Non-union
and
Mal-union

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FDA-definition non-union:

- 9 months after trauma AND 3 months without progress in healing
- But DO NOT wait 9 months before intervention!

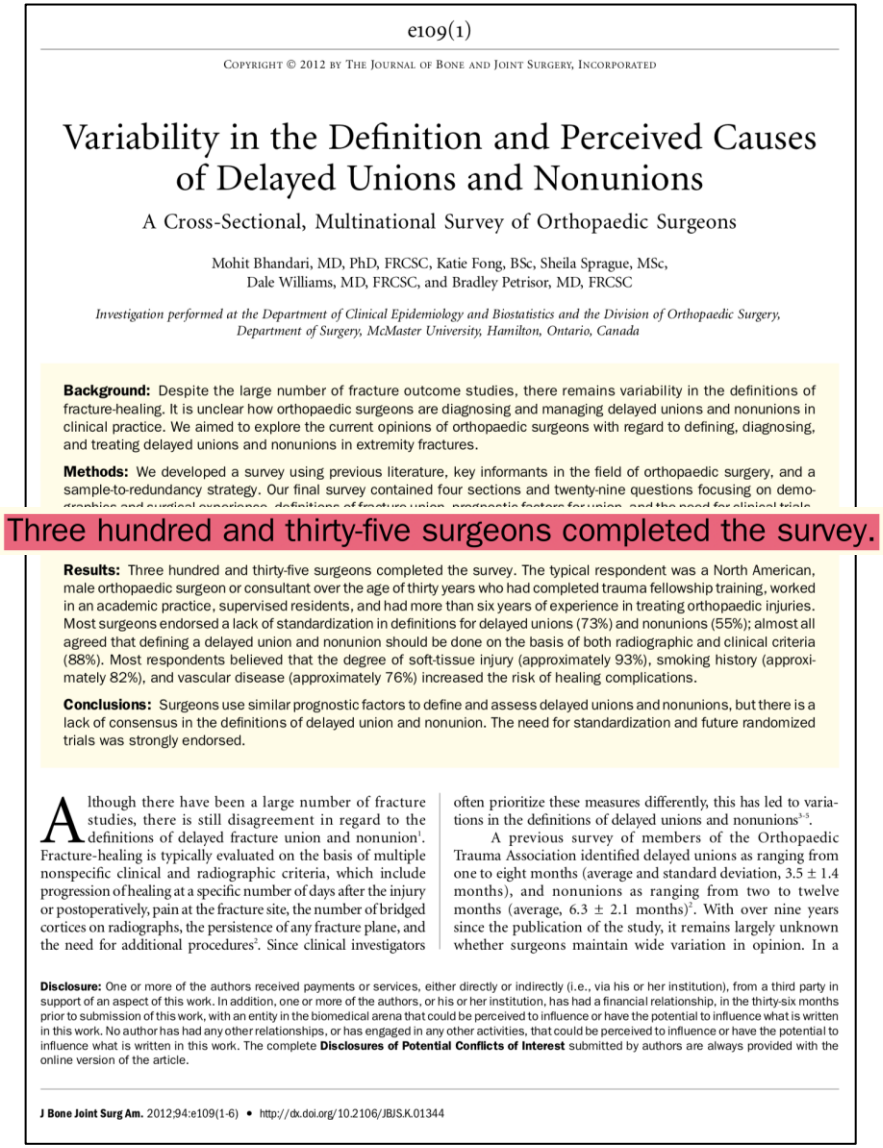
Clinical non-union definition

When to intervene ?

When it is apparent that the fracture will not heal:

- Biological vitality
- Biomechanical stability
- Infection

How to diagnose a non-union ?



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Variability in the Definition and Perceived Causes of Delayed Unions and Nonunions

A Cross-Sectional, Multinational Survey of Orthopaedic Surgeons

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Background: Despite the large number of fracture outcome studies, there remains variability in the definitions of fracture-healing. It is unclear how orthopaedic surgeons are diagnosing and managing delayed unions and nonunions in clinical practice. We aimed to explore the current opinions of orthopaedic surgeons with regard to defining, diagnosing, and treating delayed unions and nonunions in extremity fractures.

Methods: We developed a survey using previous literature, key informants in the field of orthopaedic surgery, and a sample-to-redundancy strategy. Our final survey contained four sections and twenty-nine questions focusing on demographics and surgical experience, definitions of fracture union, prognostic factors for union, and the need for clinical trials.

Three hundred and thirty-five surgeons completed the survey.

Results: Three hundred and thirty-five surgeons completed the survey. The typical respondent was a North American, male orthopaedic surgeon or consultant over the age of thirty years who had completed trauma fellowship training, worked in an academic practice, supervised residents, and had more than six years of experience in treating orthopaedic injuries. Most surgeons endorsed a lack of standardization in definitions for delayed unions (73%) and nonunions (55%); almost all agreed that defining a delayed union and nonunion should be done on the basis of both radiographic and clinical criteria (88%). Most respondents believed that the degree of soft-tissue injury (approximately 93%), smoking history (approximately 82%), and vascular disease (approximately 76%) increased the risk of healing complications.

Conclusions: Surgeons use similar prognostic factors to define and assess delayed unions and nonunions, but there is a lack of consensus in the definitions of delayed union and nonunion. The need for standardization and future randomized trials was strongly endorsed.

Although there have been a large number of fracture studies, there is still disagreement in regard to the definitions of delayed fracture union and nonunion[1]. Fracture-healing is typically evaluated on the basis of multiple nonspecific clinical and radiographic criteria, which include progression of healing at a specific number of days after the injury or postoperatively, pain at the fracture site, the number of bridged cortices on radiographs, the persistence of any fracture plane, and the need for additional procedures[2]. Since clinical investigators often prioritize these measures differently, this has led to variations in the definitions of delayed unions and nonunions[3-5].

A previous survey of members of the Orthopaedic Trauma Association identified delayed unions as ranging from one to eight months (average and standard deviation, 3.5 ± 1.4 months), and nonunions as ranging from two to twelve months (average, 6.3 ± 2.1 months)[3]. With over nine years since the publication of the study, it remains largely unknown whether surgeons maintain wide variation in opinion. In a

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Both clinical and radiologic criteria to diagnose a non-union (88%):

Clinical:

1) Inability to bear weight (84%)
2) Pain at fracture site (74%)
3) Tenderness on palpation (38%)

Radiologic:

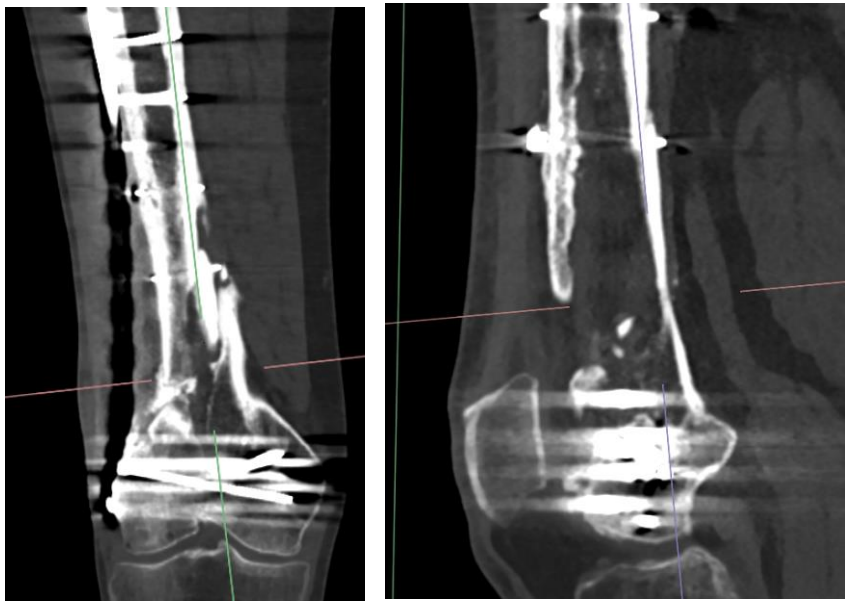
1) Lack of callus more important than persistent fracture lines (75%)

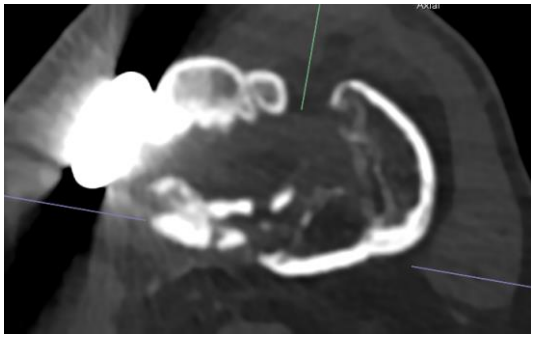
Equivocal radiographs – Can CT help ?

TABLE III Accuracy of Computed Tomography for the Detection of Nonunion*

	Clinical Gold Standard *(no. of patients)*		
	Union	Nonunion	Total
Computed tomography scan *(no. of patients)*			
Union	8		8
Nonunion	5	22	27
Total	13	22	35

*The sensitivity for detecting nonunion is 100%, and the specificity is 62% (kappa = 0.668, $p < 0.0001$).





62% specificity:

- clefts in bone of uncertain clinical importance
- risk of taking a healed fracture to surgery

(*Bhattacaryya,* JBJS Am 2006)

Classification: Septic versus Aseptic

Infection screening

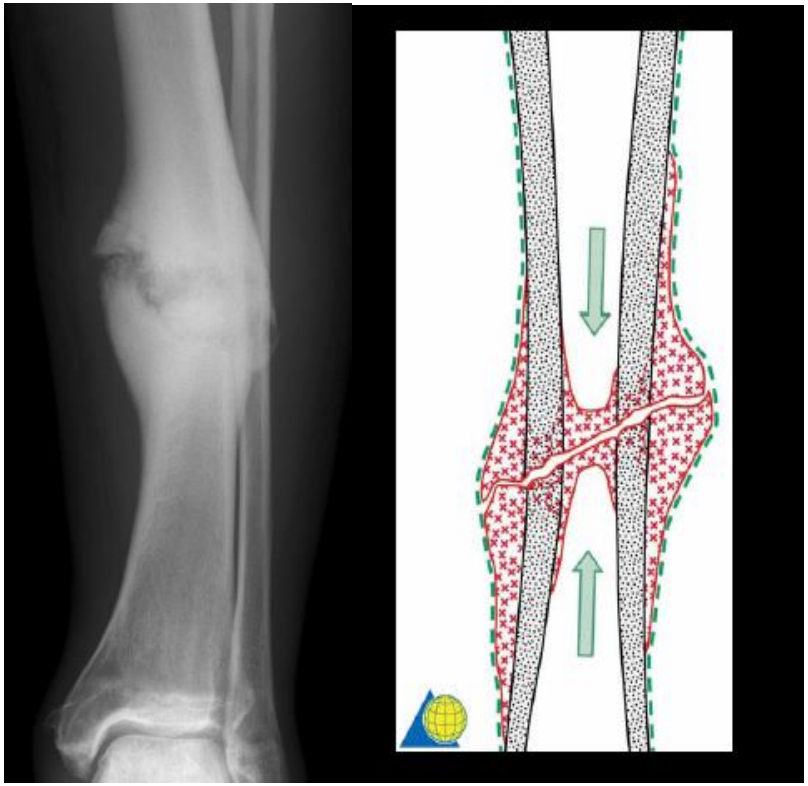
- History:
  - wound drainage
  - sinus formation
  - previous infection treatment
- Clinical evaluation
- X-ray
- CRP, (SR, blood-count)

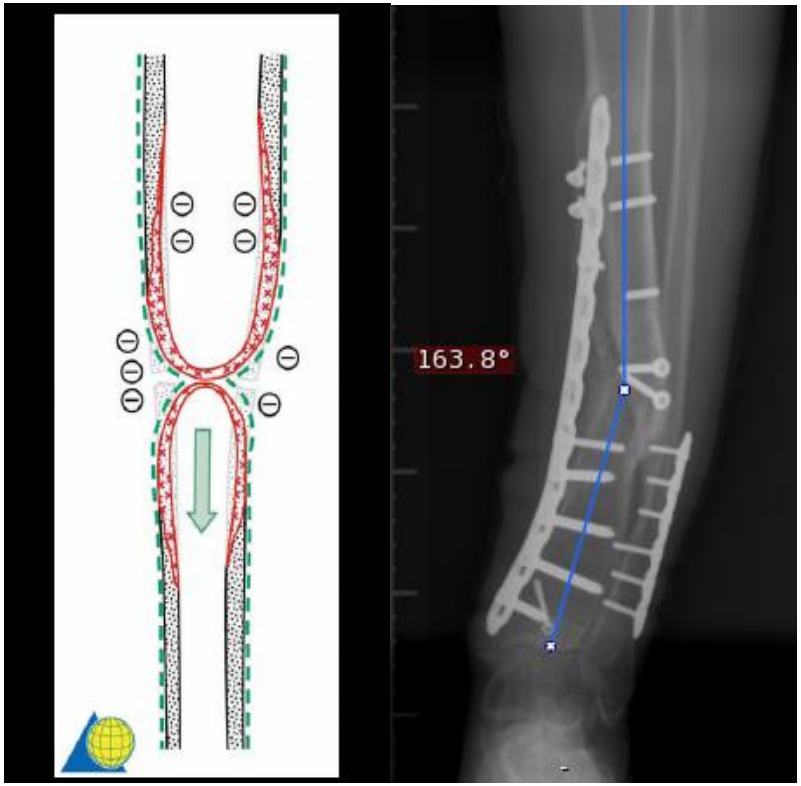
20% of aseptic non-unions have positive intra-operative cultures (*Moghaddam et al.* Injury 2015).

BASIC treatment principles

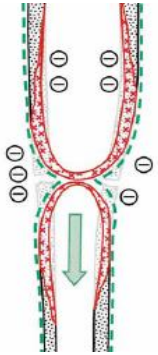
Stability:
- hypertrophic (stiff)

Biology:
- oligotrophic / atrophic (mobile)
- pseudoarthrosis (hypertrophic mobile)



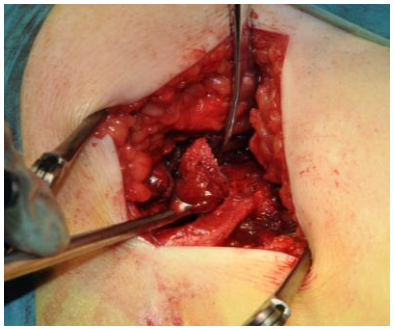


Biological stimulation



Osteo-inductive/osteogenic/(osteoconductive)

- Autograft (gold standard)
- Free flap (vascularity)
- Bone transport
- Masquelet
- Mechano-biology



Five pillars of non-union management

Optimisation of modifiable risk factors

Mechanical alignment

Stable fixation

Biological stimulation (mechano-biology)

Early functional rehabilitation

Ferreira and Malais. *Injury.* 2015

■ ANNOTATION: TRAUMA

A unified theory of bone healing and nonunion

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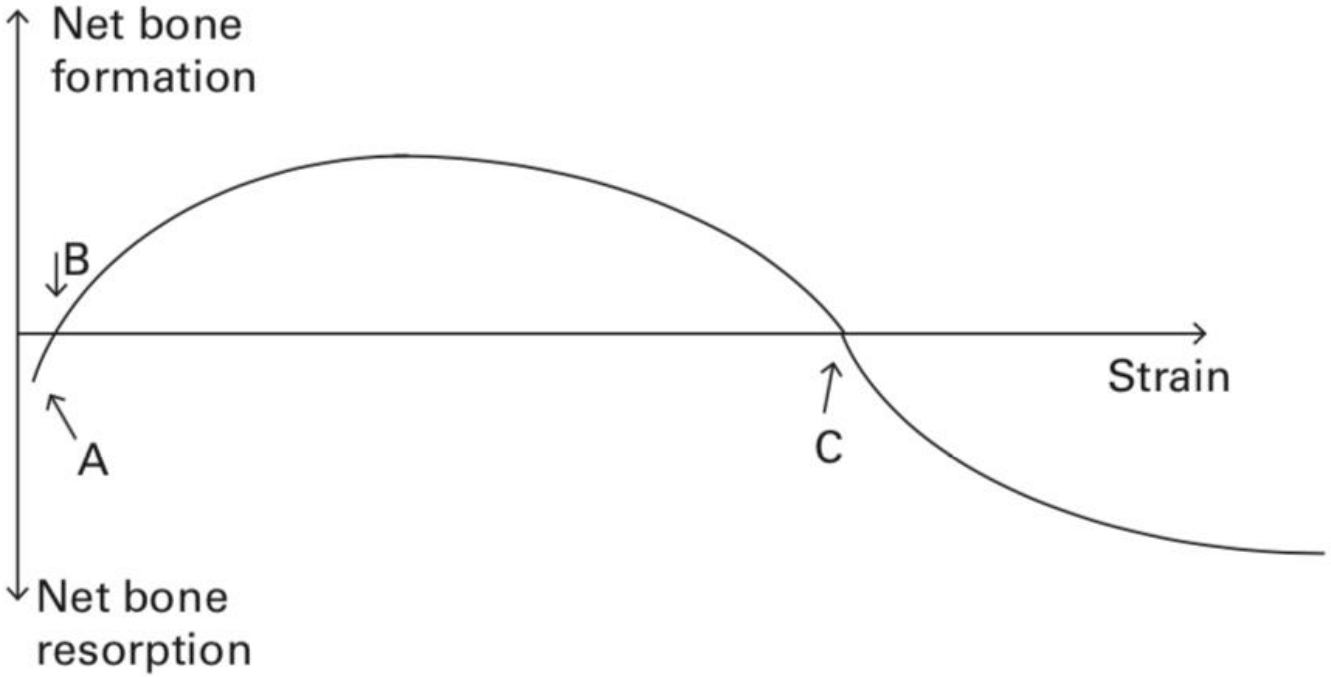
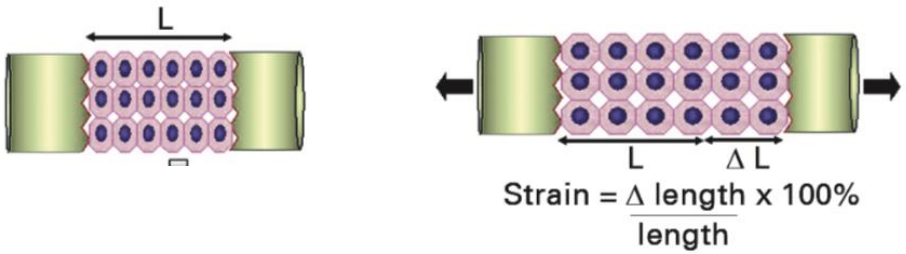
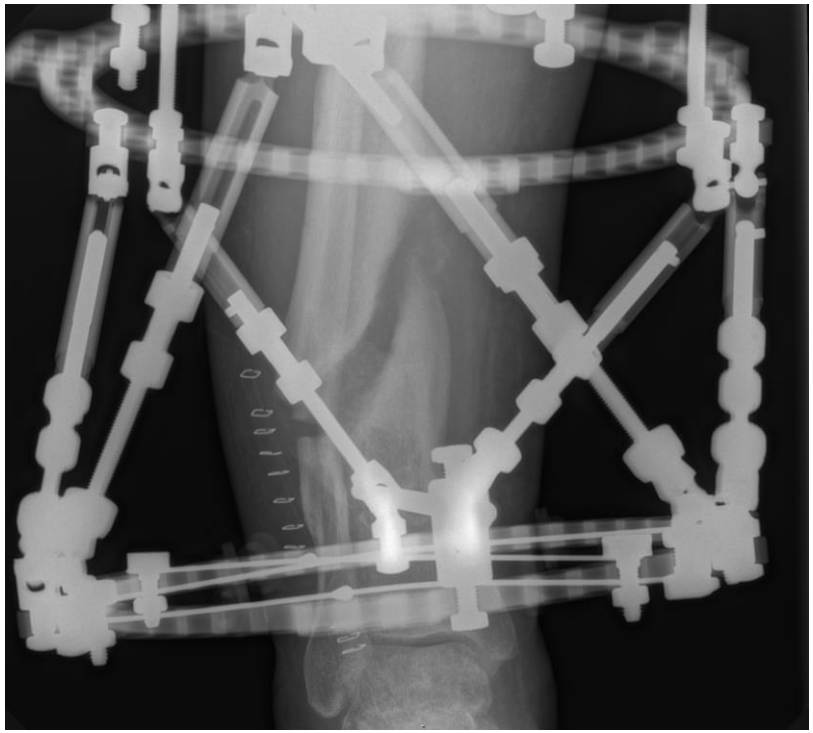




Reduction in Strain

- Reduce external load force
- Reduce inter fragmentary strain
- Correction of axis

Reduction in strain



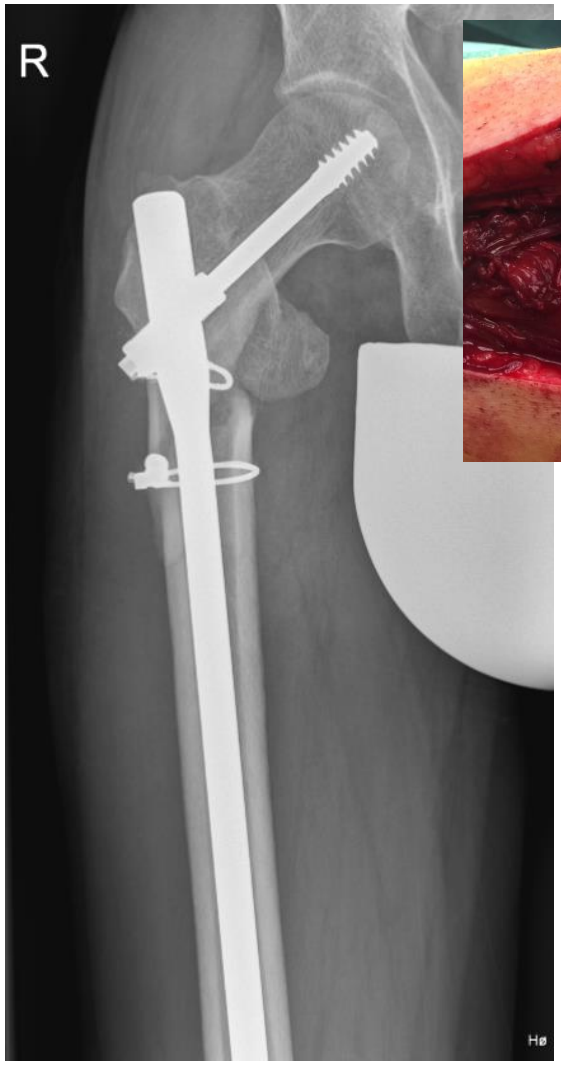
Reduction in strain

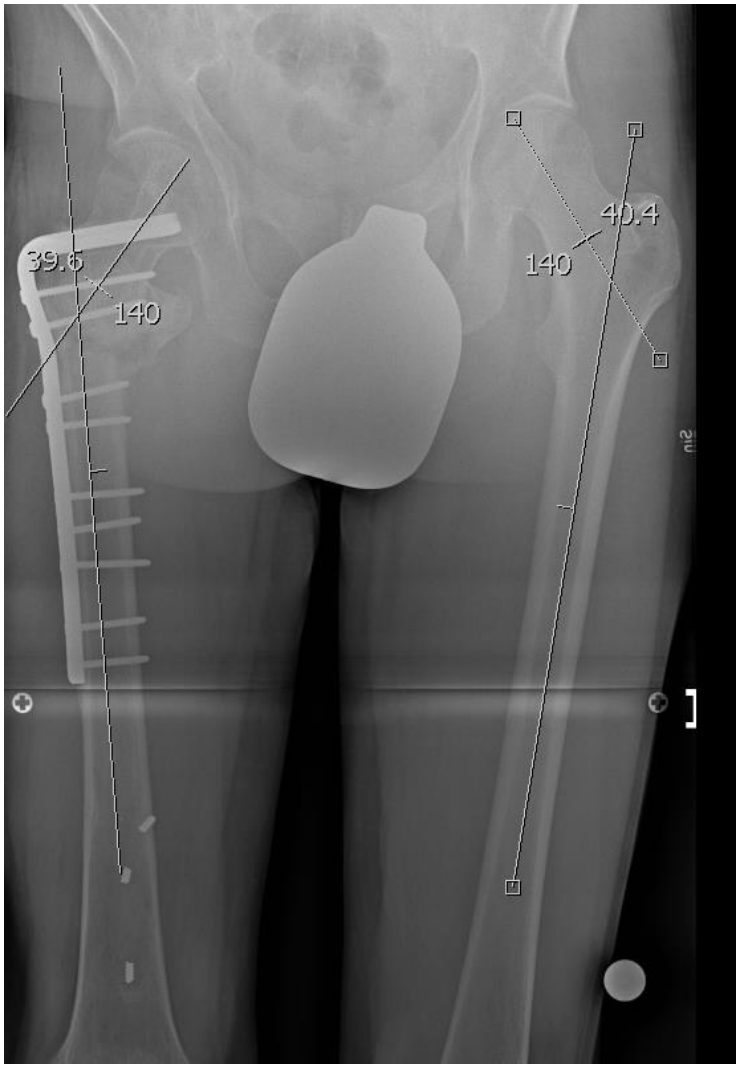
Mechanical solution ?

Biological solution ?

Both?

Mechanical Axis Correction *AND* Bone Grafting

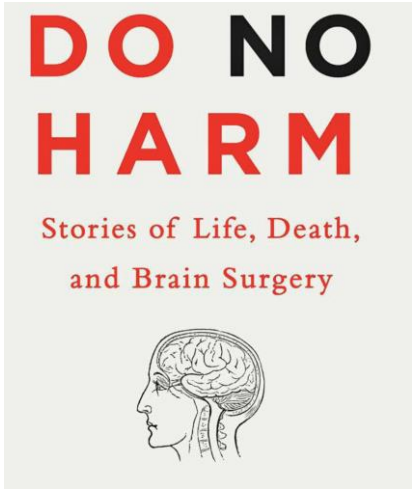




Summary: ASEPTIC non-union

- Are you sure it is aseptic ?
- Broad armementarium of treatments availaible
- Treatment principles:
  - Five pillars

Indications for surgery of malunions are less clear than for non-unions



Henry Marsh, neurosurgeon

- 3 months to learn a surgical procedure
- 3 years to learn when to operate
- 30 years to learn when NOT to operate

Indications for surgery of malunion

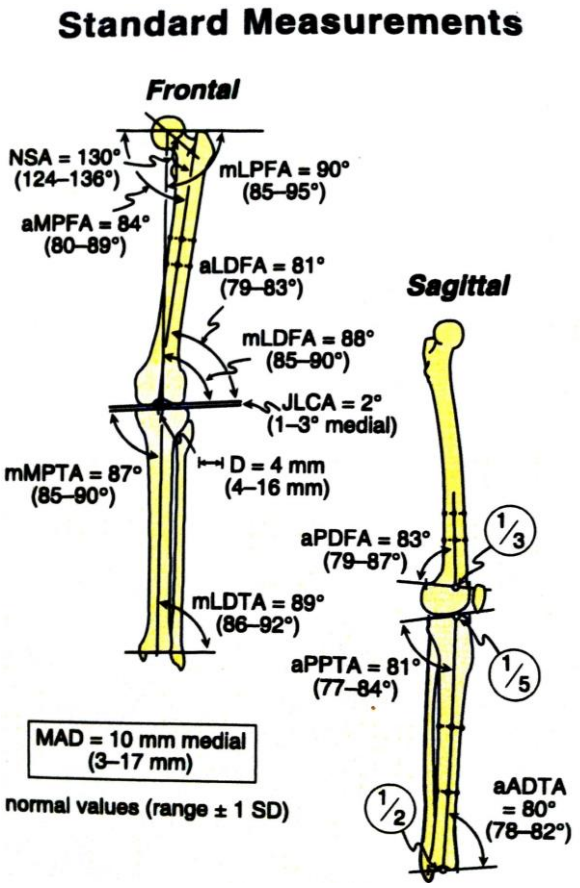
Patient must have symptoms:
- Pain (pain after trauma is often complex!!)
- Functional impairment

AND can WE do it better ?!?!?

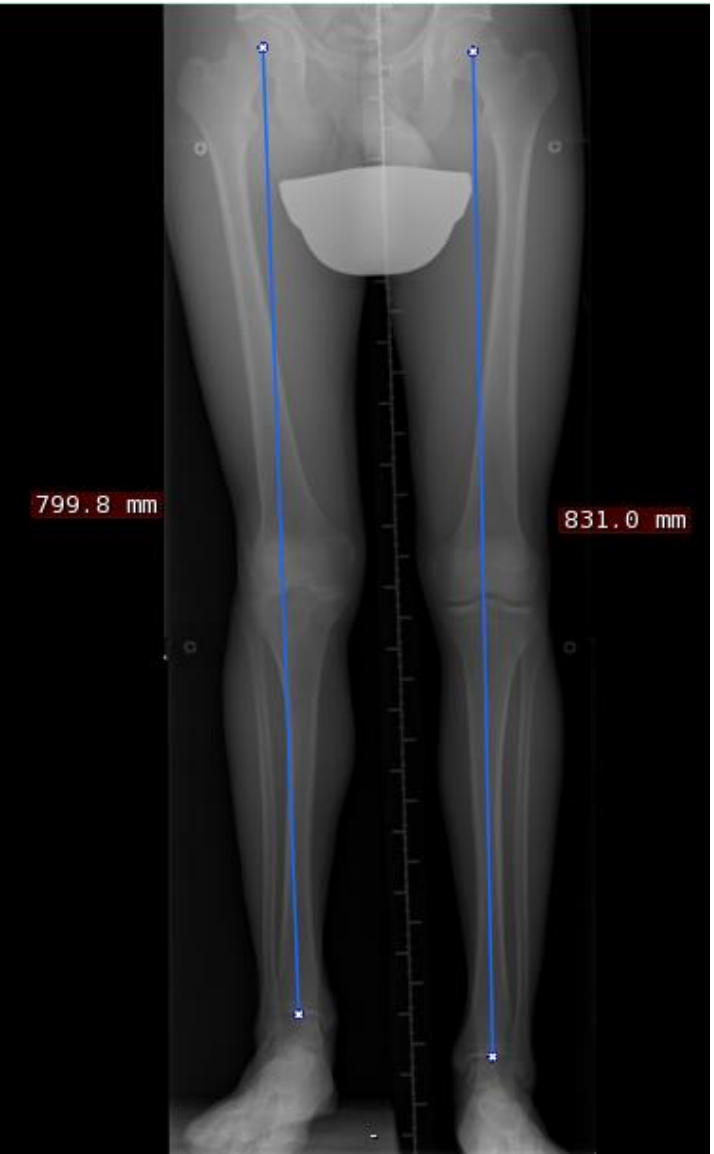
Consider complex reconstruction / arthroplasty ?

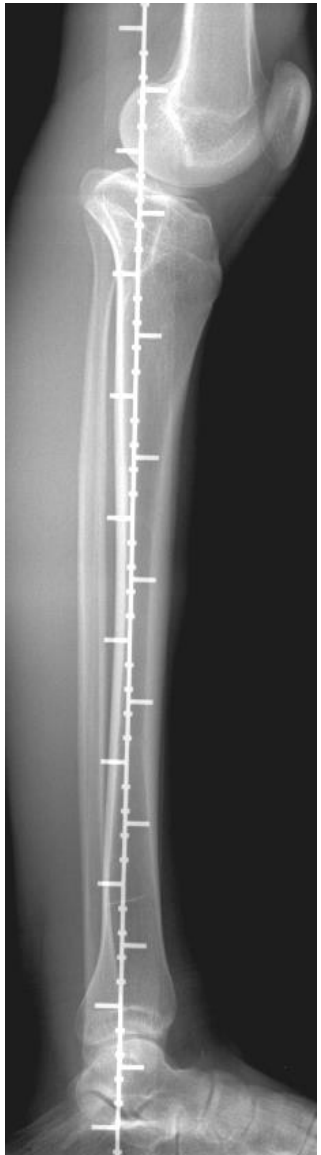
Can you do it better ?

- Mechanical alignment
- Rotation
- Limb length
  - Often shortening in malunion



Juxta-articular malunion





16 years old male

Right knee trauma at age 9

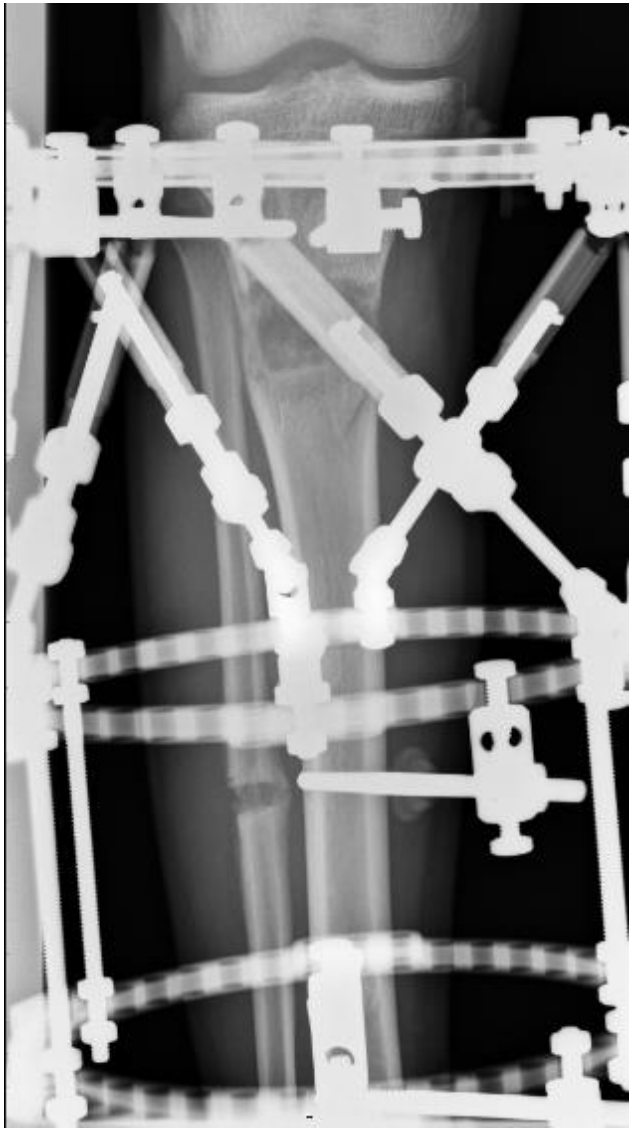
Right knee pain

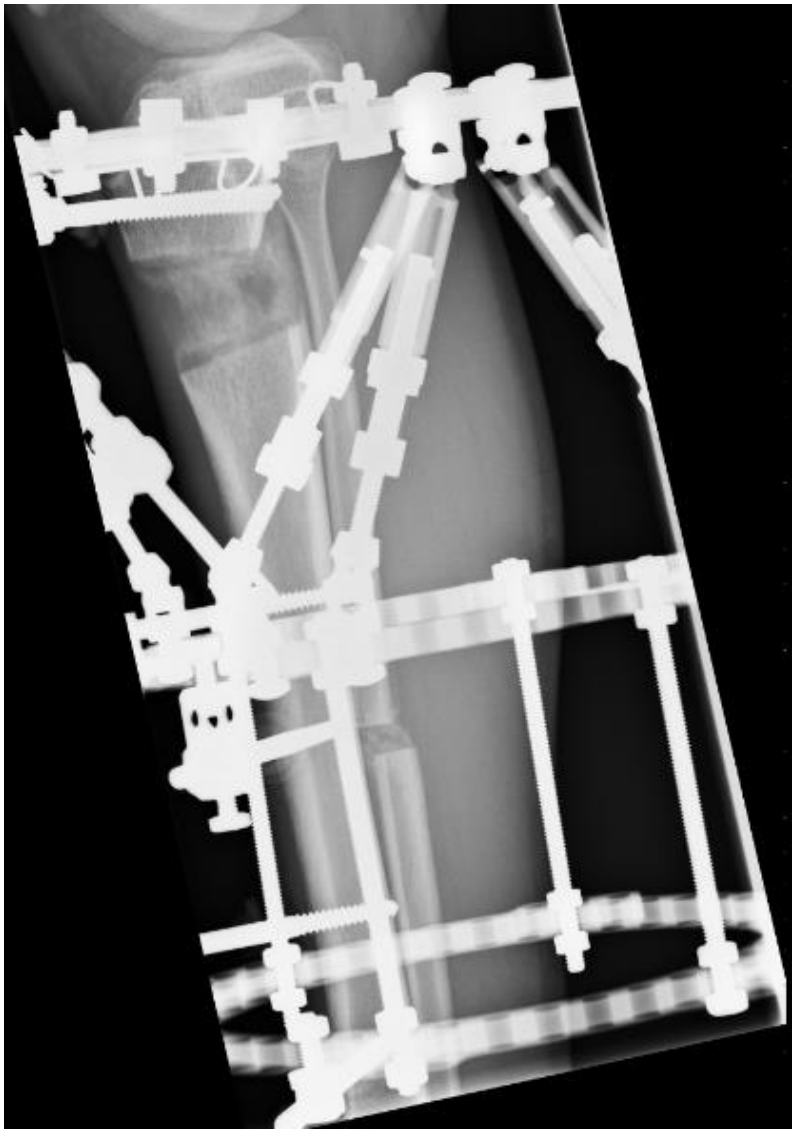
LLD: 3 cm

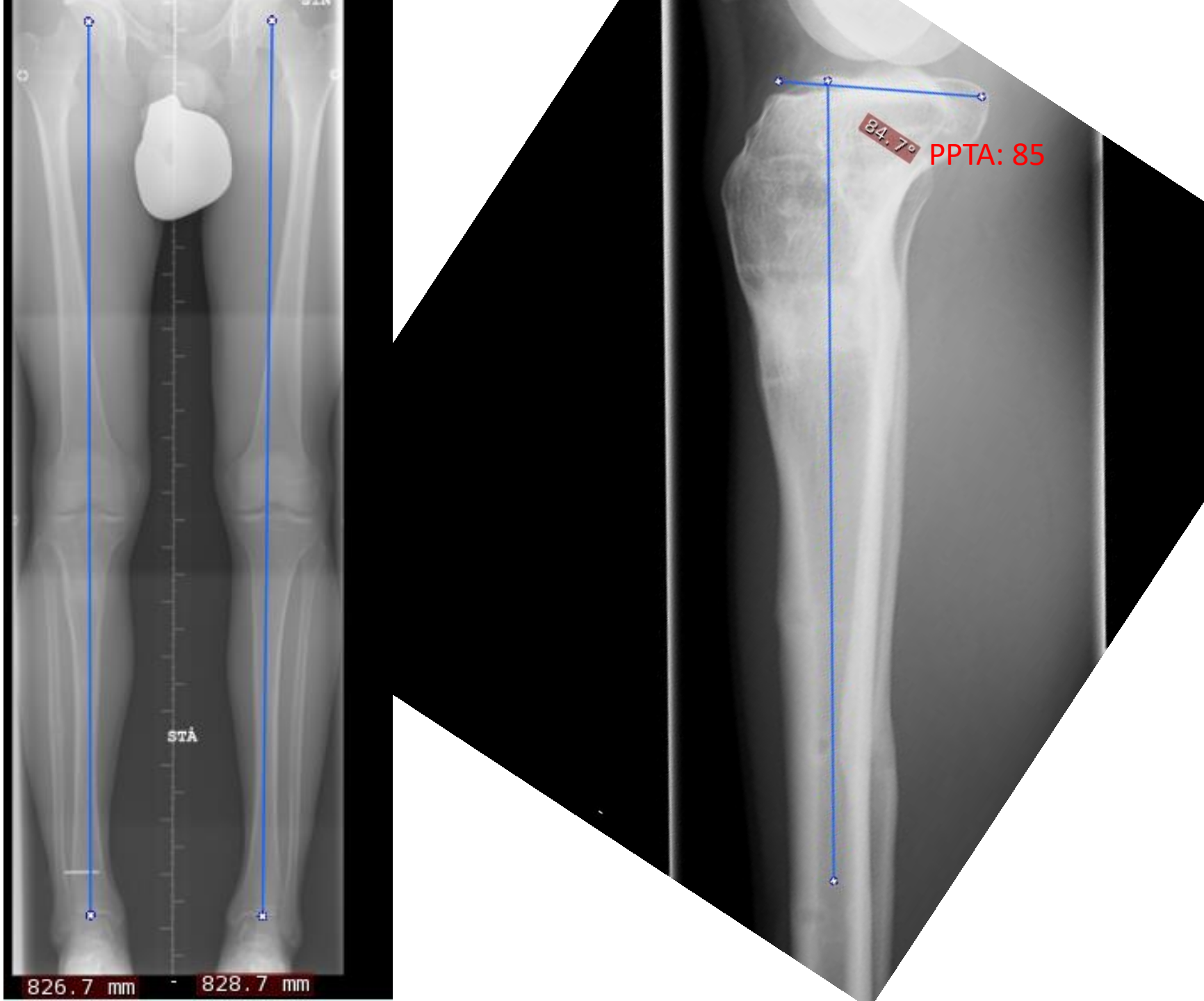
Valgus

Genu recurvatum (PPTA: 110 degrees)

Gradual correction of deformities in all planes






STÅ
826.7 mm
828.7 mm
84.7°
PPTA: 85

Take home message: MALUNION

Indications for surgery

Must have pain / functional deficit

Can WE do it BETTER ?