced with permission from Felix NA, Stuart MJ, Hanssen AD. Periprosthetic fractures of the tibia associated total knee arthroplasty. *Clin Orthop Relat Res.* 1997;345:113-124.

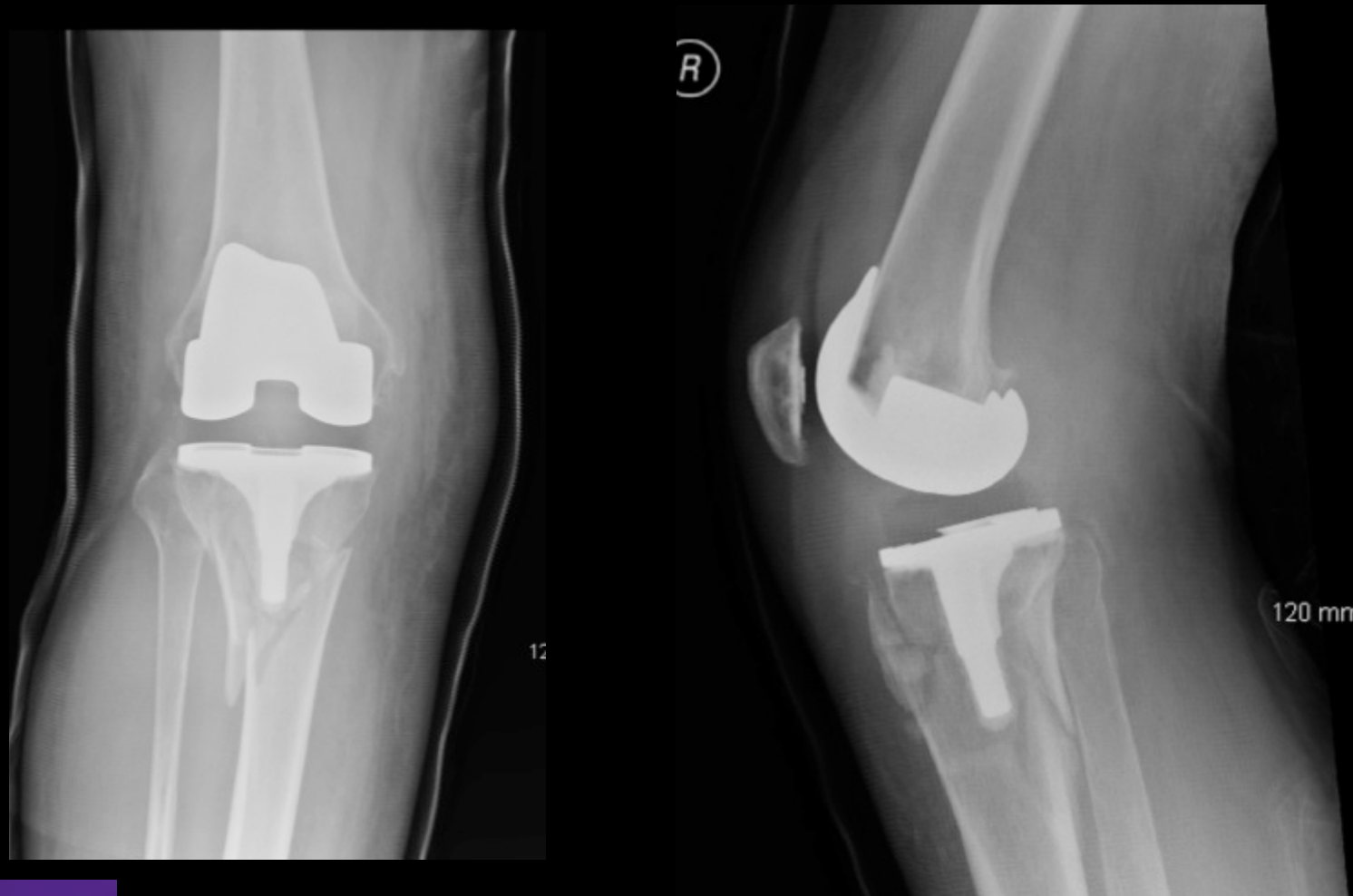
VM



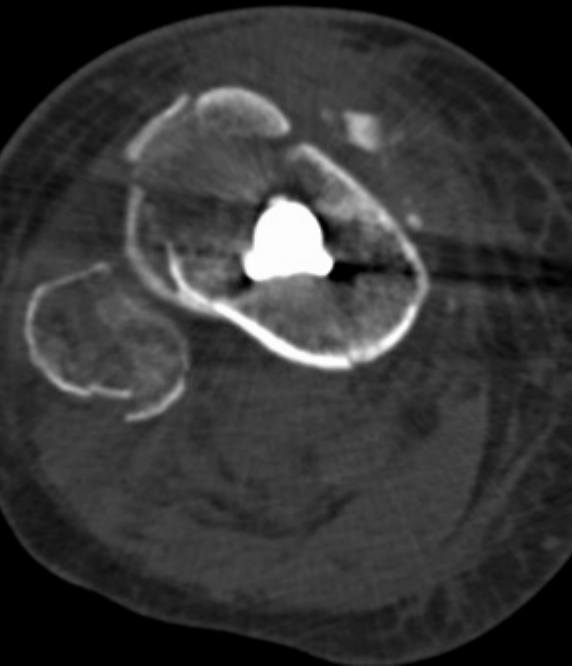
VM



EW



EW



EW

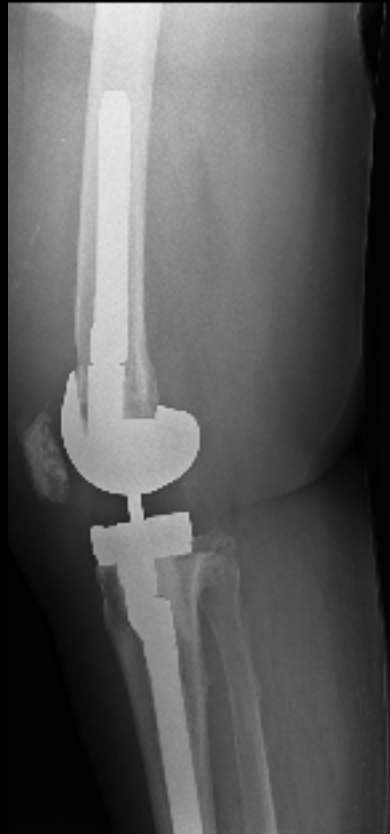


EW



AS





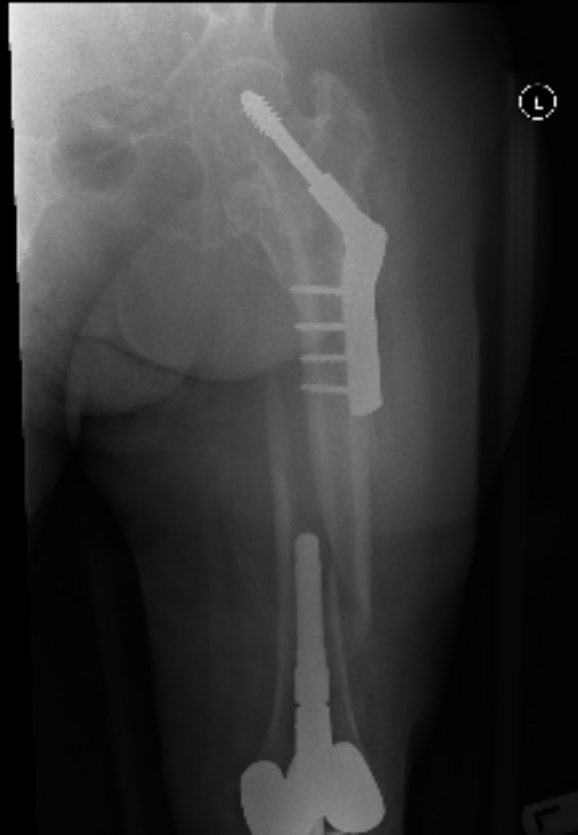
Inter-prosthetic Fx



- Between TKR and THR
- Between TKR and Hip Fixation

Span Femur with LONG PLATE !!!

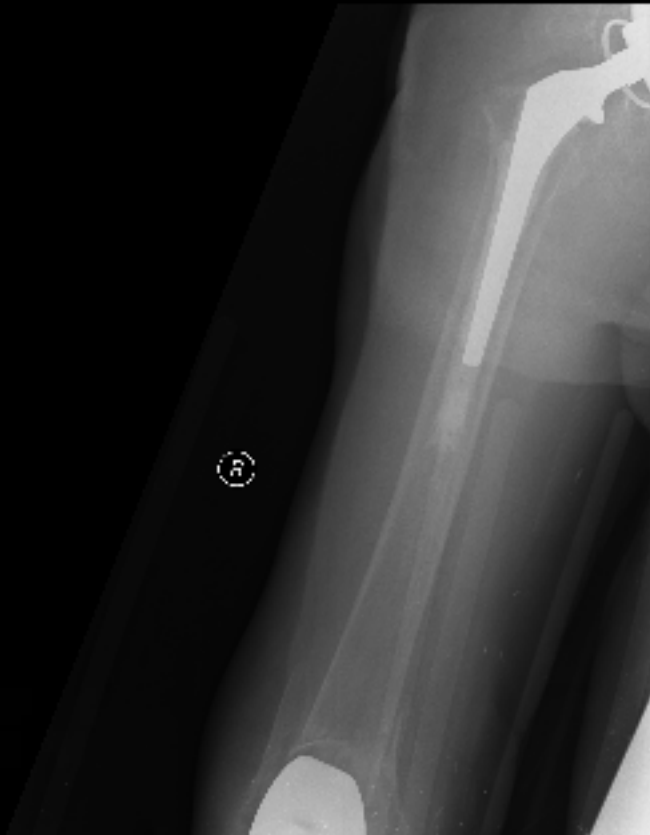
MF



MF



NH



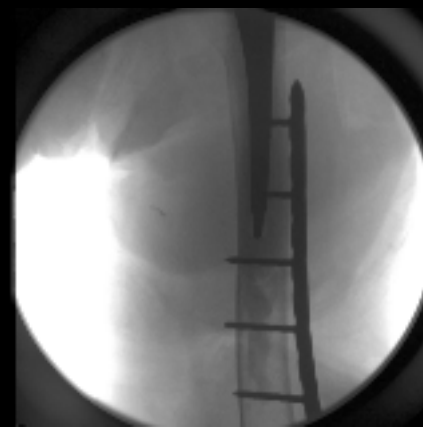
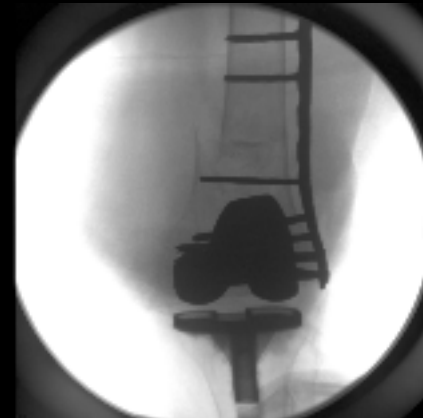
R

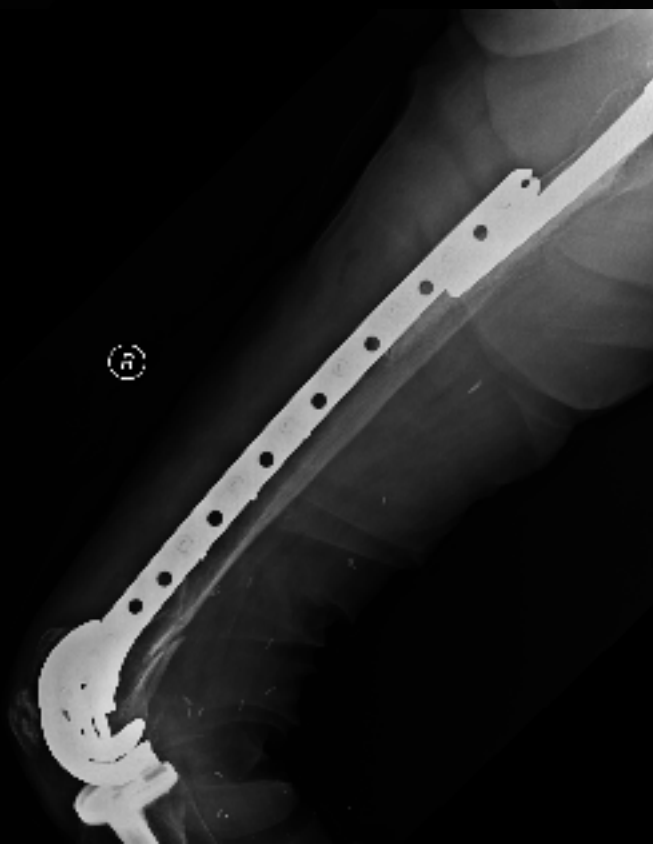
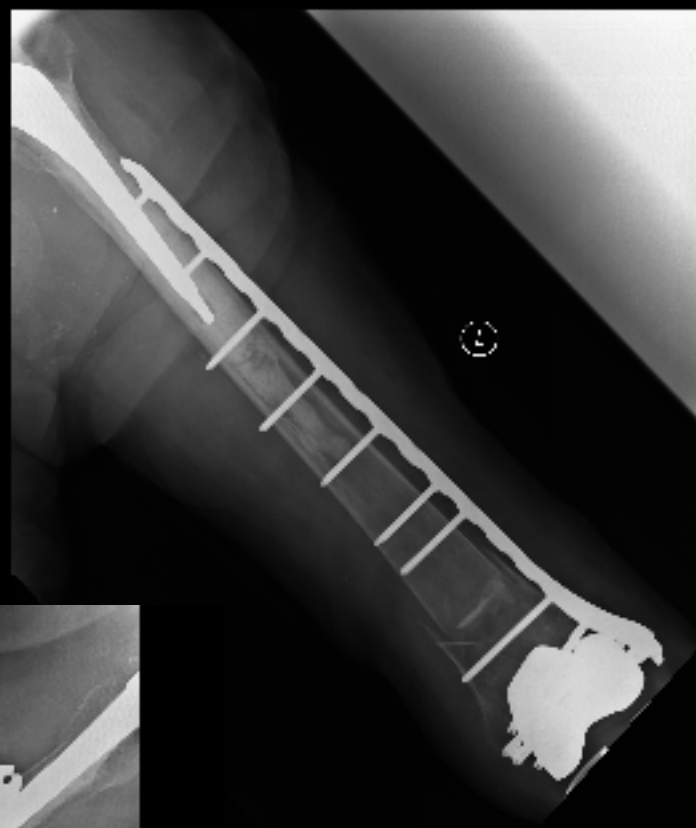


L



NH





IMN



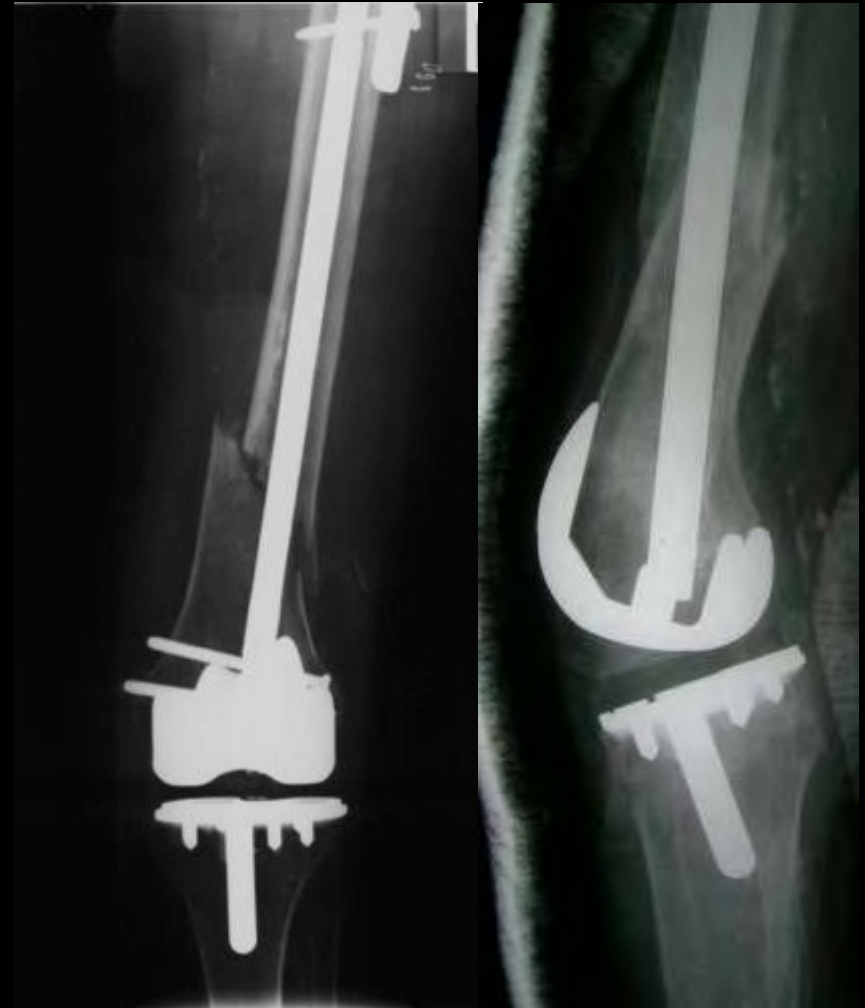
- Retrograde

- Antegrade

Retrograde Nailing



- Less invasive ?
- Technically difficult
 - Purchase
 - Stability



Retrograde Nailing



•BUT...

- Ineffective or complicated w/ “boxed” TKR
- Limited distal fixation (osteoporosis)
- Increase risk prosthetic infection
- Increase risk of polyethylene damage / 3rd body



Intramedullary Nails



- Are they more stable than plates?
 - Traditionally suggested to be biomechanically more advantageous to plates → SHAFT FX's
 - Immediate WB'ing ?

Comparison of the LISS and a retrograde inserted supracondylar intramedullary nail for fixation of a periprosthetic distal femur fracture proximal to a total knee arthroplasty



Bong M et al J Arthroplasty 2002

- Laboratory biomechanical model
- Nail
 - Greater resistance to varus load and torsional load
- LISS
 - Greater resistance to valgus load w/ bone loss

Comparison of the LISS and a retrograde inserted supracondylar intramedullary nail for fixation of a periprosthetic distal femur fracture proximal to a total knee arthroplasty



Bong M et al J Arthroplasty 2002

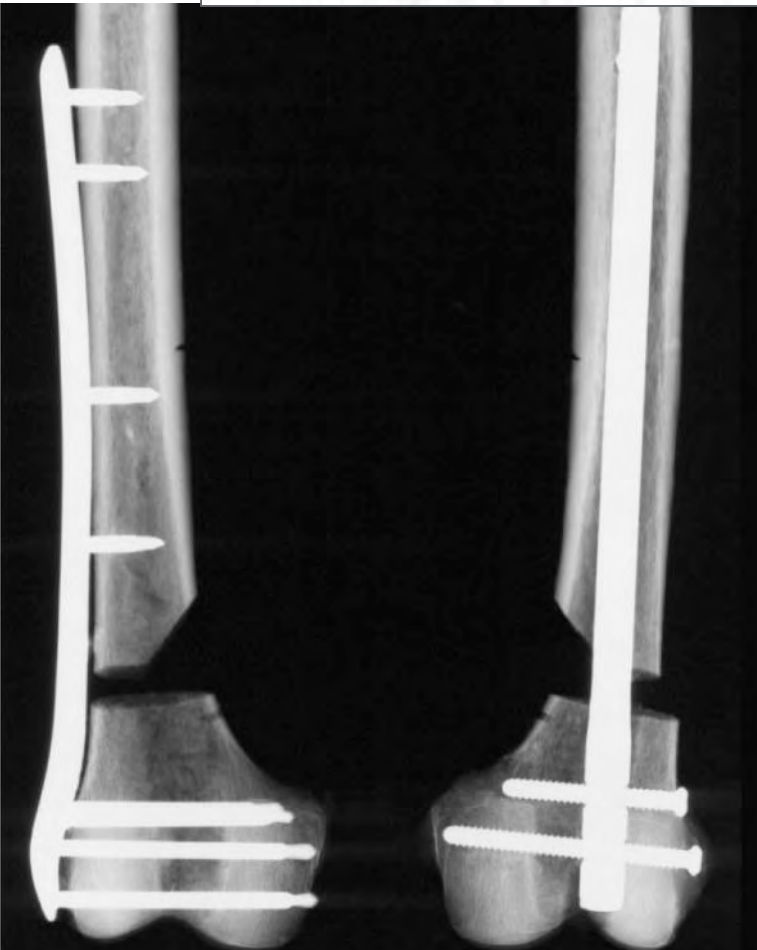
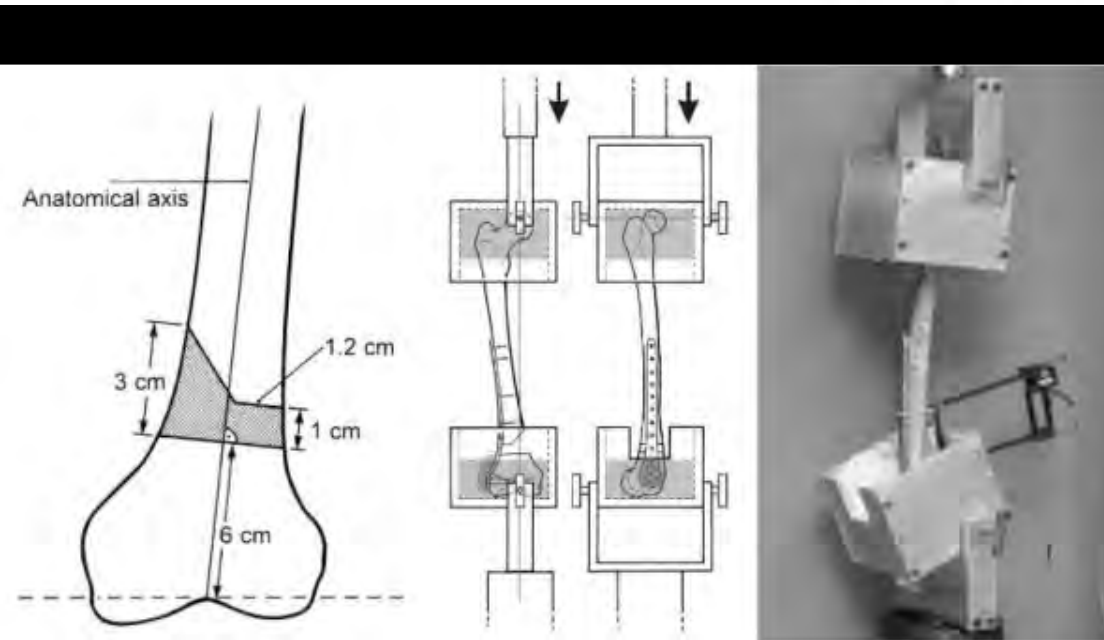
•BUT...

- Did not address osteoporotic model
- Did not address all types TKR or LOW peri-prosthetic fracture
- Did not address model w/ varus bone loss

Biomechanical Evaluation of the Less Invasive Stabilization System, Angled Blade Plate, and Retrograde Intramedullary Nail for the Internal Fixation of Distal Femur Fractures

Michael Zlowodzki, MD,* Scott Williamson, BS,† Peter A. Cole, MD,* Lyle D. Zardiackas, PhD,† and Philip J. Kregor, MD‡

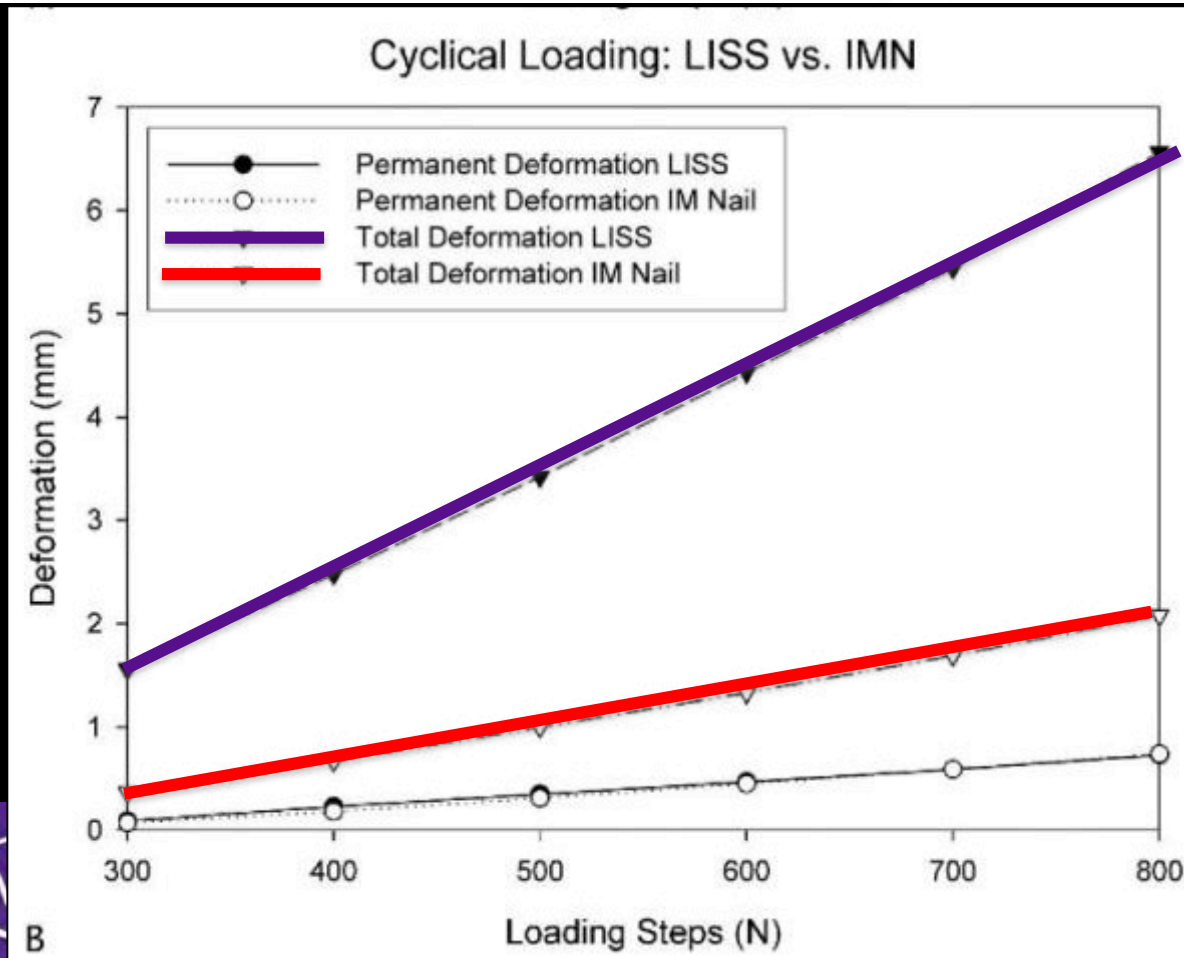
(*J Orthop Trauma* 2004;18:494–502)



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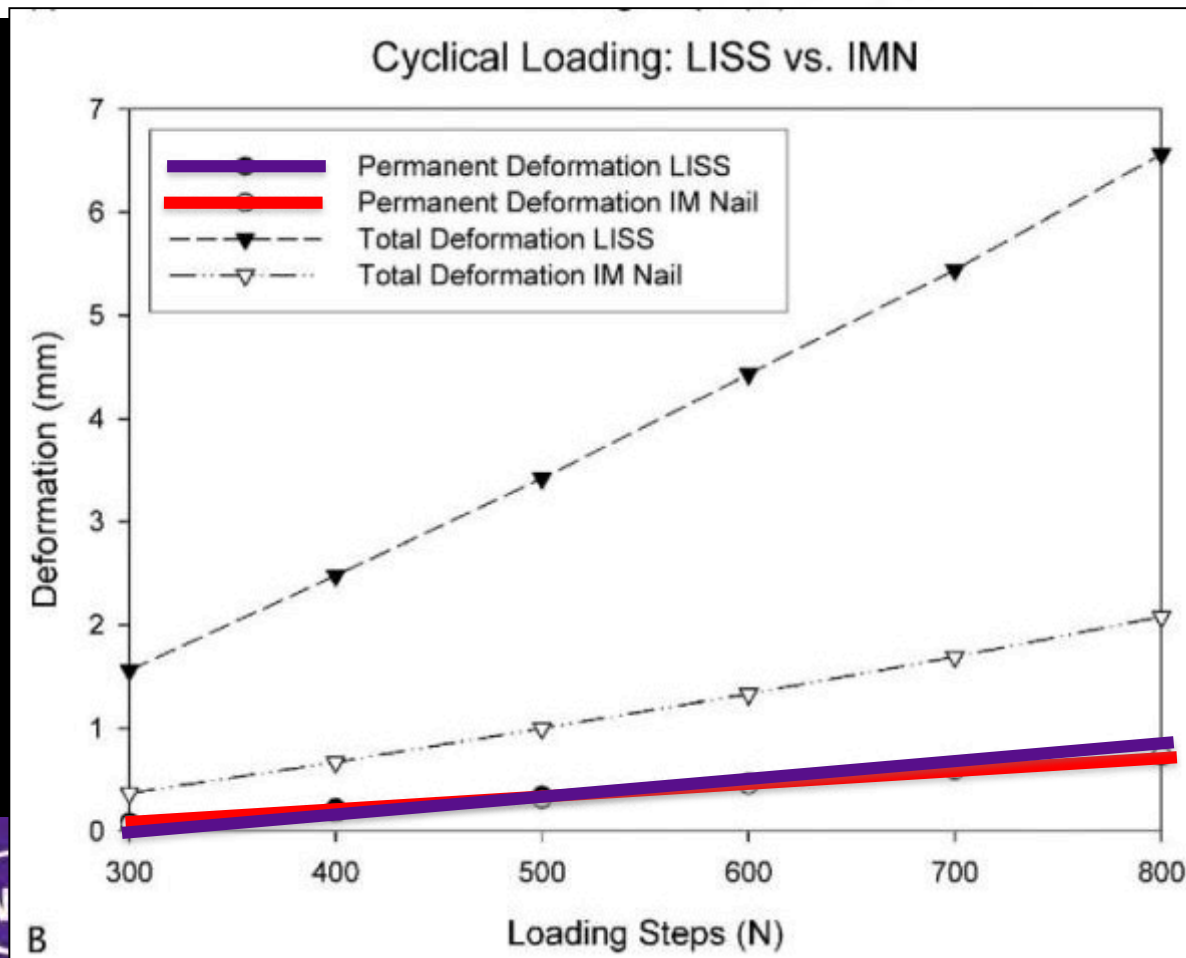
LISS > IMN
DEFORMATION W/
CYCLICAL LOADING

ELASTIC

Biomechanical Evaluation of the Less Invasive Stabilization System, Angled Blade Plate, and Retrograde Intramedullary Nail for the Internal Fixation of Distal Femur Fractures

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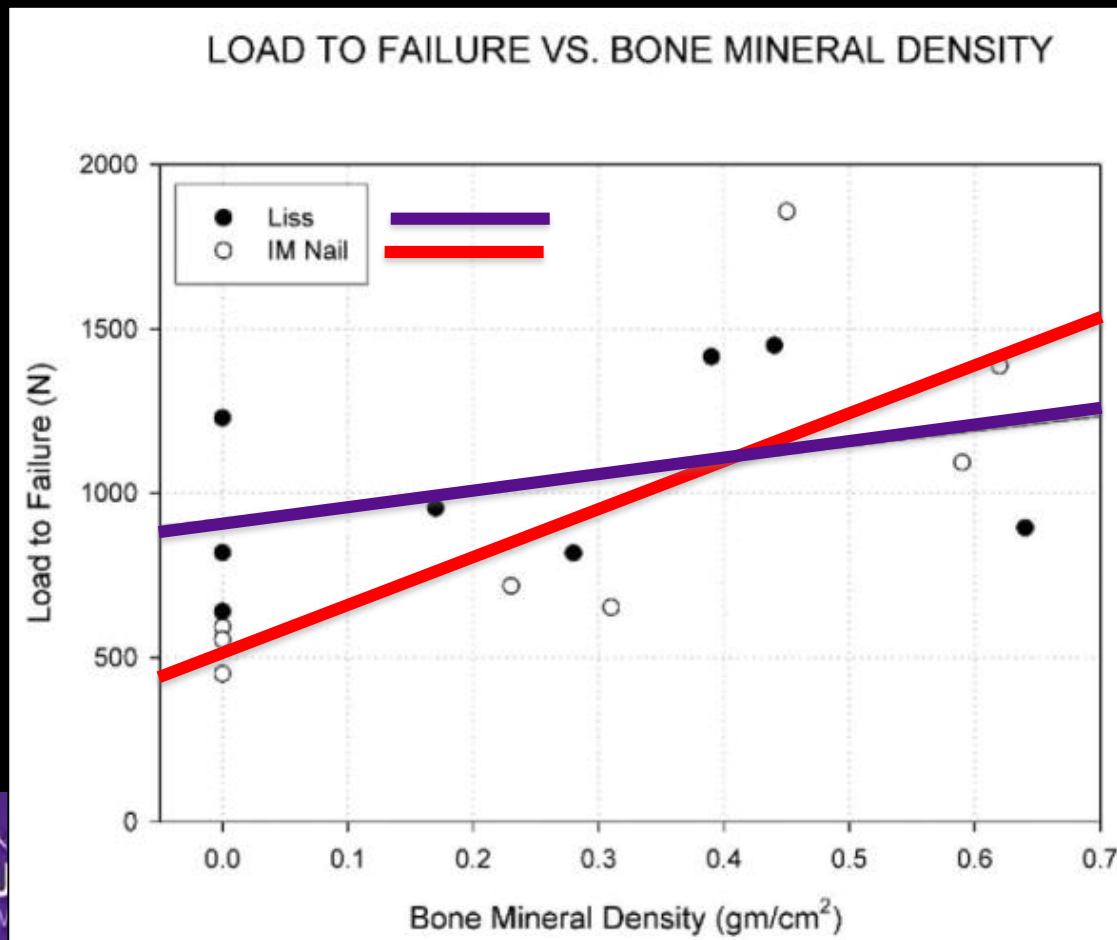
IMN & LISS
SIMILAR
PERMANENT
DEFORMATION

PLASTIC

Biomechanical Evaluation of the Less Invasive Stabilization System, Angled Blade Plate, and Retrograde Intramedullary Nail for the Internal Fixation of Distal Femur Fractures

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AXIAL LOADING:

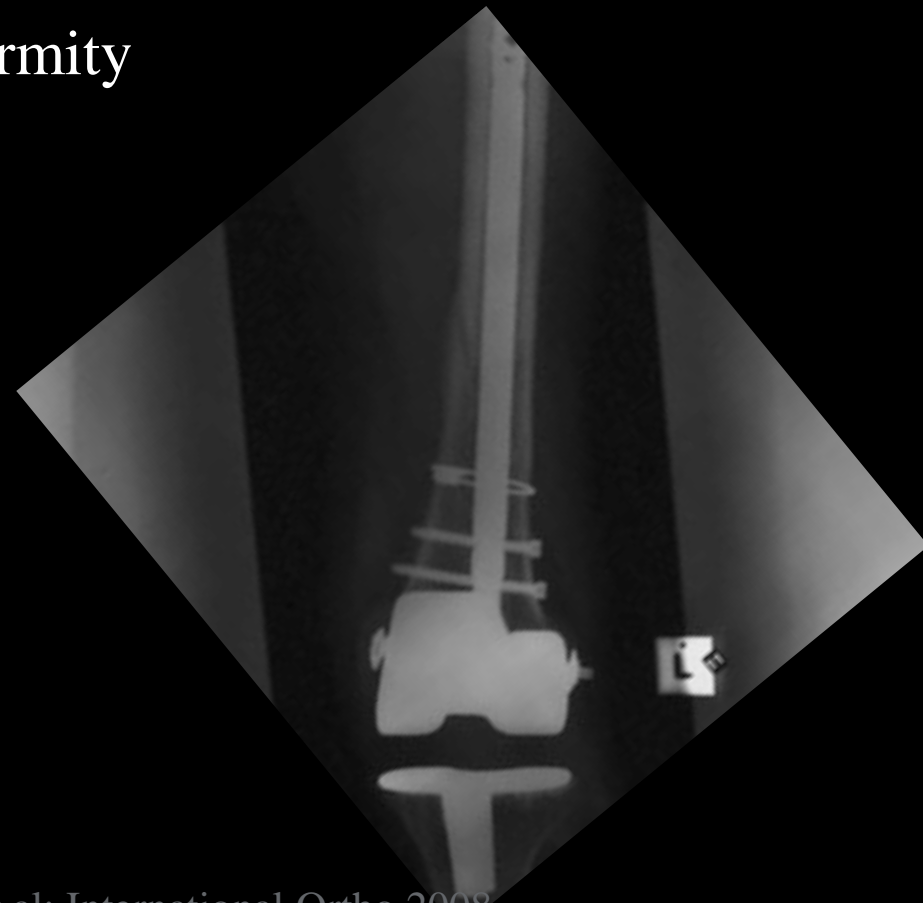
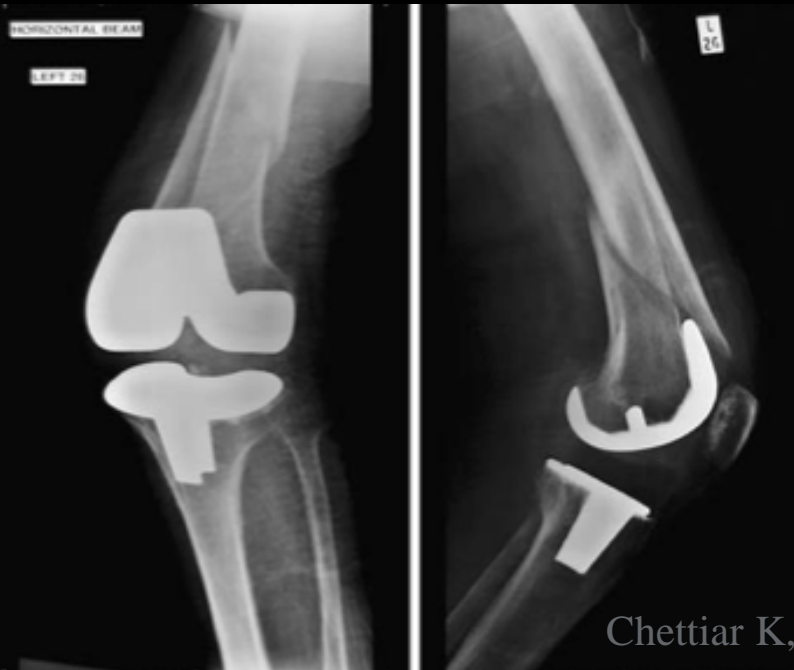
IMN < LISS
LOAD-TO-FAILURE
LOW BMD

IMN > LISS
LOAD-TO-FAILURE
HIGH BMD

Retrograde IMN



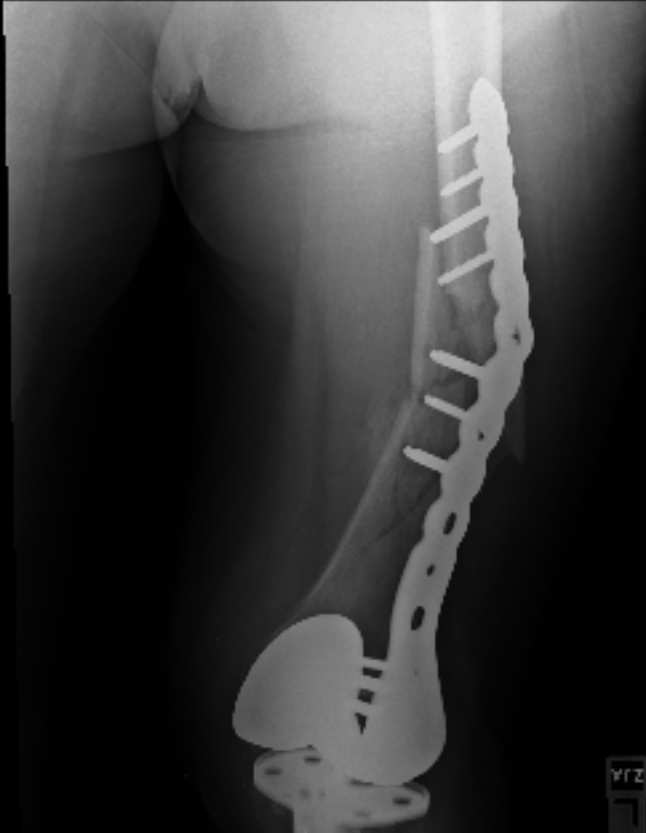
- Require accurate reduction
- May require supplemental fixation
- High union rates
- Risk valgus and extension deformity





Antegrade IMN

DN





SUPINE

PORTABLE



SUPINE

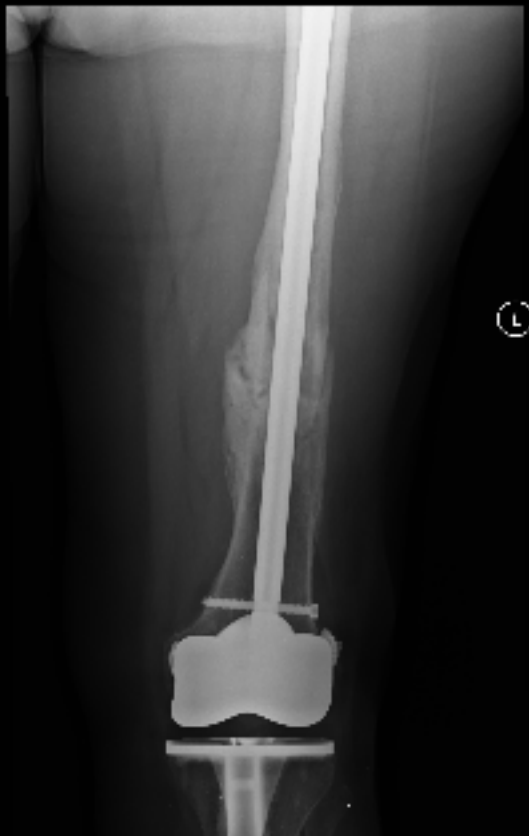
CROSS-TABLE



SUPINE

PORTABLE

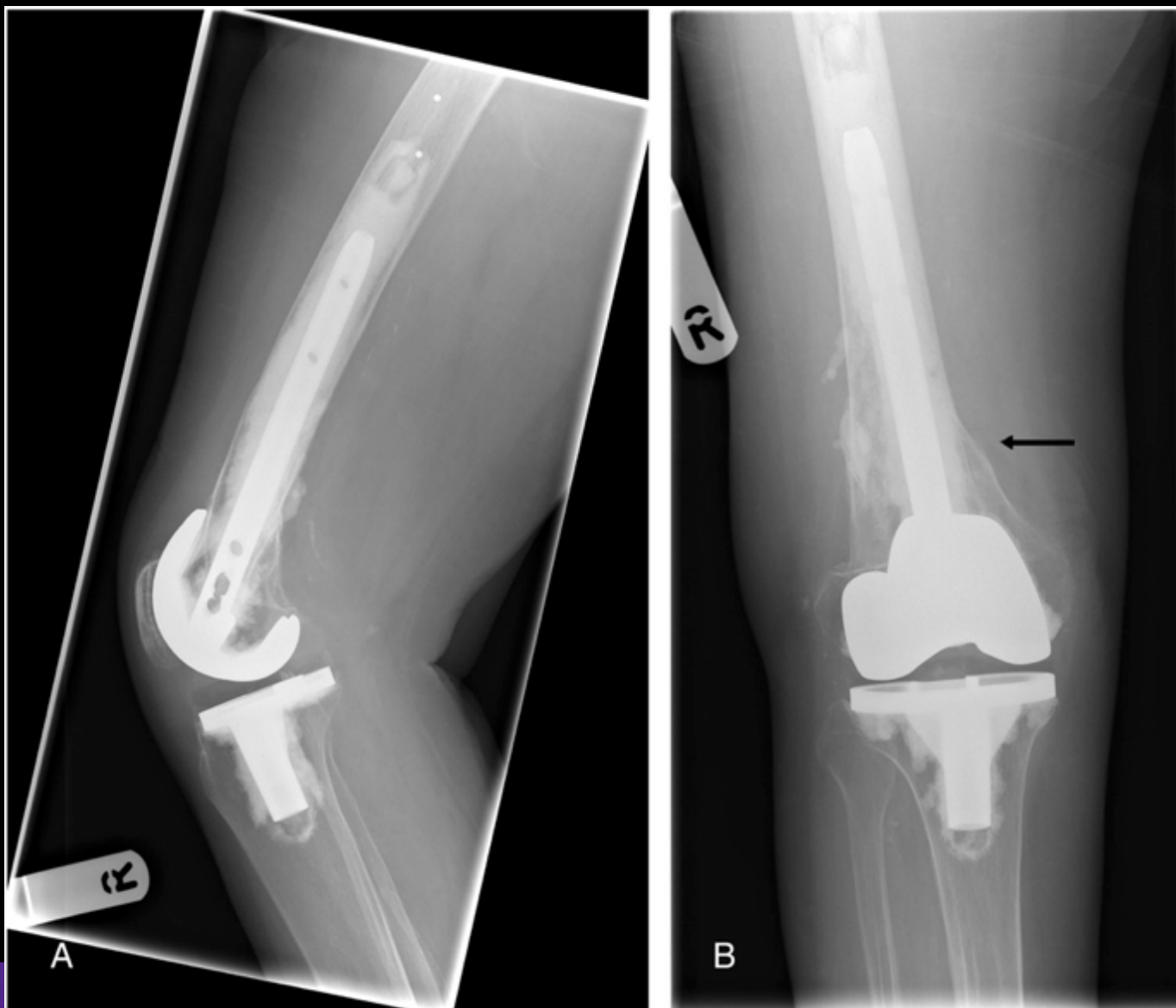
DN





Extreme Nailing

Nailed Cementoplasty





Distal Femoral Plating Technique

GOALS

- Biologic preserving !!!
 - Respect soft tissues
- Restoration of:
 - Mechanical axis
 - Length
 - Alignment / Rotation

Biologic
Felony

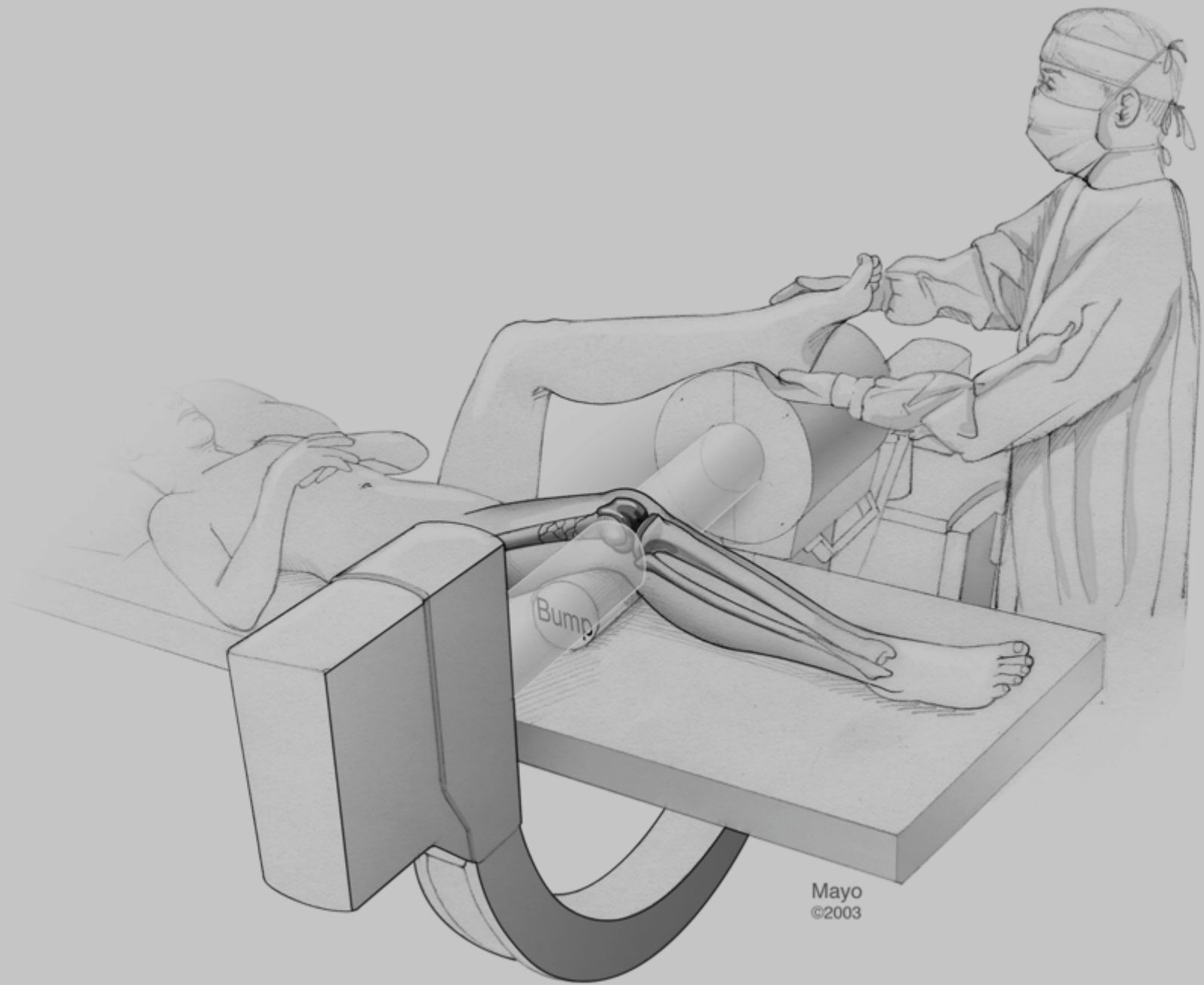


Non-articular or Simple Split



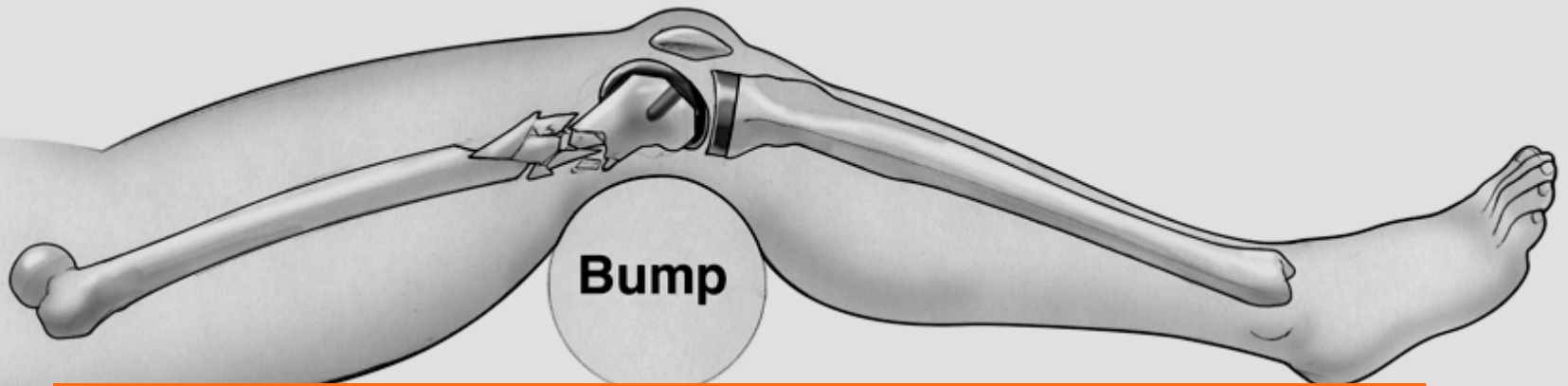
- Lateral approach
- ****Limited surgical dissection*
- *Percutaneous plate insertion*
- *Metaphysis Indirect Reduction*
 - *Bumps*
 - *Femoral Distractor*
 - *Percutaneous Pins*
 - *External fixator*





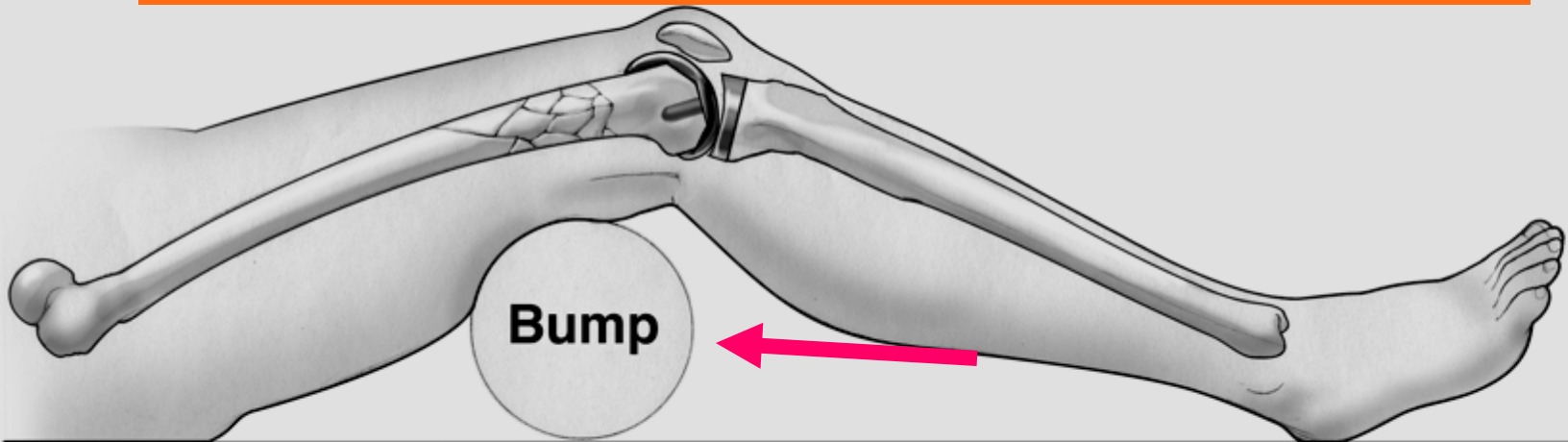
Mayo
©2003

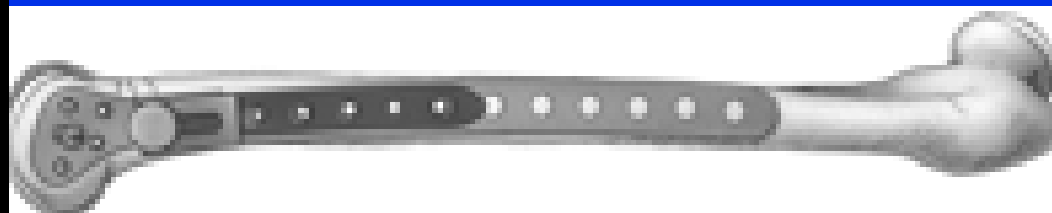
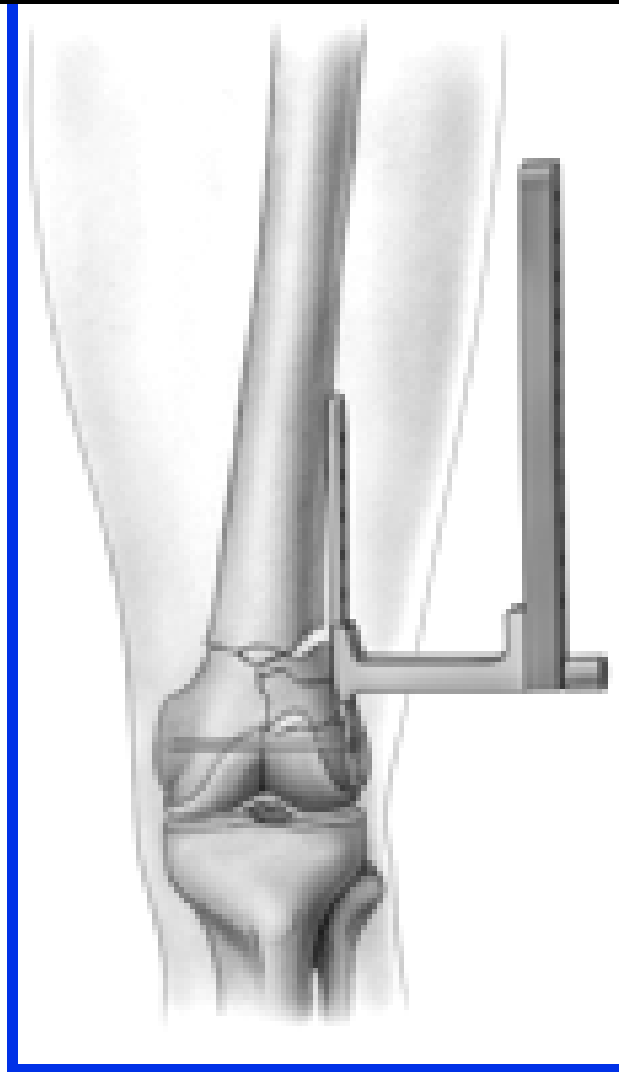
E1125372-001-0



Results of polyaxial locked-plate fixation of periarticular fractures of the knee.
Surgical technique.

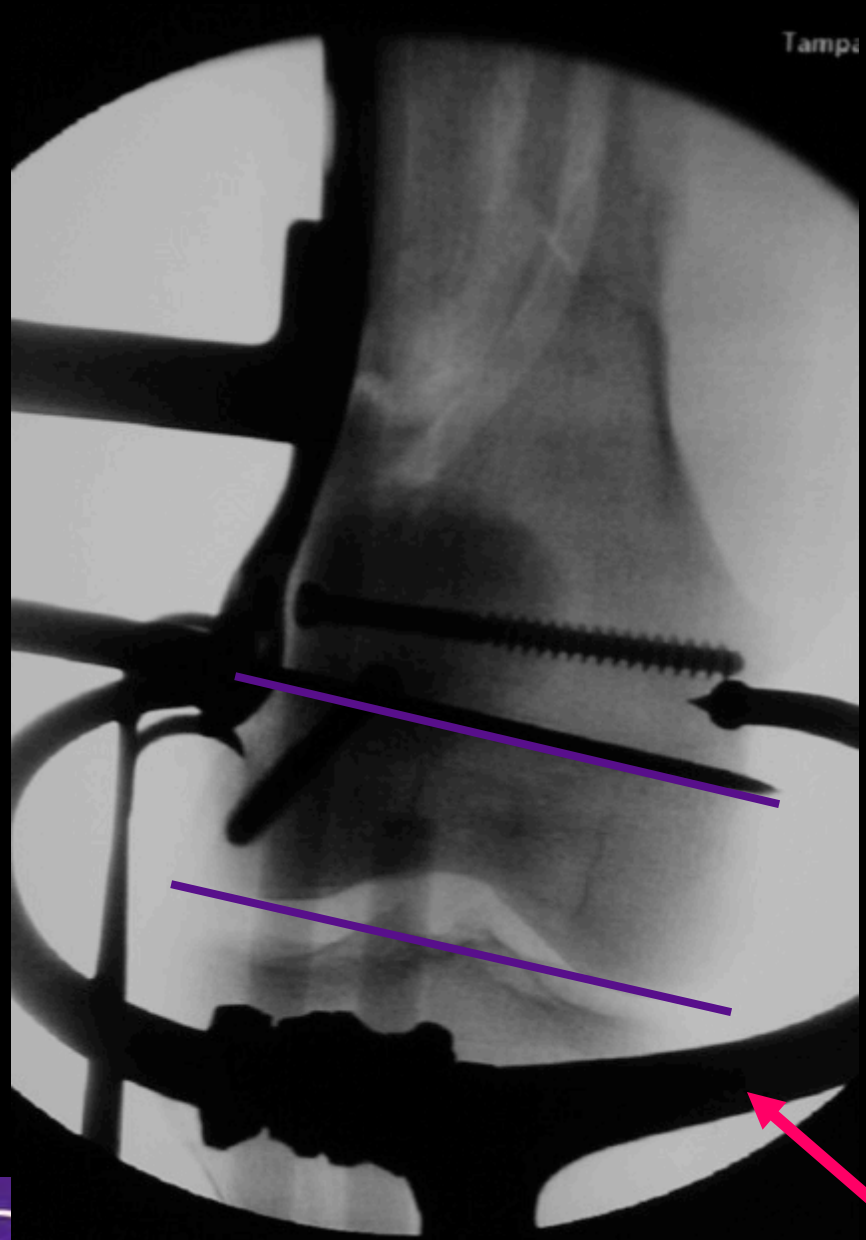
Haidukewych G, Sems SA, Huebner D, Horwitz D, Levy B.
J Bone Joint Surg Am. 2008 Mar;90 Suppl 2 Pt 1:117-30.



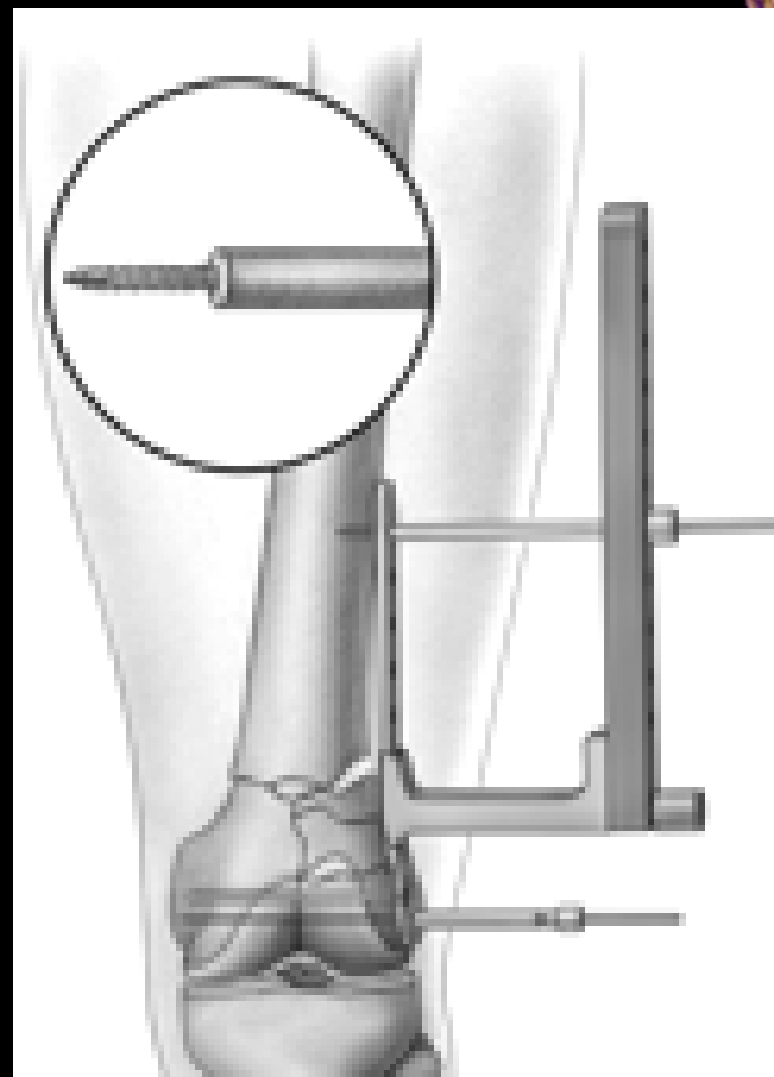
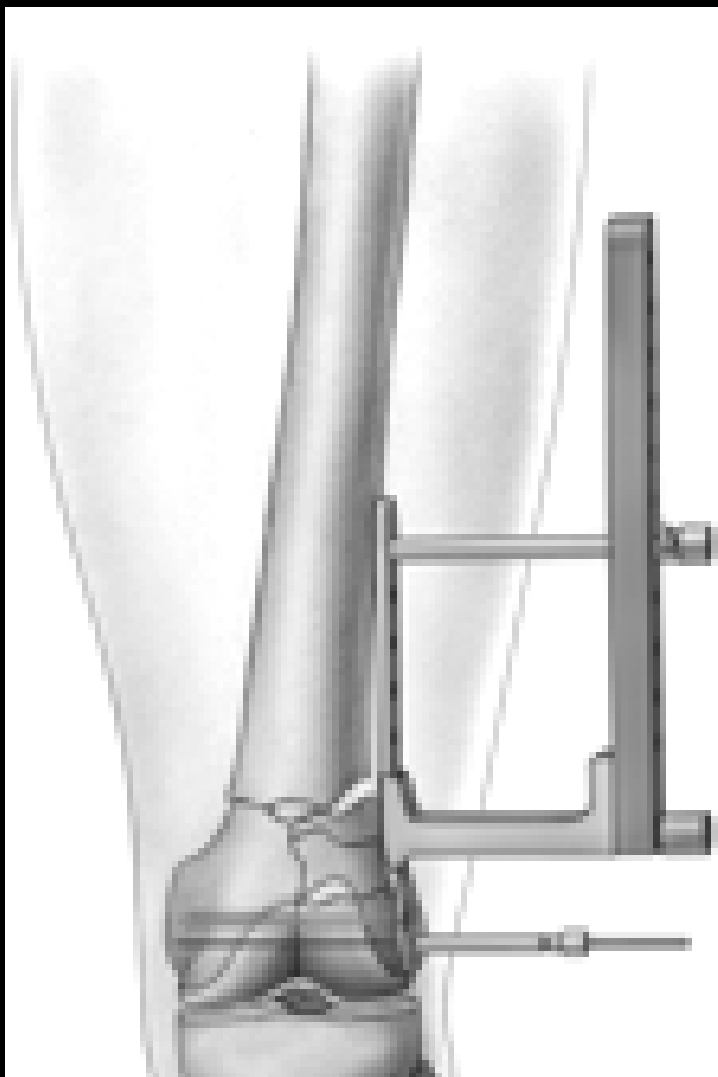




Tampa



cVp
mA

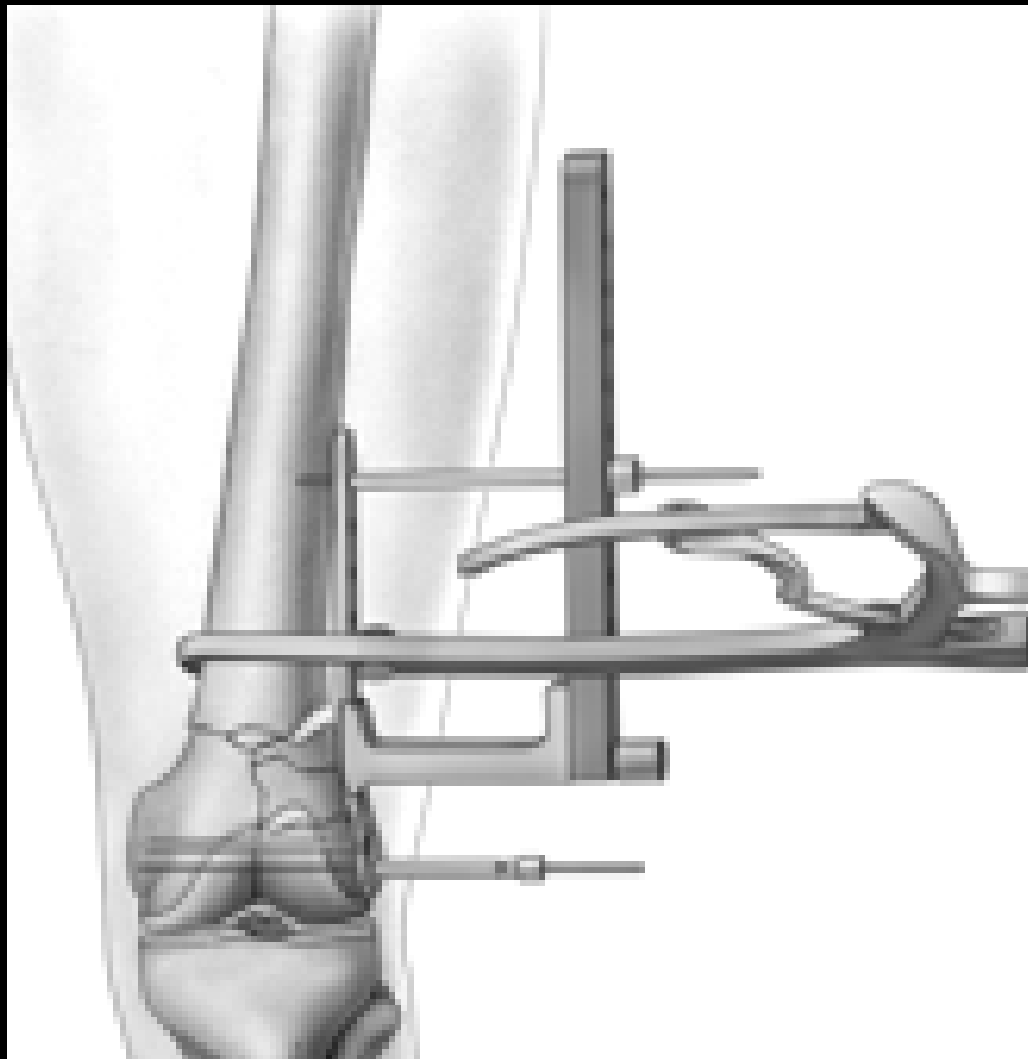


Results of polyaxial locked-plate fixation of periarticular fractures of the knee. Surgical technique.

Haidukewych G, Sems SA, Huebner D, Horwitz D, Levy B.

J Bone Joint Surg Am. 2008 Mar;90 Suppl 2 Pt 1:117-30.





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Plate Placement Problems



- Prior to complete plate fixation, must confirm appropriate location *distally and proximally!!!*



Plate Placement Problems



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Plate Placement Problems



- Prior to complete plate fixation, must confirm appropriate location *distally and proximally!!!*



Plate Placement Problems



**MALALIGNMENTS
USUALLY VALGUS**



Diagram Courtesy of
George Haidukewych, MD



**FRACTURE SITE
DISTRACTION**

**INABILITY TO
COMPRESS**

Diagram Courtesy of
George Haidukewych, MD

Podiatric Surgery



DISTRACTION

MALALIGNMENT

MALPOSITION

Diagram Courtesy of
George Haidukewych, MD



NONUNION

LOSS OF FIXATION

Diagram Courtesy of
George Haidukewych, MD



- CHALLENGES

- SITUATIONS FOR SPECIAL
CONSIDERATION

-SALVAGES

RetroIMN for PP FEMUR FXs



- Distal 1/3 Fx's around Primary TKR
 - No "box" (CR)
 - If "box" (PS) with:
 - Removable polyethylene plug
 - Pre-existing hole
 - Try to avoid "making a hole" with a metal cutting burr
- Less Invasive?
- More biologically friendly?



CHALLENGES



- Lack of access
 - “Box” (PS) without ability to pass
 - Revision TKR
 - THR above
- Iatrogenic damage
 - Patella or tibia polyethylene
- Limited Distal Fixation
- Limited offerings that actually “Dial-in-Deformity”
 - Worse with CR or PS ???



DEFORMITY



Due to entry access

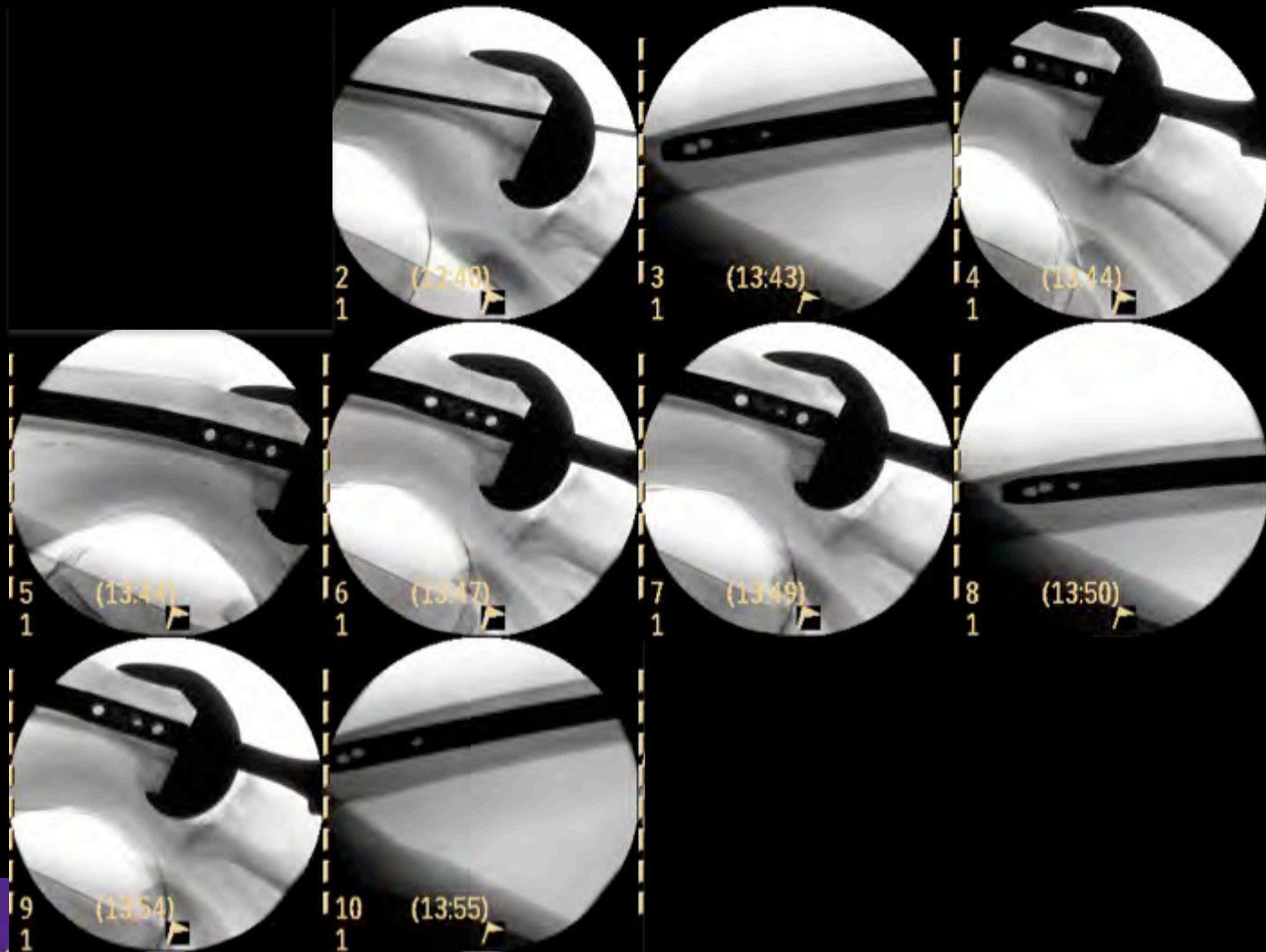
APEX-POSTERIOR

Lack of purchase in distal fragment

VALGUS



PS



2012-5-11 13:28:03

9:48:23 AM

2012-5-11 13:28:24

9:51:08 AM

CR

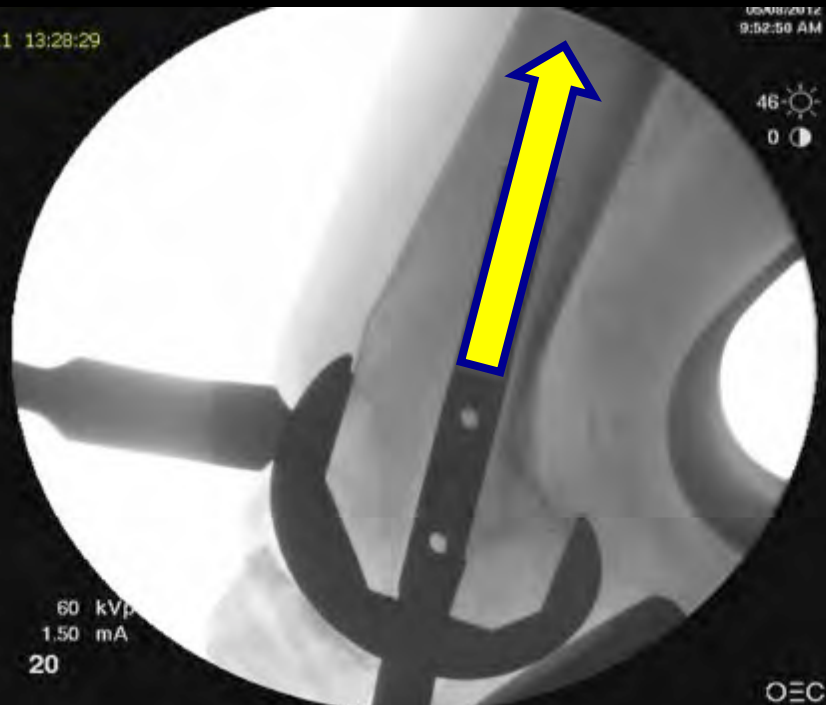


2012-5-11 13:28:02

9:48:19 AM

2012-5-11 13:28:29

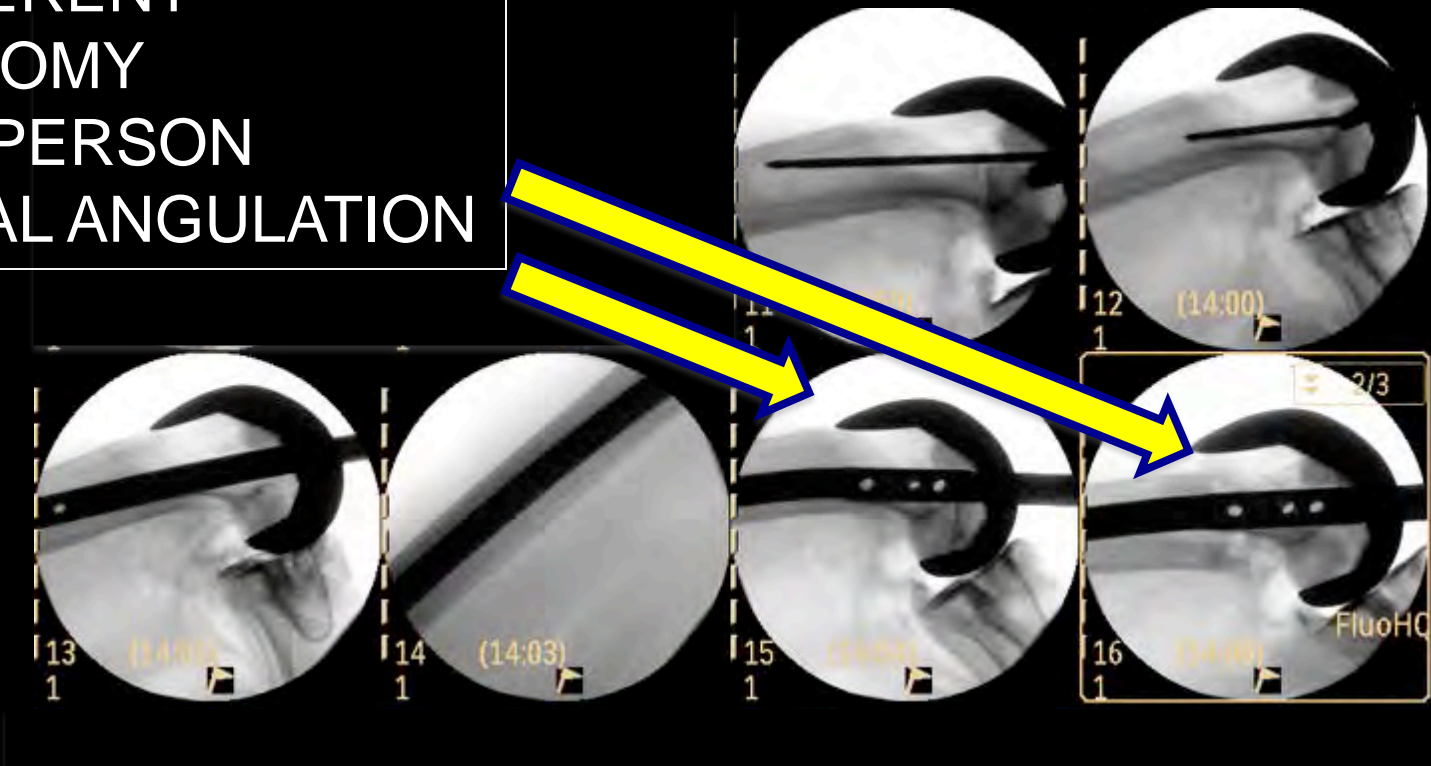
9:52:59 AM



CR

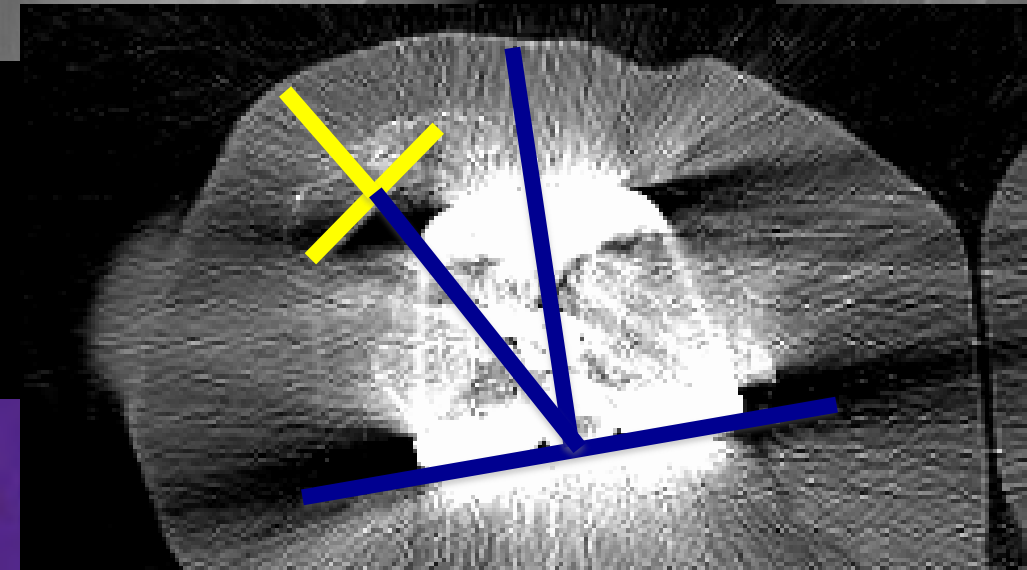
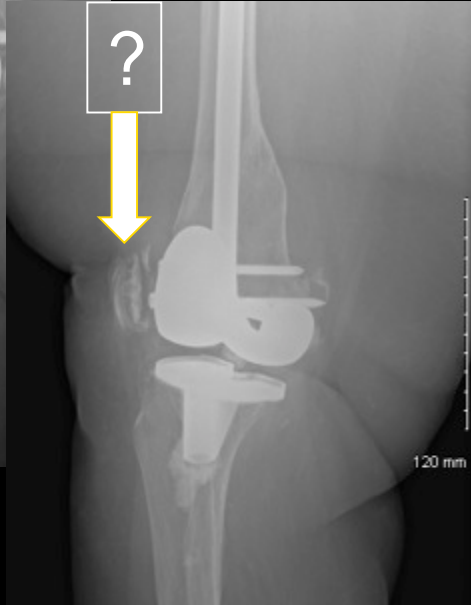
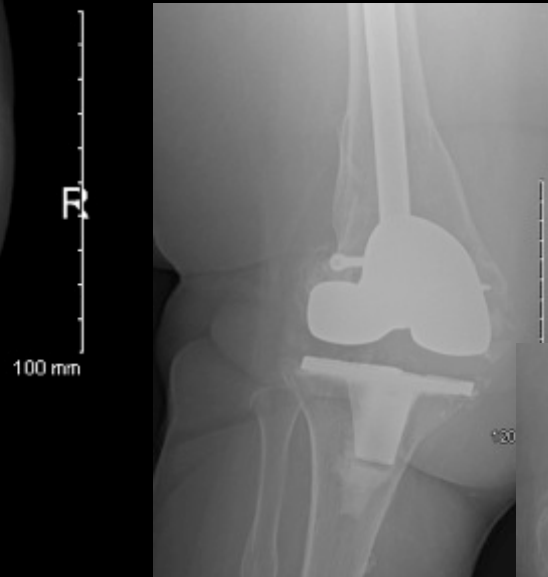
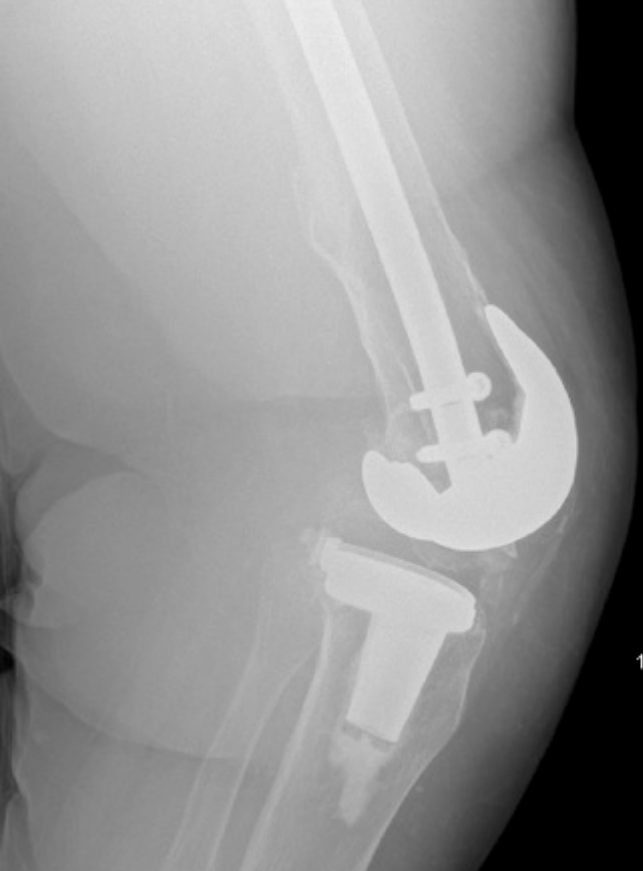


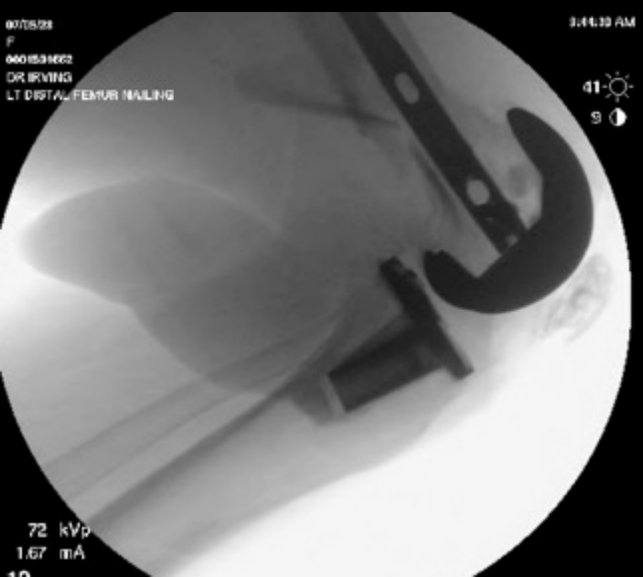
DIFFERENT
ANATOMY
PER PERSON
DISTAL ANGULATION





Nails CAN BE very FORGIVING at times...





Patient has full extension and >90 degree flexion!

LOL – Seriously?

SS Left Side

Nails CAN BE very
FORGIVING at times...
but
NOT ALWAYS !!!

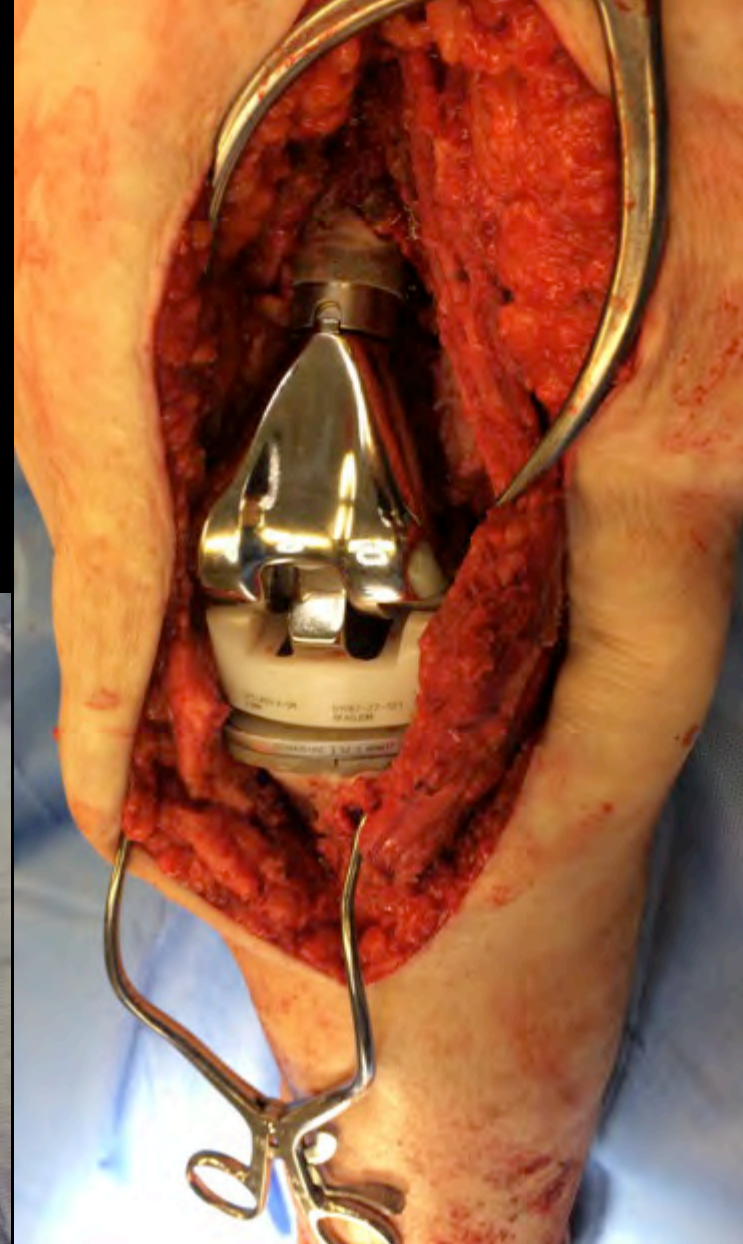
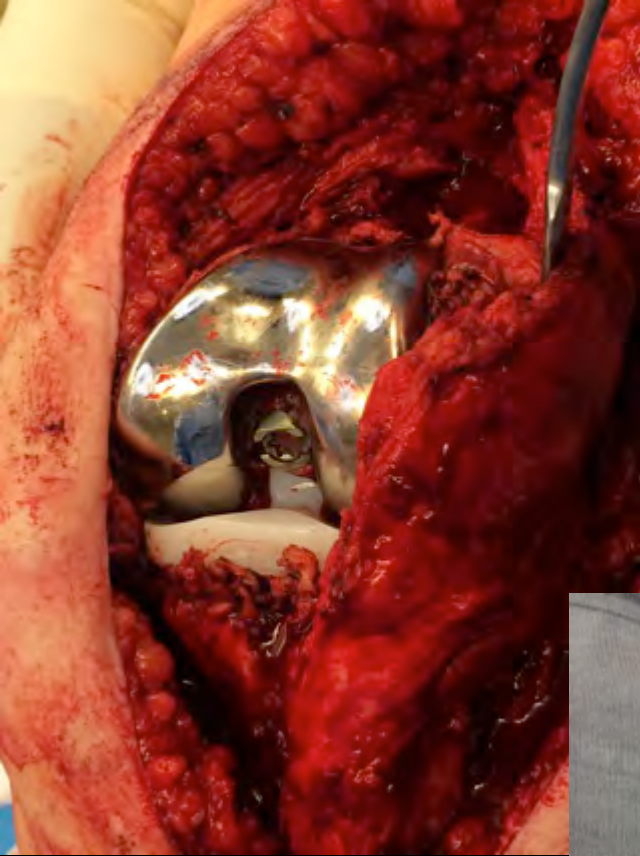


10 months from IMN
Limited ROM
“Why am I in PAIN !!!”

**INADEQUATE
STABILITY W/
CURRENT
IMN ALONE**



SS
Left Side



SS
Left Side



L
13

SOME ANSWERS FOR DENSITY OF FIXATION



- Multi-lock screws
 - Multi-directional support with fixed angle screw within a screw
 - LISS vs Blade idea
- Screw configuration
 - Additional screws
 - Take advantage of PM and PL condyles
- Plate attachment to Nail
 - ALL OF THE ABOVE !!!

SCREW CONFIGURATION

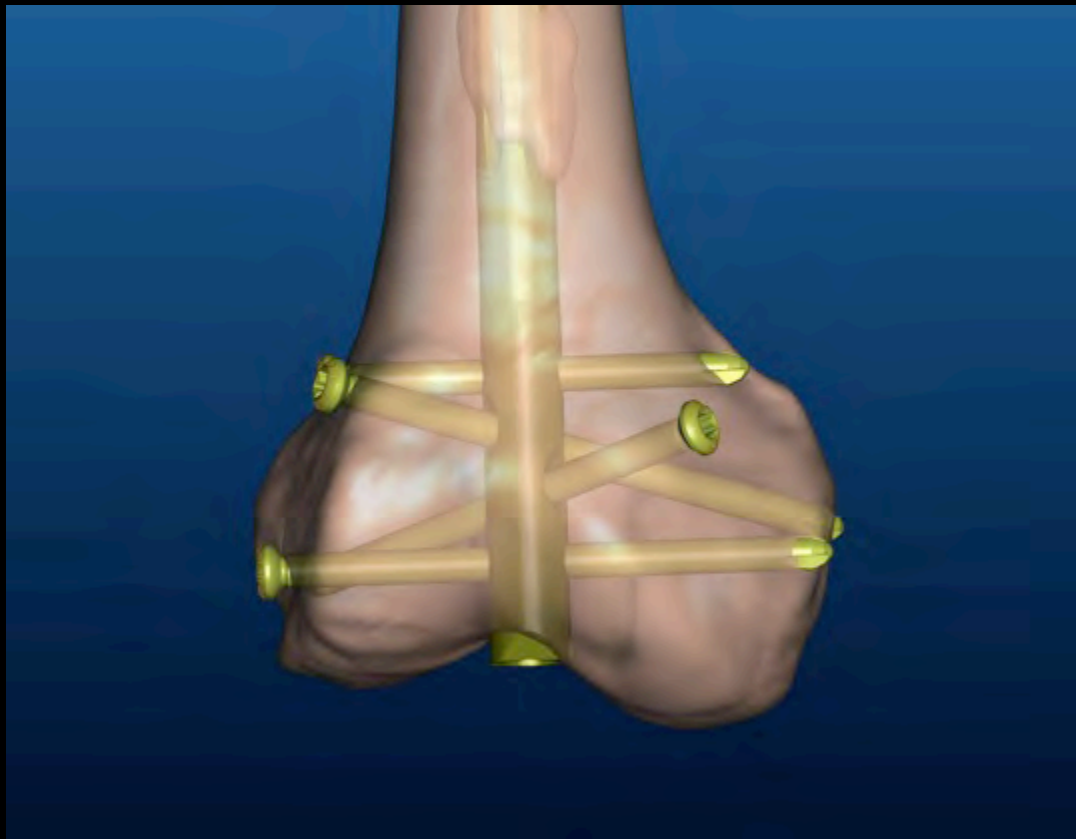
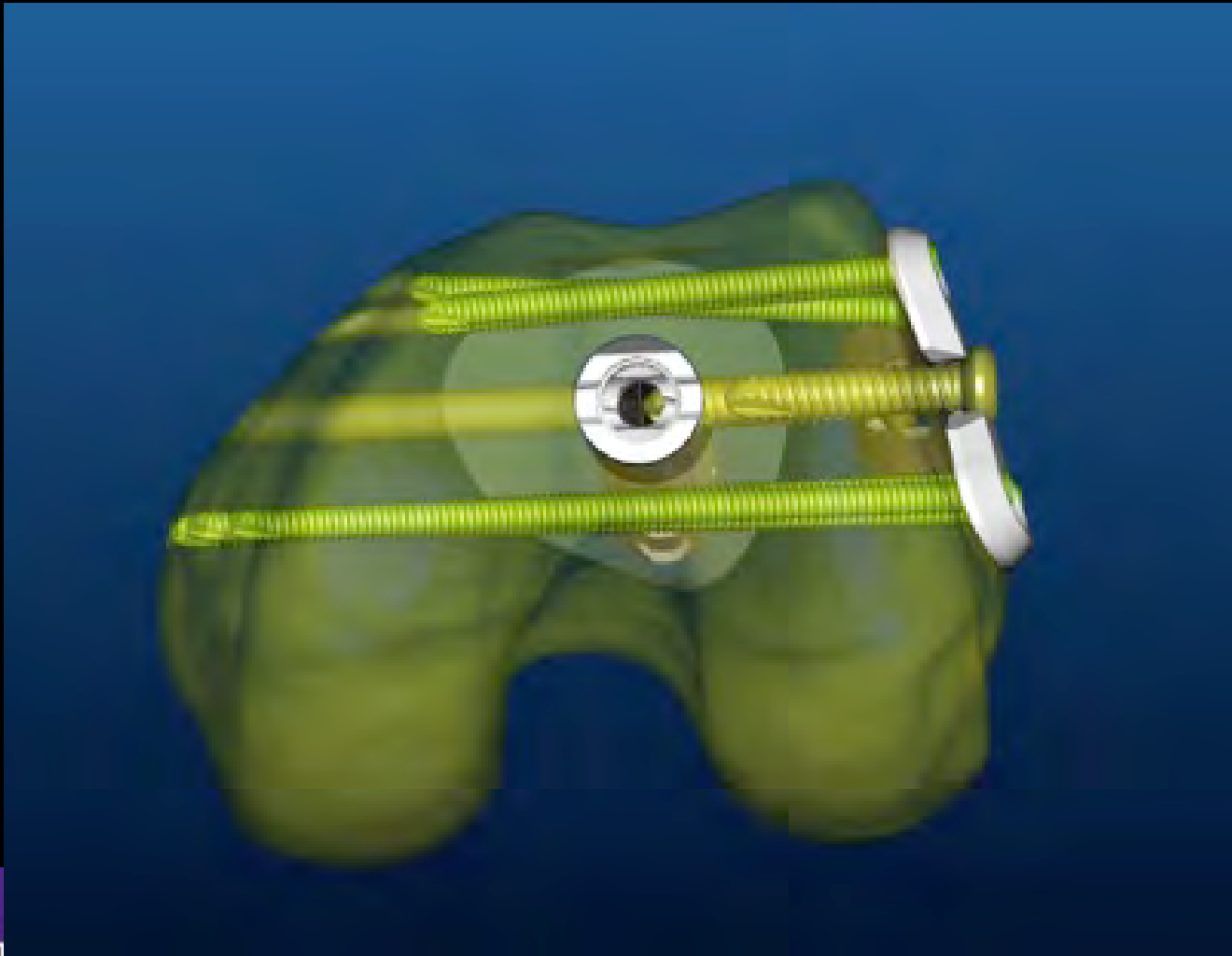




PLATE ATTACHMENT



WHERE COULD WE GO WITH THIS?



• Plate – Nail combo's

- Fx “needing” a nail with a THR above or rev TKR below
- Metaphyseal Nonunions requiring better fixation

Koval KJ, Seligson D, Rosen H, Fee K. J Orthop Trauma. 1995;9(4):285-91.

Distal femoral nonunion: treatment with a retrograde inserted locked intramedullary Nail

- 25% union rate of nonunions with retrograde IMN alone

- Osteoporosis
- Avoid deformity (Distal Femur, Proximal & Distal Tibia)
- “Dial-in” stability

• LINKED NAIL / PLATE COMBOS...

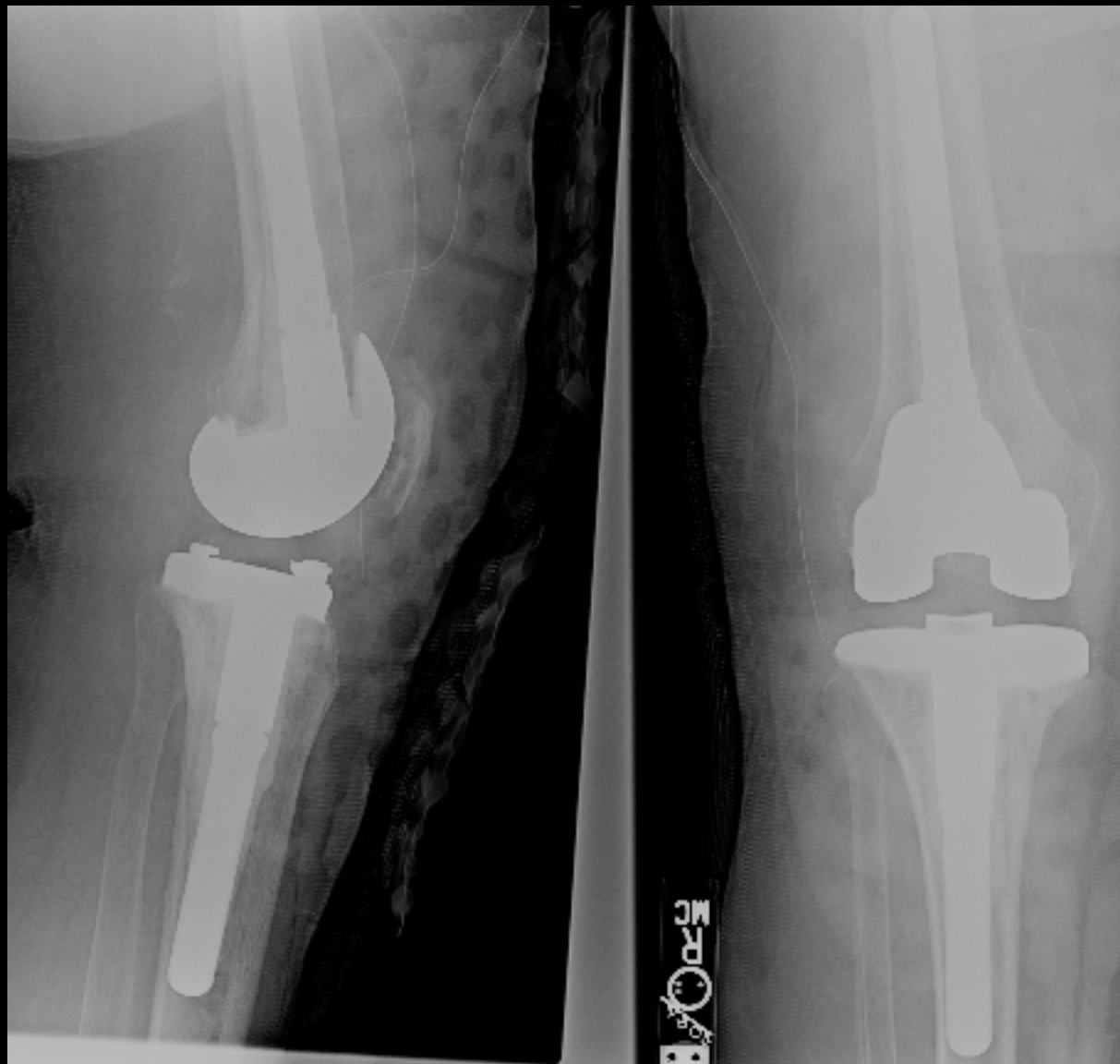


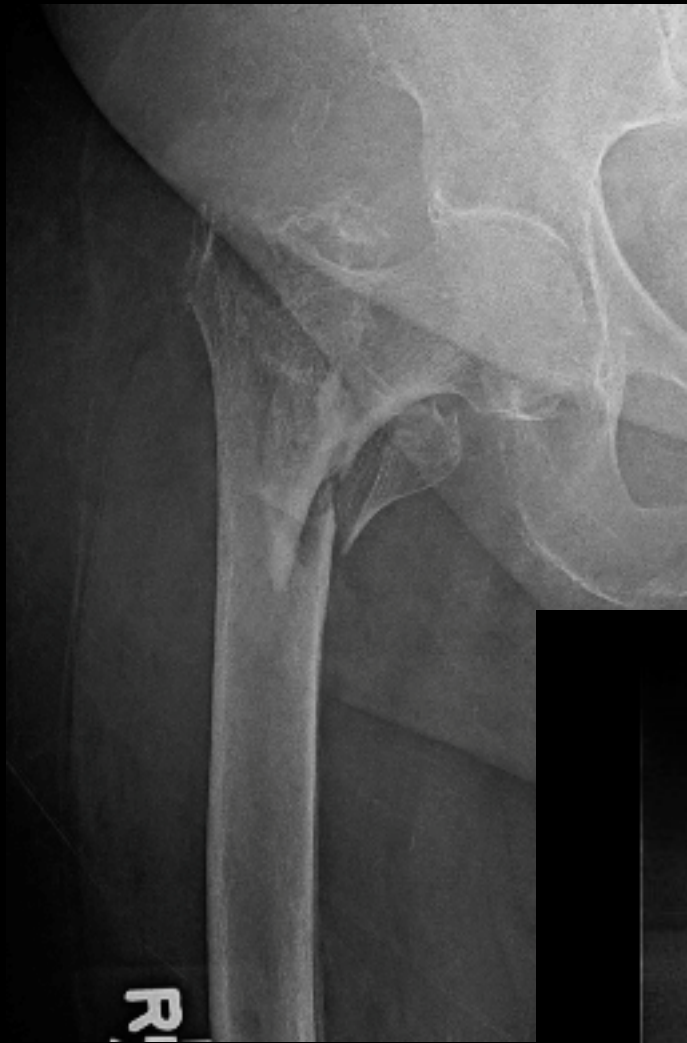
Patient BP

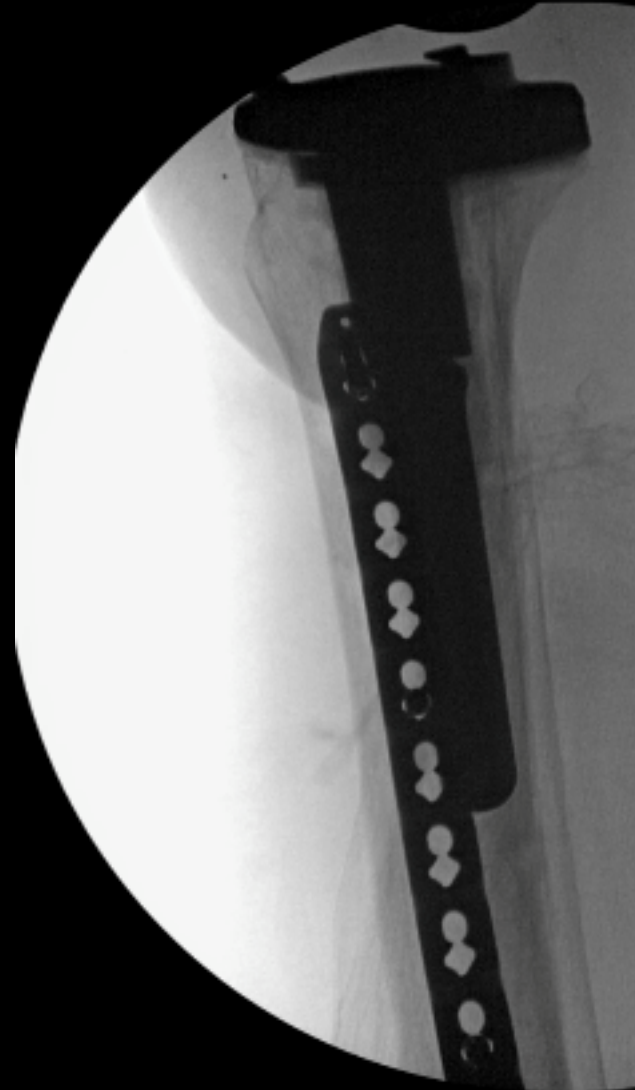
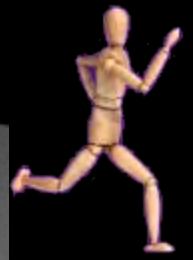
Periprosthetic tibia

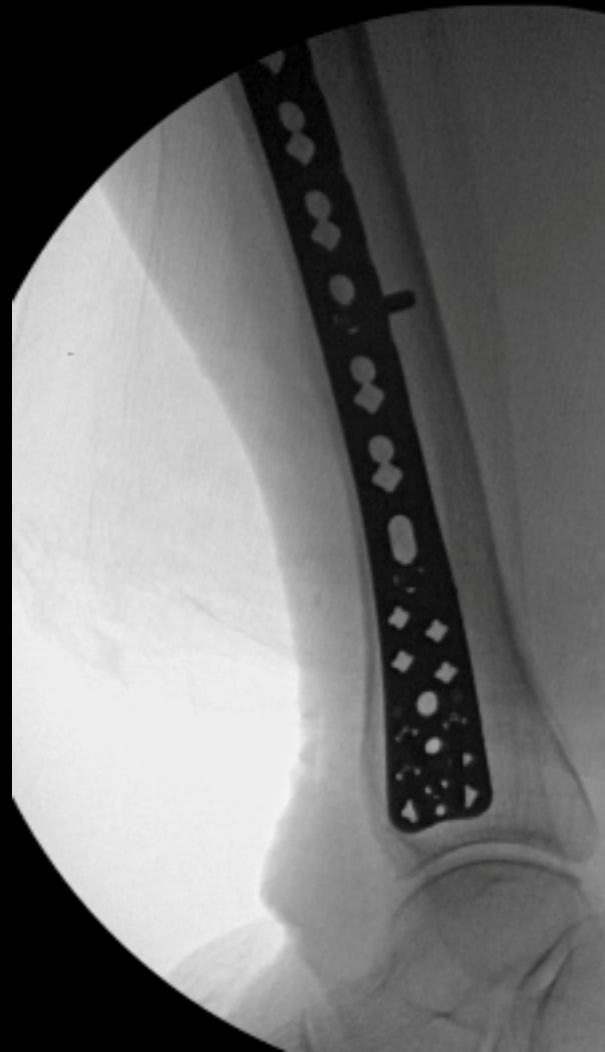
Subtroch fx above stemmed tkr

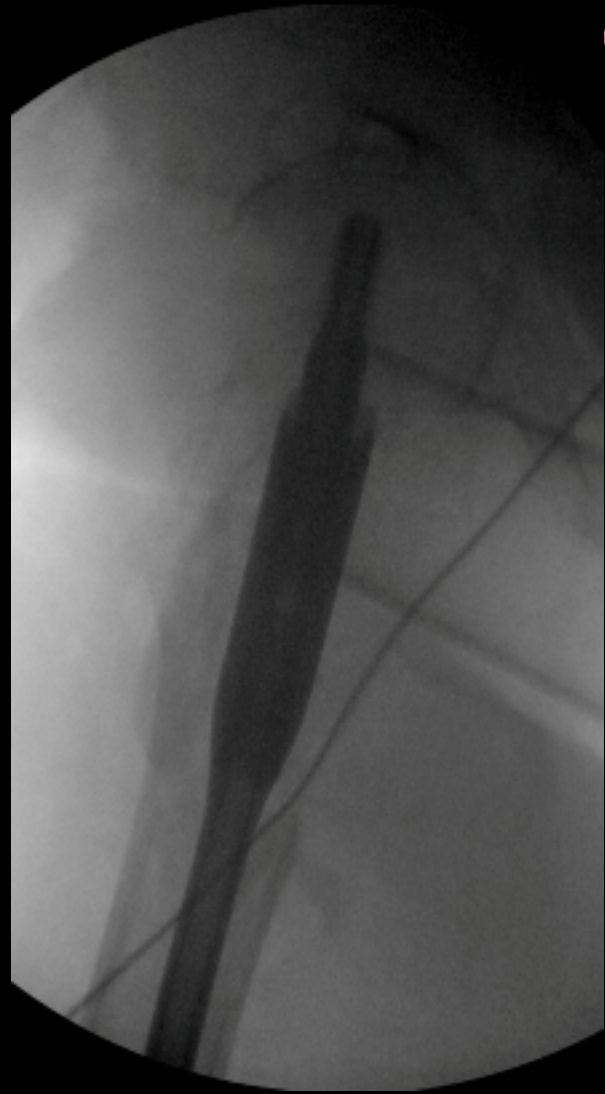
Original Revision – 6 months Prior



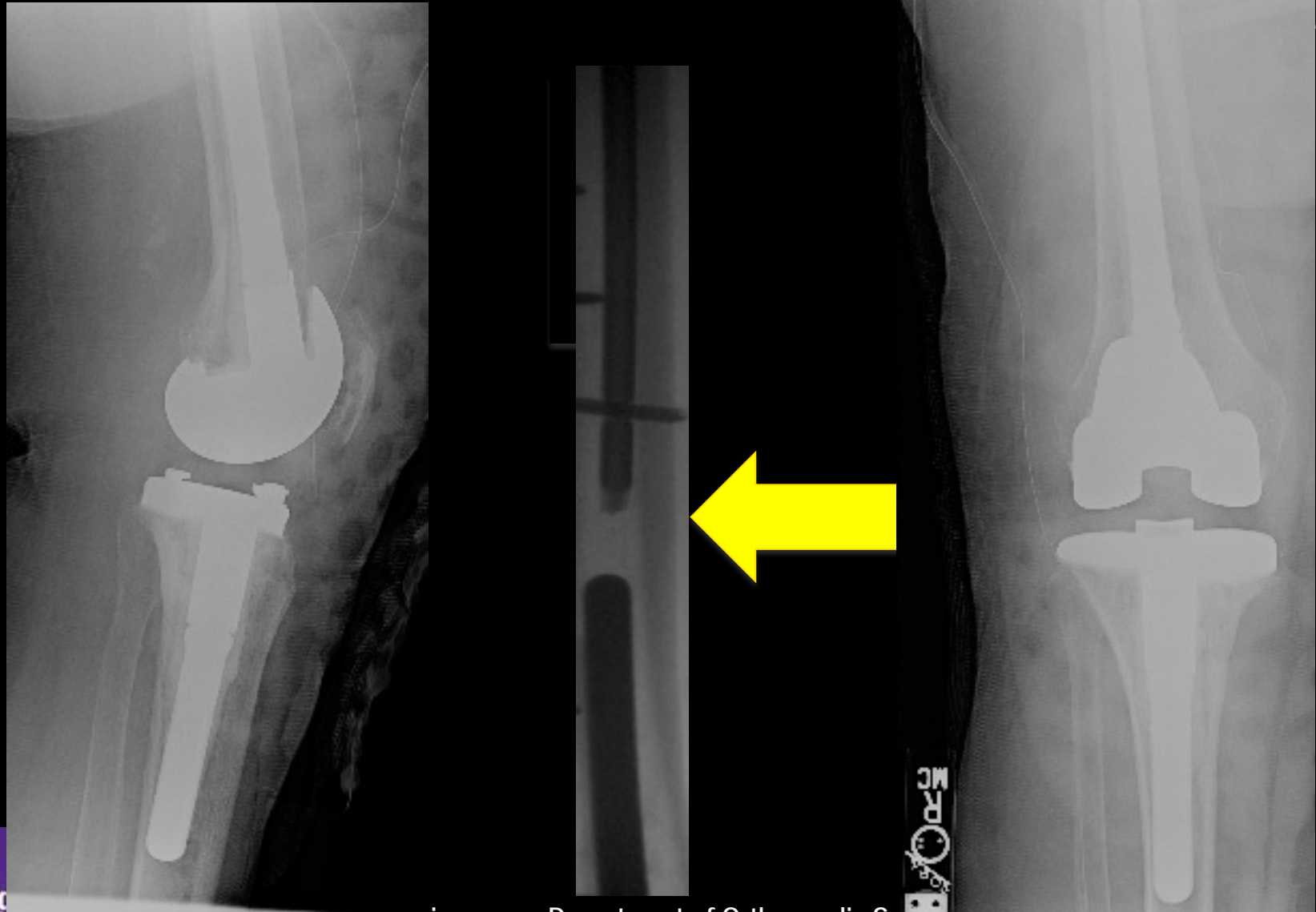


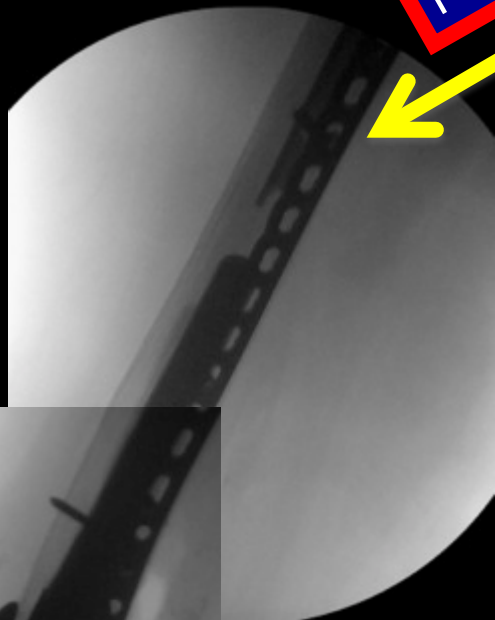
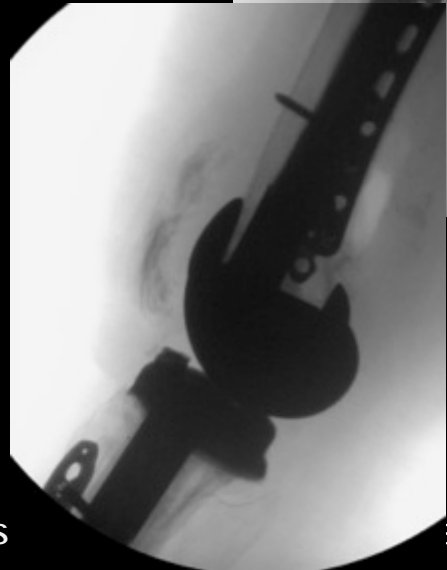
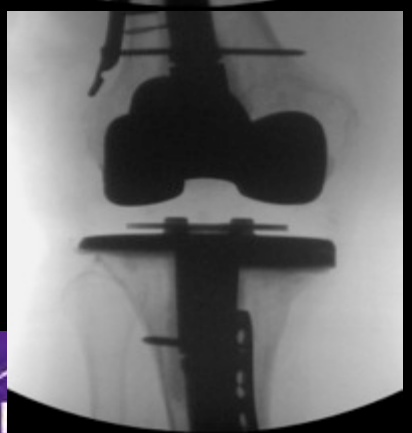




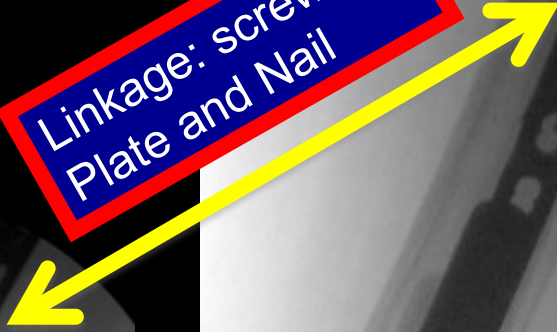


REMEMBER ???





Linkage: screw thr
Plate and Nail



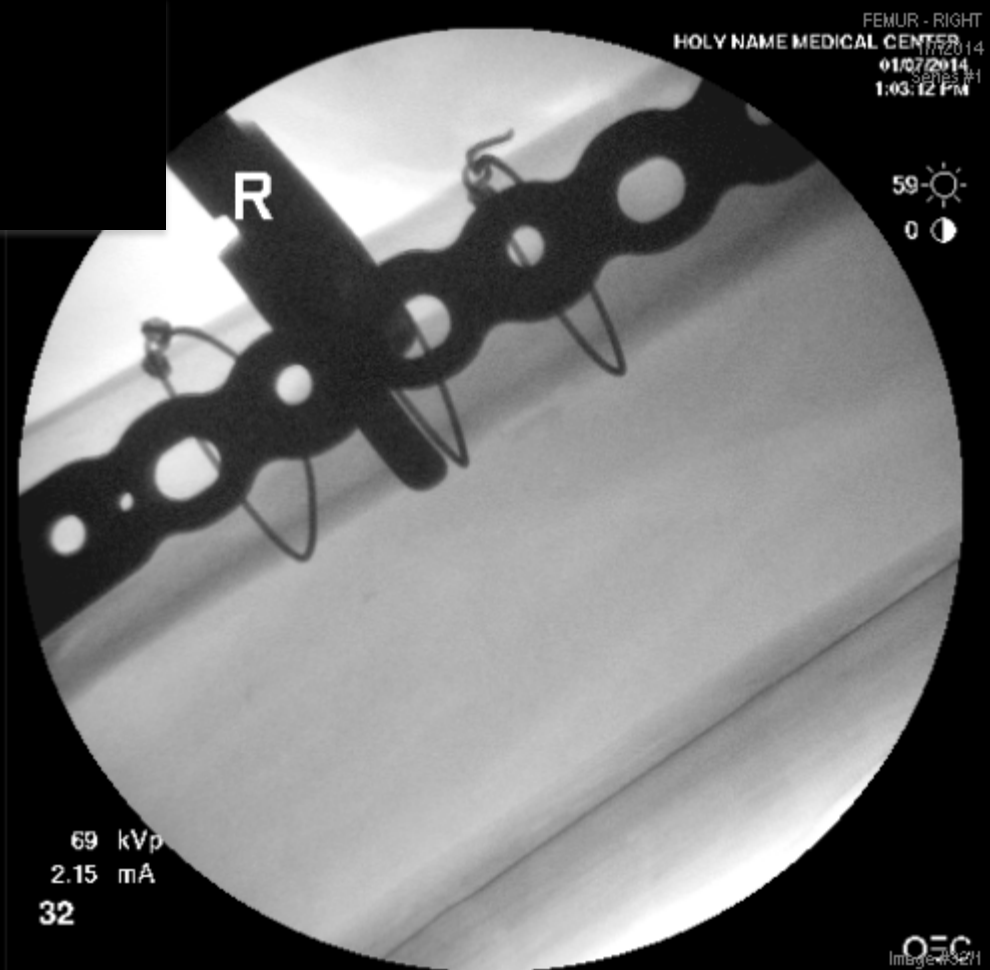
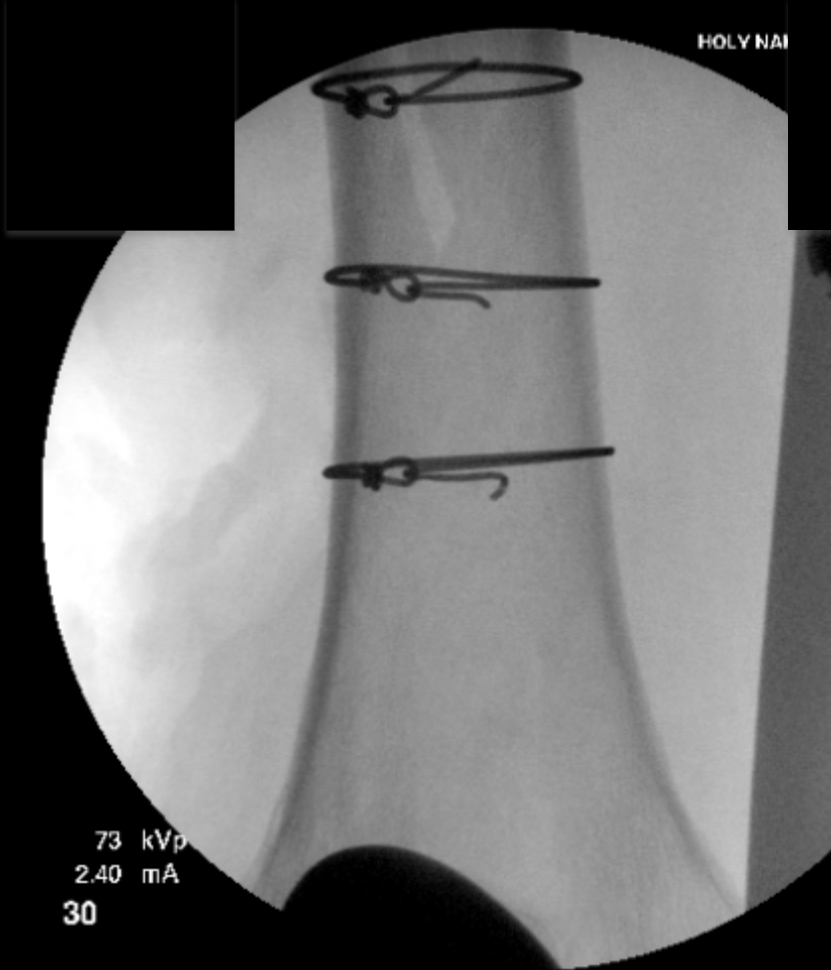


Reasonable operation choice done wrong...

77 yo male periprosthetic fracture



77 yo male periprosthetic fracture

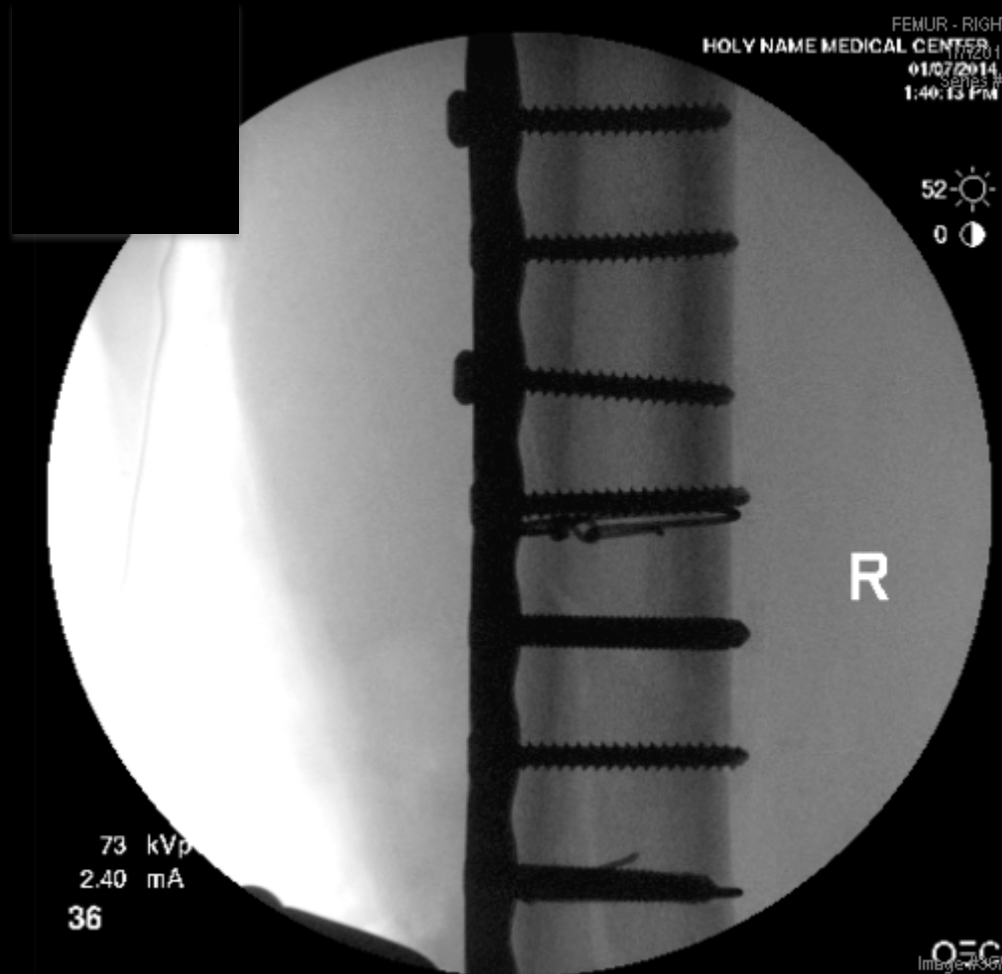


www.hol 256/H28

HOLYN www.hol 256/H28

OEC
Image #32/1
HOLY NAME MEDICAL CENTER

77 yo male periprosthetic fracture



www.hol 256/128

056
Image #3671
HOLY NAME MEDICAL CENTER

77 yo male periprosthetic fracture



Locked screws in Fx Zone

Excessively Rigid Fixation

Short segment proximal fixation

NOT Balanced Fixation

Multiple cerclage

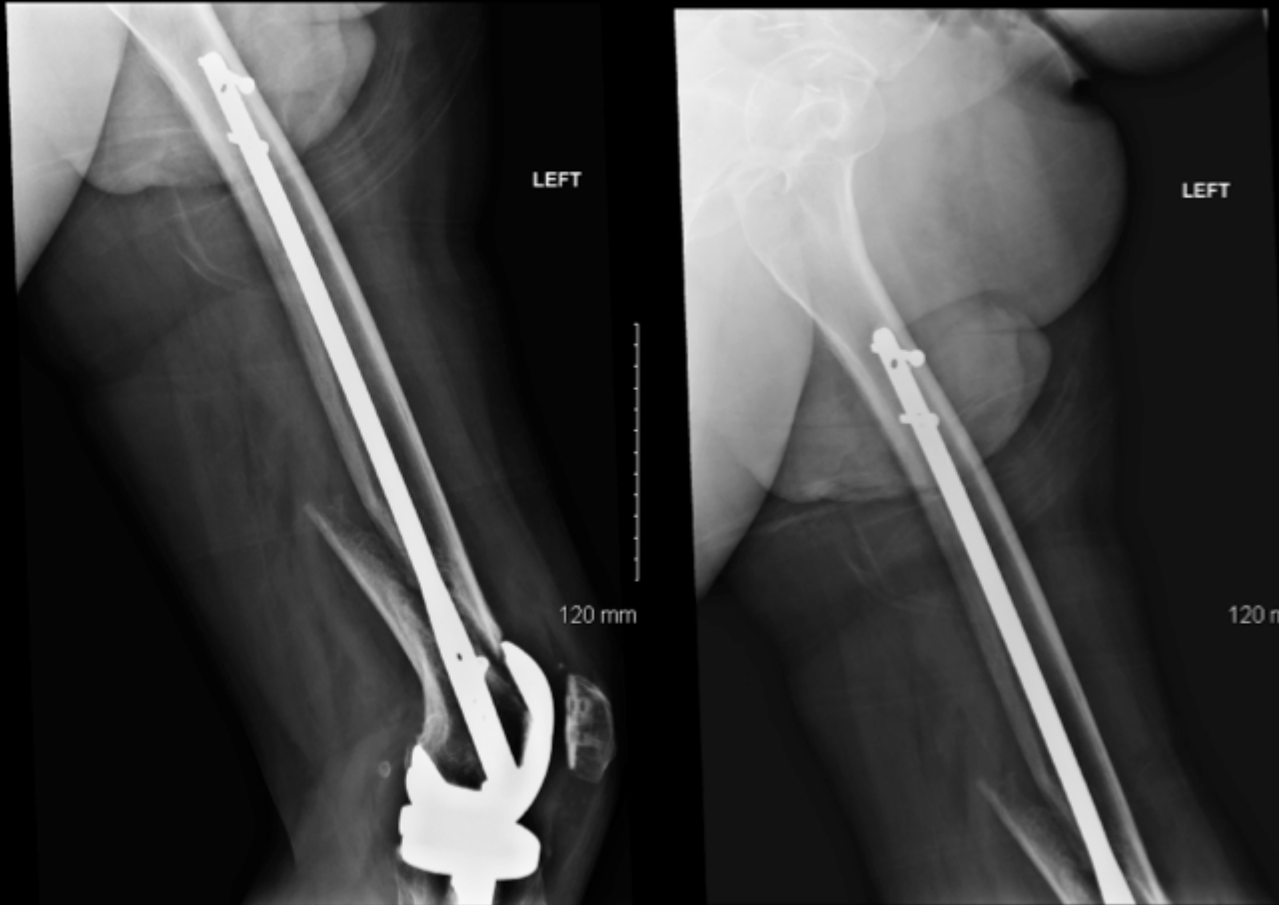
Dissection to get “Chicken Claw”



77 yo male periprosthetic fracture



EV – vacation in Mexico gone wrong



EV



EV



JZ



Distal Femoral Fx 10 yrs ago w/ 4 time nonunion s/p platings above TKR

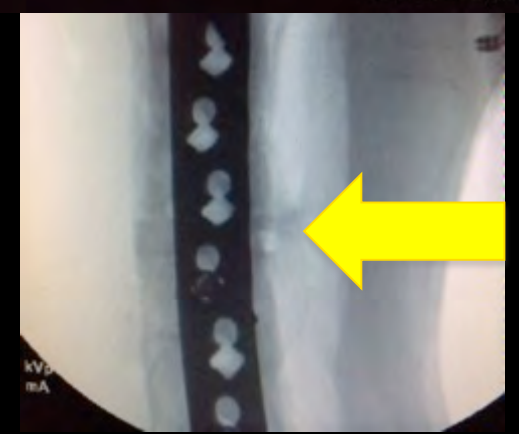
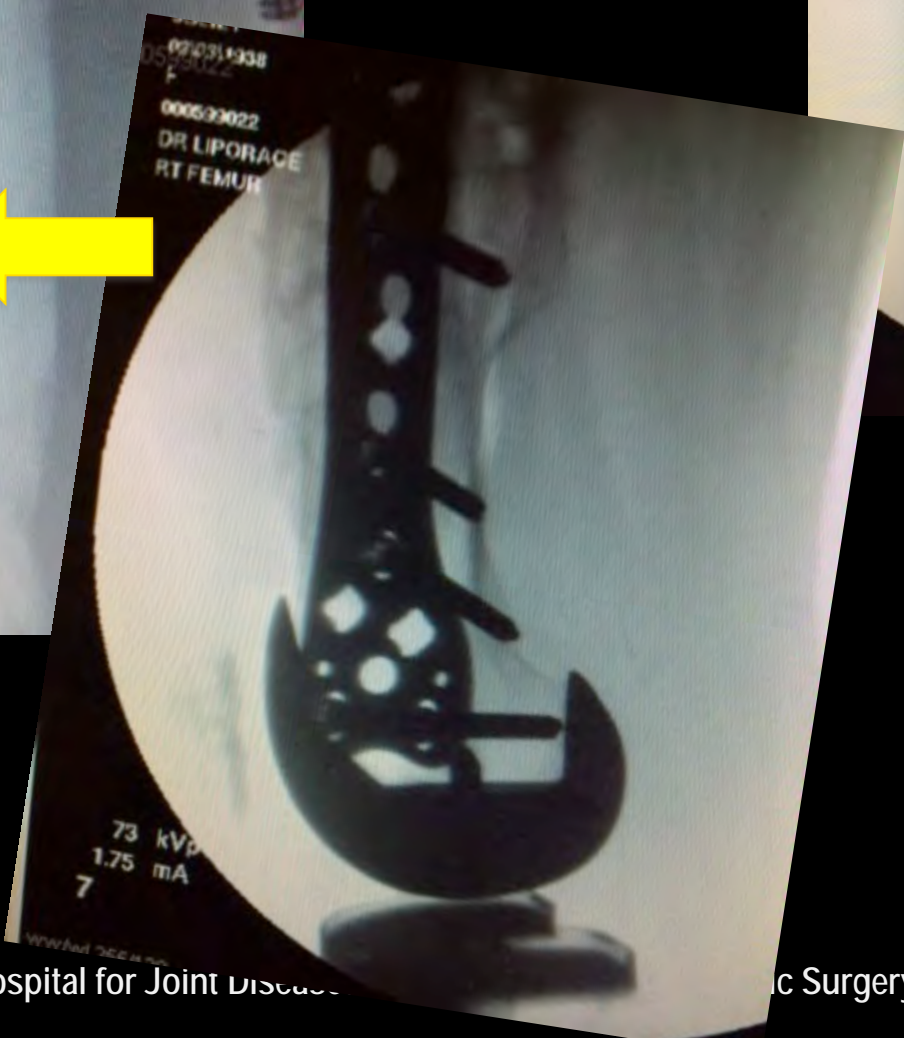
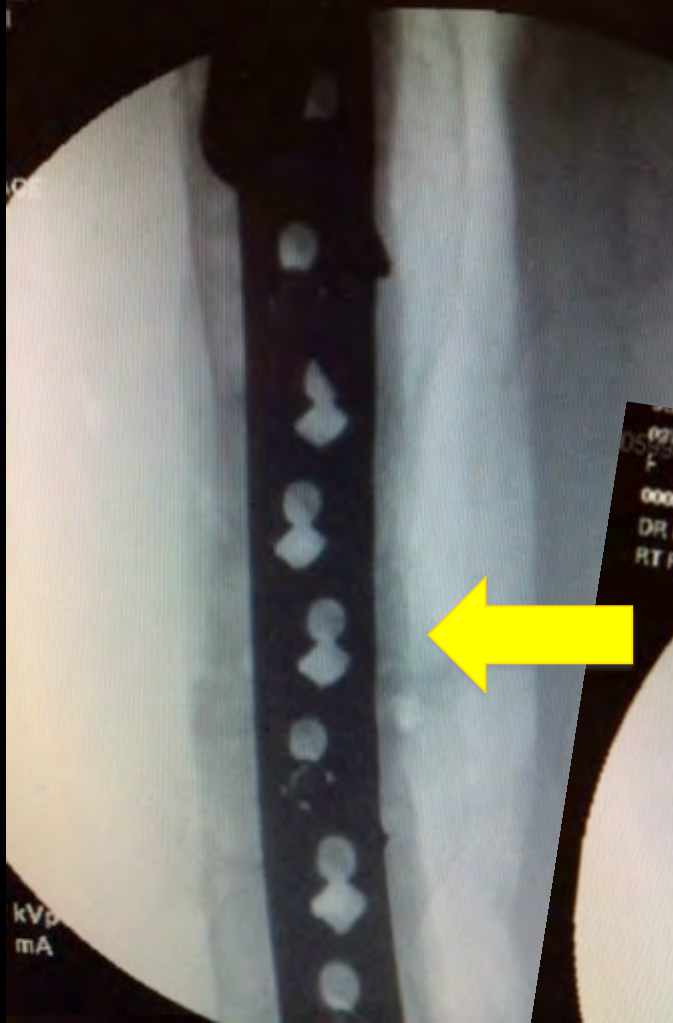
THR above that had previous fx at stem tip

Non-ambulator x 2.5 years

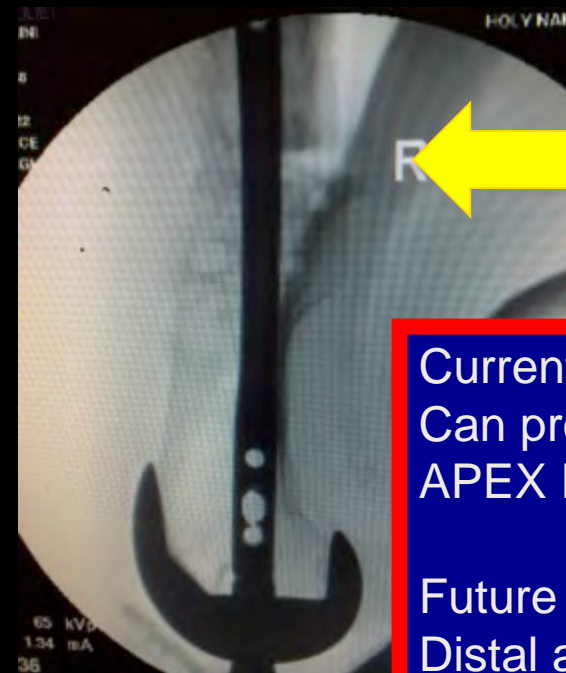
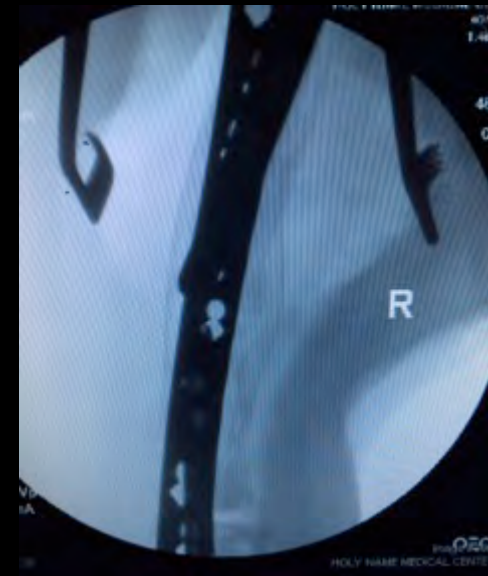
*****INFECTED*****



ROUND 1
RESECTION ATROPHIC NU
ANTIBIOTIC PLATE



ROUND 2: Nail - Plate



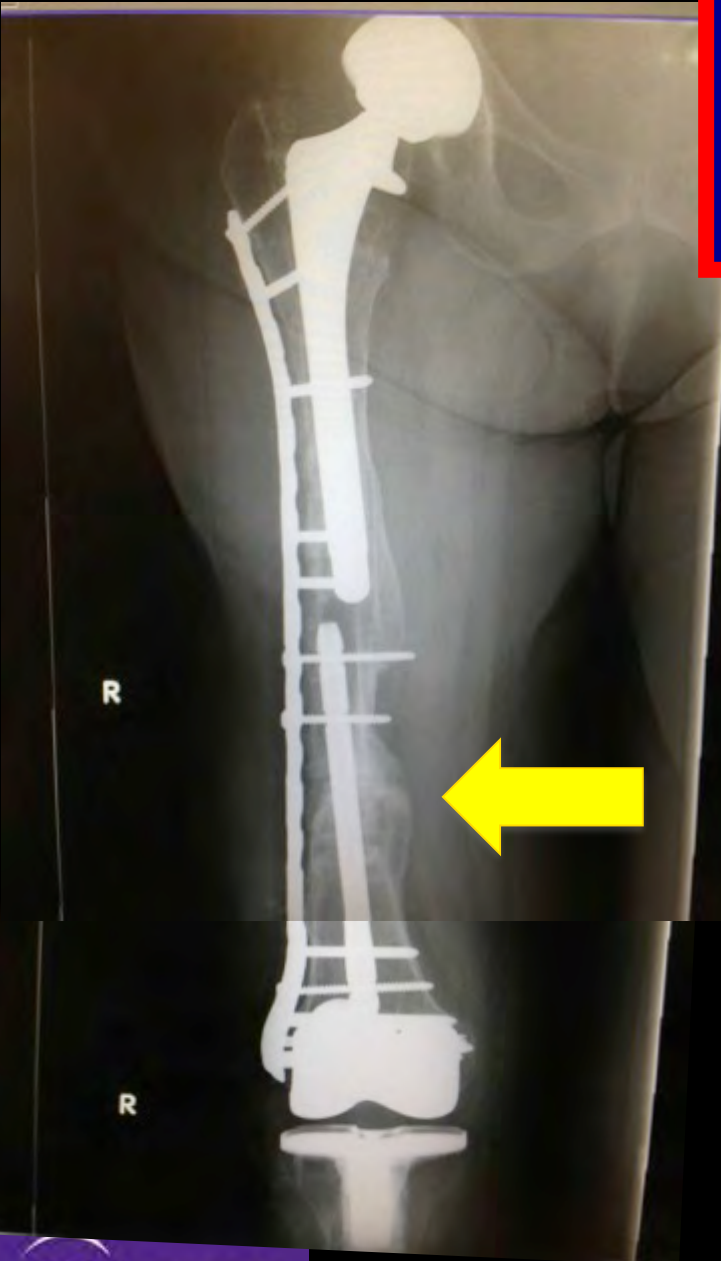
Current IMN offering
Can promote
APEX POSTERIOR:
Future Directions →
Distal angular options?



LINKED Plate / Nail
BOTH:
Proximally &
Distally w/ IMM



2.5 months post-definitive op
Uses walker – 1st time in 2.5 yrs
Proximal and Distal N/P Linkage



CALLUS

PLATE-NAIL SUMMARY



- Improve “reliability” and “feasibility” of current retrograde IMN usage
 - Improve stability – DISTAL FRAGMENT
 - Decrease late deformity
- Allow for improvement with ease of REDUCTION
- PREVENTATIVE Tx of potential Interprosthetic fx
- Allow for expanded IMN nailing indications
- Can “dial-in” desired amount of STABILITY

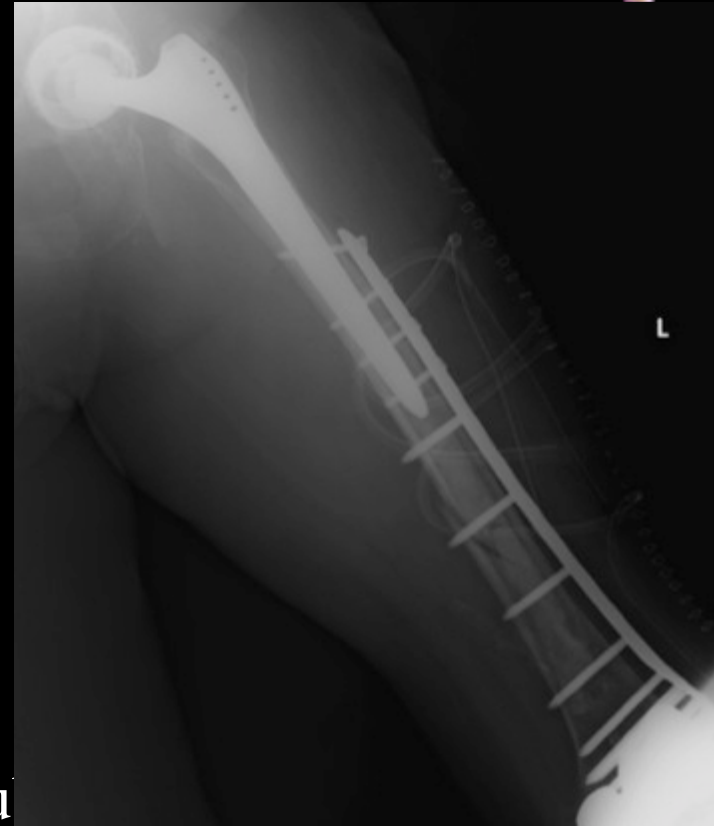
Future directions



- Implants to accommodate tibia IM fixation
- Modular implants
 - Modular Plate
 - Modular Nail / Plate or Locking washer
- Mating Implants
 - TKR with THR above

Top 5 DO's

- Complete radiographs
 - Implant or bone incompetence
- Distal Femur Fx's if implant stable
 - INDIRECT reduction techniques
- Distal Femur Fx's retrograde IMN
 - Check box status
 - "Healthy" incision
 - Don't ream polyethylene
 - Don't leave reamings in joint
- Consider polyaxial implants and bone su
augmentation



• If THR above, span both implants

(Platzer P, et al: Injury 2010)

Top 5 DON'Ts



- Don't accept axis deviations → implant wear
- Don't leave loose implants
- Don't use incompetent fixation
 - Allograft with cables ONLY
 - Wires only
 - Screws only or NON-Balanced plate fixation
- Don't delay post-op ROM
- Don't delay surgery in elderly
 - Systemic manifestations similar to hip fx's



Thank you