Periprosthetic Lower Extremity Fractures:

What and When to Do Something

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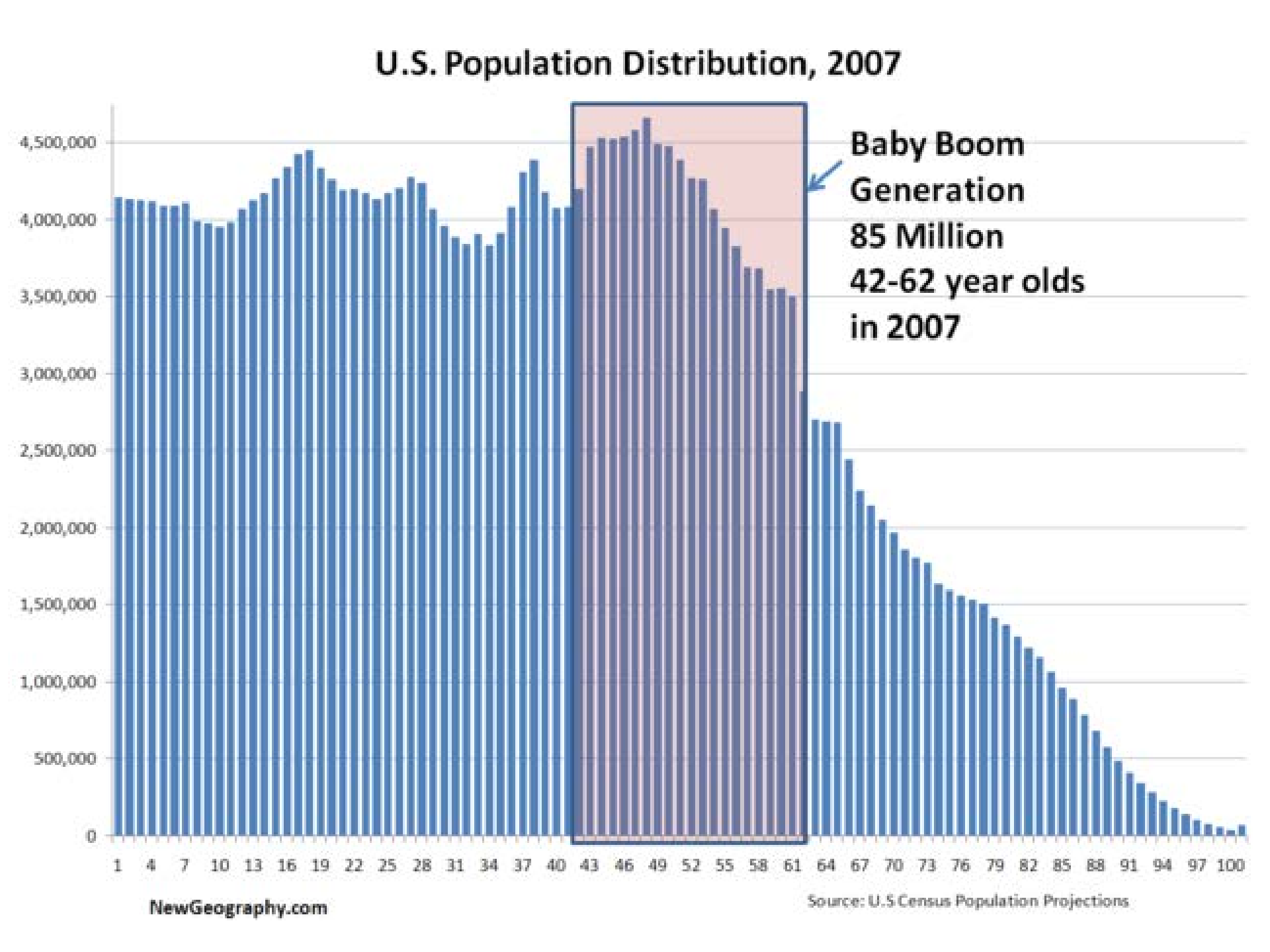
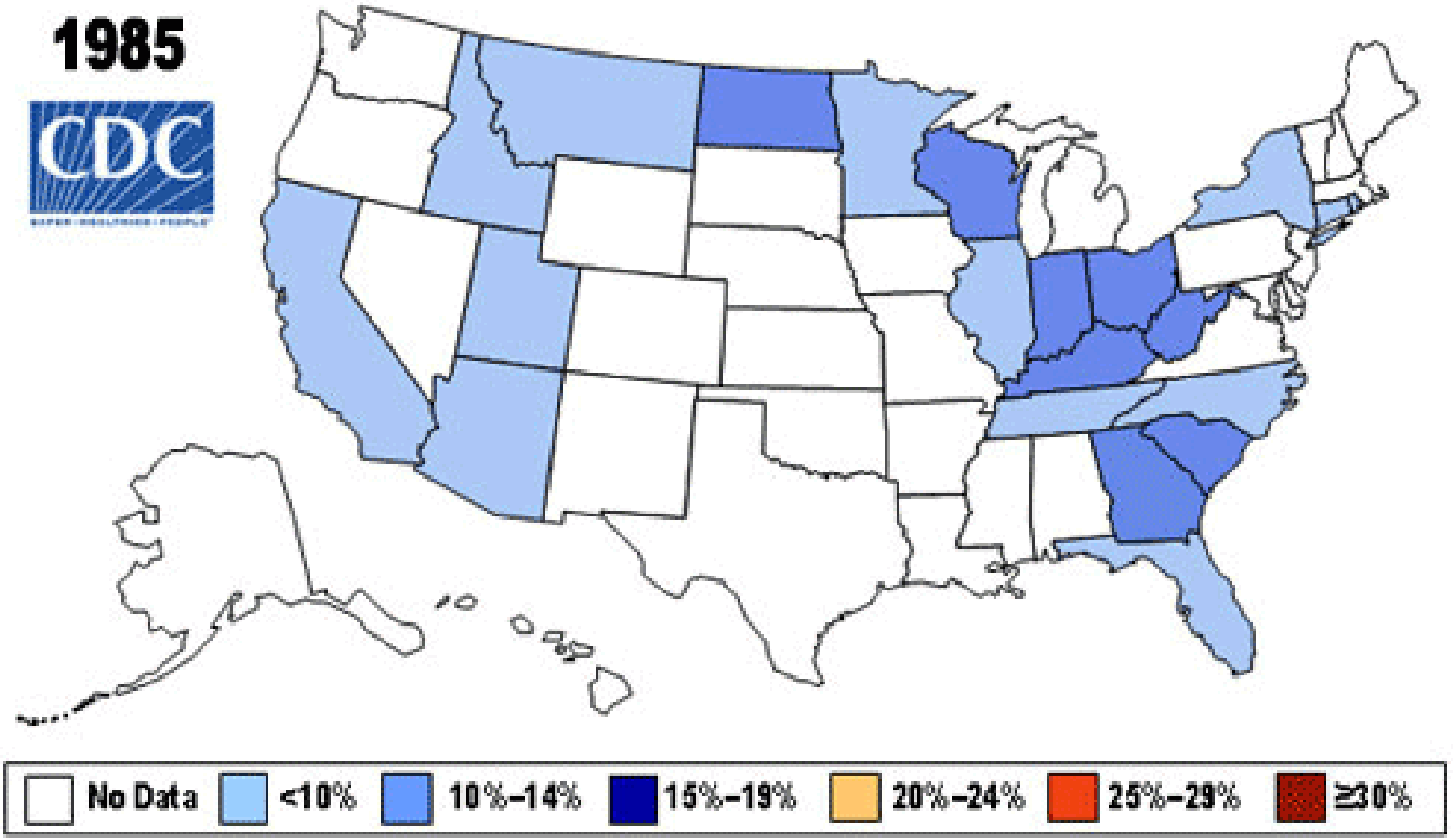
Dignity Health Medical Group

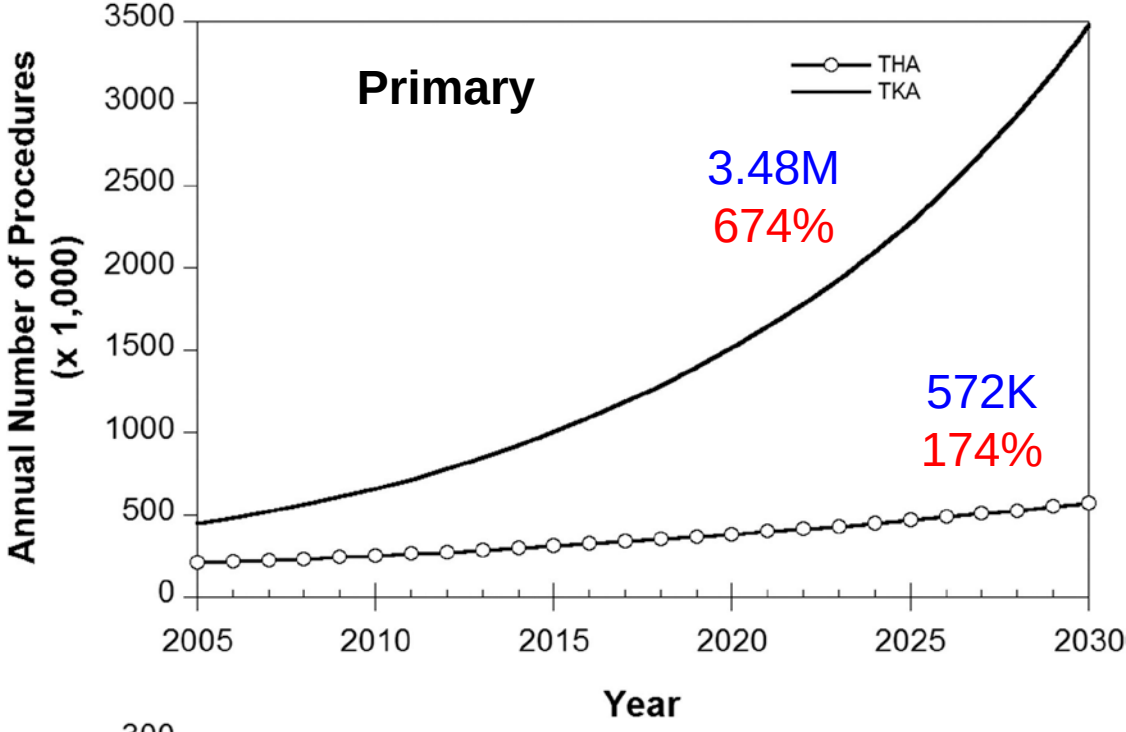
Creighton UNIVERSITY HEALTH SCIENCES PHOENIX

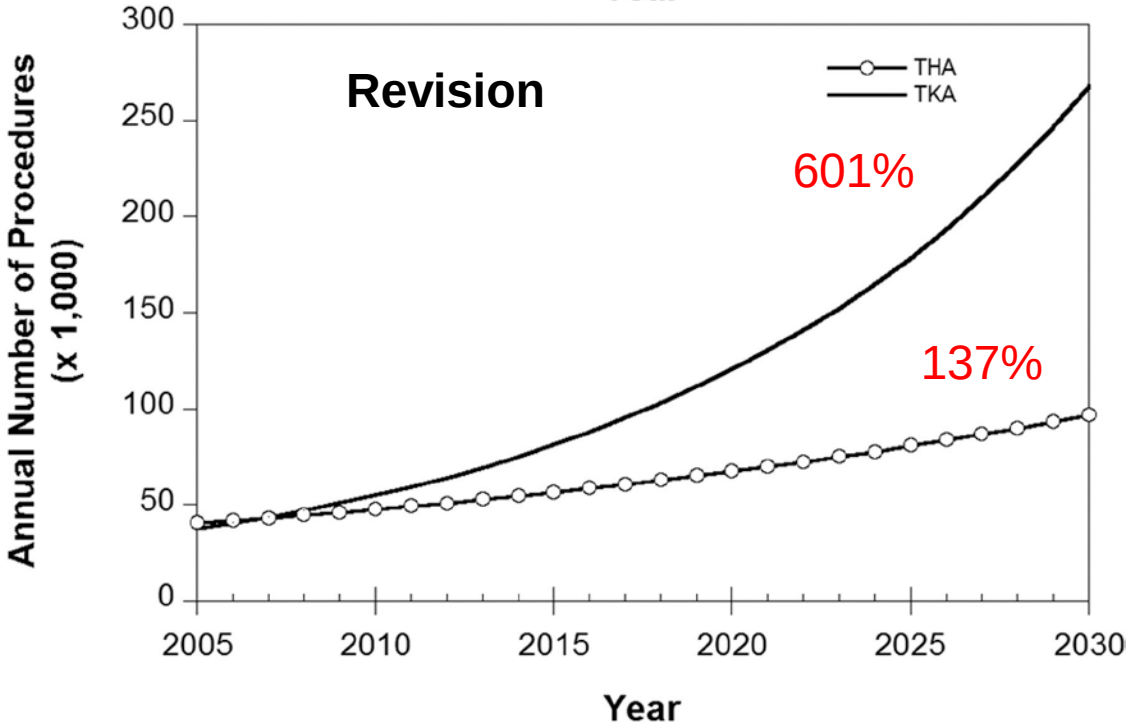

U.S. Population Distribution, 2007
Baby Boom
Generation
85 Million
42-62 year olds
in 2007
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94 97 100
NewGeography.com
Source: U.S Census Population Projections

1985

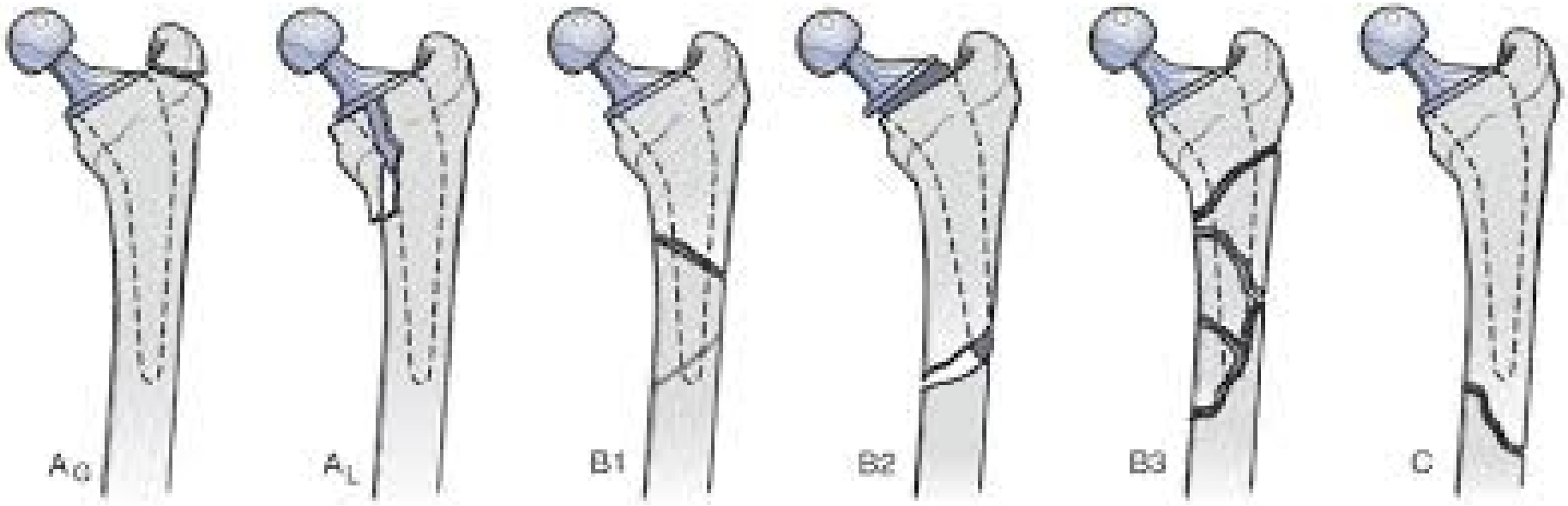


Total Joint Arthroplasty





Femur – Total Hip Arthroplasty



Vancouver Classification

- Consolidates the 3 most important factors
  - Site of the fracture
  - Stability of the implant
  - Quality of the surrounding bone
- Other factors: Age, general health

Vancouver Classification System

- Type A Trochanteric
- Type B Shaft Fracture around stem
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  - B3 implant unstable / bone deficiency
- Type C Shaft Fracture below component
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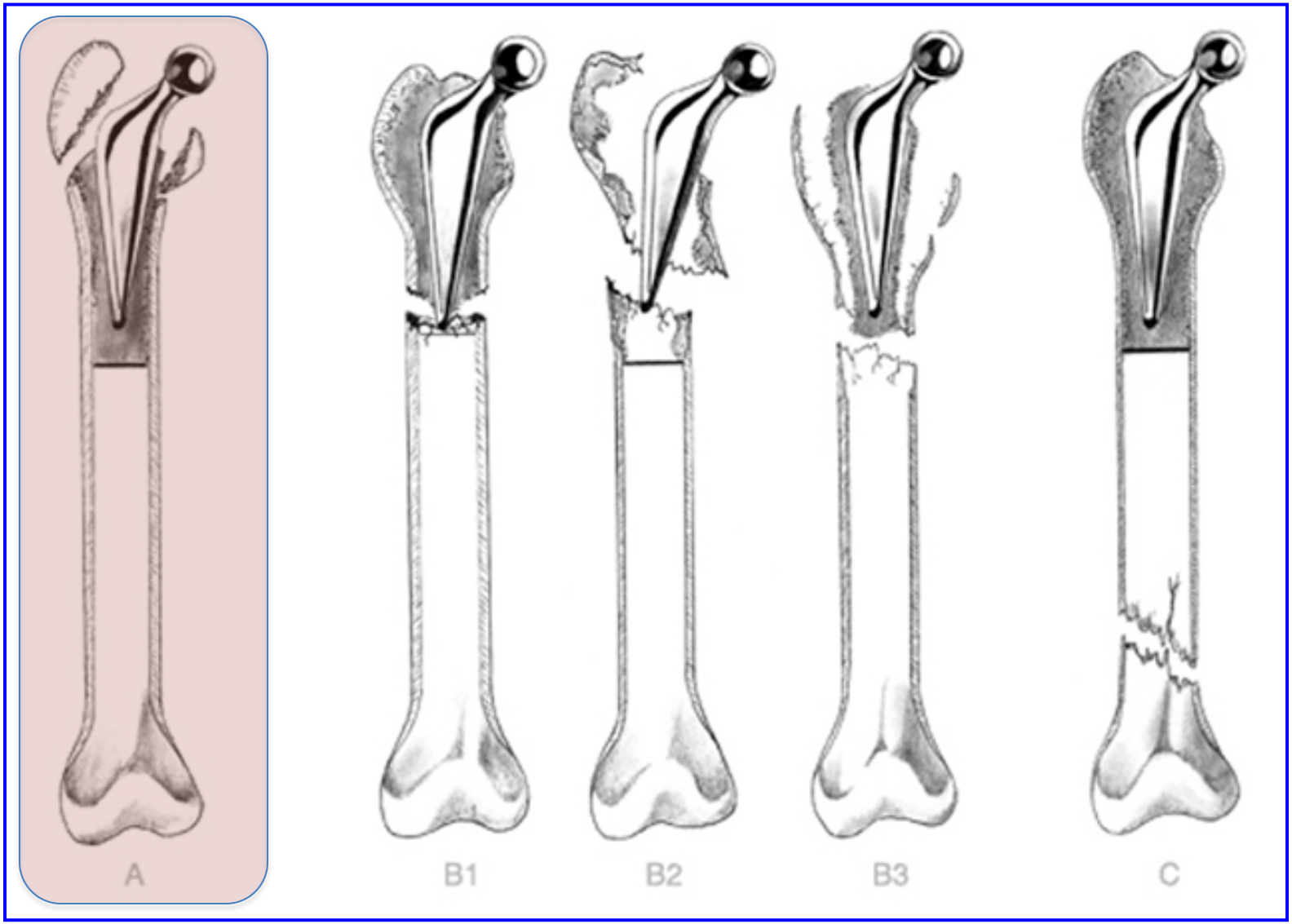
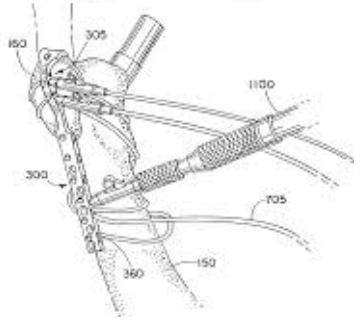
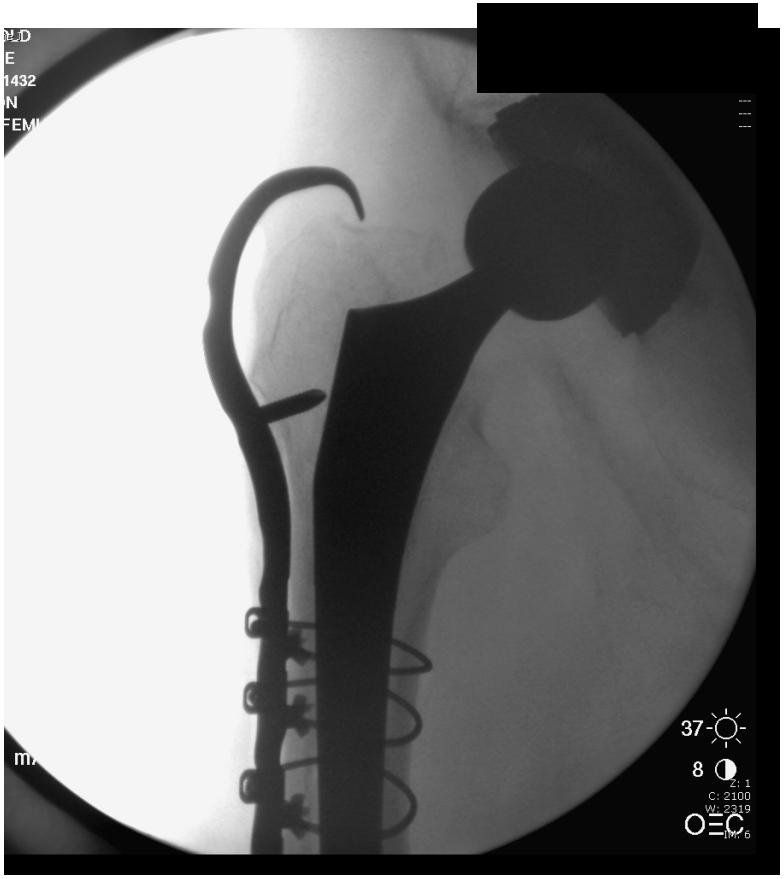
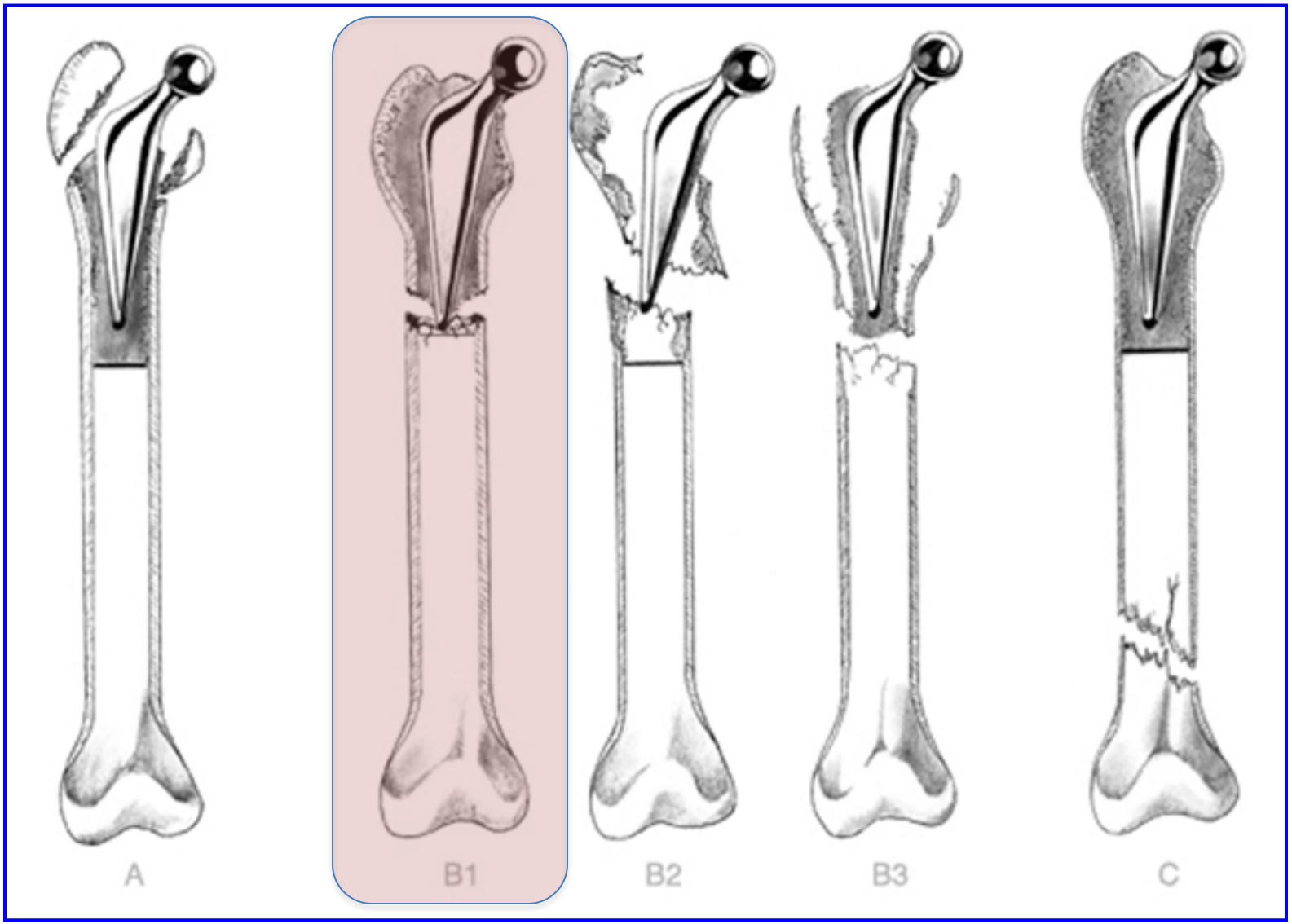


Vancouver A – Gr Troch Fx




37
8
C: 2100
W: 2319

Vancouver Classification System



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Is implant stable vs unstable??

- Key to treatment
- CT may be helpful to notice subtle motion artifact in shaft / cement mantle
- Stable (B1)
  - ORIF
- Unstable (B2)
  - Usually revise stem with ORIF

What's New in Peri-Prosthetic Fractures

- Biomechanics of fixation
- Locking plate technology
  - Out of plane screw orientation
    - Achieving 90-90 fixation
  - Cable integrated plates
    - Less reliance on cables overall
  - Development of “Flexible” fixation
    - Far cortical locking
  - Span entire (protect) femur

Principles

Splint the **entire** bone

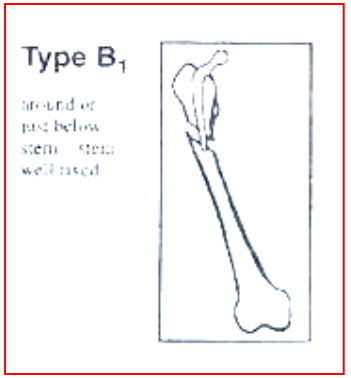
Screws when possible

Maintain fracture environment that **optimizes** fracture healing

Biomechanics

- Plate with distal screws and proximal cables better than allograft struts and cables alone
- Screws better than wires or cables
- Locked screws advantage for osteoporotic bone

Treatment



ORIF

Standard screw/plate devices

Screw/plate devices modified to accept cables

Ogden Concept

Screw/plate/cable devices with allograft struts

Allograft struts alone

New fixed-angle screw/plate devices

Treatment
Plates

Why so many techniques?

Driven by the presence of the prosthesis ± cement mantle

Bicortical screws:

Difficult

available at level of lesser trochanter and proximal.

Unicortical screws:

questionable fixation potential

Cables:

questionable fixation potential

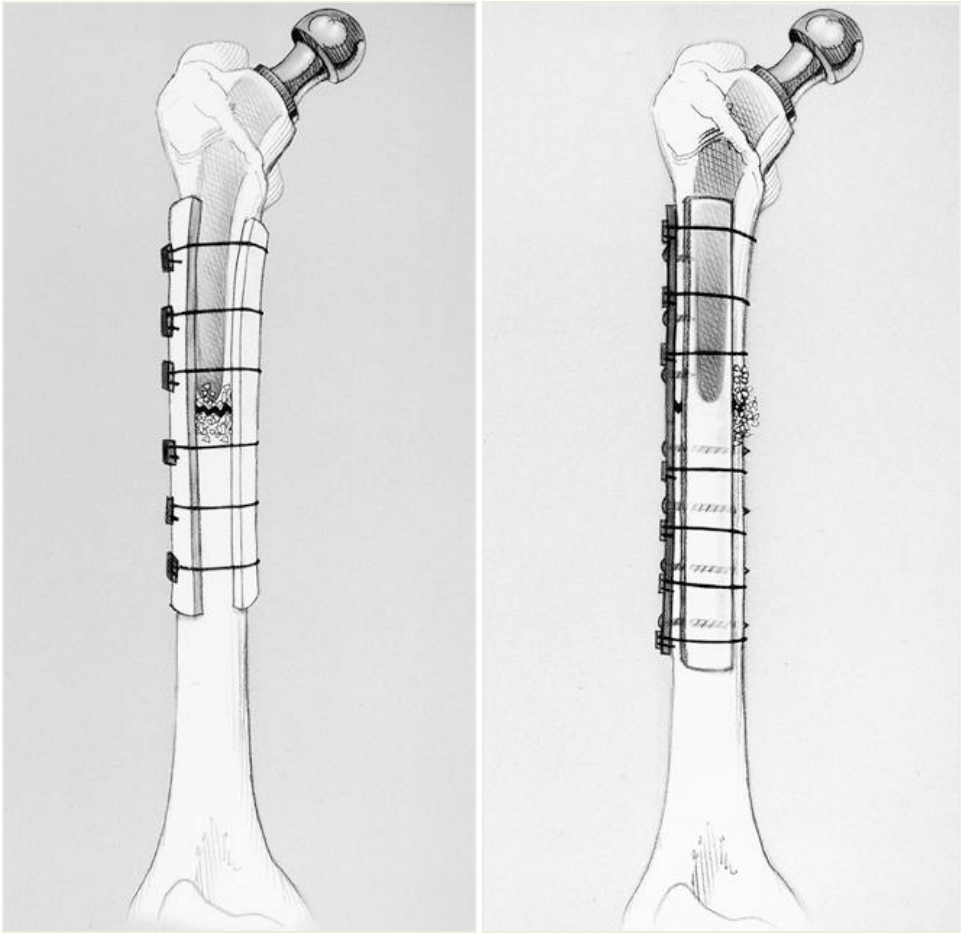
Effect on cement mantle?

Proximal fixation remains challenging

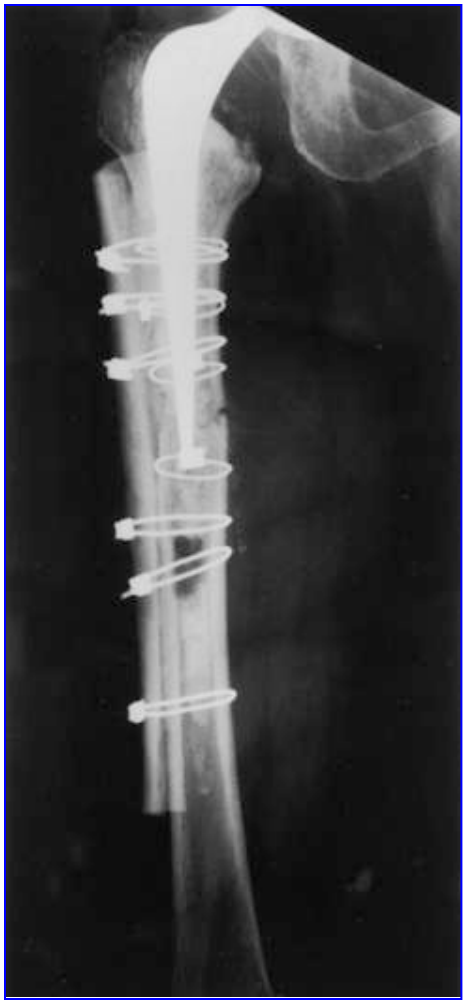
Treatment

Allograft Struts

- Allograft Struts
  - Cabled around the fracture
  - “Biologic plates”
  - Ultimately incorporates and increases bone stock
  - Similar (identical) modulus of elasticity, prevents stress shielding of the host bone.

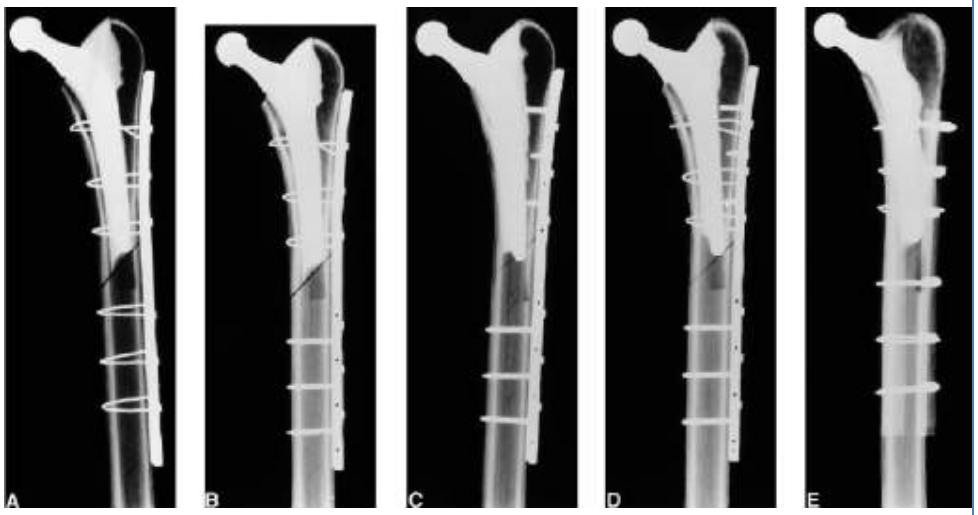


Injury



Immediate ORIF with allograft struts

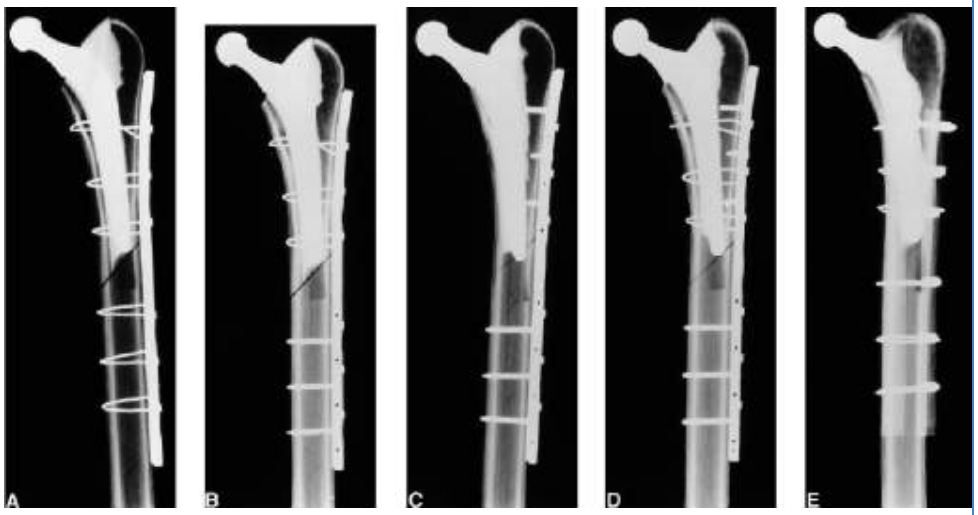
Dennis et al , 2000



- Biomechanical study
- Testing of 5 constructs
  - Simulated fx around THA
  - Good quality bone – synthetic femur
  - Cable ready plates, cables, and cortex screws

Dennis MG, et al, J Arthroplasty 15:523, 2000

Dennis et al , 2000

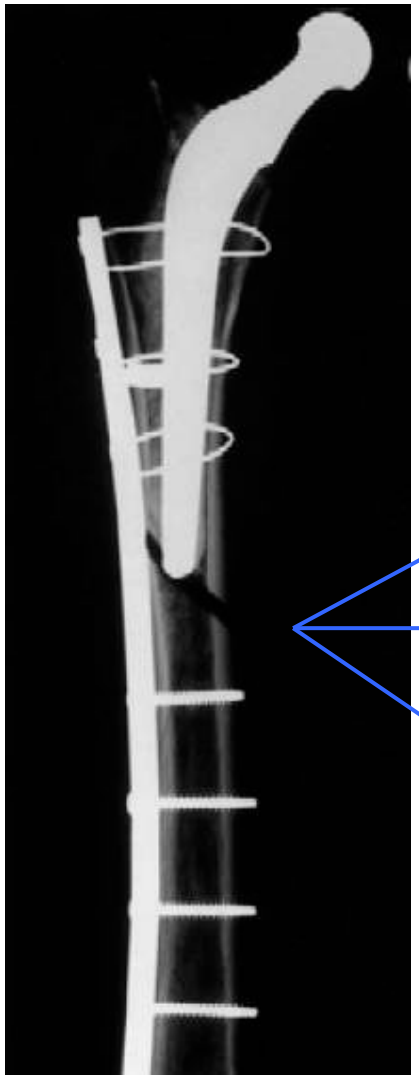


- Constructs included:
  - 6 cables
  - 3 cables proximal & 3 bicortical screws distal
  - 3 unicortical screws proximal & 3 bicortical screws distal
  - 3 cables & 3 unicortical screws proximal and 3 bicortical screws distal
  - 2 allograft cortical struts, 6 cables, & no plate or screws

Dennis MG, et al, J Arthroplasty 15:523, 2000

Treatment

Biomechanics: Summary



Classic Ogden Concept

Addition of unicortical screws ↑ fixation

Replacement with bicortical screws ↑ fixation

More stable than 2 allograft struts and cables

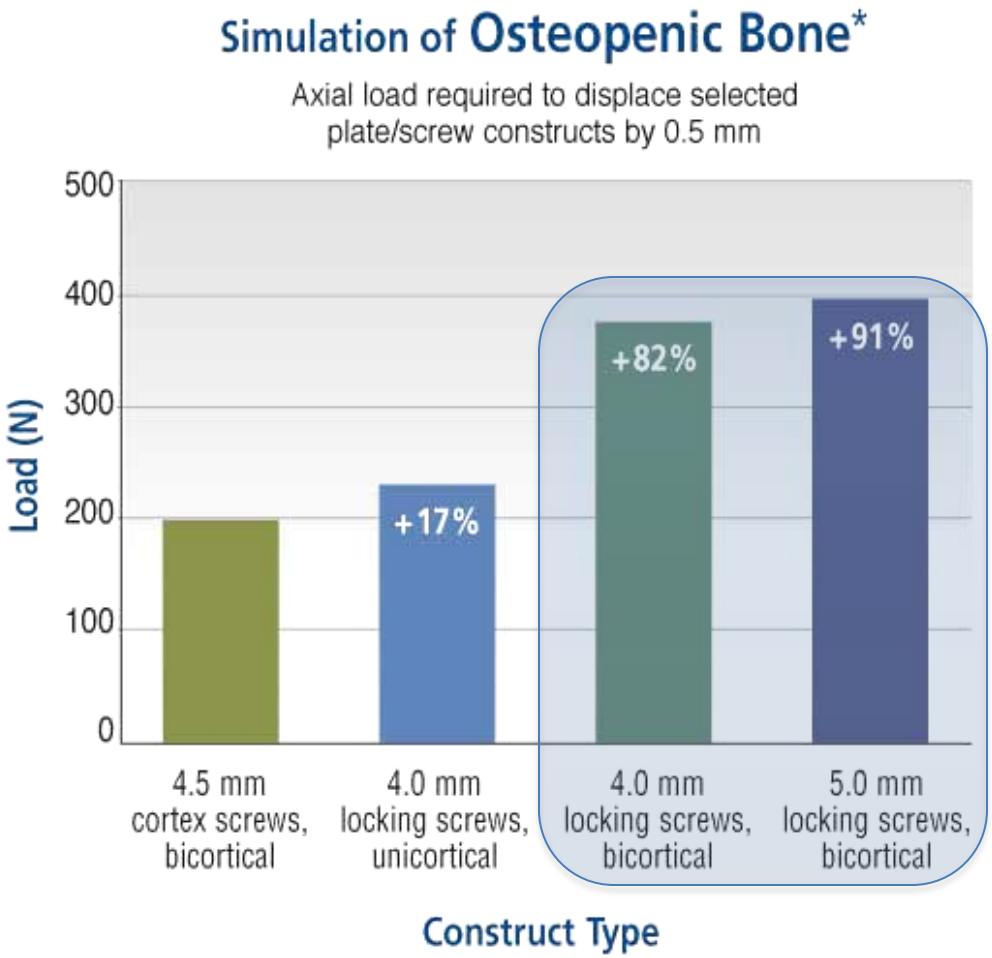
Dennis, J. Arthroplasty, 2000
Dennis, J. Orthop. Trauma, 2001

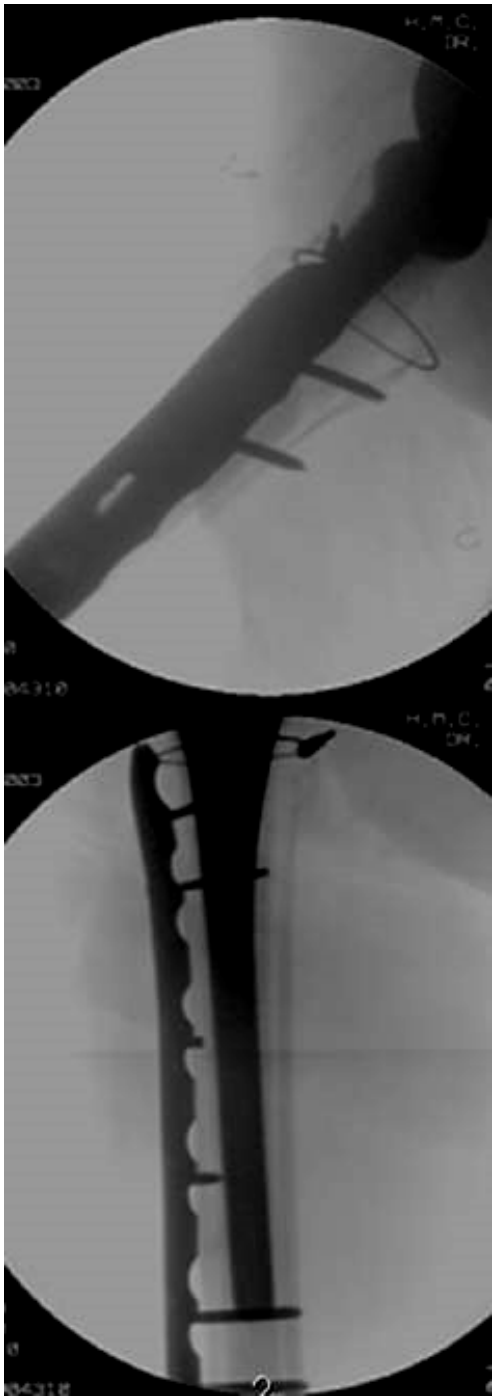
Treatment

Successful Clinical Results

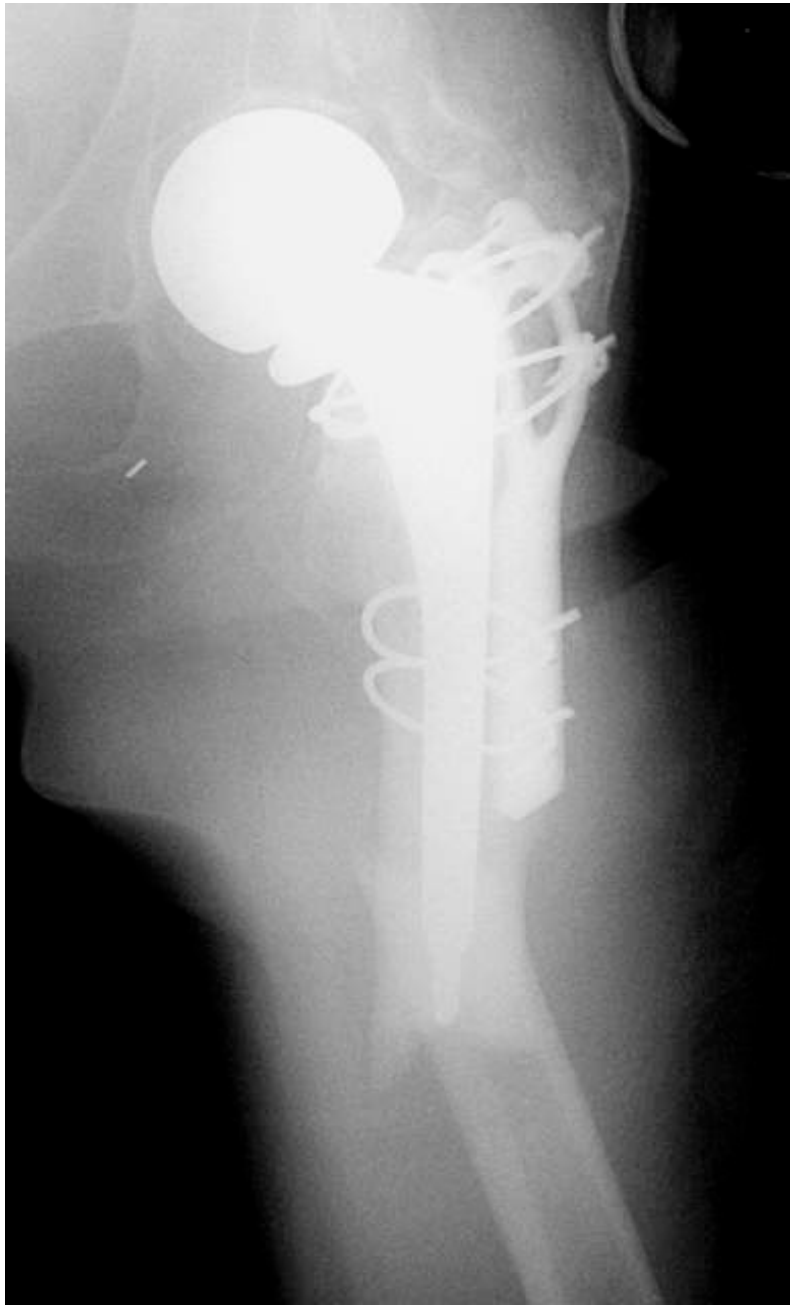
- Allograft Struts
  - Penenberg, Orthop Trans, 1989
  - Chandler, Semin Arthrop, 1993
  - Wong, OCNA, 1999
  - Head, CORR, 1999
  - Haddad, JBJS-Br, 2000
- ORIF (Cable/Plate)
  - Haddad, Injury, 1997
  - Kamineni, Injury, 1999
  - Tadross, J. Arthrop, 2000
  - Venu, Injury, 2001
- ORIF (DCP)
  - Stern, Orthop Rev, 1991
  - Serocki, J. Arthrop, 1992
  - Jukkala-Partio, Ann Chir Gynae, 1998
  - Siegmen, Unfallchirg, 1998

Osteoporotic Bone





B1

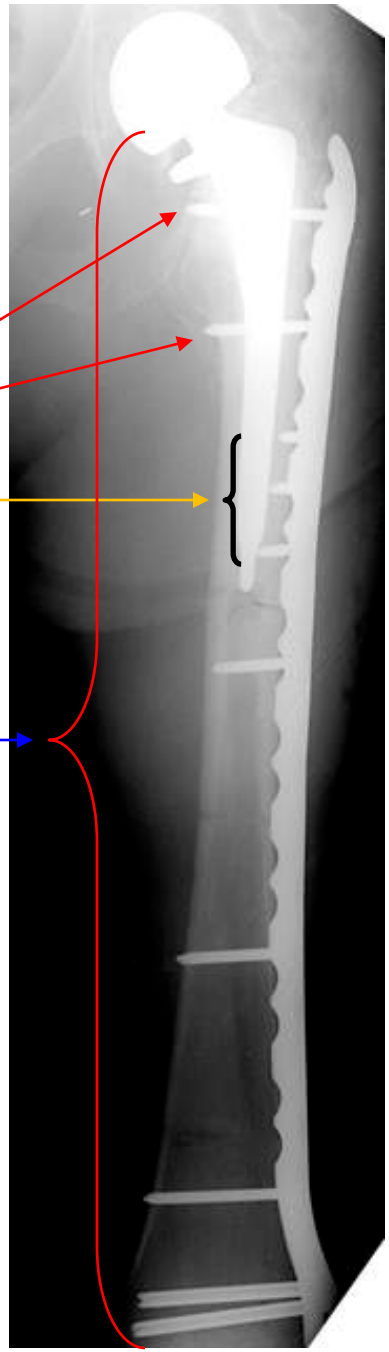


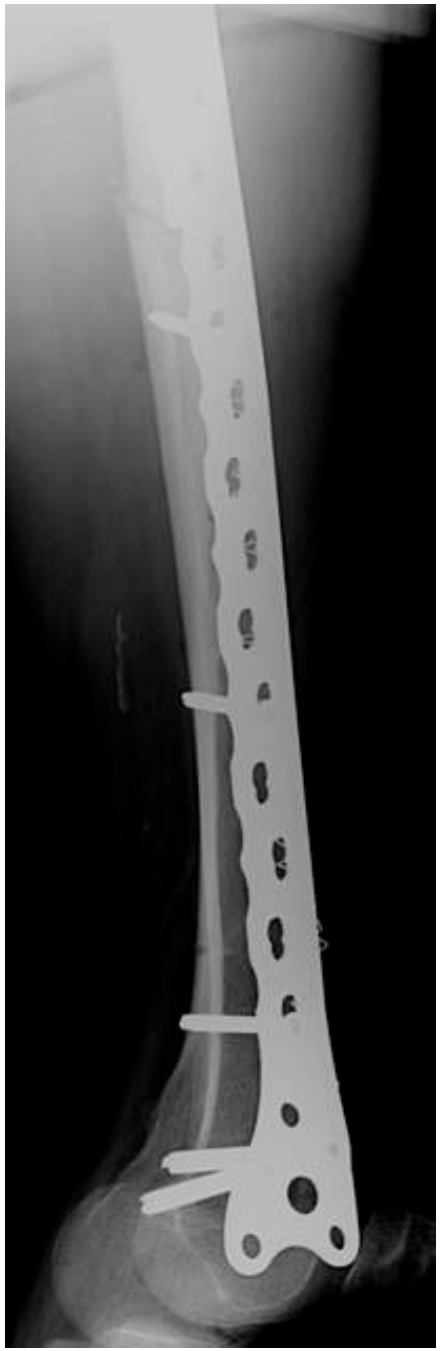
B1

Bicortical locking screws

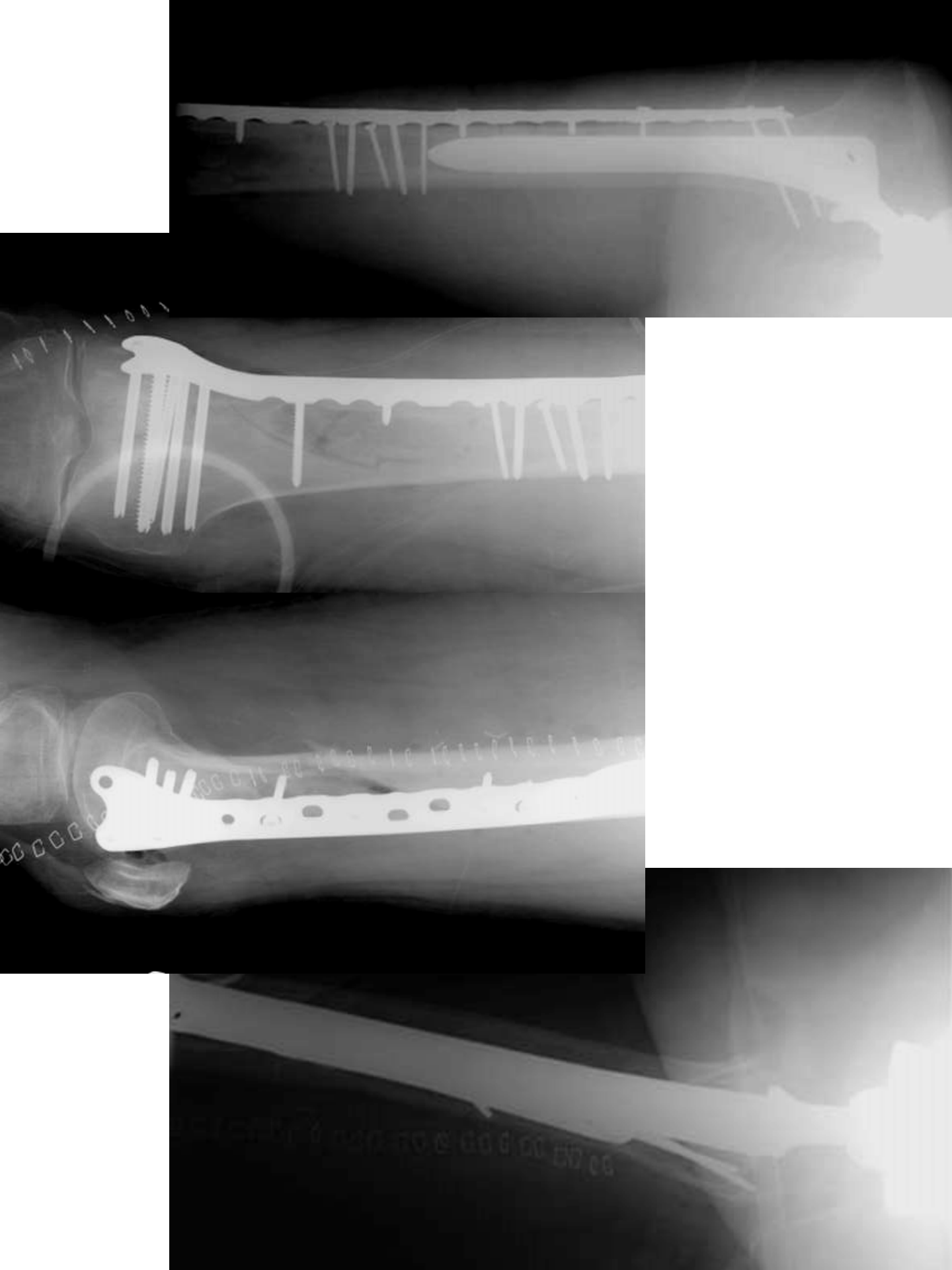
Unicortical locking screws

Span the entire femur



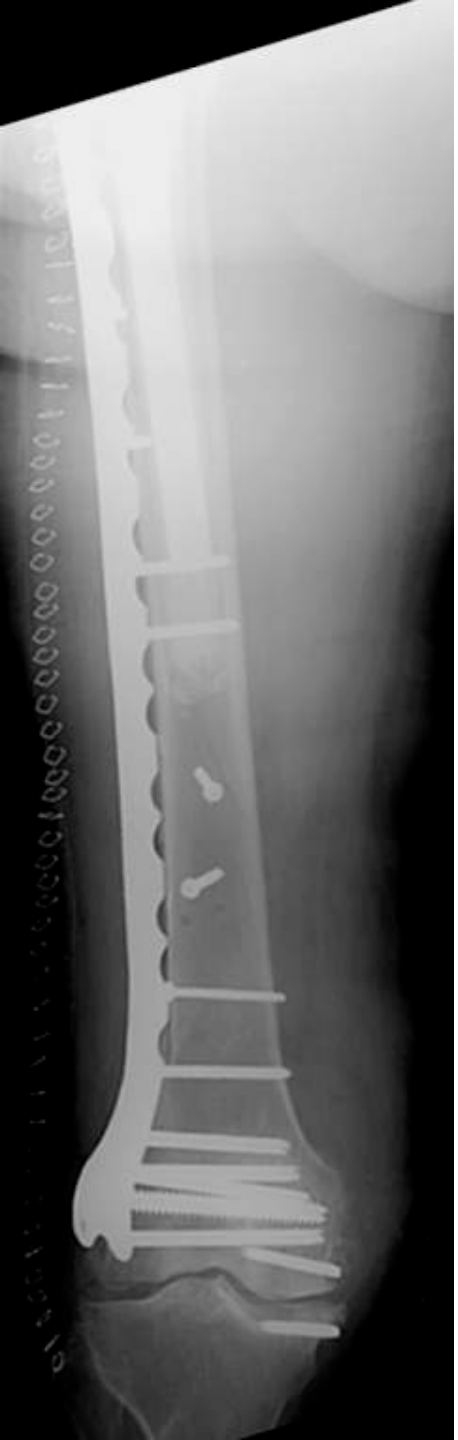


B1




R

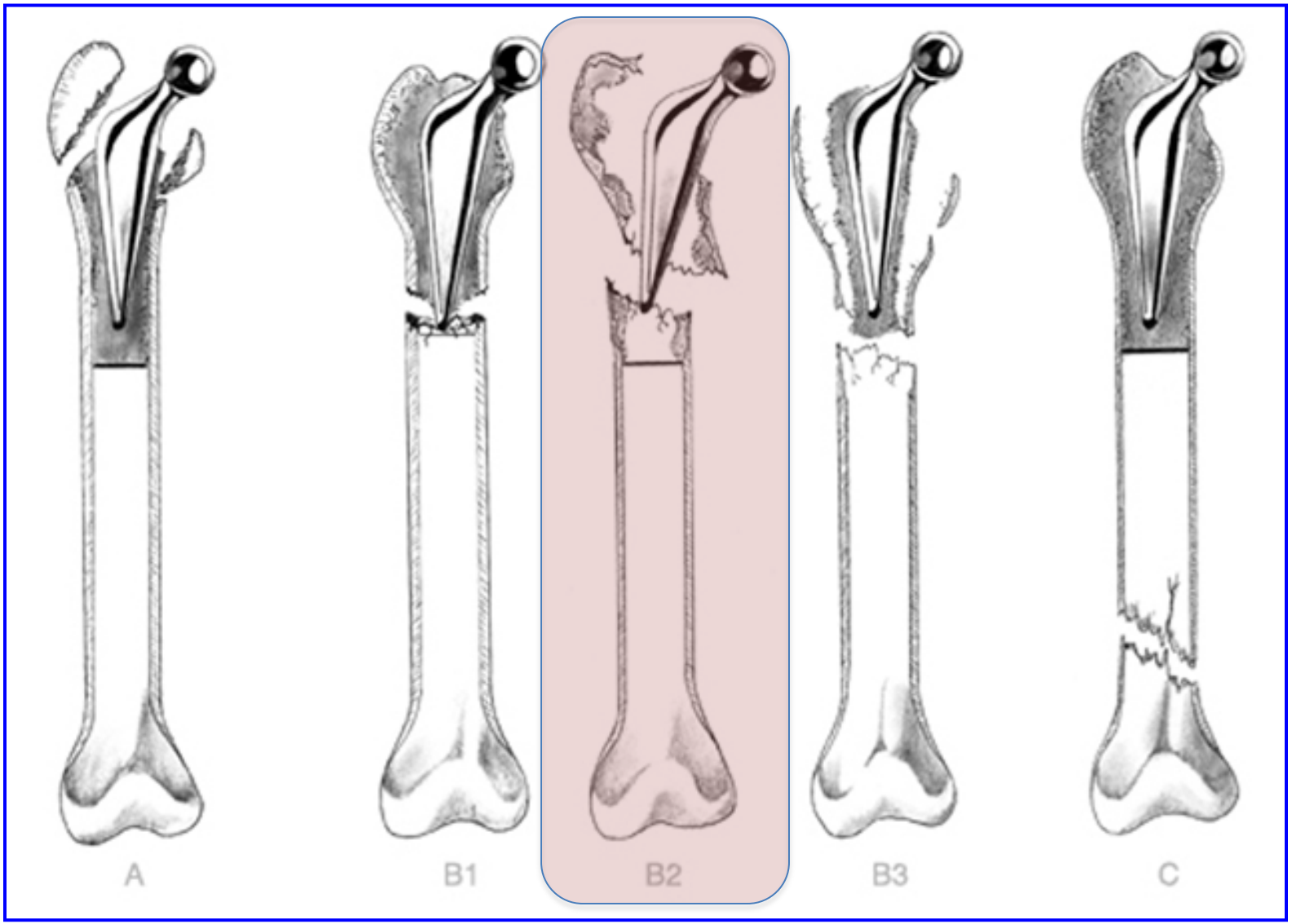

R


R


R

Vancouver Classification System



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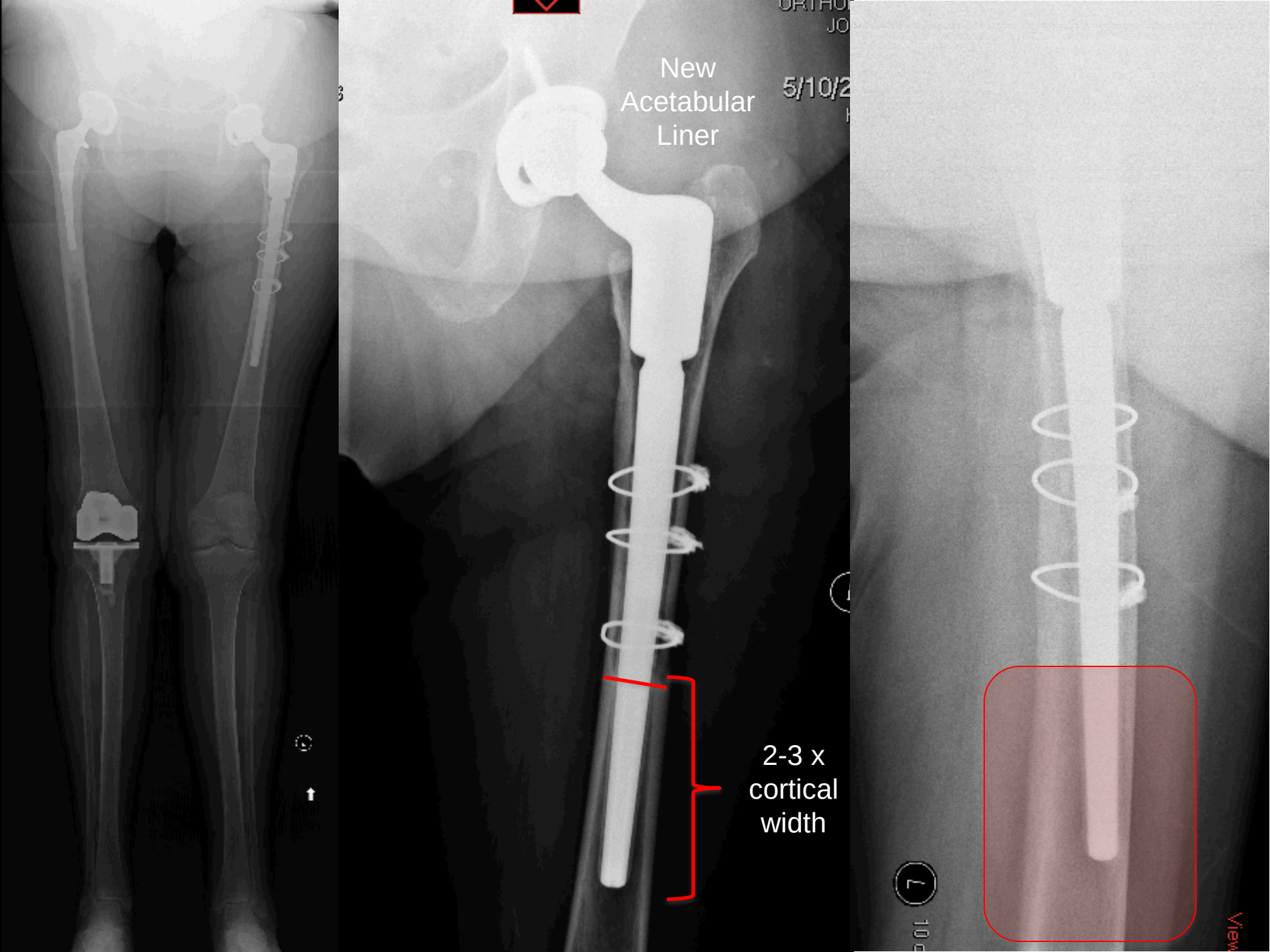
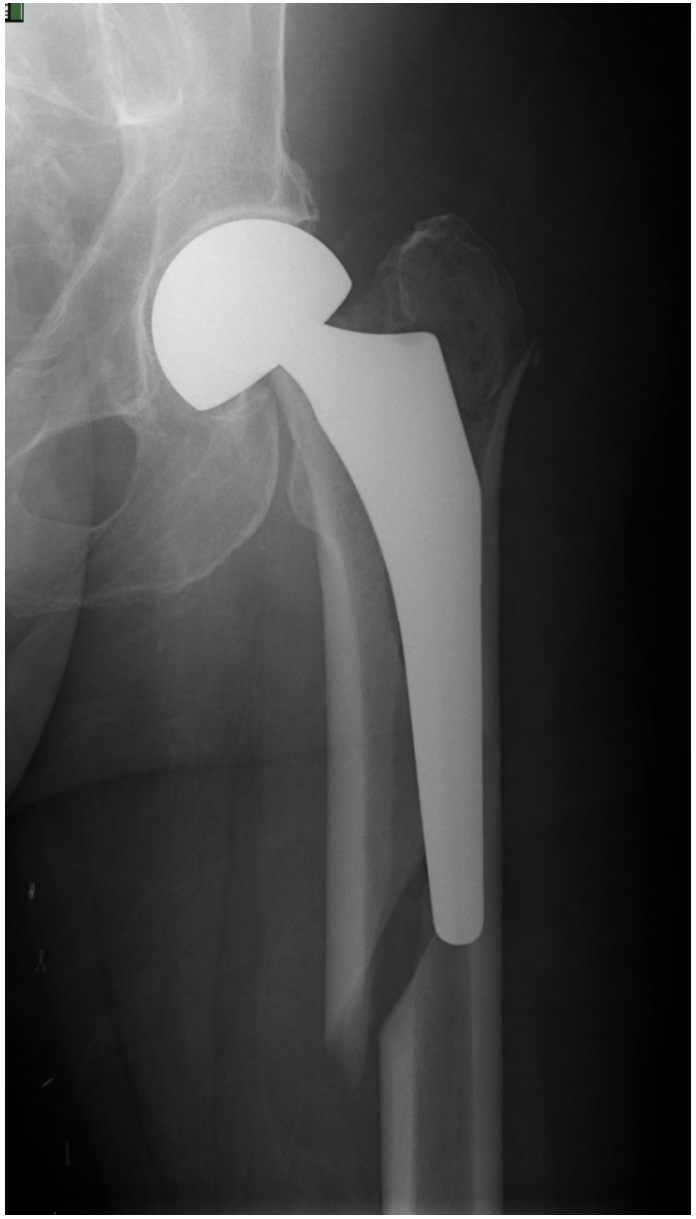
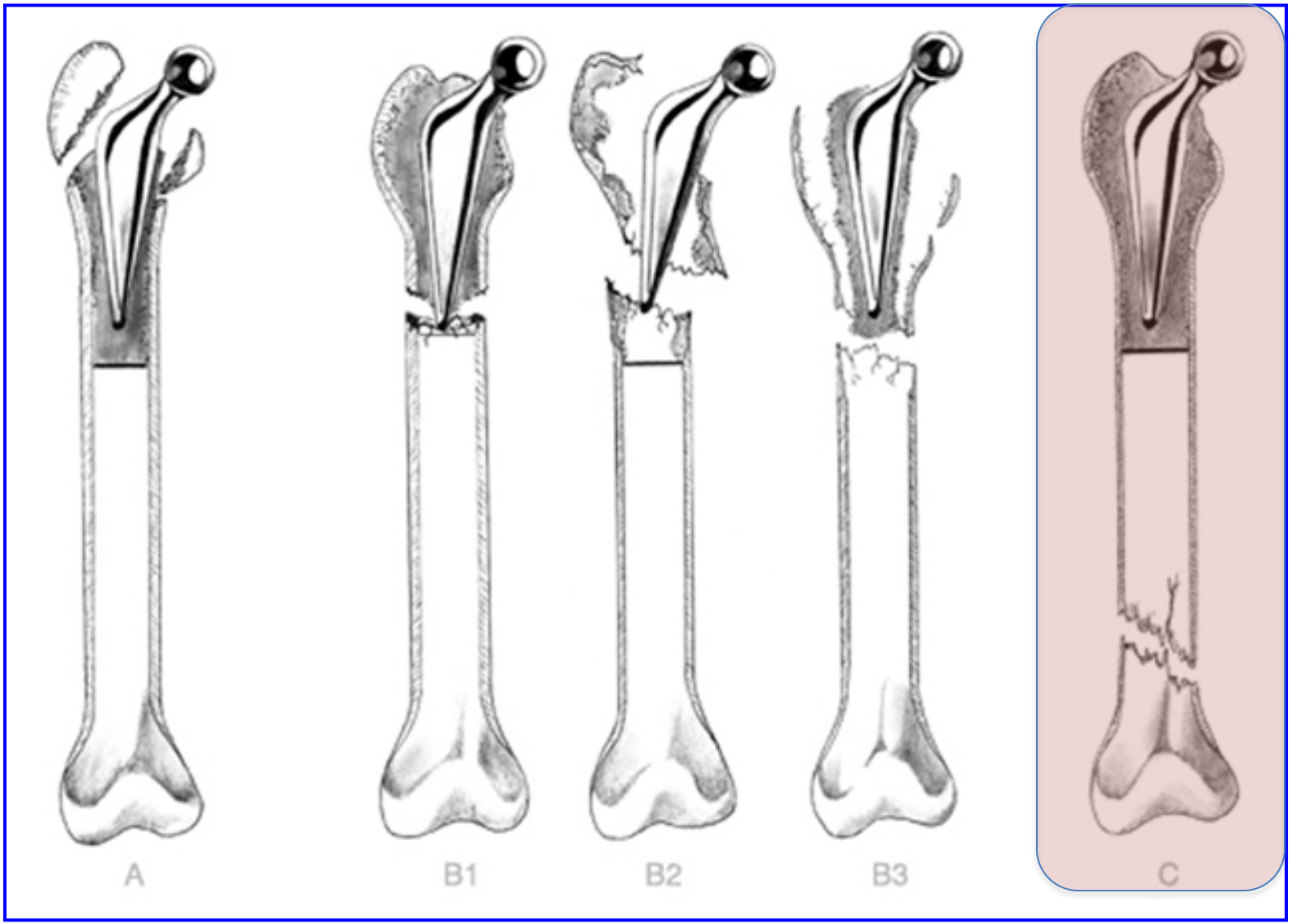
87 Female, L THA 1992, R THA 1995
3 mo increasing pain L thigh
Initial Presentation to ED


New
Acetabular
Liner
2-3 x
cortical
width



Vancouver B_2 fracture with good bone stock
1)long cylindrical fully coated revision stem
2)lateral plating that protects the entire length of the femur.

Vancouver Classification System



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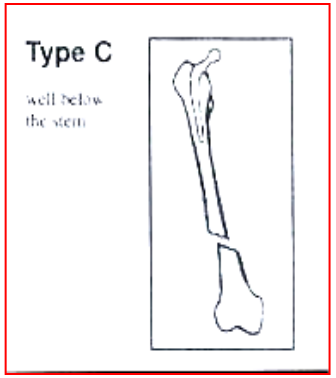
Treatment

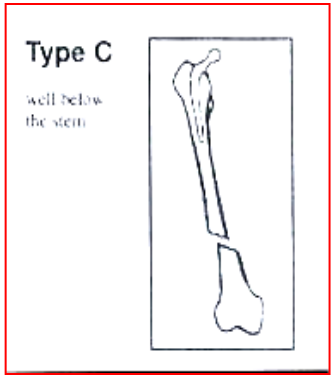


Distal to stem of the prosthesis

Treat with “standard” ORIF techniques

Not so simple…..

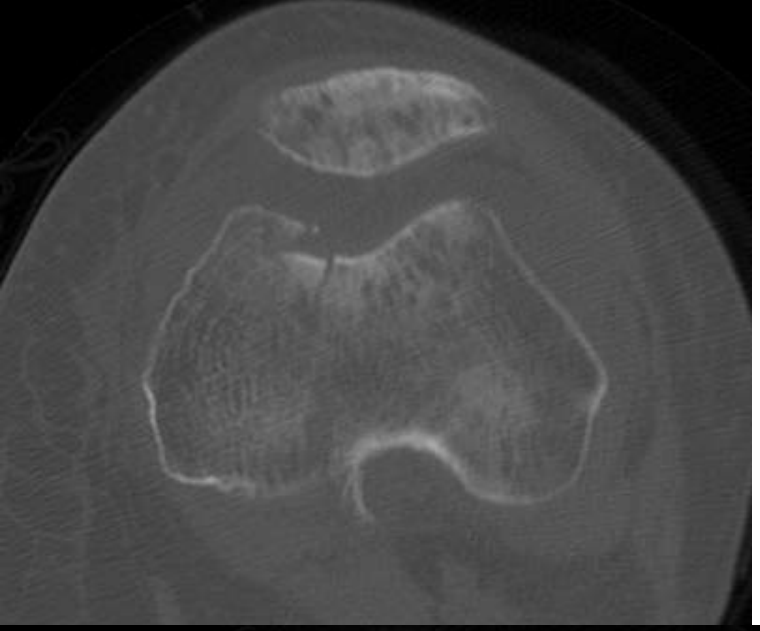
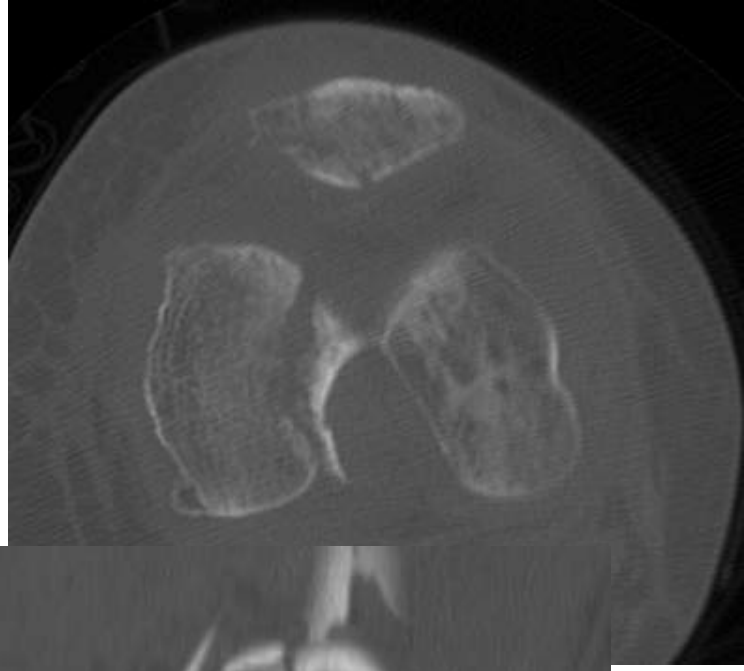
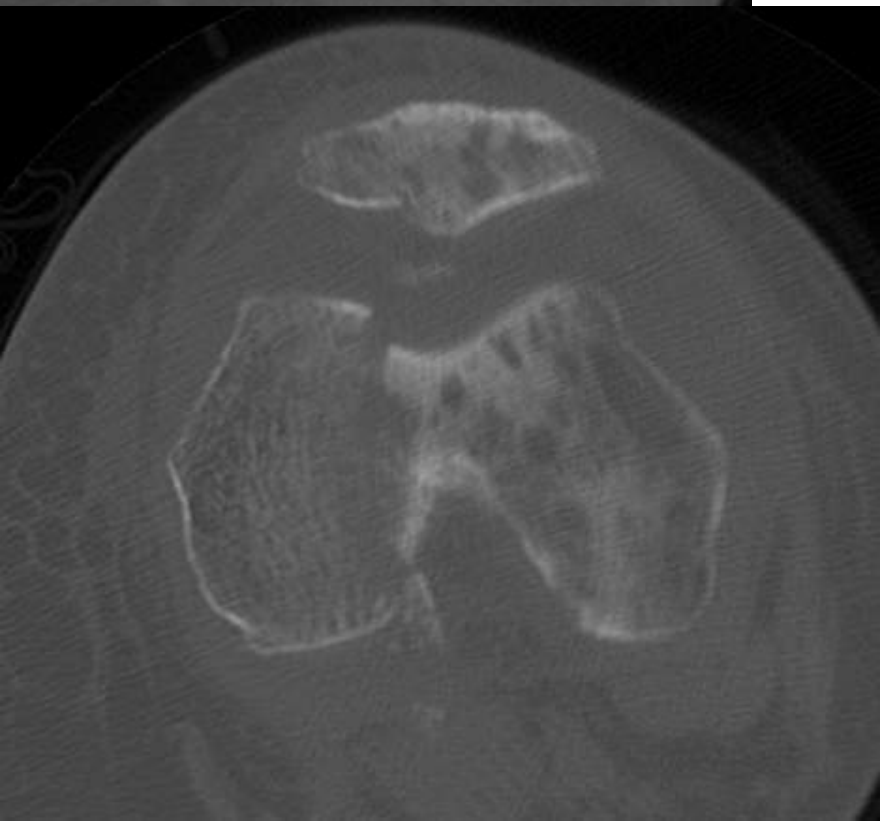
Treatment

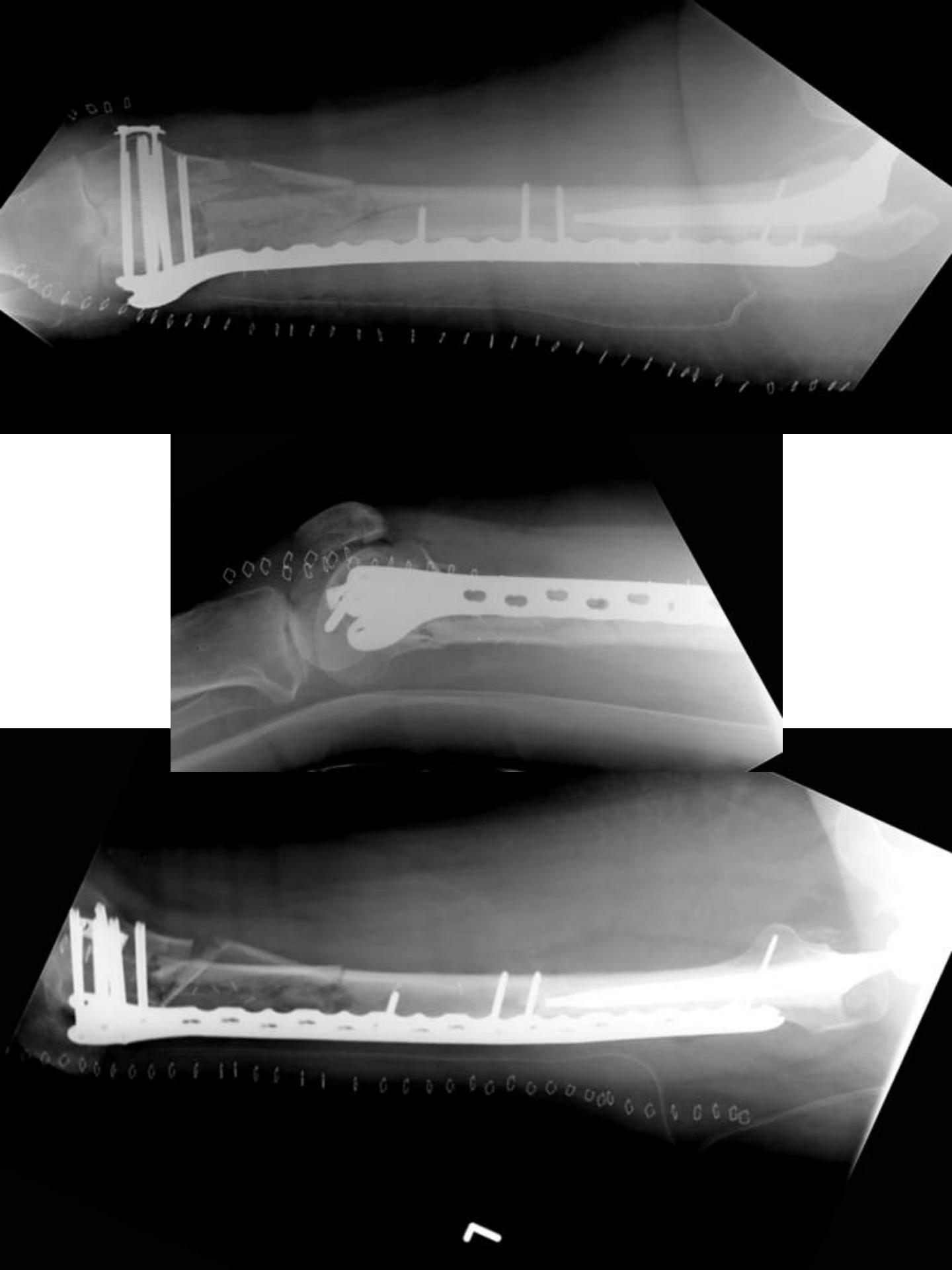


- Basic Principles
  - Span beyond the prosthesis tip to avoid stress riser

    Harris, J. Trauma, 2003
  - Still need to worry about proximal fixation
  - Still need to worry about poor bone
  - Locked implant…..


L

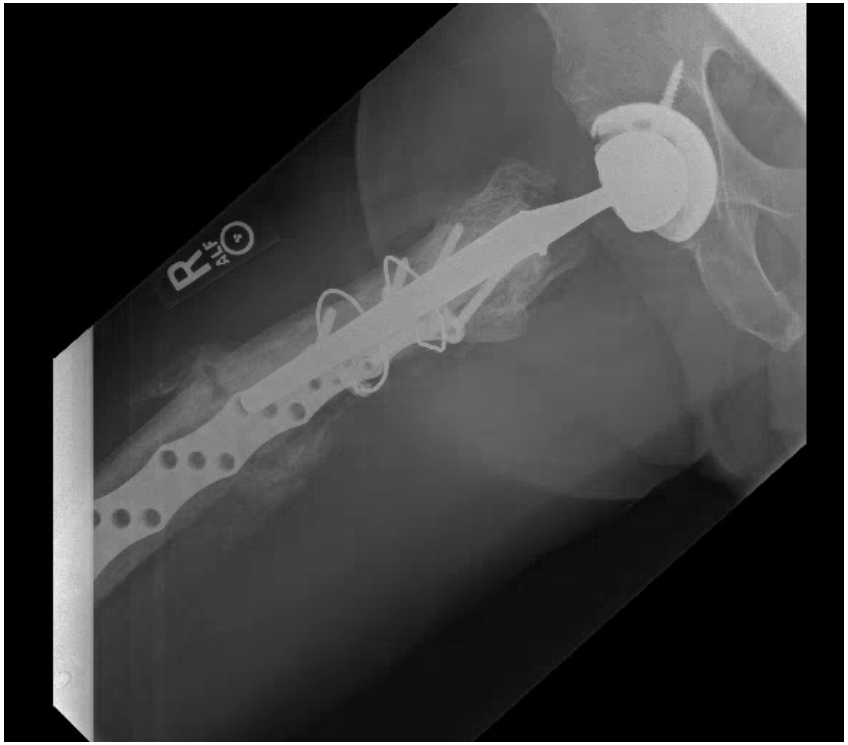




71 y/o M, fall

Its just a shaft fracture.....

Intra Op

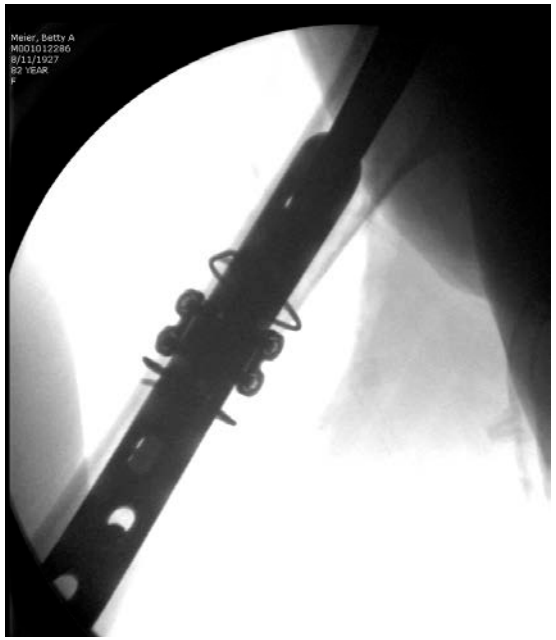


6 weeks

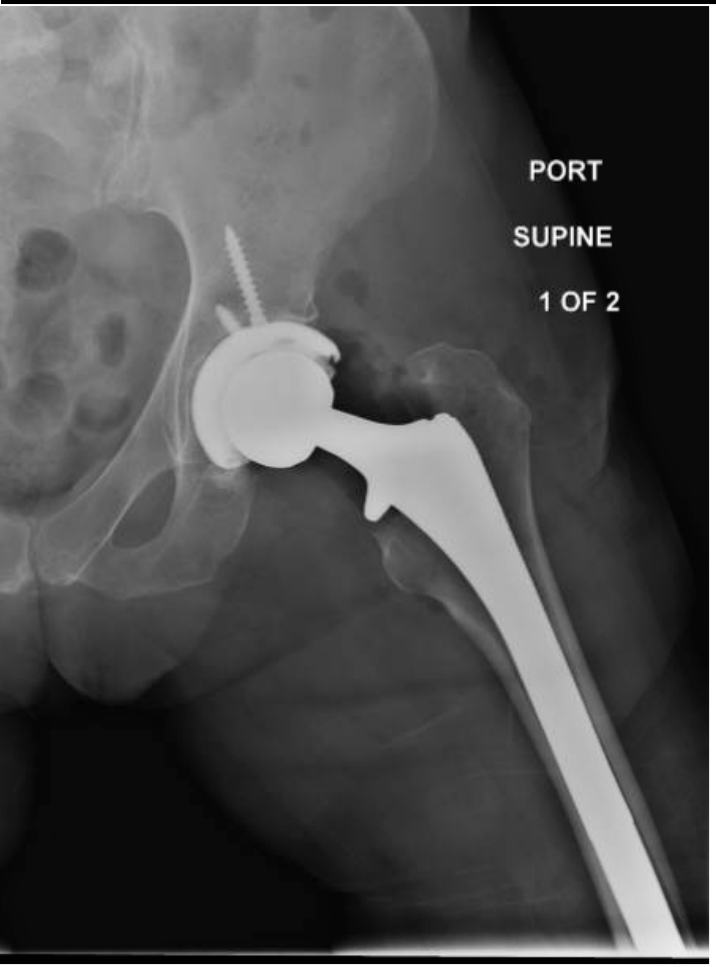
4 months

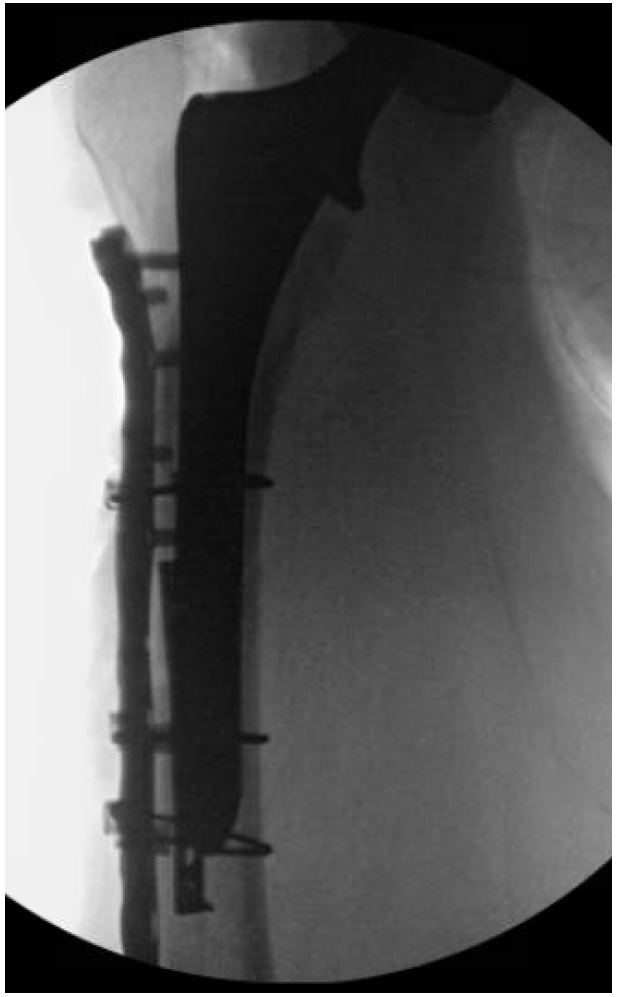
Ability to Achieve Off Axis Fixation

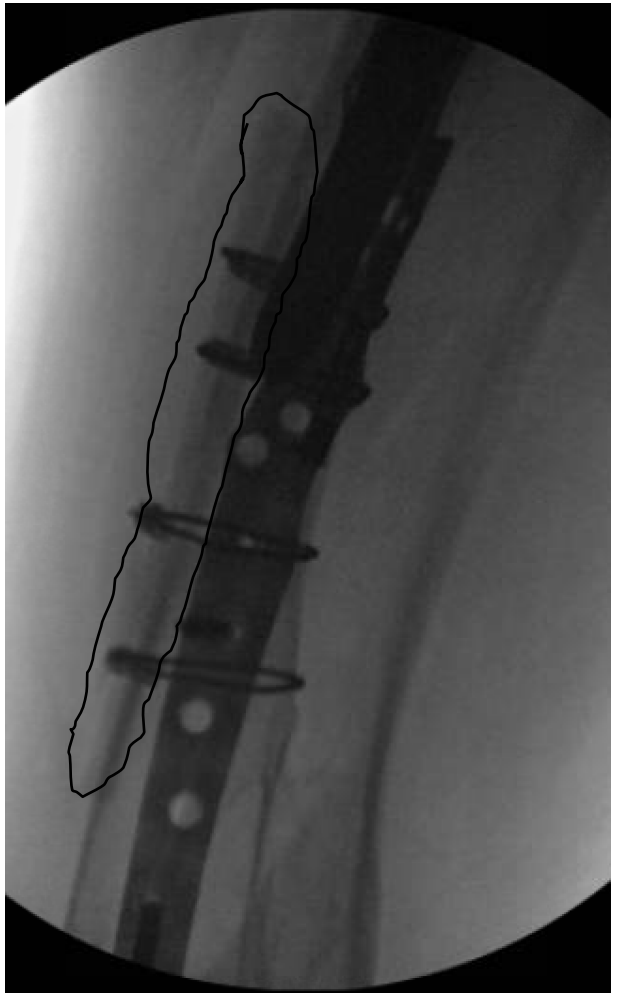
- Plate specific “hybrid” plates with 4.5mm / 3.5mm out of plane fixation



70F s/p primary THA….Hx Ollier’s Dx

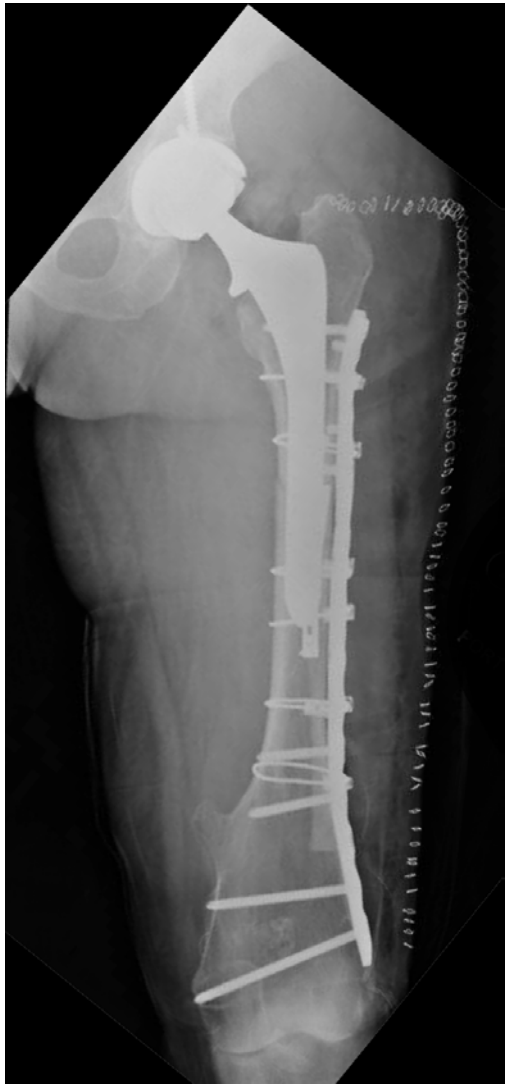


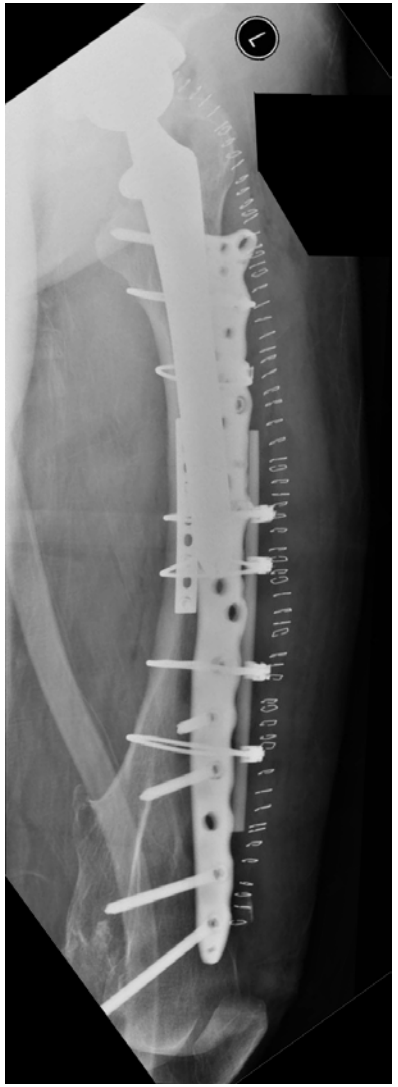




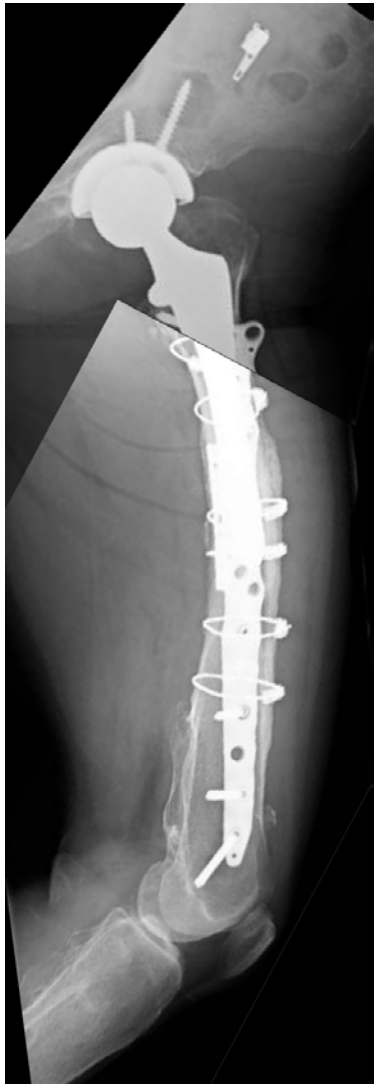
Allograft plates for poor bone or bone defects....+ locking screws +cerclage.....

Postop

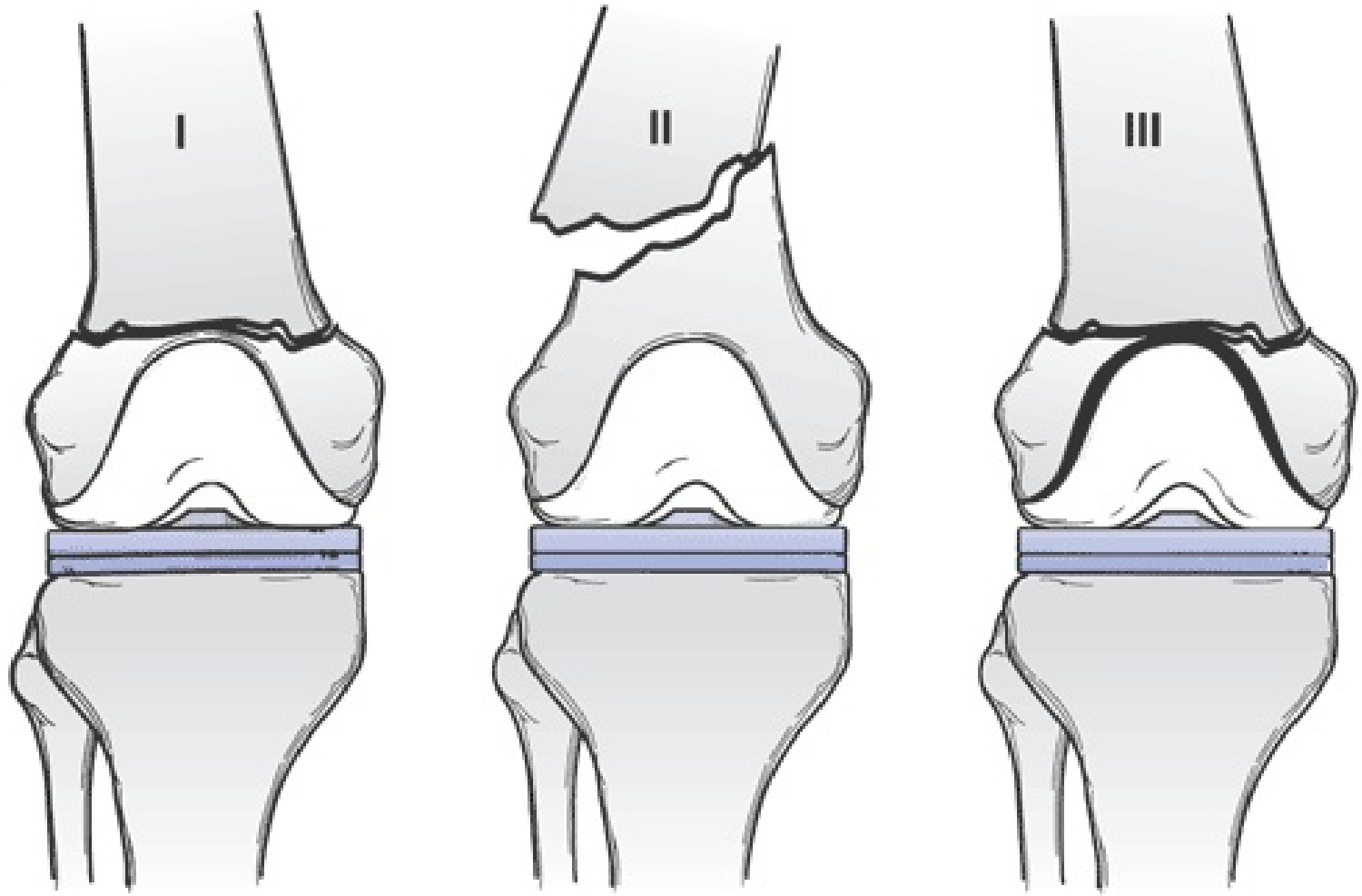




2 years



Femur – Total Knee Arthroplasty



Classification

Type I

- **Undisplaced fracture**
- **Prosthesis intact**

Type II

- **Displaced fracture**
- **Prosthesis intact**

Type III

- **Displaced or Undisplaced fracture**
- **Prosthesis loose**

Lewis and Rorabeck (1997)

Complex Treatment for Distal Fractures

- Real estate issue….
  - Well fixed stem
    - Cement mantle and large stem
    - P. Stabilized with large “box”
    - Open vs closed “box”
  - May be difficult to gain bi cortical purchase
    - Unicortical locking screws
    - Limited bone….level of fracture…..

Posterior Stabilized

Notice the "box" in the middle of the femoral component.

The plastic has an elevated post.

Cruciate Retaining

Notice that there is a space in the middle of the femoral component.

The plastic does not have a post.

Treatment Goals

- Restore axial alignment and length
- Stable fixation
- ROM as soon as possible
- Maintain fracture environment suitable for boney healing
- Return to pre-injury mobility

ORIF best accomplishes these goals

Usually?!?!?!

Treatment Options

- Retrograde intramedullary nail
- Conventional plating
- Locked plating
- Revision with stemmed prosthesis, allograft, or tumor prosthesis

The Problem(s)

- Usually elderly
- Osteolysis
- Limited distal fixation due to TKA
- PS Cam design of TKA
- Notch – Canal diameter mismatch
- Early ROM desired

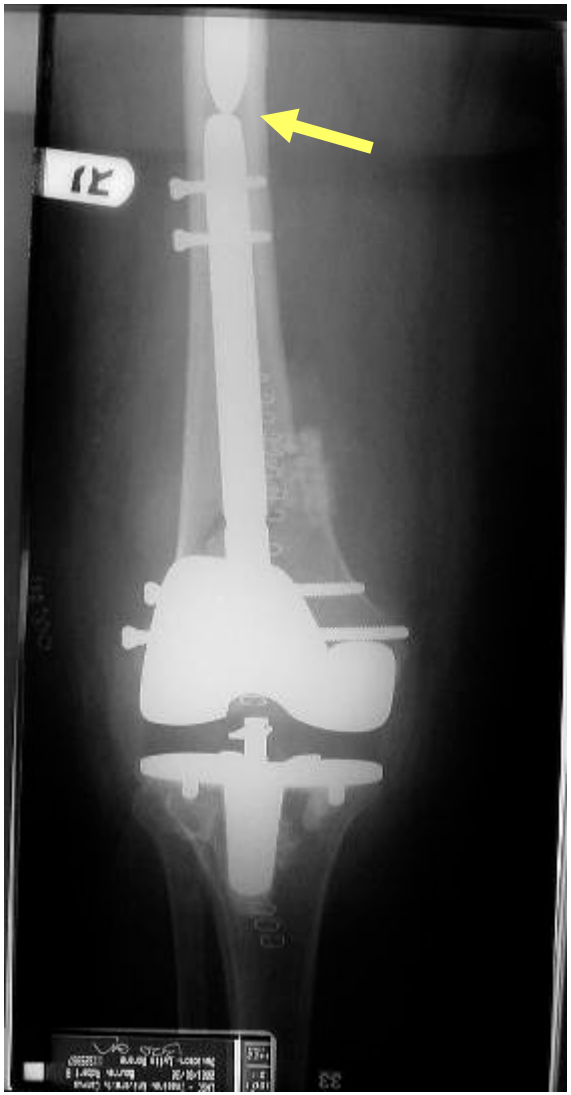
The Problem(s)

Distal Fixation

Retrograde IMN vs ORIF

- Limited literature
- PS vs CR
- Canal diameter considerations
- TKA Notch vs canal diameter
- Femoral stem above?

Inter-Device Distance (IDD)

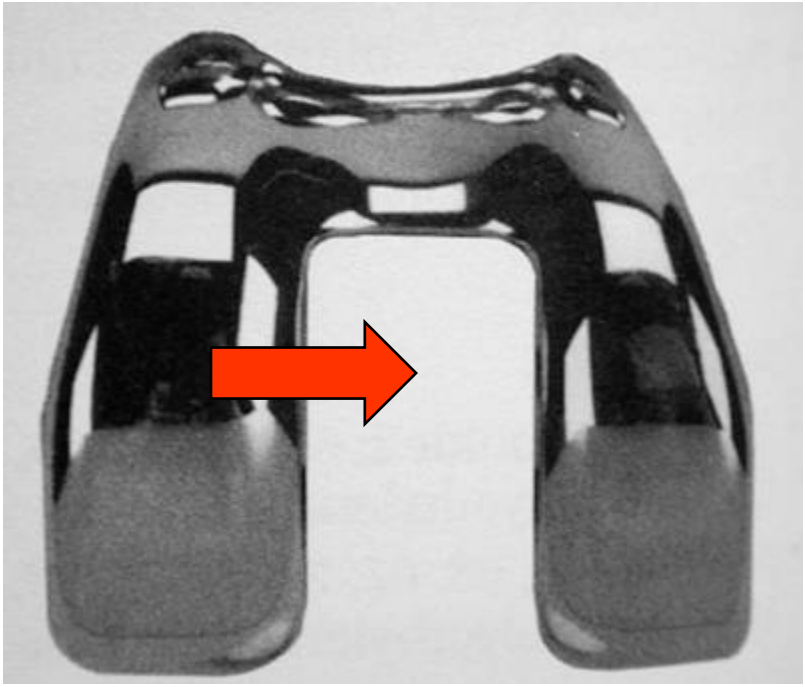


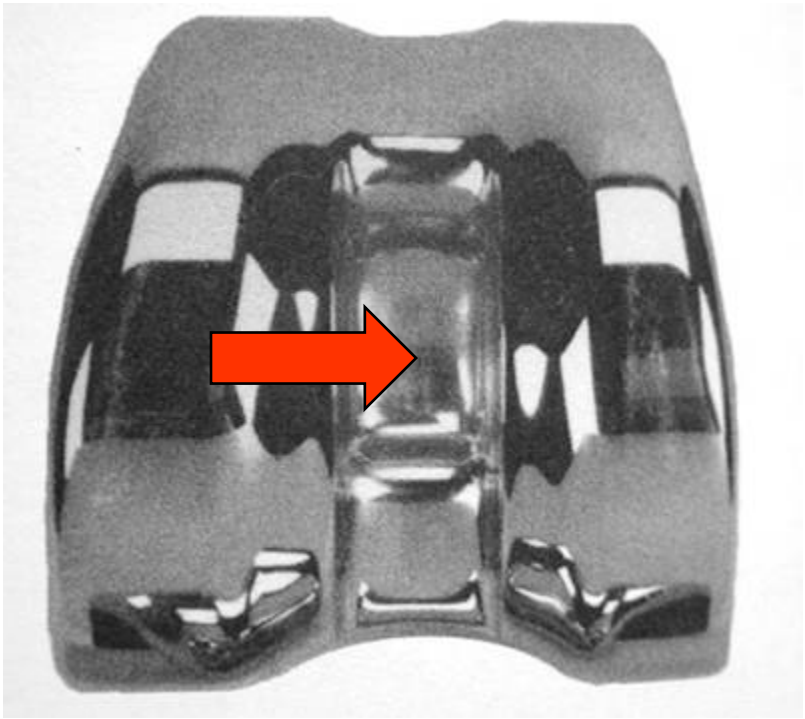
Retrograde Nailing

Is the notch open or closed?

If open, is it large enough?

- Narrow notch and closed box seen in posterior stabilized knees





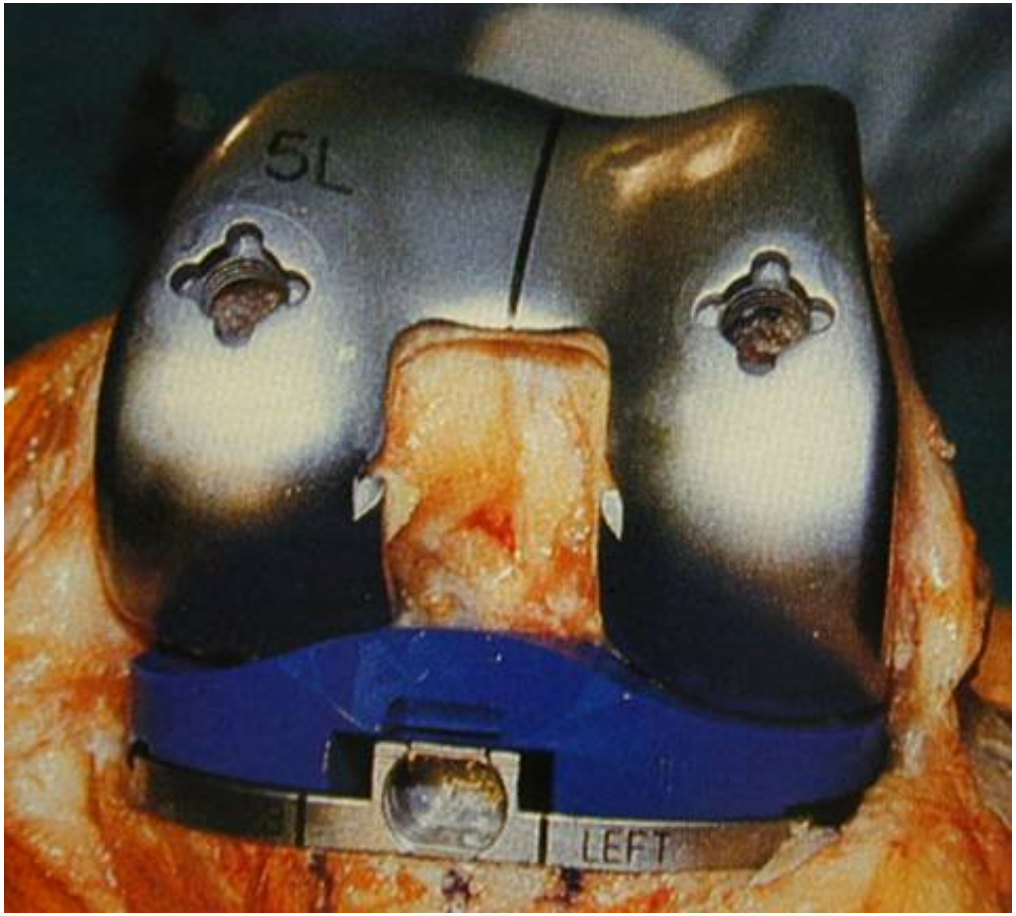
Retrograde Nailing

Problems:

- Stability of distal segment with interlocking bolts
- Toggle of the nail in the distal metaphysis

↓

- Nail size
- Uniplanar interlocking bolts
- Bone quality
- Capacious distal metaphysis
- Distal fracture patterns



Retrograde Nailing

Nail size canal diameter mismatch

Limited fixation distally

Poor stability

Poor quality bone

Largely replaced by locking implants

Biomechanics

Bong, Egol, Koval J. Arthroplasty Oct. 2002

Biomechanical study comparing retrograde inserted intramedullary nail and LISS for supracondylar fractures proximal to TKA

The retrograde inserted nail may provide greater stability.

Biomechanical Evaluation of the LISS, Angled Blade Plate, and the Retrograde Intramedullary Nail for the Fixation of Distal Femur Fractutres: An Osteoporotic Cadaveric Model
Kregor: OTA 2002

- Osteoporotic cadaveric femuri (age 70 yo)
- Tested to failure in axial loading and torsion
- Axial loading: 34% higher load for LISS Vs blade plate and 24% higher than IMN
- Loss of distal fixation with CBP and IMN
- Plastic deformation with LISS and no loss of distal fixation
- Torsion strength same for CBP, but higher for IMN

Clinical Evidence?

LISS

- Schultz M, Injury, 2001
- Kregor PJ, Injury, 2003
- Althausen PL, J. Arthroplasty, 2003
- Markmiller M, CORR, 2004

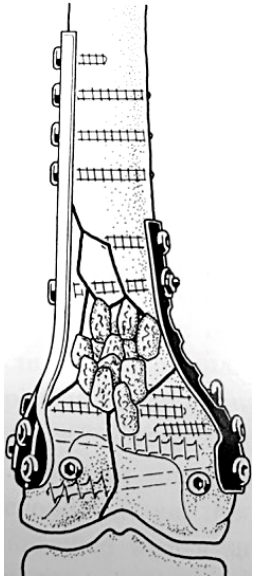
Retrograde Nail

- McLaren AC, CORR, 1994
- Murrell GA, J. Arthroplasty, 1995
- Rolston LR, JBJS-A, 1995
- Jabczenski FF, J. Arthroplasty, 1995
- Bezwada HP, J. Arthroplasty, 2004

Evolution of Plating

Conservative → Stability → Biology → Locked Plating

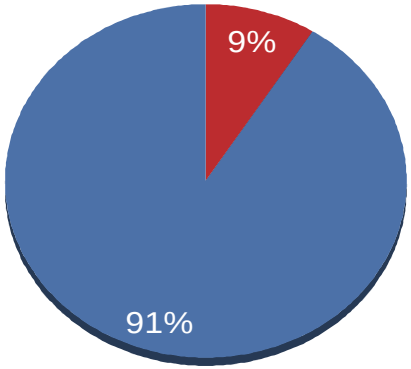
1950 1960 1970 1980 1990 2000



Supracondylar Plate Outcomes

Nonunion: Before Locked Plates

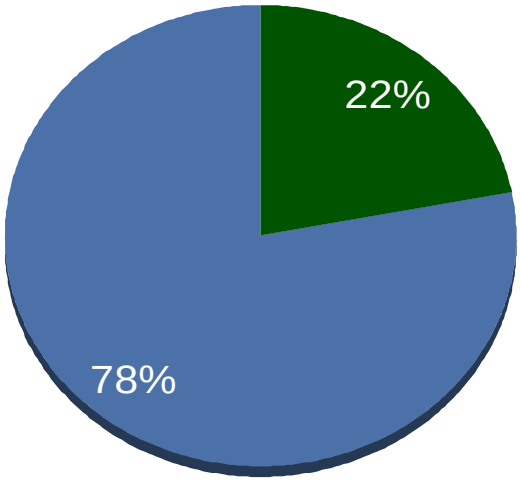
2001-2004: 0-9%	
Kregor, Injury (2001)	8.00%
Schutz, Injury (2001)	9.00%
Schandelmaier, Injury (2003)	9.30%
Syed, Injury (2004)	0.00%
Fankhauser, Acta (2004)	4.30%
Kregor, JOT (2004)	9.00%



Locked Plate Outcomes

Nonunion: After Locked Plates

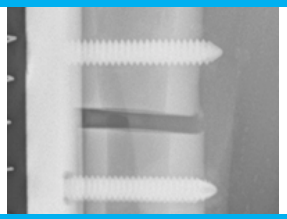
2011-2012: 16-22%	
Henderson, COOR (2011)	20.0%
Gross, AAOS (2011)	22.00%
Rodrigues, AAOS (2011)	21.00%
Hoffman, Injury (2012)	22.00%
Vallier, JOT (2012)	16.00%
Streubel, JBJS-B (2012)	15.00%



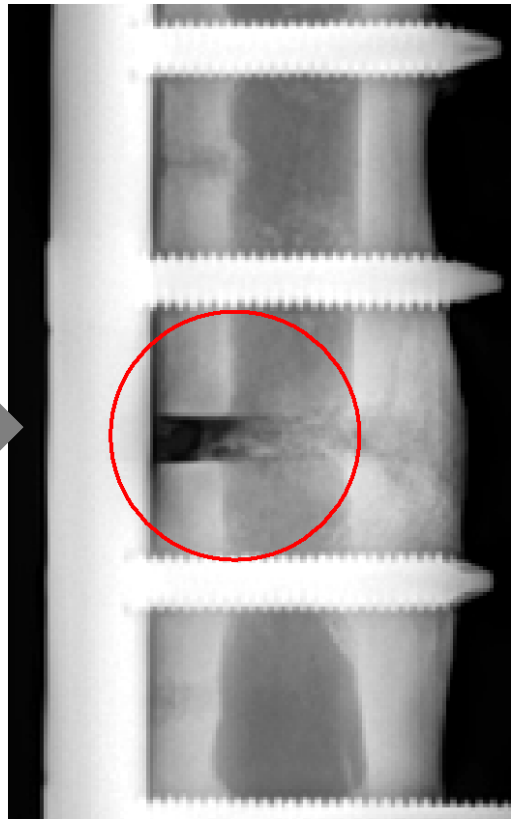
Locked Plating Callus

"Nature heals,

the physician assists"



9 weeks



"Nature wants to heal,

the implant resists"

Symmetric (p=0.91)

34% ↑ Callus (p=0.04)

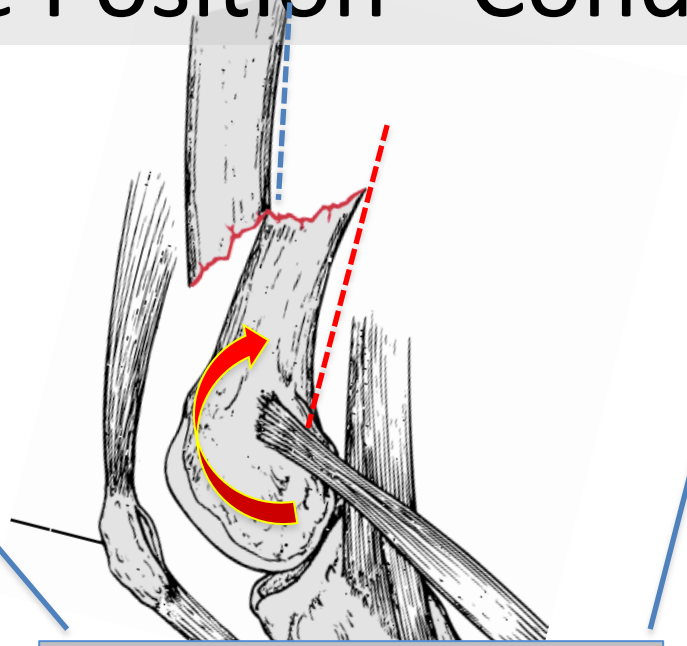
44% ↑ BMC (p=0.01)

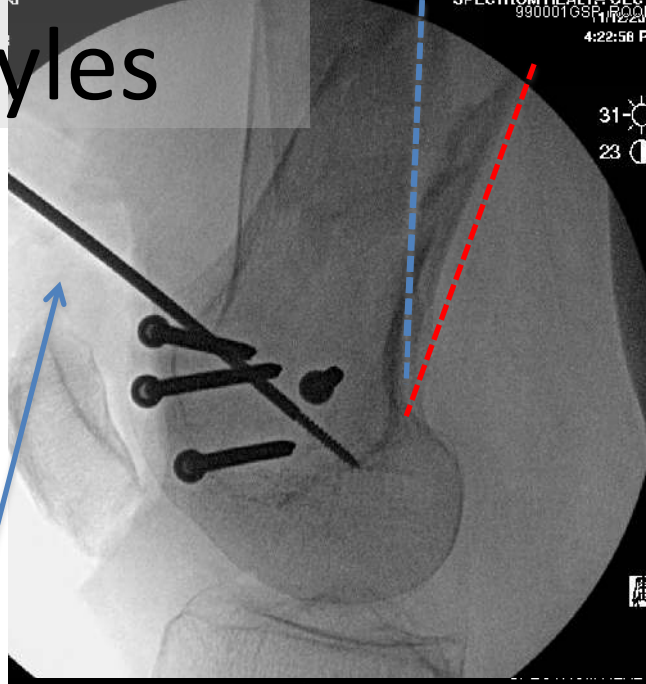
Bottlang et al

More “Flexible” Fixation

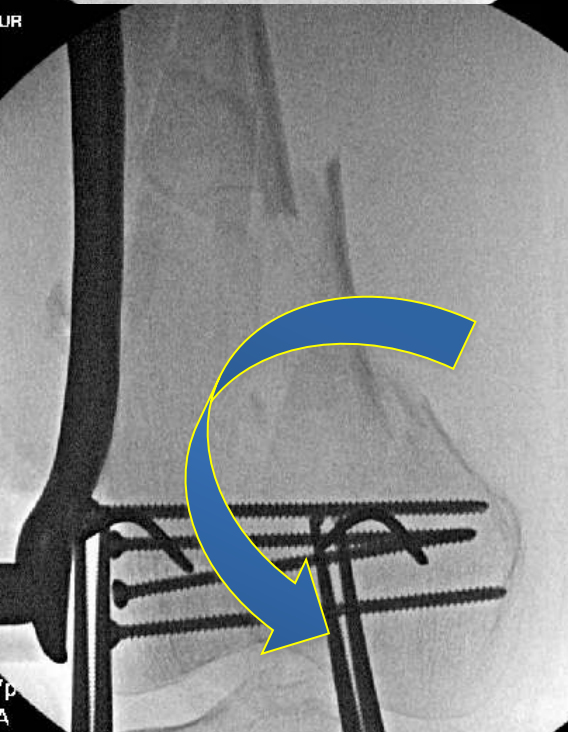
- Fewer shaft locking screws
- Over drill near cortex…but lock screw….”far cortical locking”
- Longer plates….span and protect entire bone….also reduces strain at fx site

Plate Position - Condyles





2.5 mm Condylar Schanz Pins



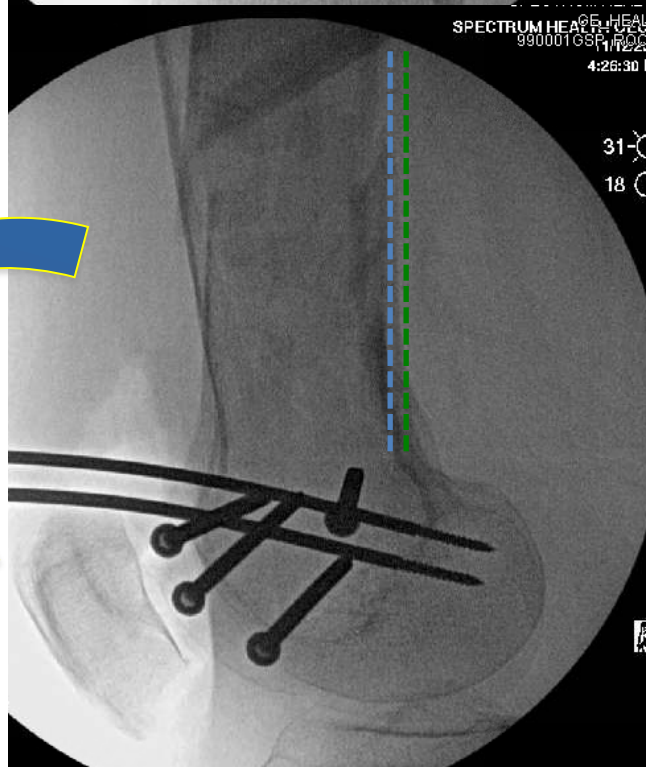
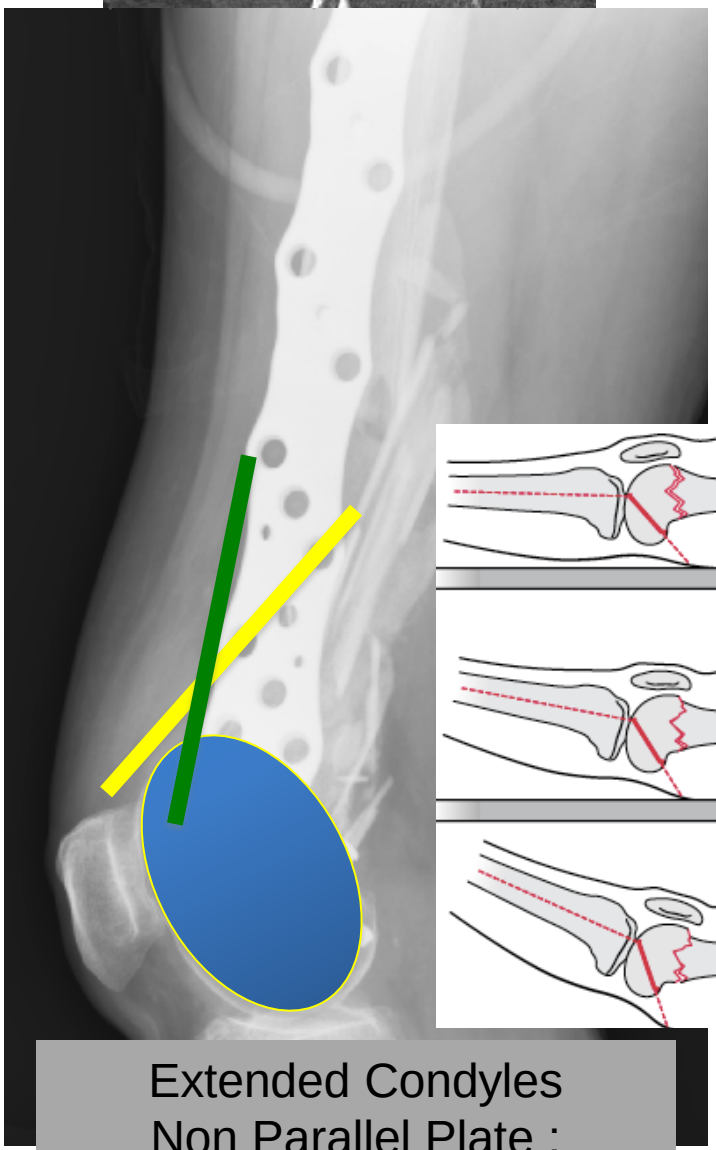
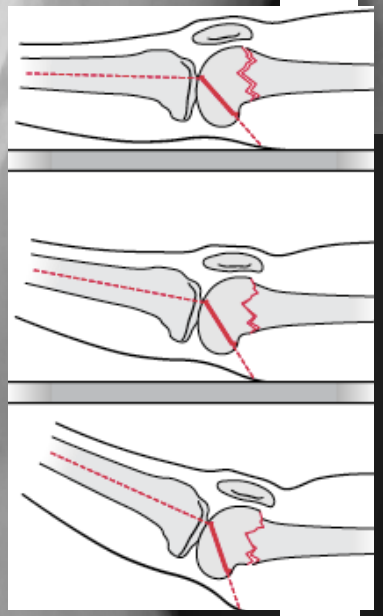


Plate Position - Condyles

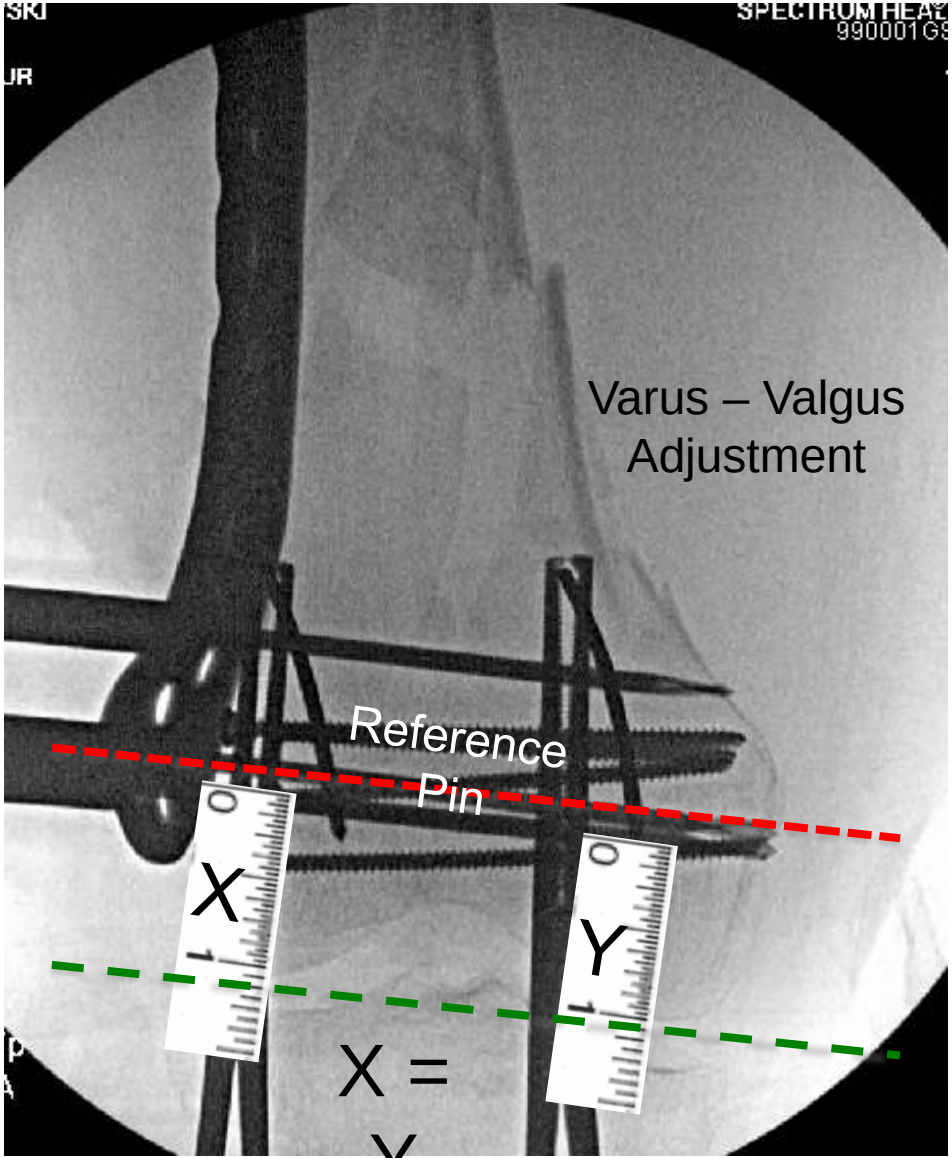




Notch View - AP

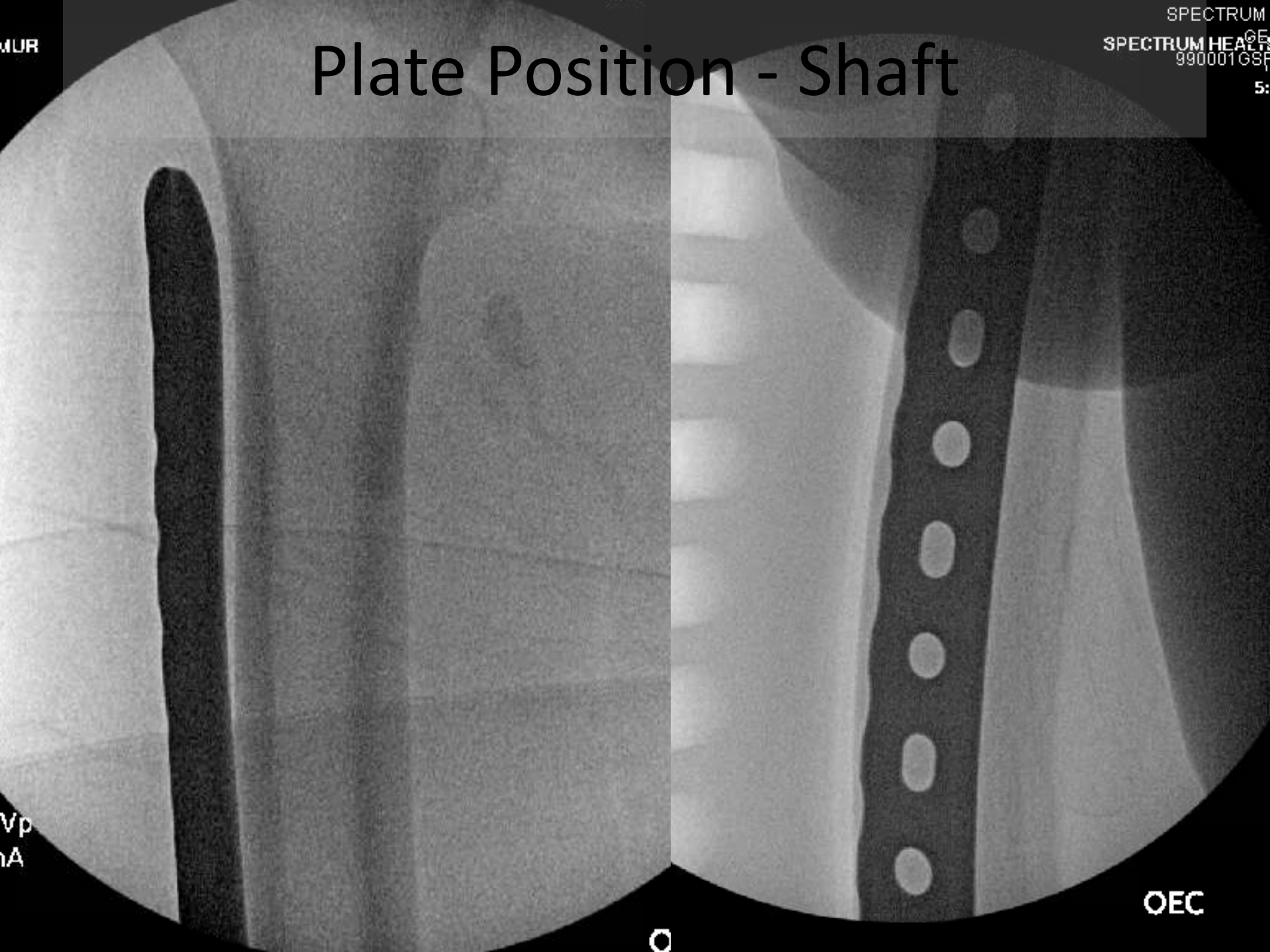
Extended Condyles
Non Parallel Plate :

Plate Position - Condyles

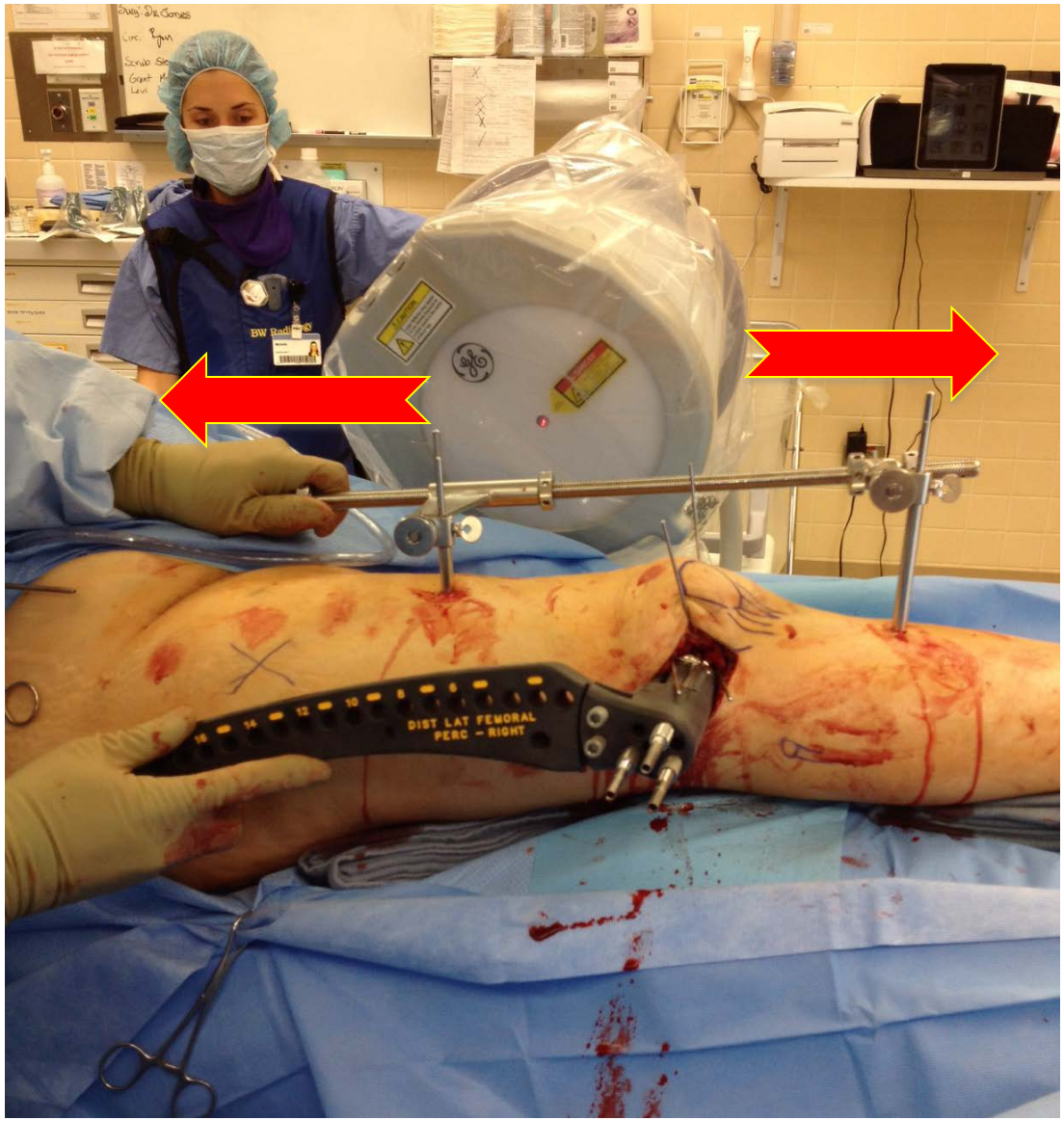


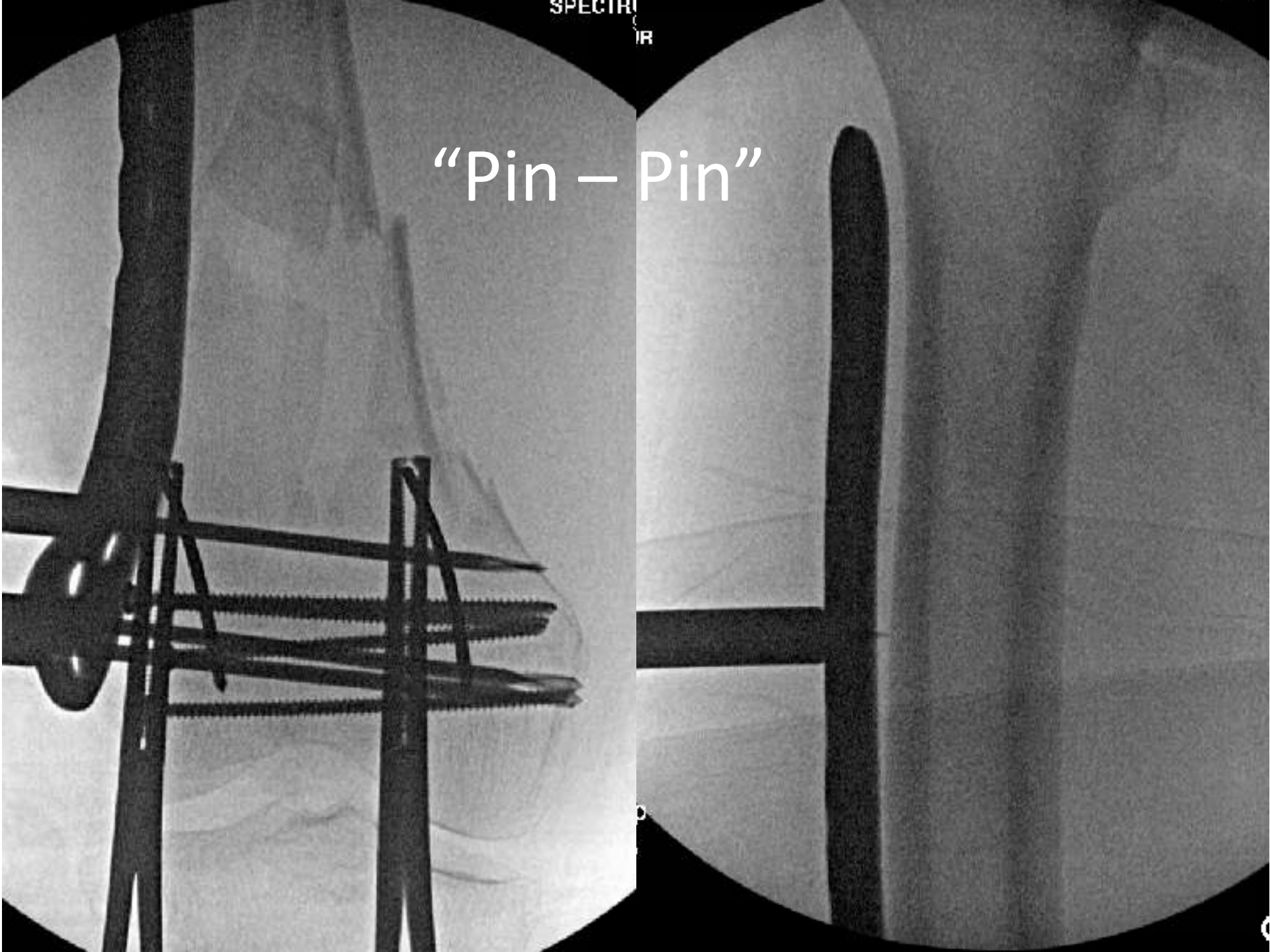
Center of
Condyles

Plate Position - Shaft

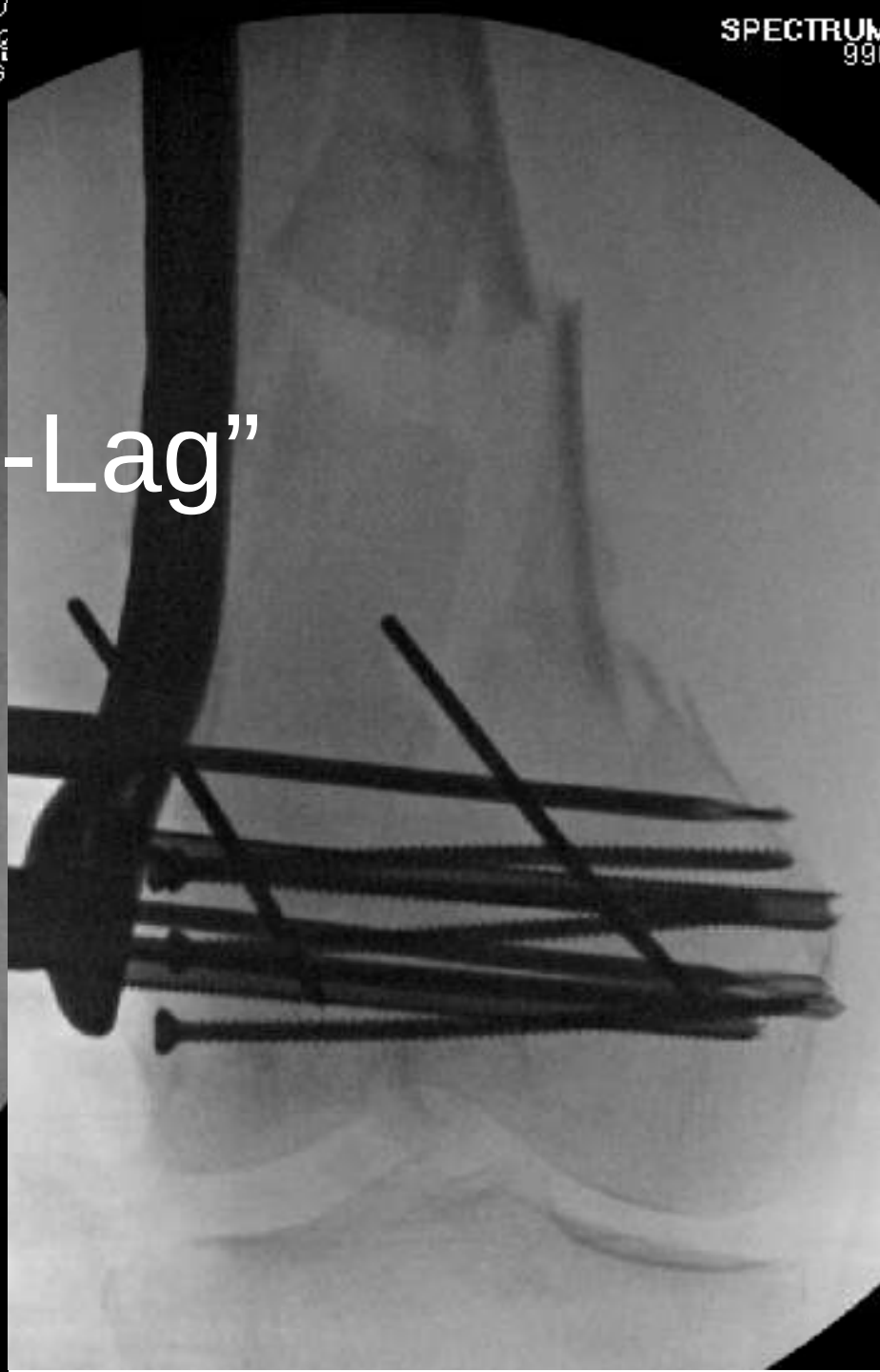


Obtain Length



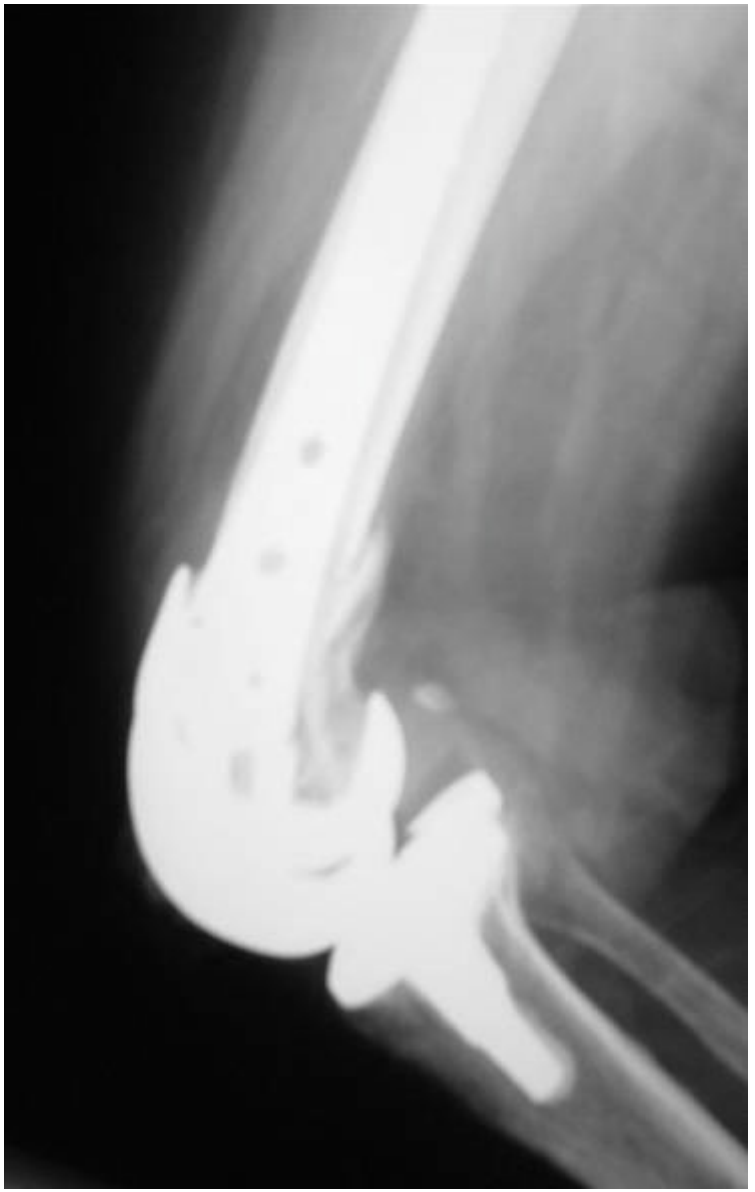

“Pin – Pin”

“Lag-Lag”




“Lock-Lock”

12 WEEKS



Periprosthetic Supracondylar Fracture

7 months post-op

Healed Supraconcylar Fracture

Healed Supracondylar Fracture and Shaft Fracture

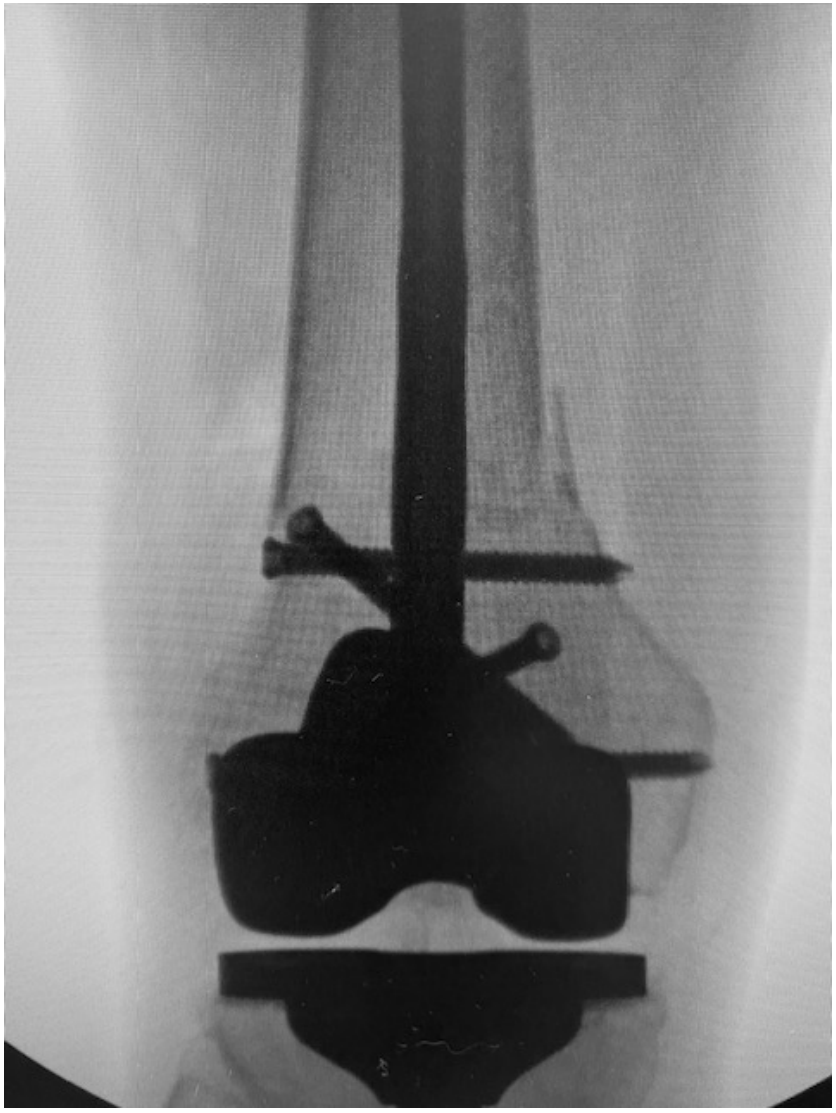
Retrograde Intra-medullary Nail

Nail size canal diameter mismatch

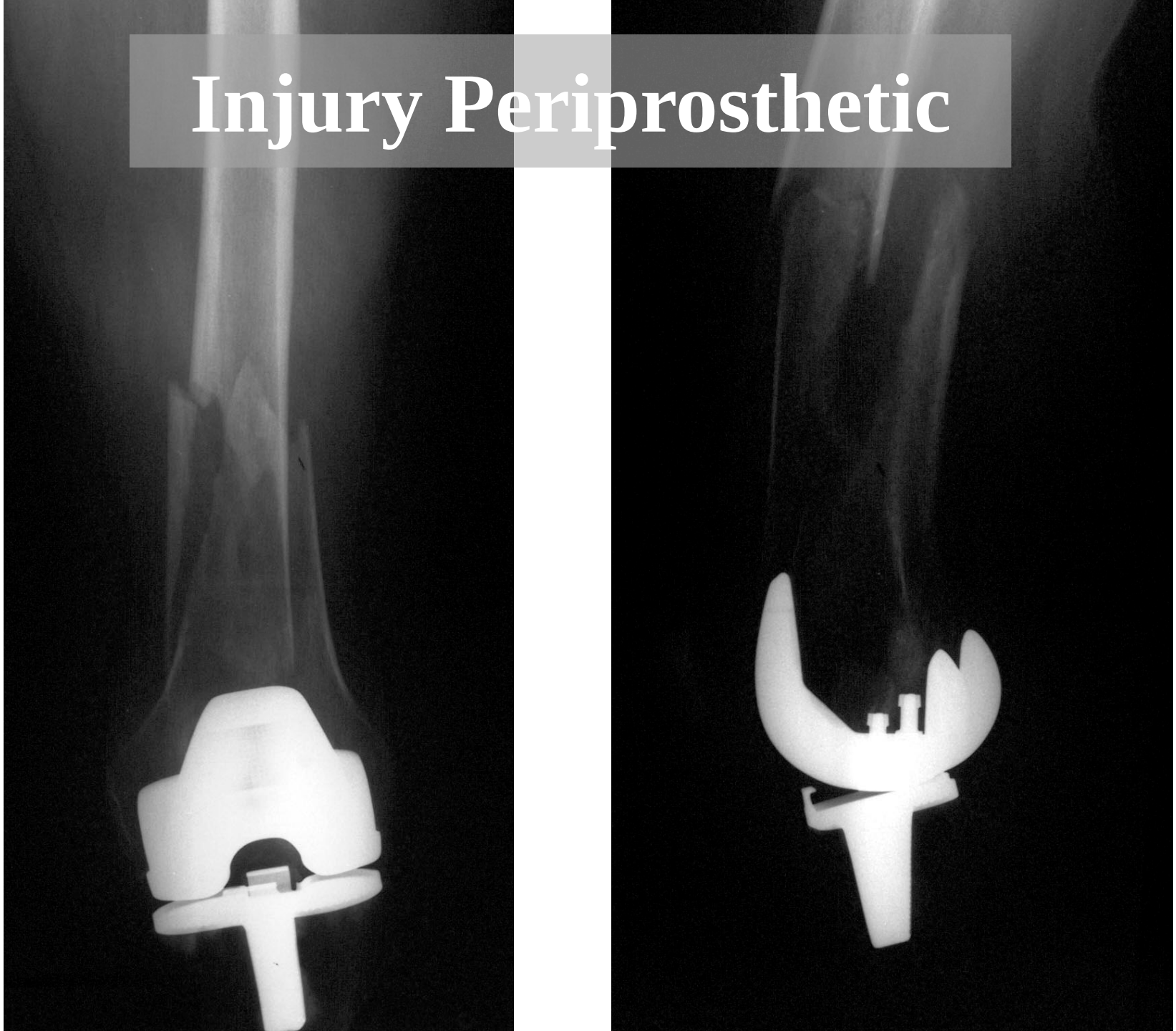
If Too Posterior → Hyperextension

SC Femur 5 Years Post Op

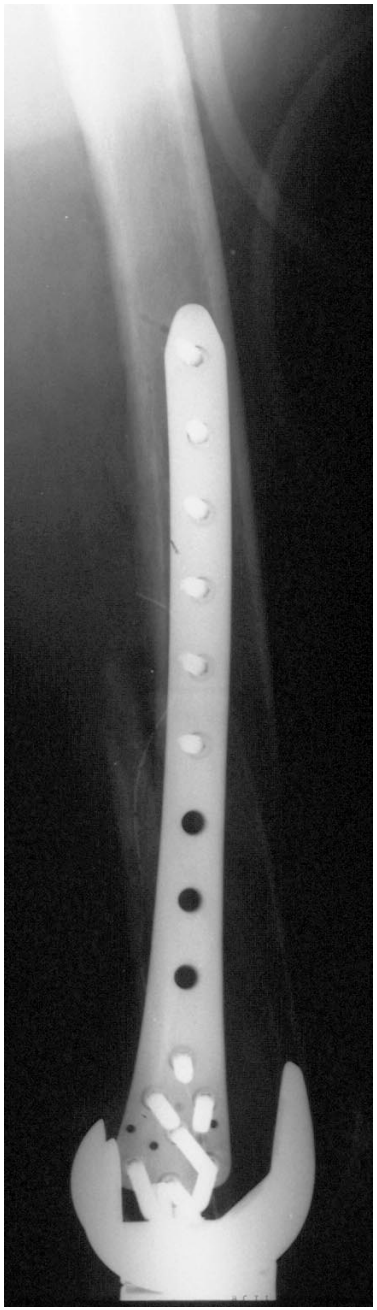
Retro IMN - WBAT



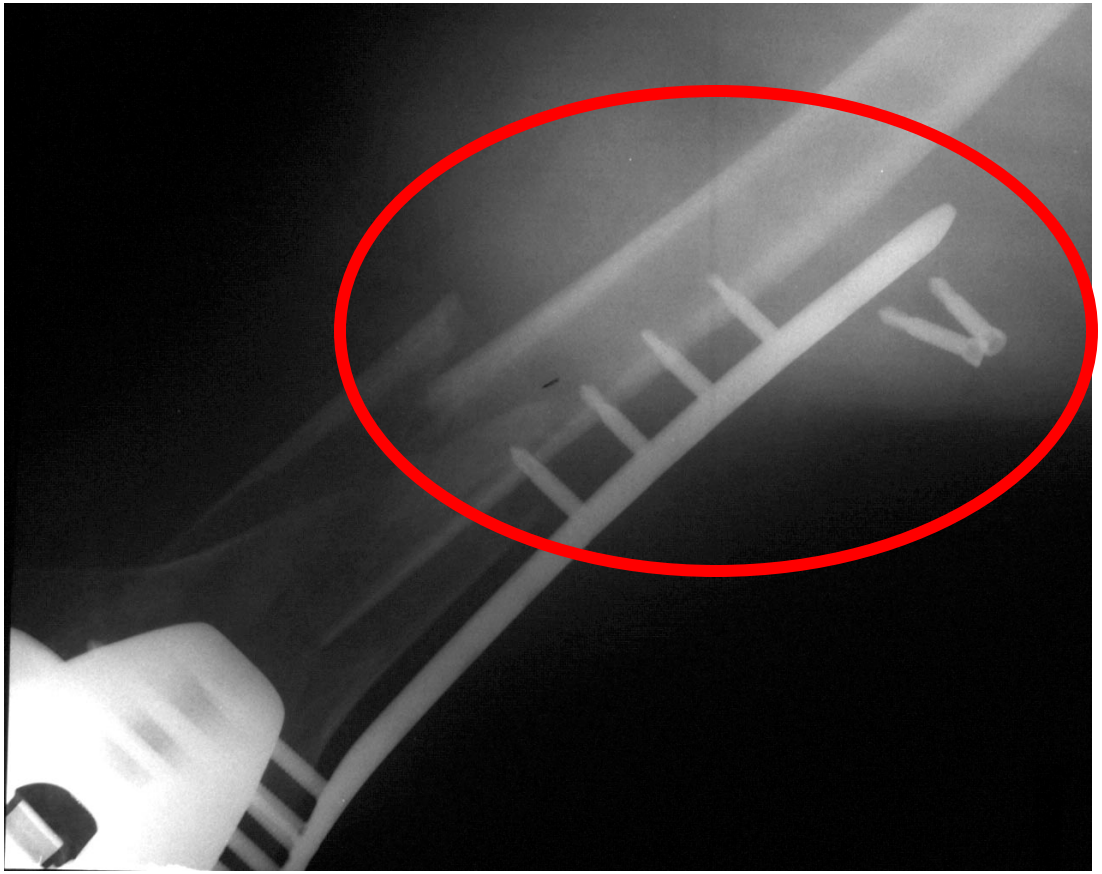
Injury Periprosthetic

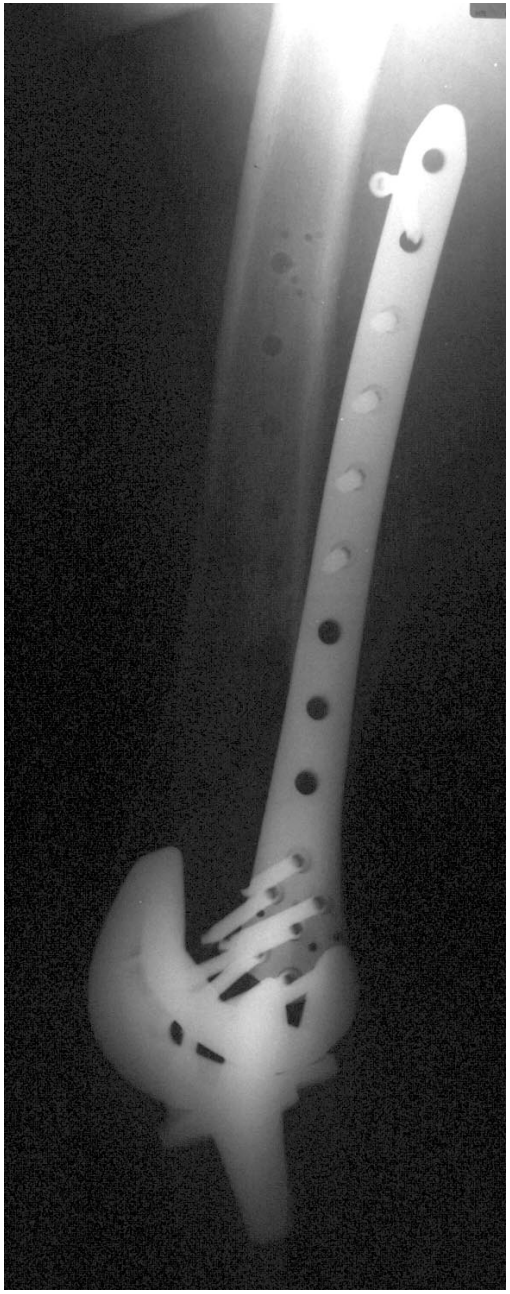


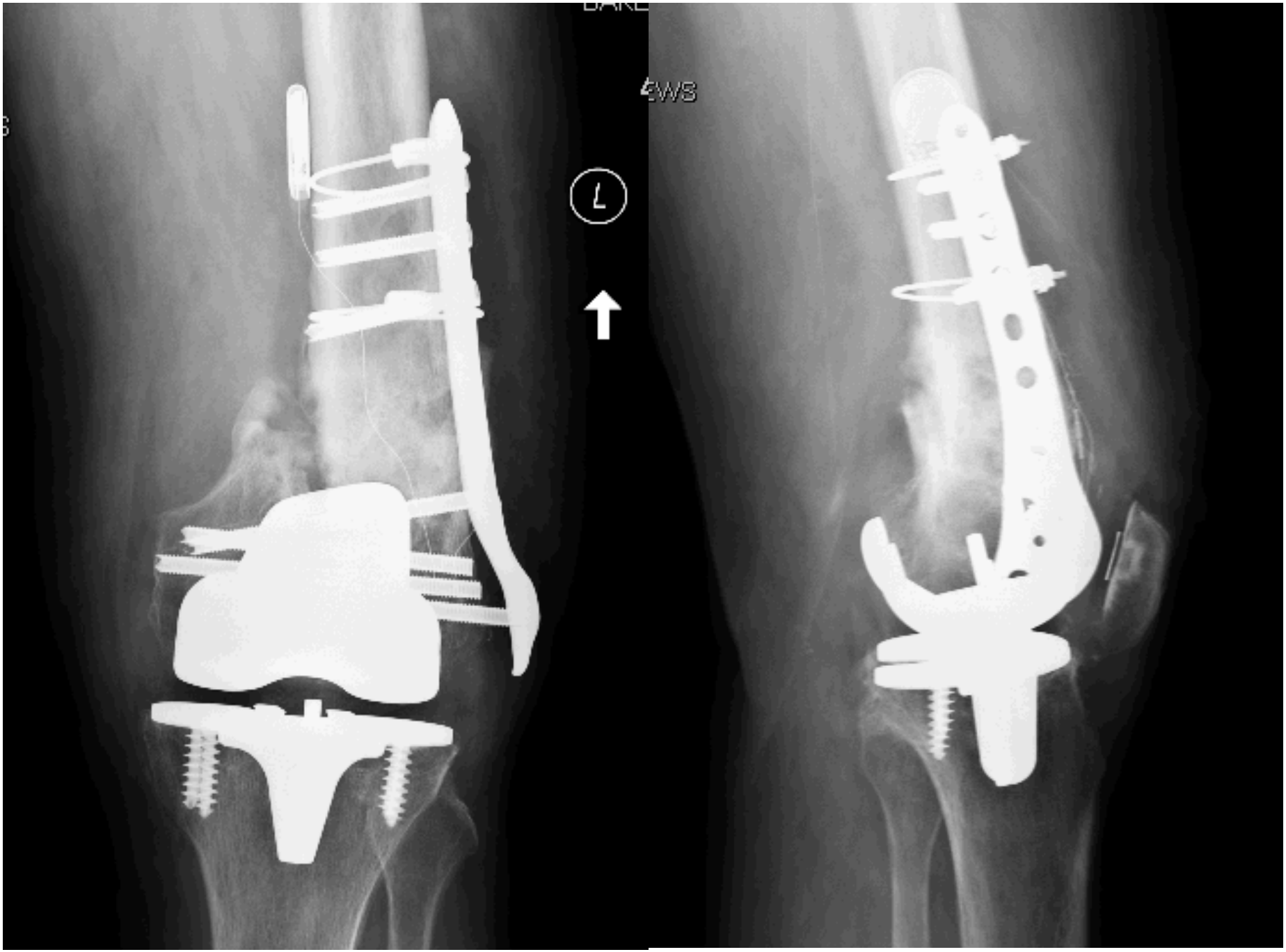
Post Operative



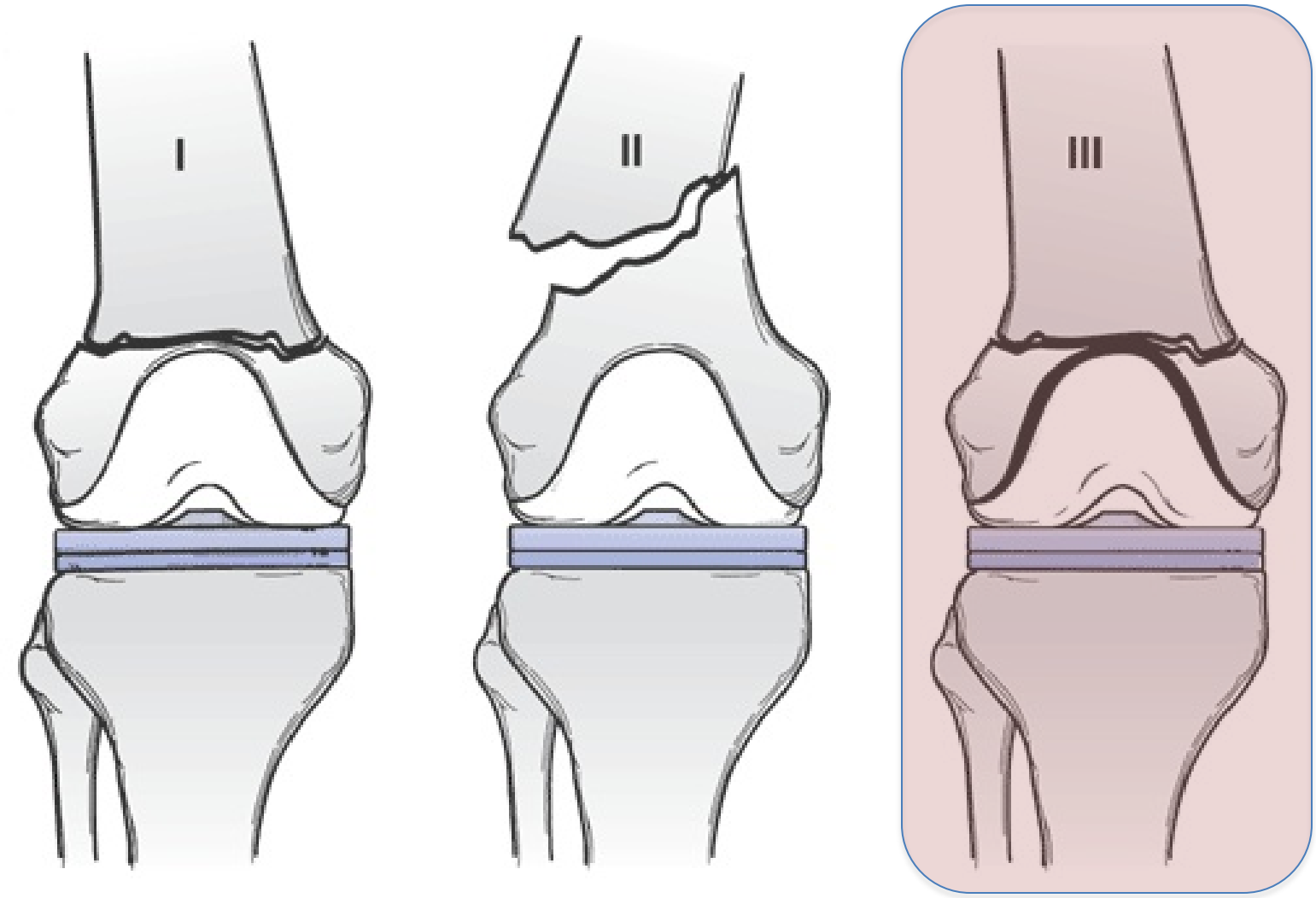
Screw Pull Out & Cut Out



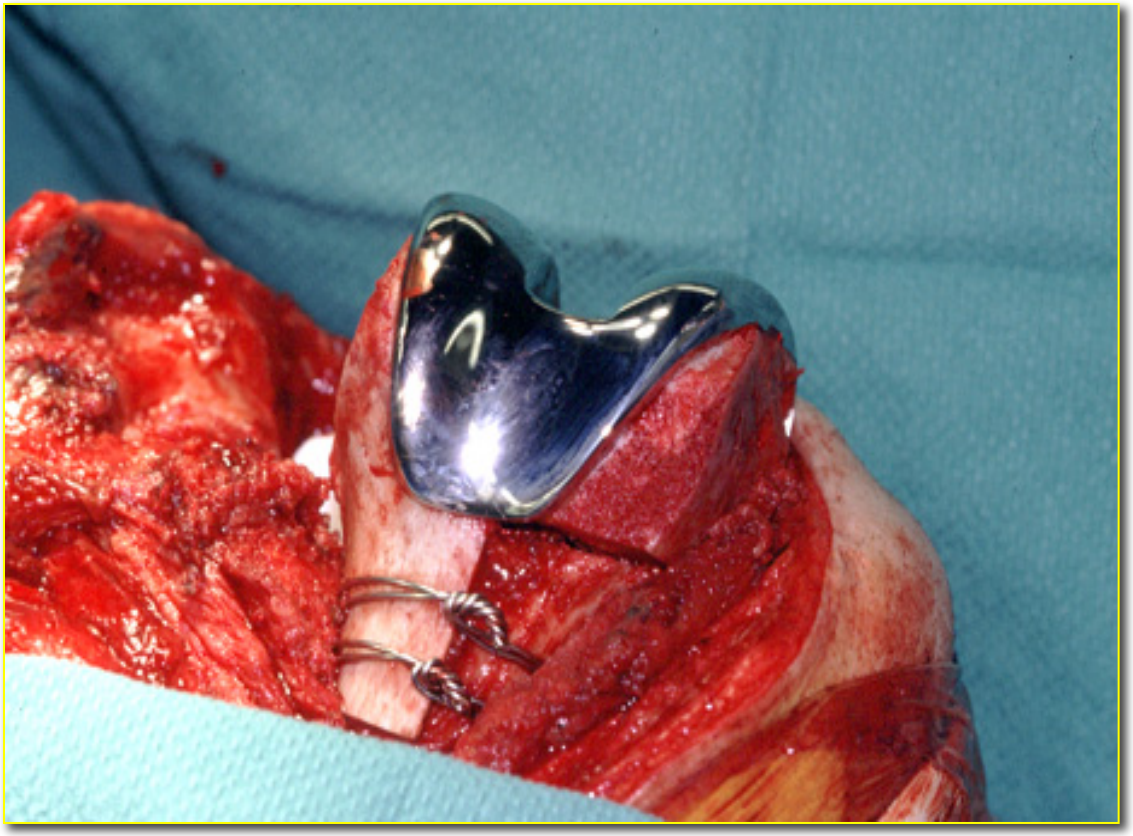



L

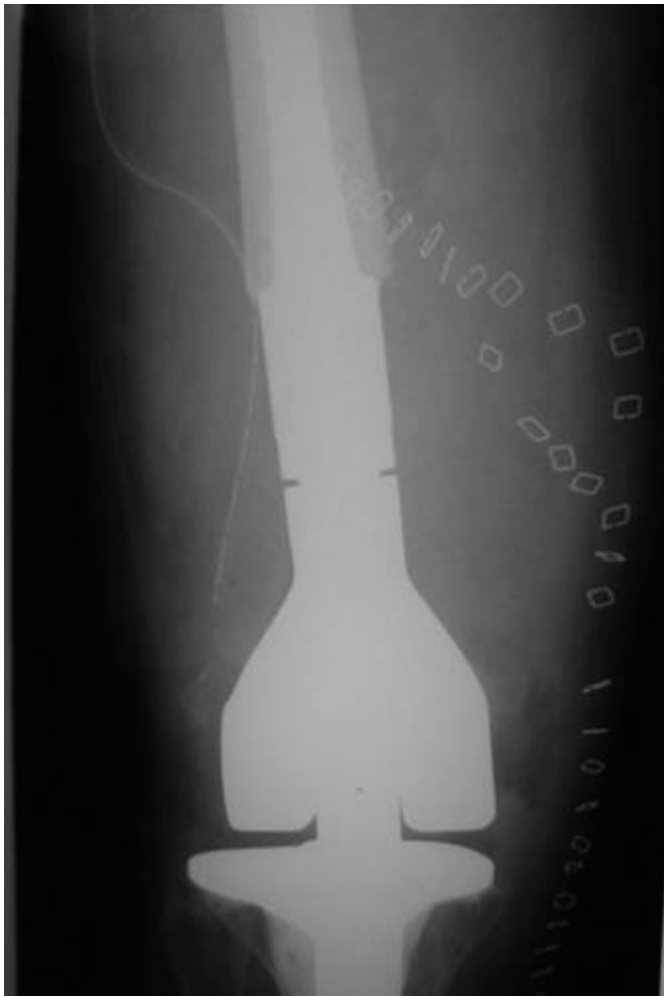
Femur – Total Knee Arthroplasty

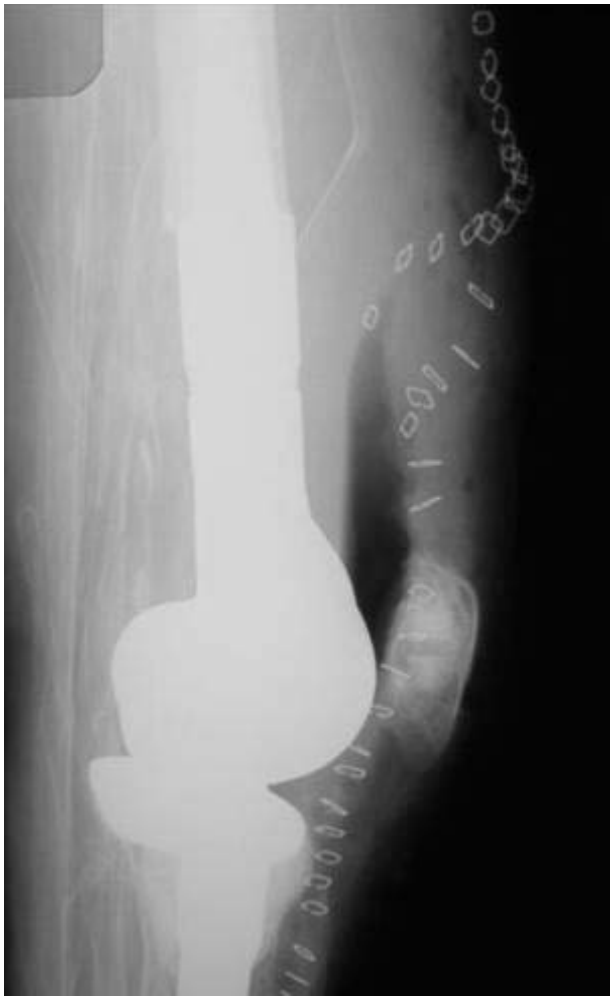


Allograft-Prosthetic Composite

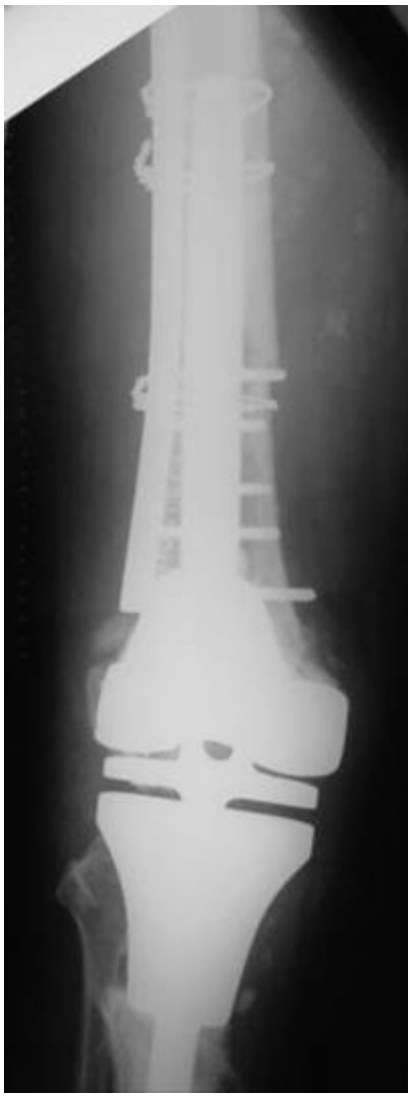


Constrained Rotating Hinge

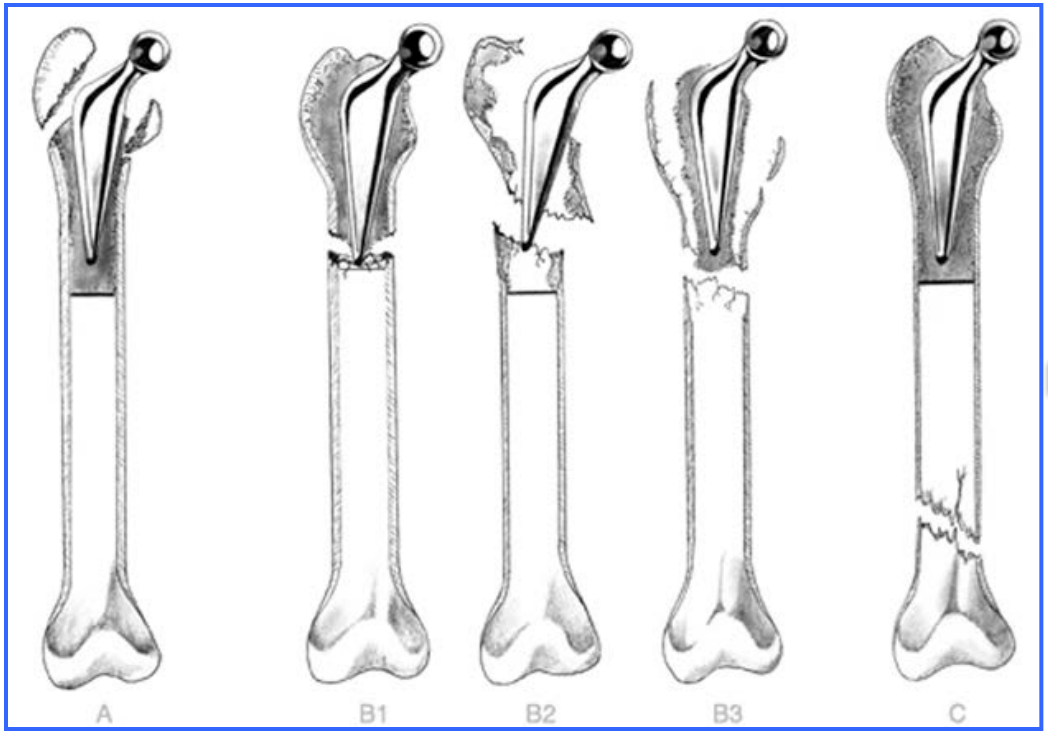


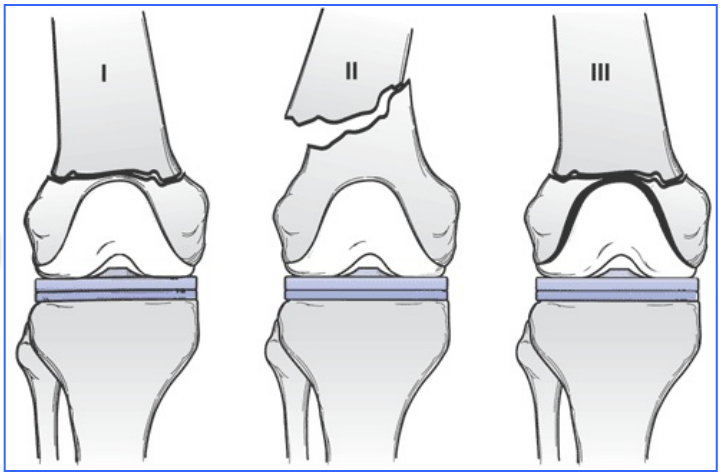


Constraint comes at a price!

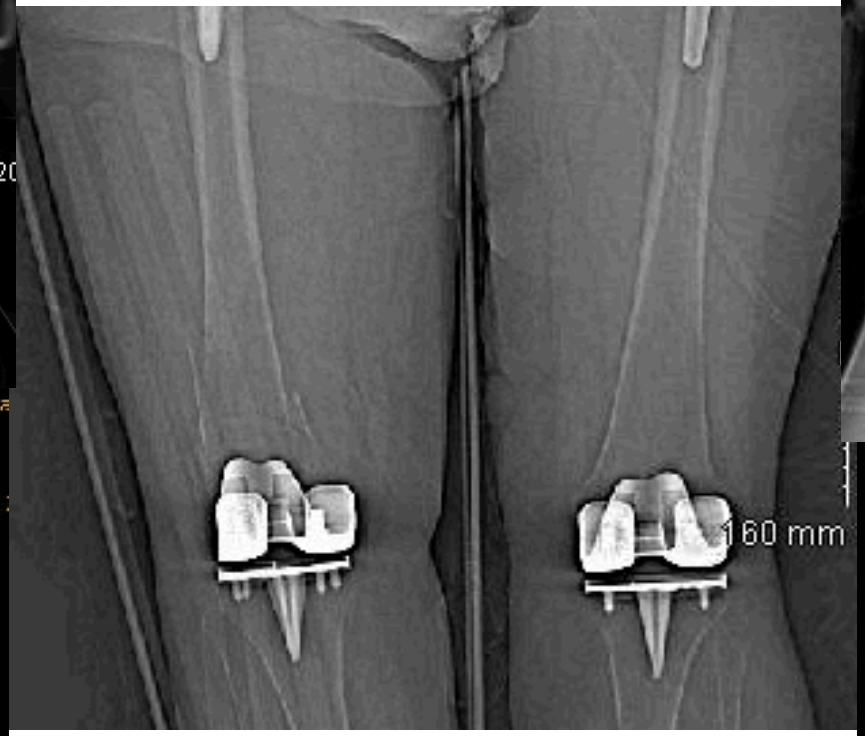


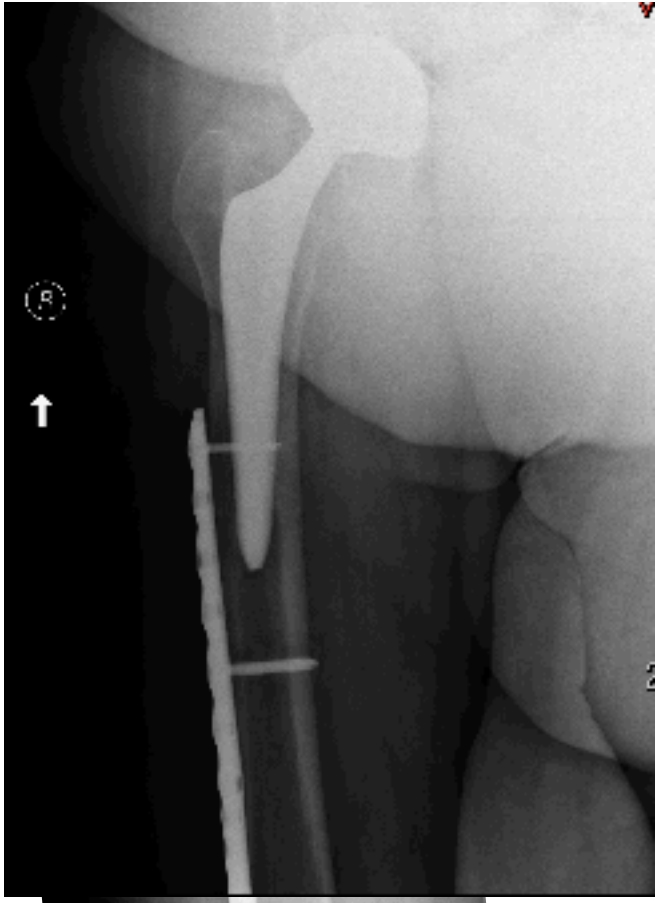
Femur – Total Hip & Knee Arthroplasty Inter-Prosthetic



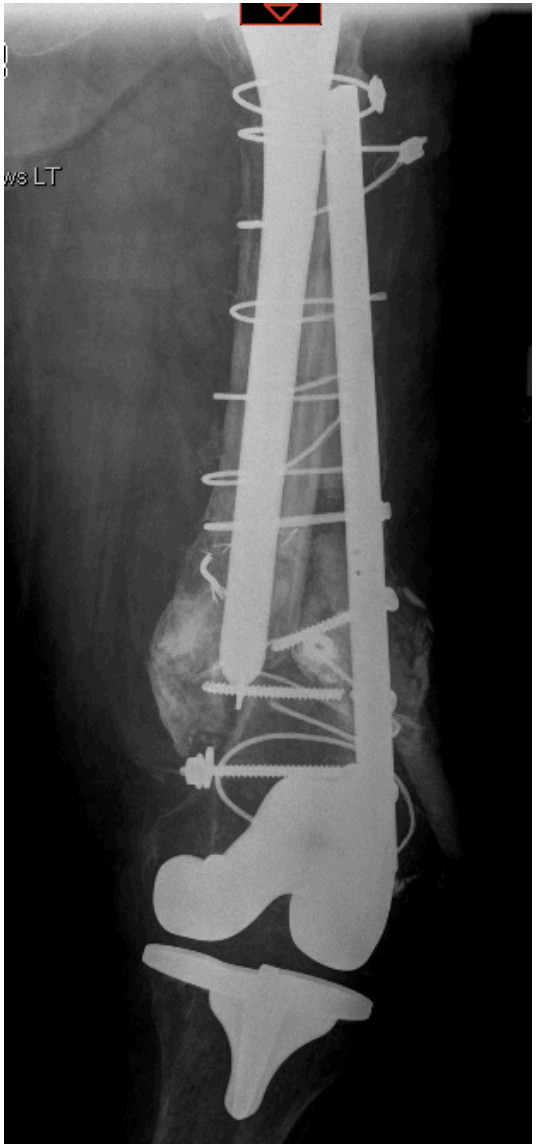


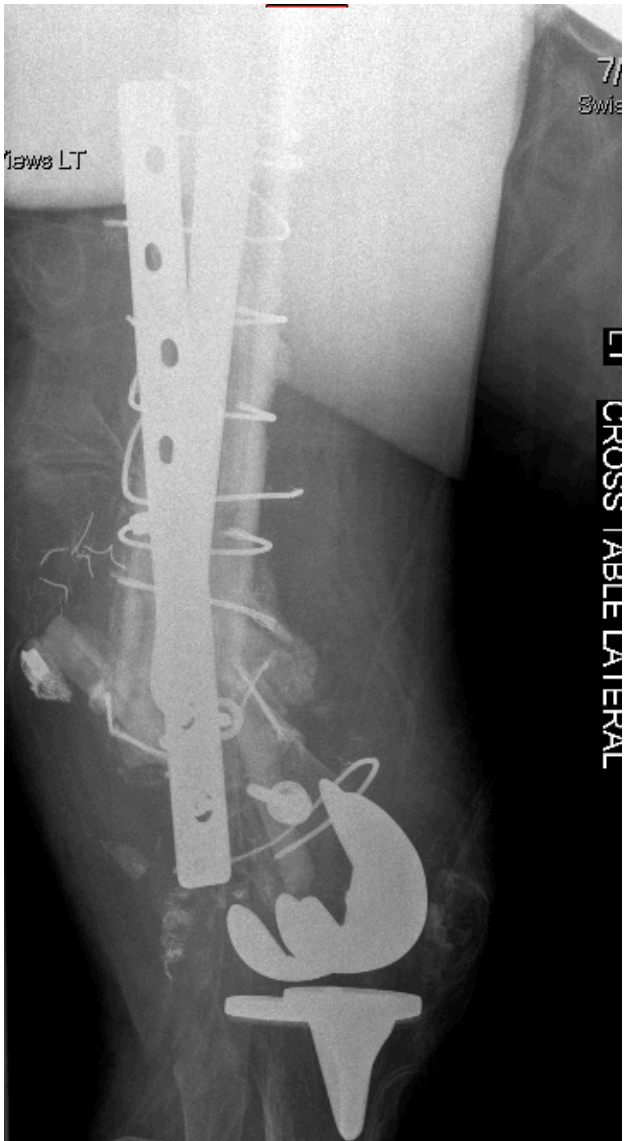
83F, LGF



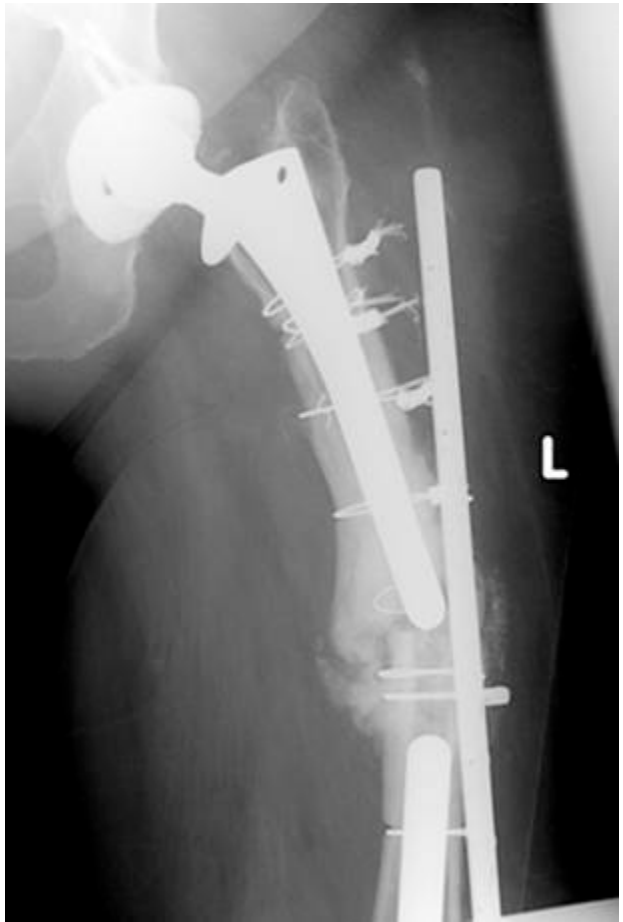


86F, RA, 6 yr MVA





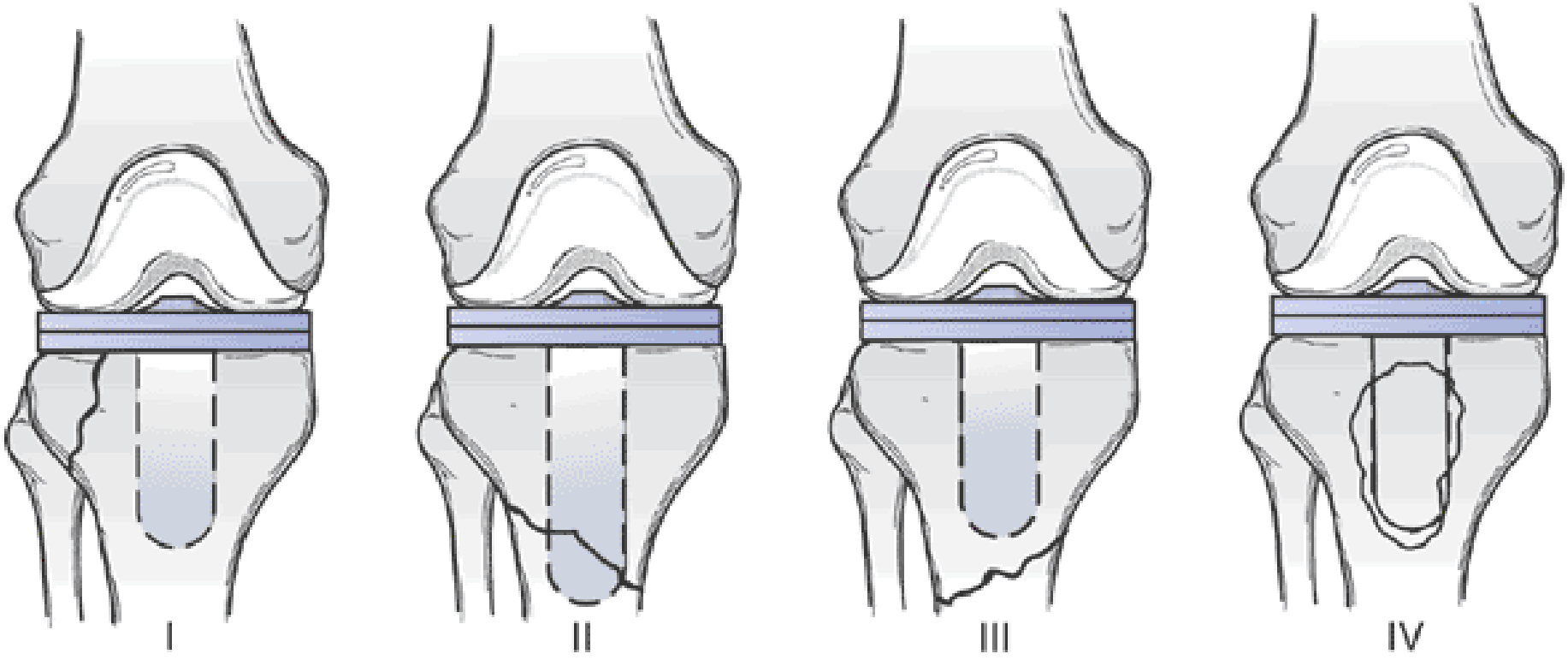
70 yo
280 pounds
TMTC previous ops




CROSS-TABLE


UTH
EWS
R
R
ORTHOP
4/14/201
K

Tibia – Total Knee Arthroplasty



Treatment Options

1st Step

- To establish whether implant is loose

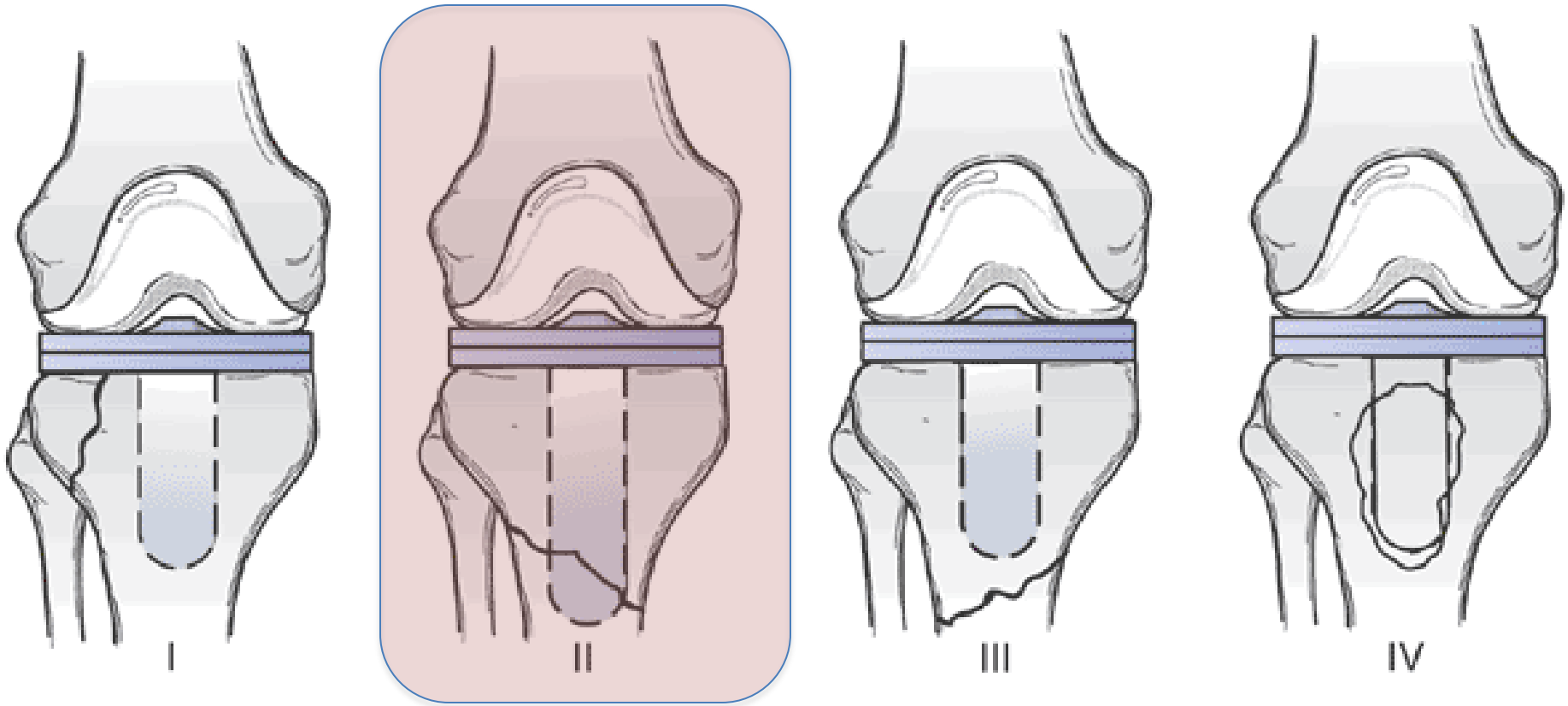
2nd Step

- To identify fracture displacement
- To decide if reduction is needed

3rd Step

- To determine appropriate treatment for displaced fracture

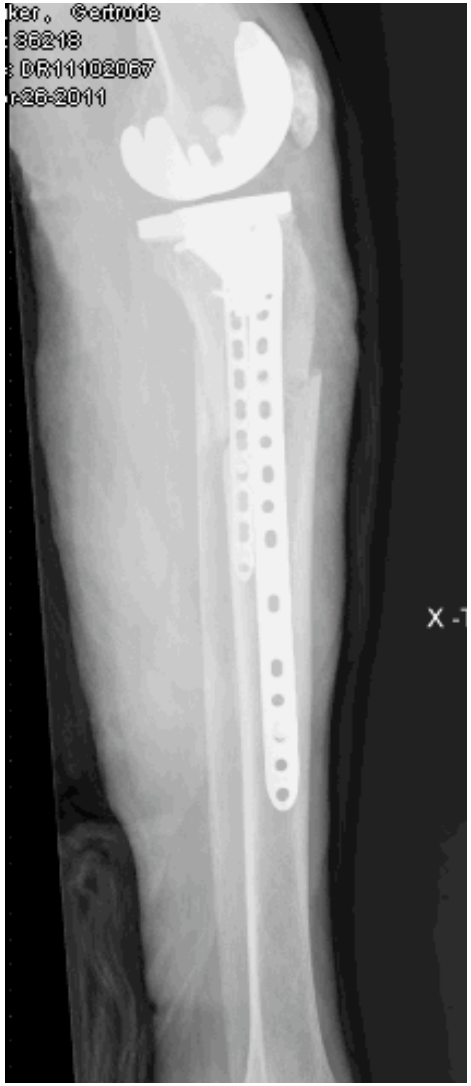
Tibia – Total Knee Arthroplasty



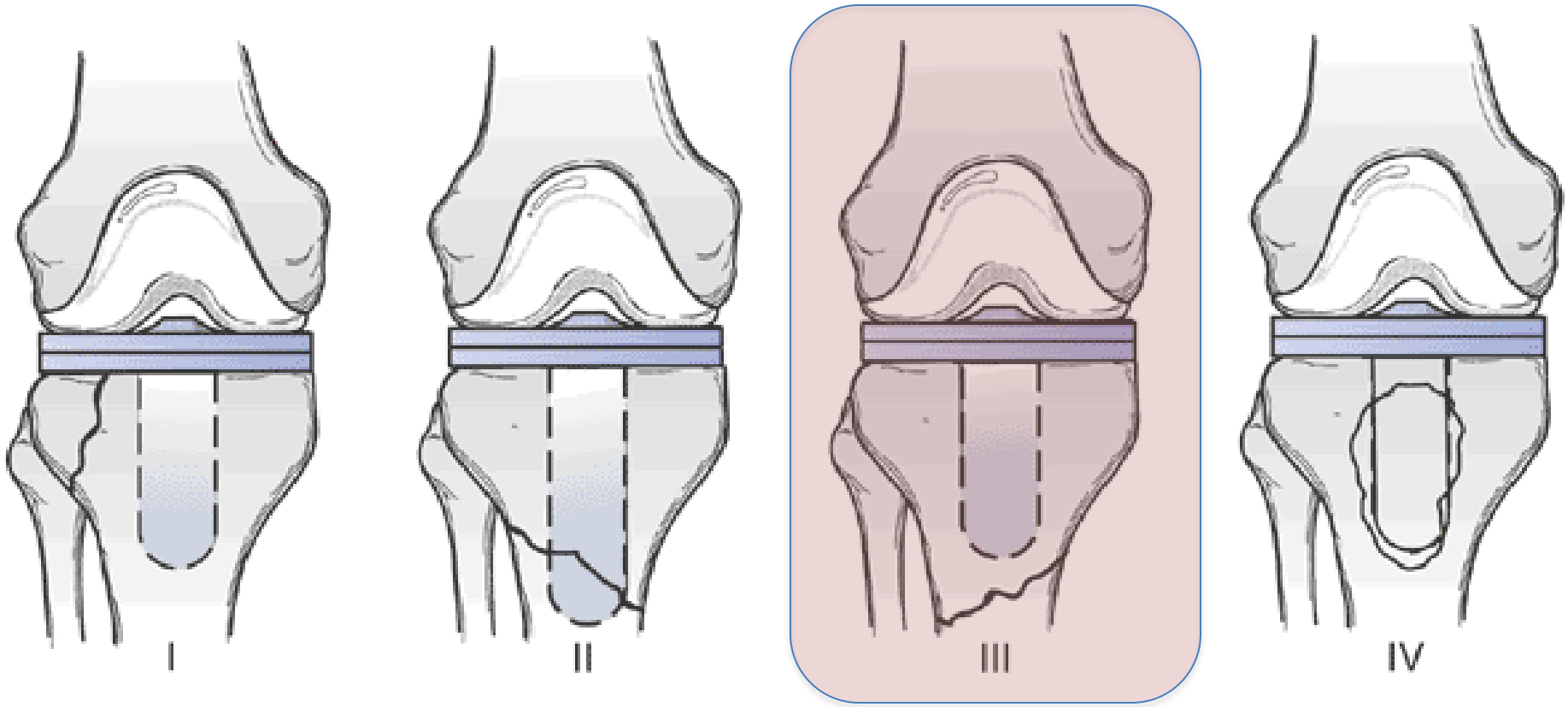
TKA, Periprosthetic

Lateral Locked ORIF

Final ORIF



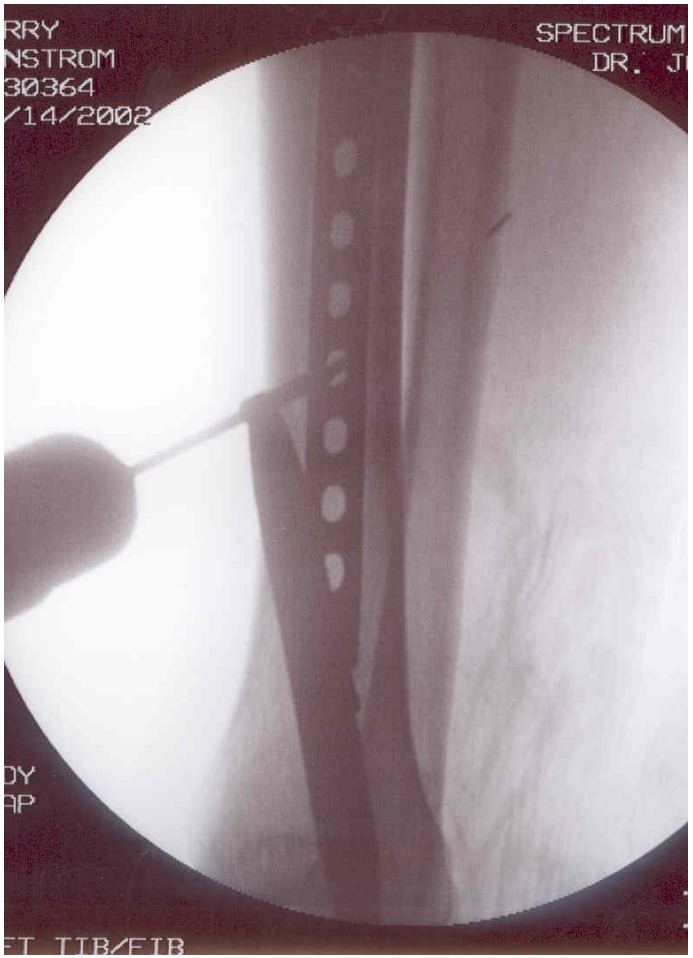
Tibia – Total Knee Arthroplasty



74 yo M, CABG, IDDM

CR/ LLC


RRY
NSTROM
30364
/14/2002
SPECTRUM I
DR. JON
19
RDY
NAP


RRY
NSTROM
30364
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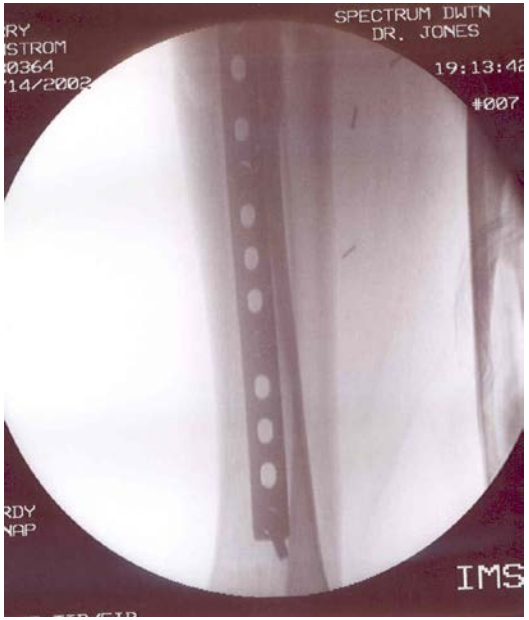
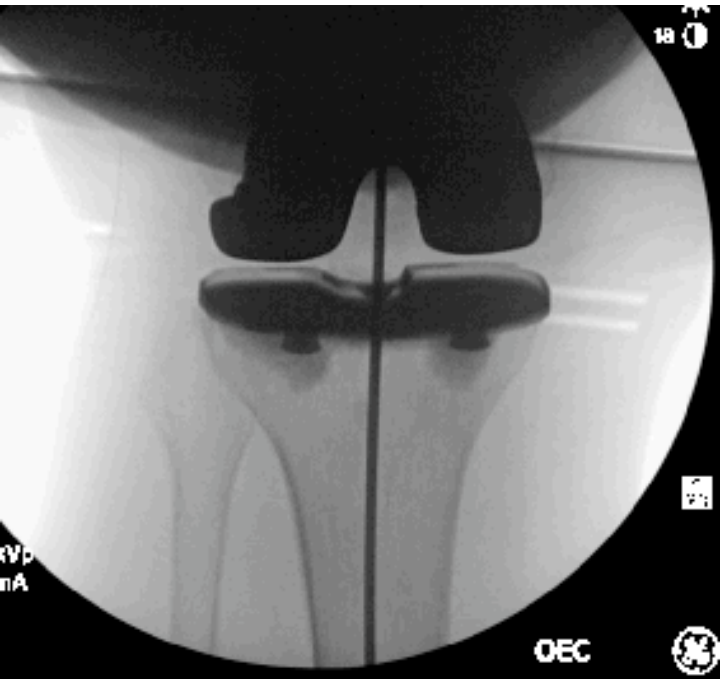
SPECTRUM
DR. J
DY
AP
FT TIB/FIB


SPECTRUM DWTN
DR. JONES
TIB/FIB


SPECTRUM DWTN
DR. JONES
#007

76M, TKA 5 yr, Open IIIB Tibia

Start Site



Ream

Insert IMN


Final
Alignment &
Healing

Distal Tibial Periprosthetic

IMN Healing

Summary: Patient

Periprosthetic fracture incidence increasing – younger age

Periprosthetic fxs - difficult manage – Implant, Osteoporosis

Patients may be difficult to manage – NWB

Team approach – Trauma & TJA, Medicine, Geriatrics

Consider functional goals for patient – WB ASAP

Consider skill of the surgeon – treat 1° or wait/refer

Summary

Assess fracture location

Stability of prosthesis

Adequacy of available bone

Summary

Unstable prosthesis: Revise

Stable prosthesis: Fix

Plate long… (protect the whole femur)

Locking implants!

Locking plates often superior to retrograde nails (and certainly conventional plates)

Summary

Supplemental struts for *bone deficiency* (not instability)

Cables of questionable value

Direct reduction in simple patterns, bridging in complex fracture patterns

Overlap implants (don’t leave a gap)

Conclusion

Check for Stability of Implant

Check for Quality of Bone

Treat Entire Bone

Beware of Transverse Fracture at Tip of Stem

Thank You

Dignity Health
Medical Group

Creighton
UNIVERSITY
EALTH SCIENCES
PHOENIX