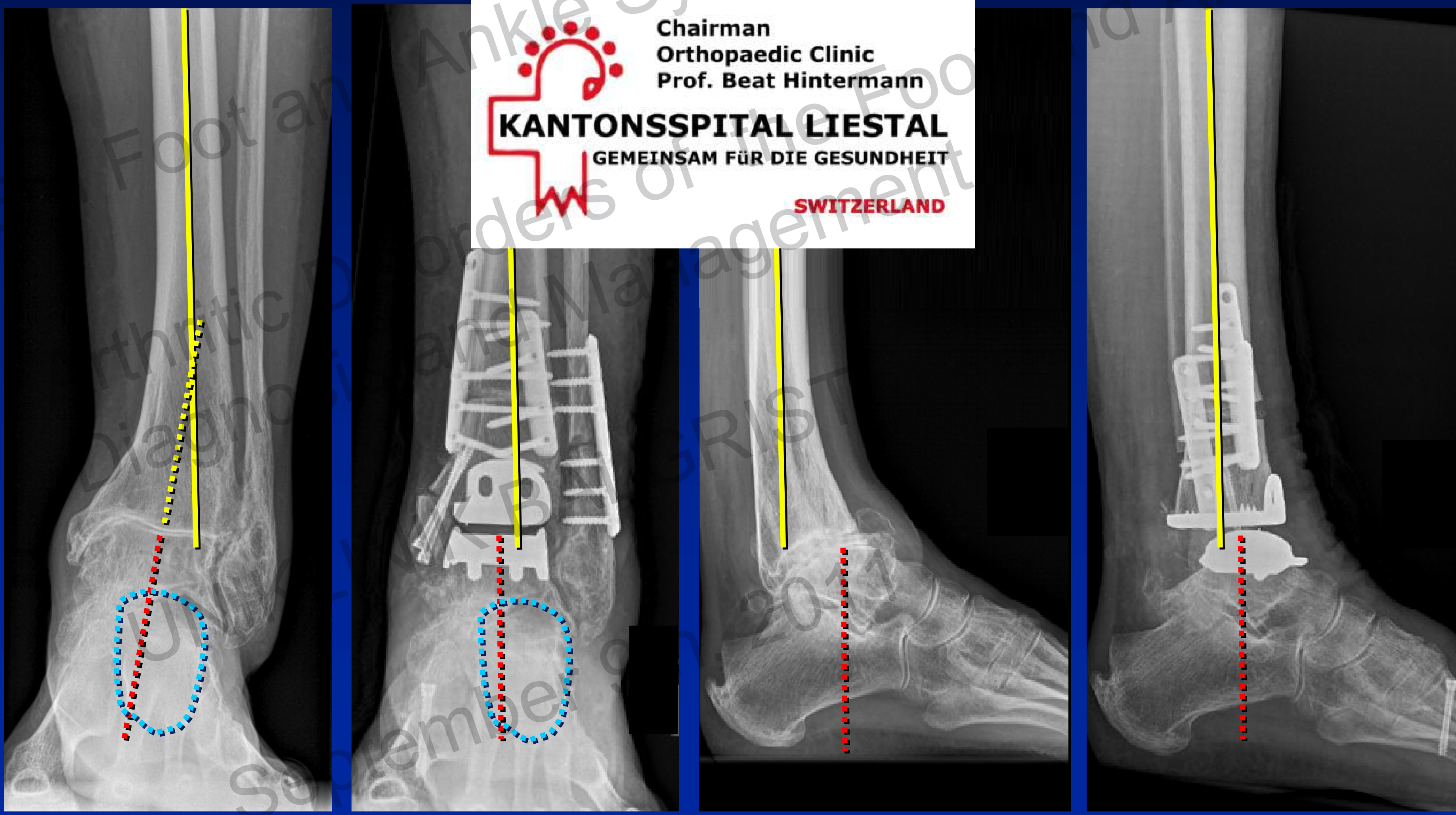
History, Technique and Outlook of Total Ankle Replacement – from Simple to Complex



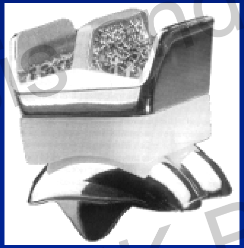
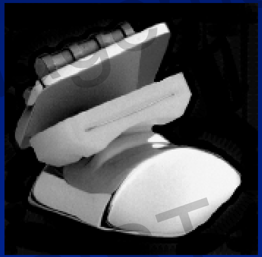
Chairman
Orthopaedic Clinic
Prof. Beat Hintermann

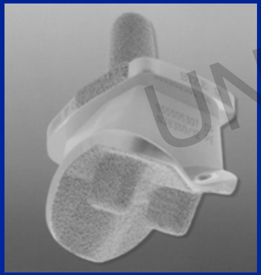
KANTONSSPITAL LIESTAL
GEMEINSAM FüR DIE GESUNDHEIT
SWITZERLAND

Evolution of Ankle Prostheses

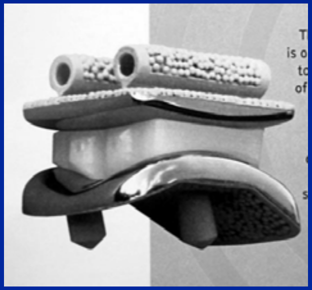
(Too) Many Ankles ...





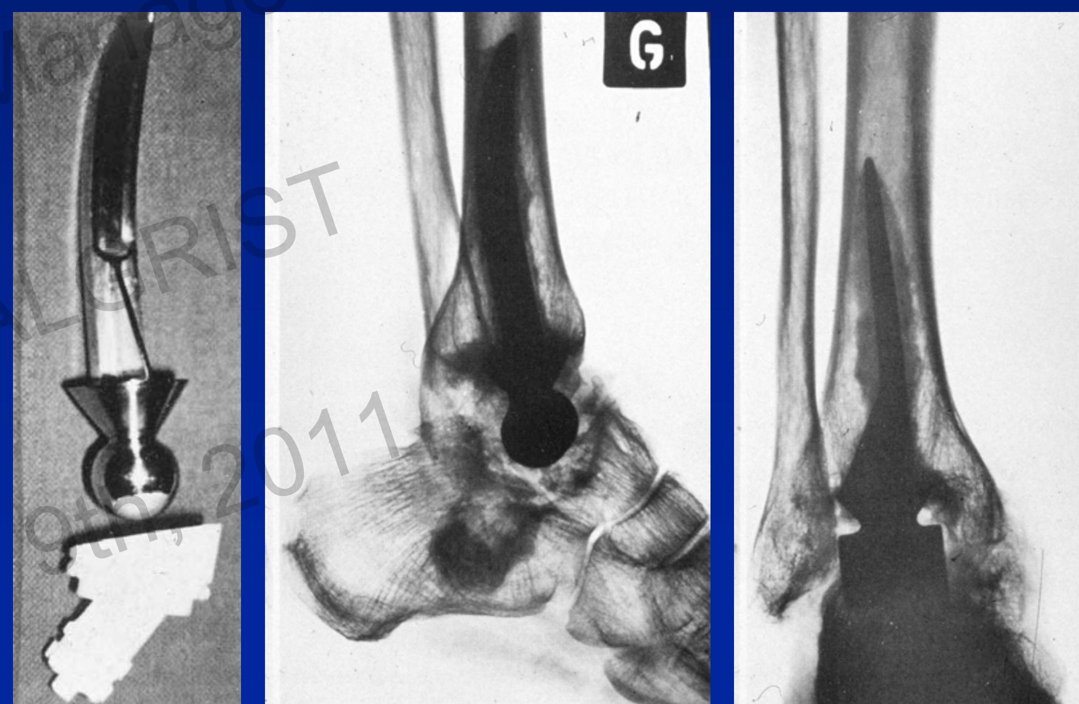



First Generation

first prosthesis

Lord and Marotte 1973

- "reversed hip"
- cemented
- congruent
- no-anatomic
- fixed
- 2 components

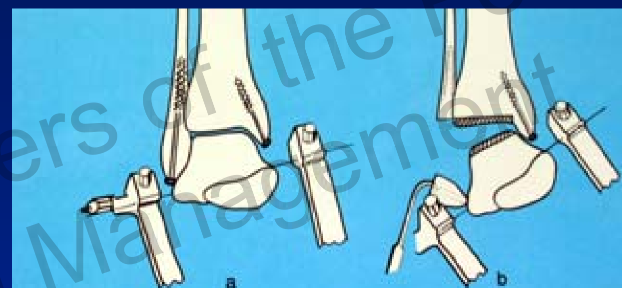


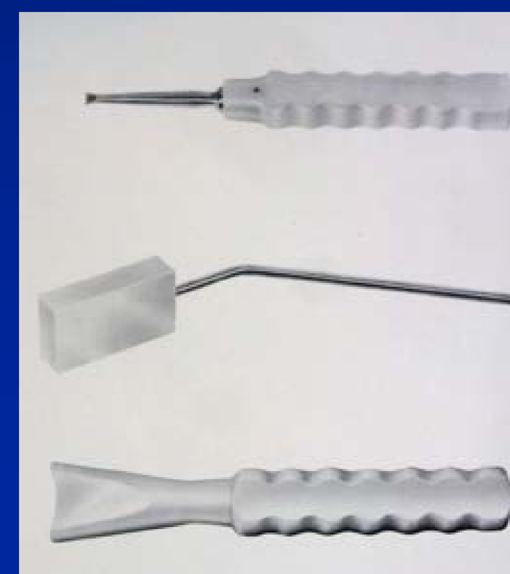
TAR – History, Technique and Outlook

First Generation

St. Georg 1973

- constrained
- semi-congruent
- anatomic
- fixed
- 2 components





First Generation

Problems		Causes
• early loosening	→	Inaccurate instrumentations
• bone collapse	→	excessive bone removal
• component migration	→	cement fixation
• implant breakage	→	constrained designs
• malleolar fractures	→	lack of biomechanical studies
• skin problems	→	inappropriate techniques
• Infection	→	inappropriate techniques

First Generation

It was concluded ...

The Journal of Bone and Joint Surgery

EDITORIAL

CAN THE ANKLE JOINT BE REPLACED?

Clearly the answer to the question of replacing the ankle joint using current techniques must be "no". With improvements in prosthetic design, the elimination of the use of acrylic cement and improved anatomical access, this view could be reversed with particular benefit to the rheumatoid patient.

D. L. HAMBLEN

D. L. Hamblen, FRCS, Professor of Orthopaedic Surgery
Western Infirmary, Glasgow G11 6NT, Scotland.

Which is the Best Ankle ?

I have not the Answer

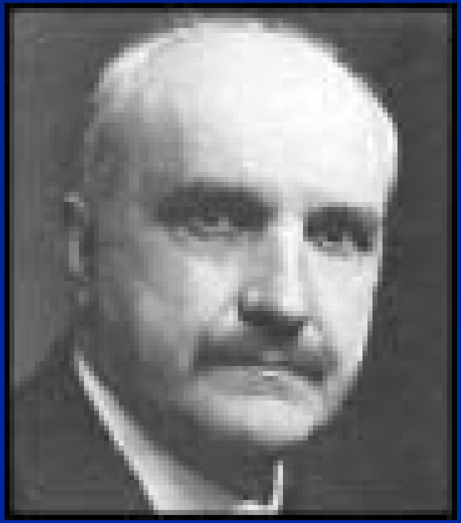
- More studies
- ….
- I am not indep…

But, is that the real question ?

Learn from the Past

Poet and Philosopher George Santayana 1905

Those who cannot remember the past are condemned to repeat it.



We Wanted an Ankle !

All of us were …

- Disappointed
  - ➞ S.T.A.R. ankle
  - ➞ instrumentation
- Aware of need of
  - ➞ restoring anatomy as close as possible
  - ➞ 3 components
  - ➞ cementless fixation
  - ➞ anterior approach

Anatomical Features

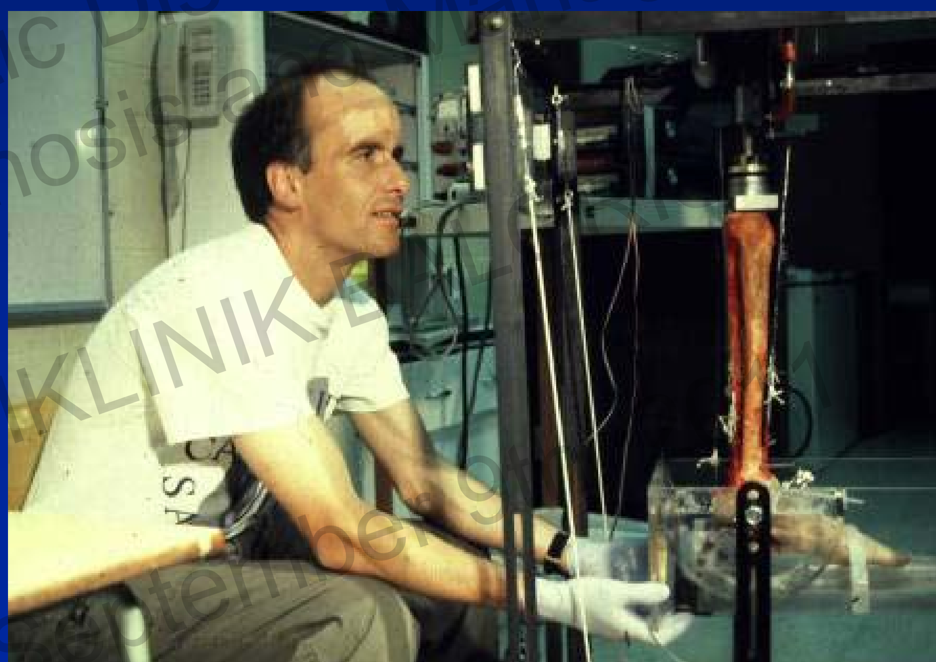
Ankle Joint

- Complex geometry
  - → helical axis
  - → medial > lateral radius
- Complex ligamentous system
  - → isometric position of each ligament
- Need of
  - → restoring anatomy as close as possible

My Thoughts Started in 1991

Research Fellowship University of Calgary

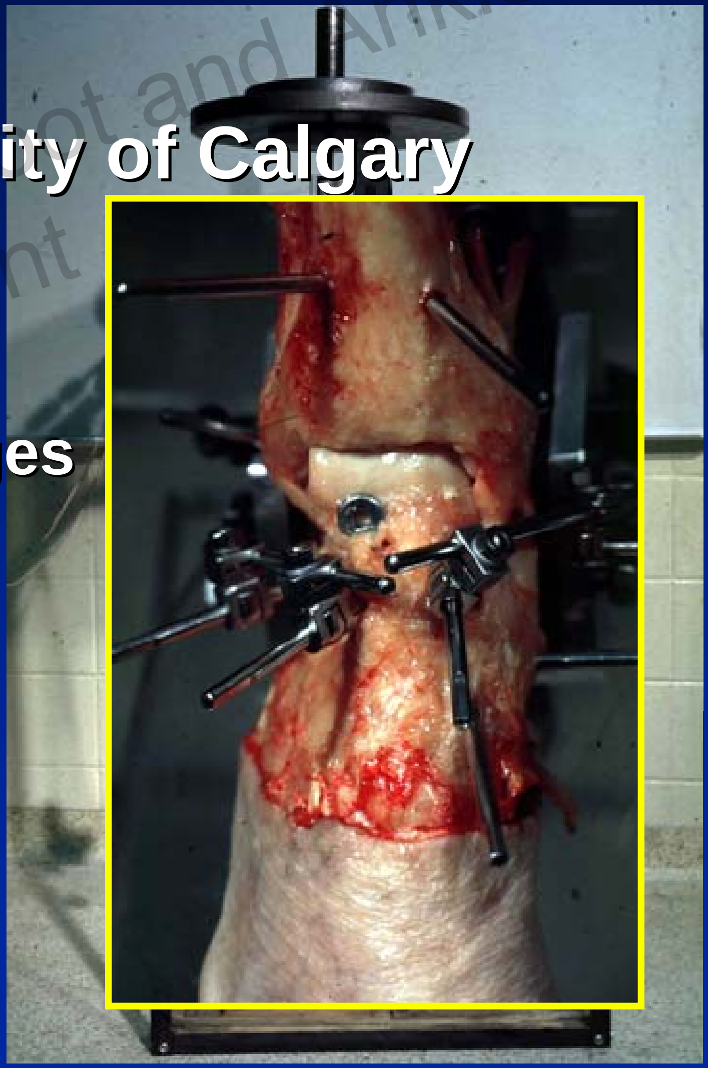
- Biomechanics
  → the kinematics of the ankle



My Thoughts Started in 1991

Research Fellowship at University of Calgary

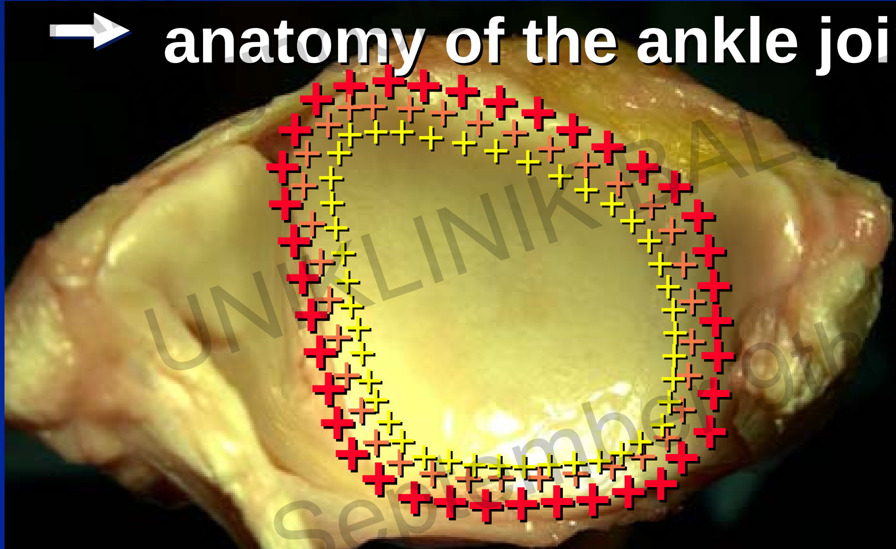
- **Biomechanics**
  - → kinematics of the ankle
  - → **the effect of morphologic changes**

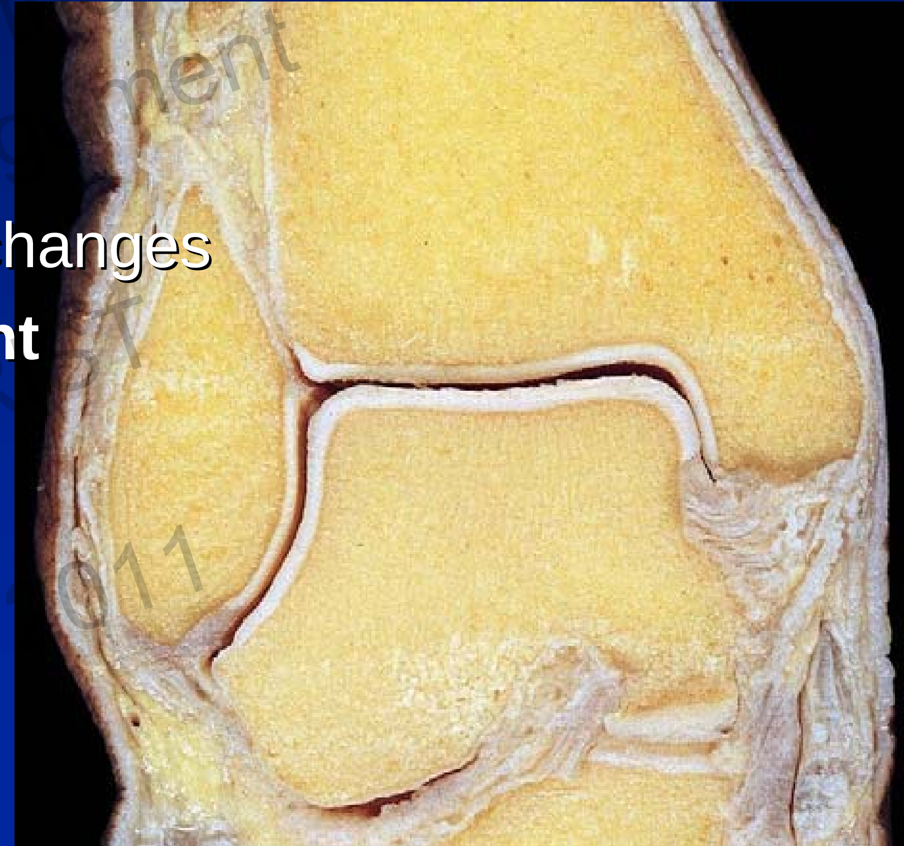


My Thoughts Started in 1991

Research Fellowship at University of Calgary

- **Biomechanics**
  - → kinematics of the ankle
  - → the effect of morphologic changes
  - → **anatomy of the ankle joint**





HINTEGRA

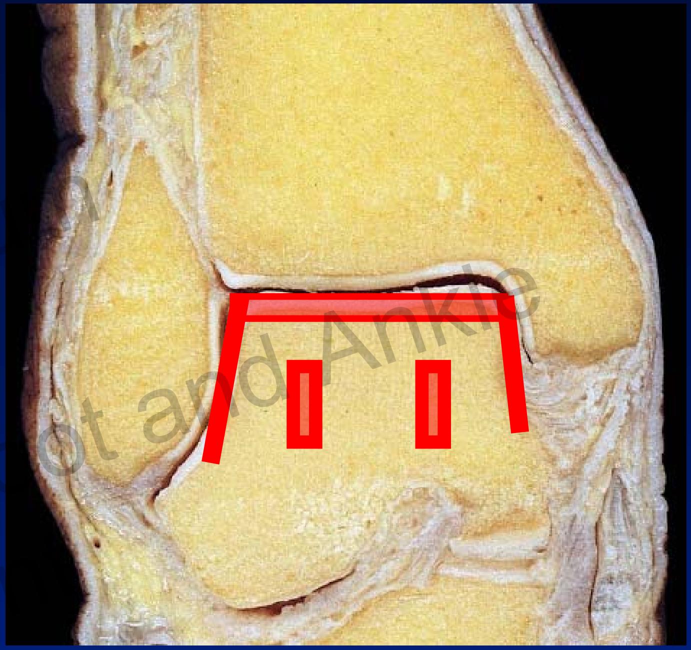
Ankle Design

Tibial Component

- anatomical shape
- full coverage of distal tibia
  → optimal force transmission
- resistance against torsional forces
  → 4 mm of thickness
- minimal stress shielding
  → flat contact area with peaks
- bone ingrowth
  → double coat

HINTEGRA

Ankle Design



Talar Component

- anatomical shape
- conical shape
  - → smaller radius medially
  - → larger radius laterally
- minimal stress shielding
  - → small pegs
- resurfacing
  - → medial gutter
  - → lateral gutter

HINTEGRA

Ankle Design

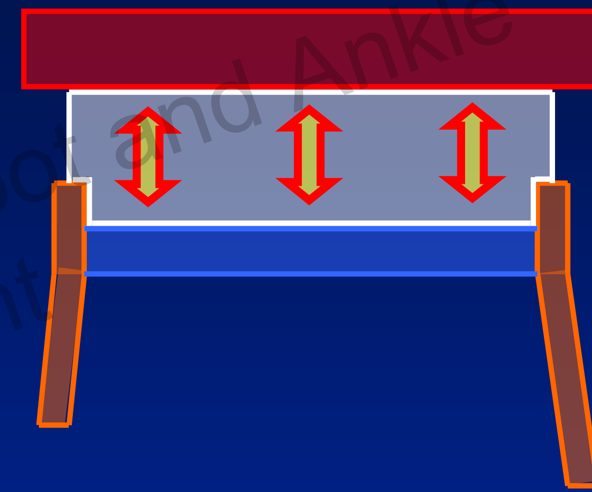
Mobile Bearing

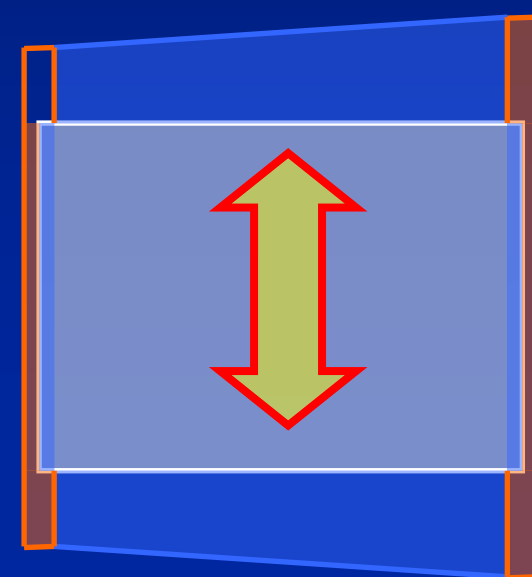
- high density polyethylene
- minimal thickness of 5 mm
  → mechanical strength
- fully covers the talar component
  → stability against e- / inversion
  → optimal pressure distribution
- undersized to the tibial component
  → no weakening
  → optimal pressure distribution

Hypothesis

Less Granuloma Formation

- Design of talus
  - → anatomically shaped
  - → guides polyethylene insert
- Design of polyethylene insert
  - → covers completely talus
  - → optimal force distribution
- Only compressive forces
  - → protected against rotational and translational forces





HINTEGRA

Wear-Testing

Electromicroscopic Analysis

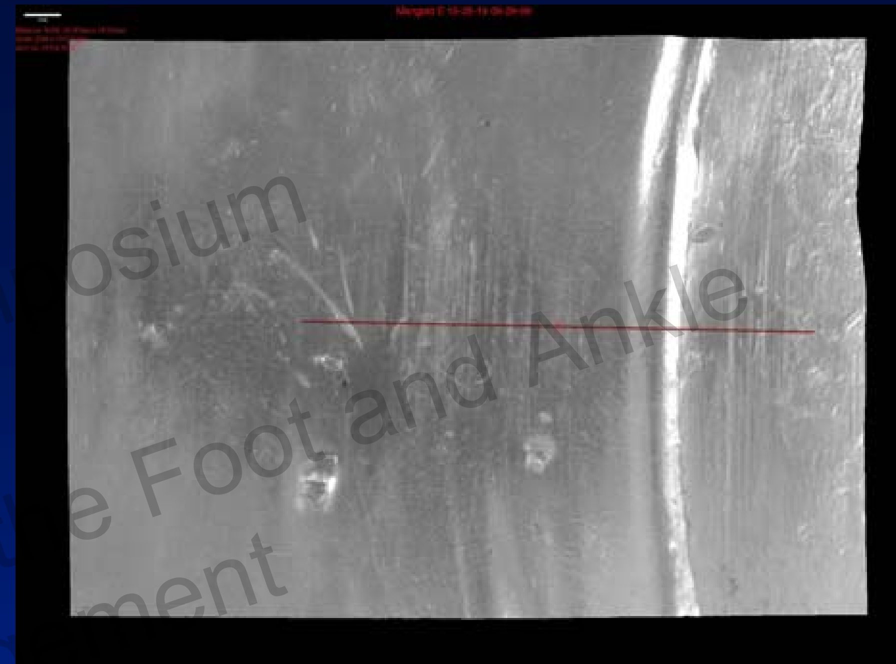
- 15 retrieved PE insert
  - → gender f = 7
    m = 8
  - → weight 81.9 (53-120) kg
  - → BMI 27.9 (22.9-37.6) kg/m^2
  - → age at TAR 48 y (32 – 74)
  - → revision at 27 (2 – 67) mo

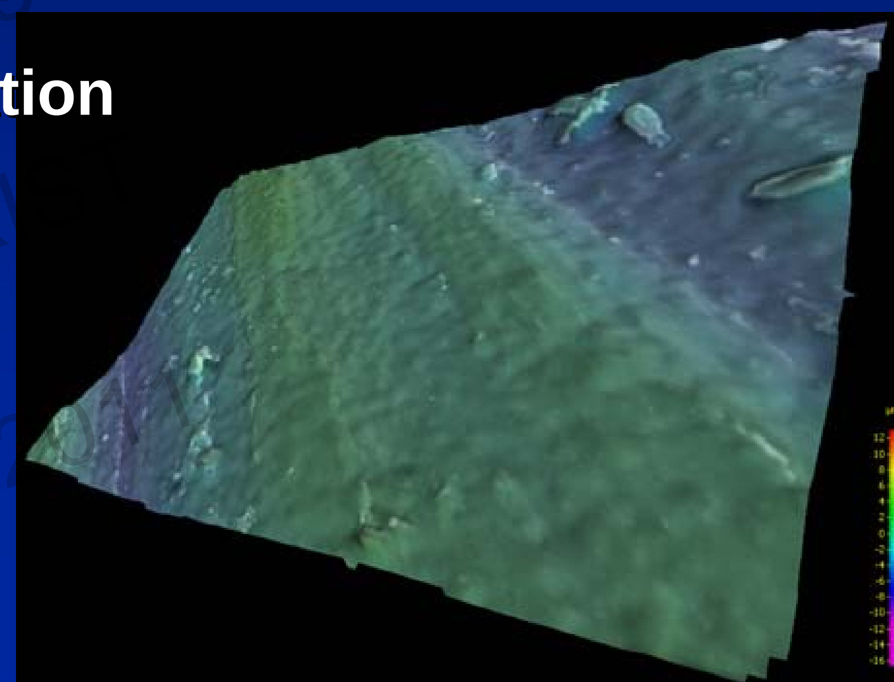
HINTEGRA

Analysis

Technique

- Spluttered with gold
- Light microscopy
  → 6-, 12-, 24-time magnification
- Electronic microscope
  → optic profilometry
  → optic investigation



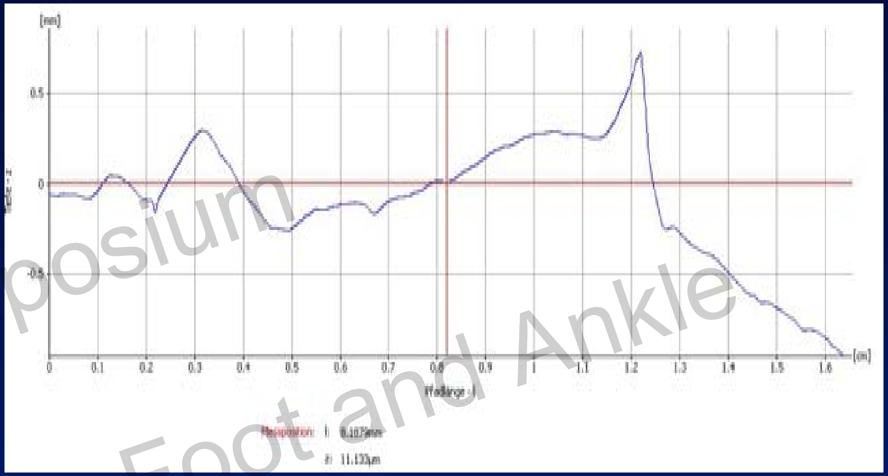


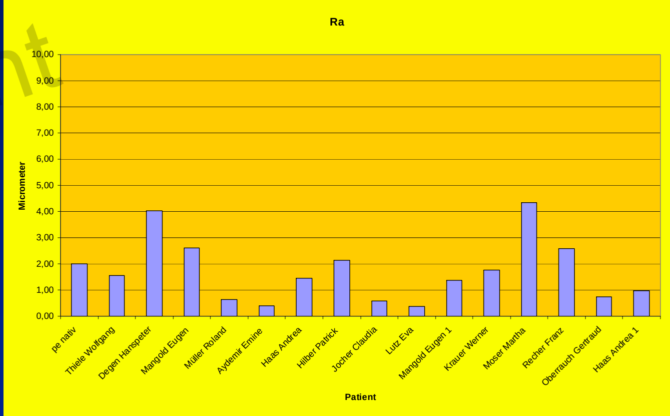
HINTEGRA

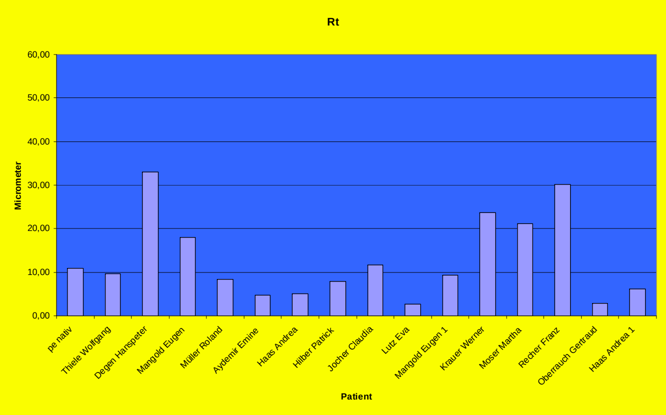
Analysis

Results

- Average roughness
  - ➞ 0,51 and 5,00 µm
- maximum roughness
  - ➞ 3,60 µm and 36,54 µm
- Not dependent on
  - ➞ duration of TAR
  - ➞ weight / BMI of patient
- Higher ($p < 0.005$)
  - ➞ men than females







Kinematic Analysis

University of Calgary (Victor Valderrabano)

- **HINTEGRA**
  - → **mimics physiologic motion pattern more than other ankles**

HINTEGRA

First Case - 02. May 2000

The Case

- valgus tilt at tibiotalar joint
  ➞ hindfoot valgus
- motion left
  ➞ DF / PF 8 – 0 – 20°

m, 68 y

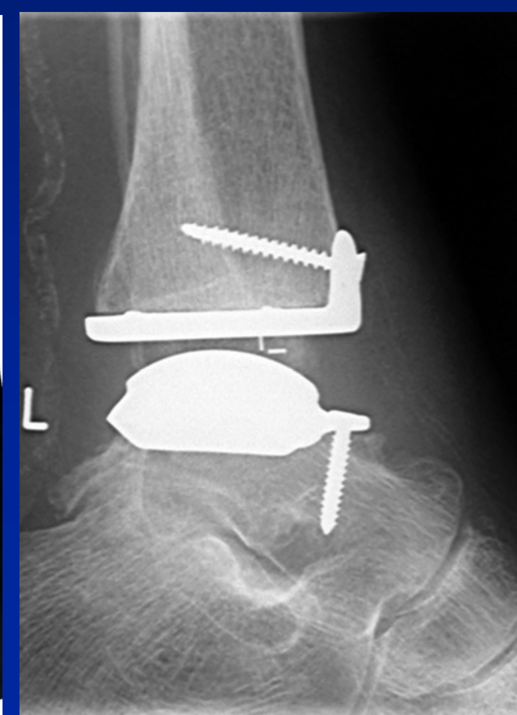
- Posttraumatic OA
  ➞ ankle fracture 42 y
  ➞ conservative treatment
- pain

HINTEGRA

First Case

The Result

- implants
  → after 6 weeks stable

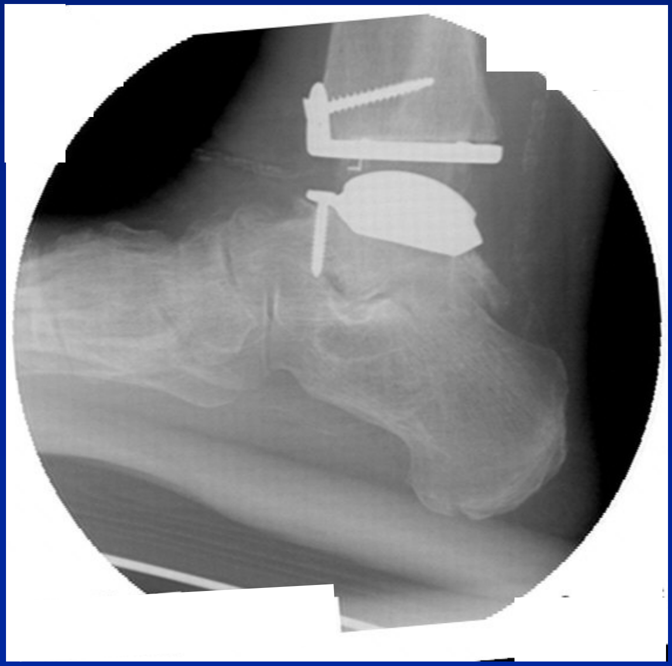


HINTEGRA

First Case

The Result

- **implants**
  → after 6 weeks stable
- **motion**
  → **after 12 mo very satisfactory**

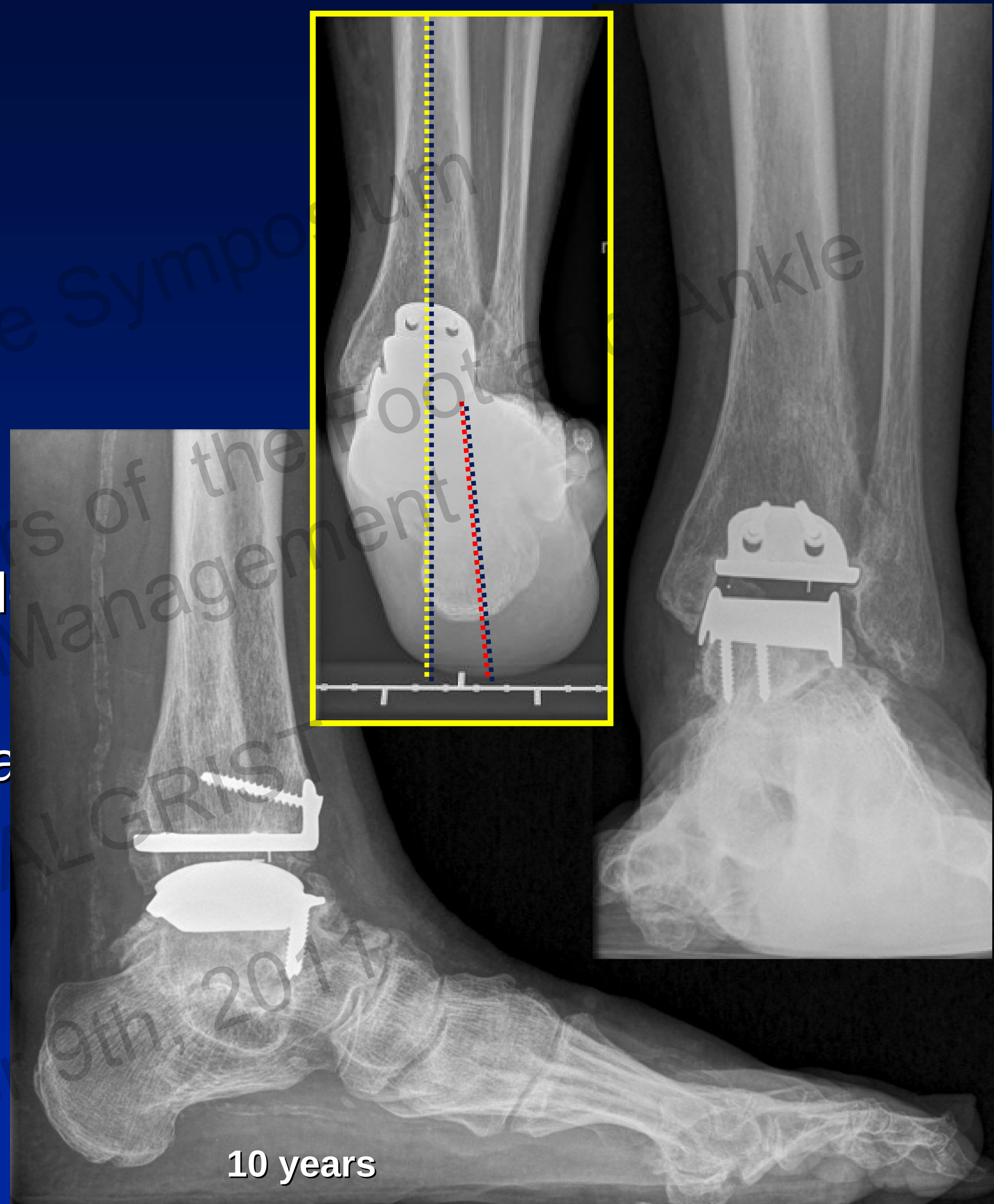


HINTEGRA

First Case

The Result

- **implants**
  → after 6 weeks stabl
- motion
  → after 12 mo very sa
- **medial pain**
  → **after 10 years**
  → **increased valgus deformity**

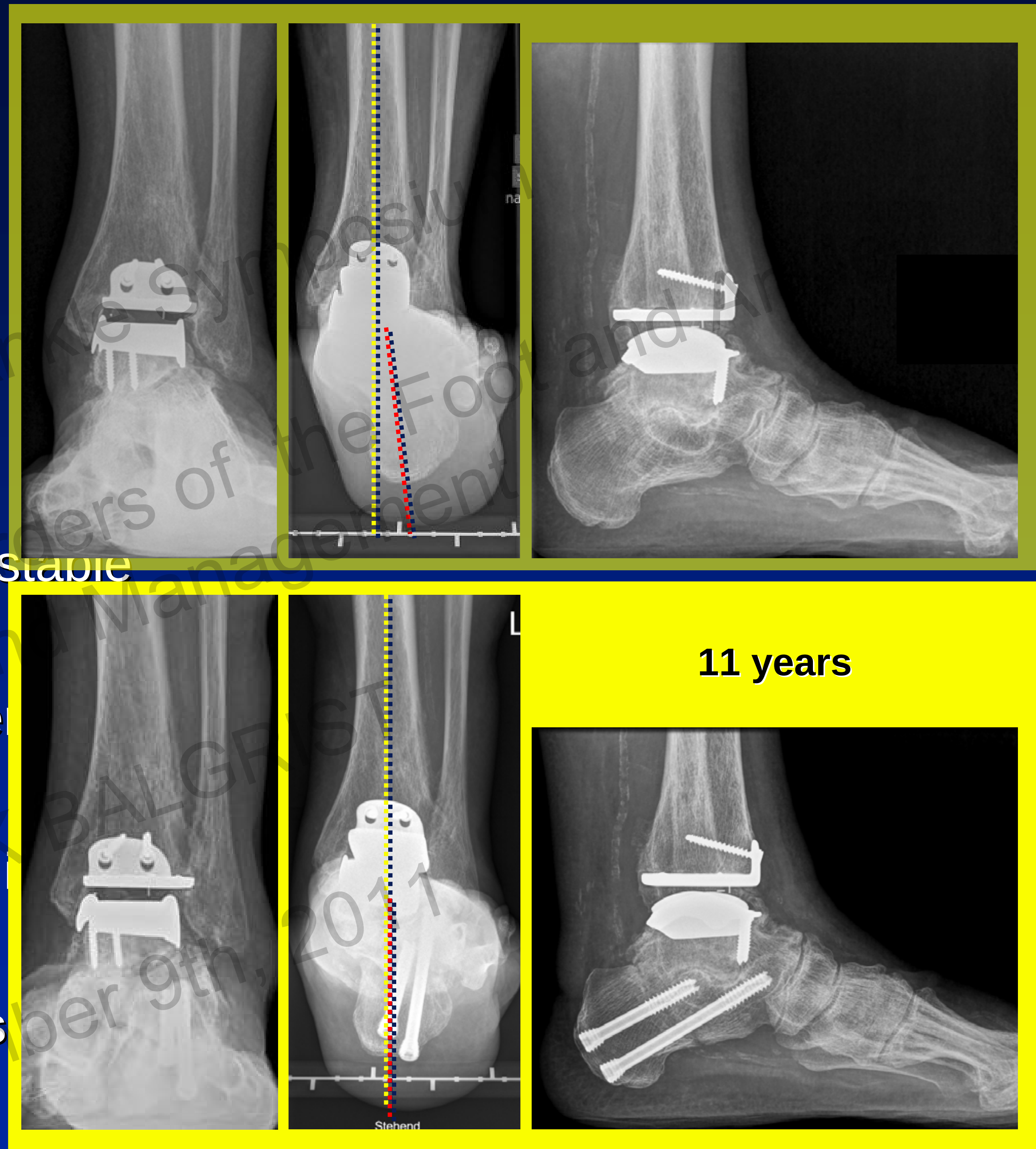


HINTEGRA

First Case

The Result

- **implants**
  → after 6 weeks stable
- motion
  → after 12 mo ve
- medial pain
  → after 10 years i
- **final follow-up**
  → **after 11 years**
  → **pain free**



HINTEGRA

Encouraging Results

Survivorship-Analysis : HINTEGRA Ankle (n = 576)

- single coated without pegs (n = 48)
  ➔ 12 revisions (25.0%)

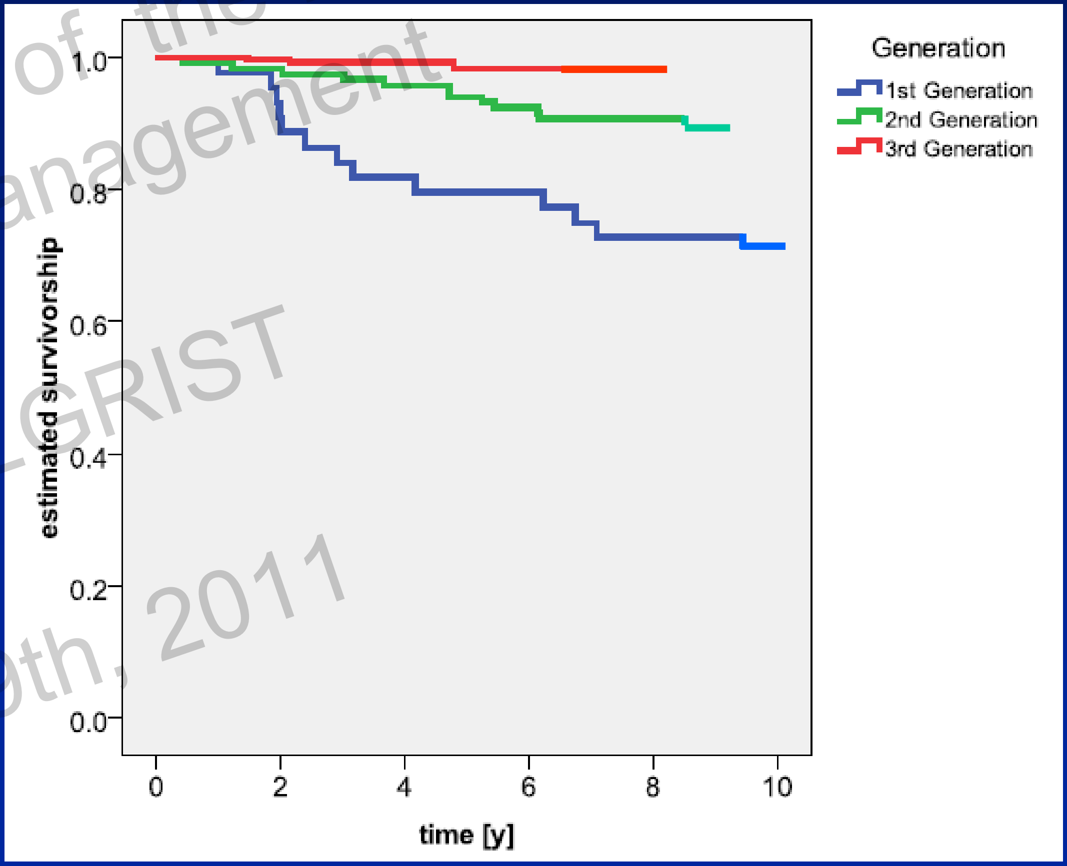
At 10 years
72.2%

- double coated without pegs (n = 140)
  ➔ 9 revisions (6.4%)

At 9 years
91.1%

- **double coated with pegs (n= 388)**
  ➔ 4 revisions (1.0%)

At 8 years
98.2%



HINTEGRA

Tibial Bone-Implant Interface

Bone-Implant Stability

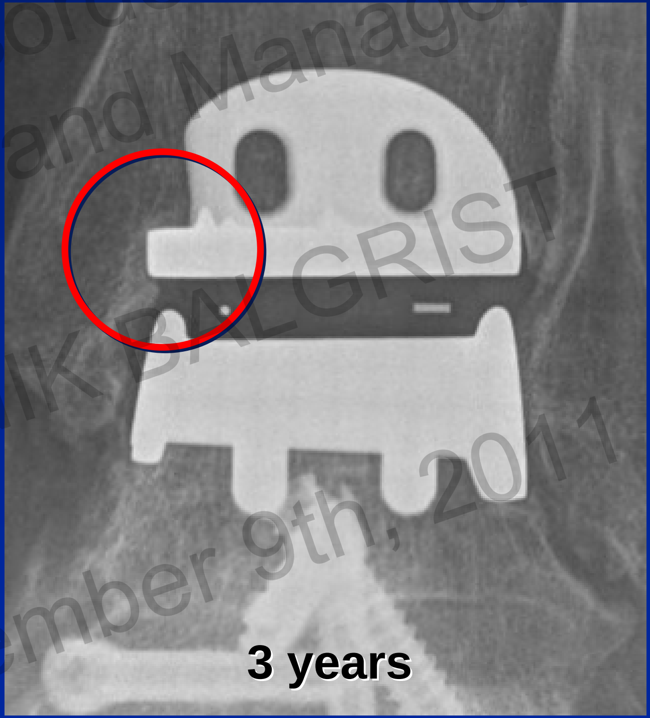
- Primary
  → sufficient

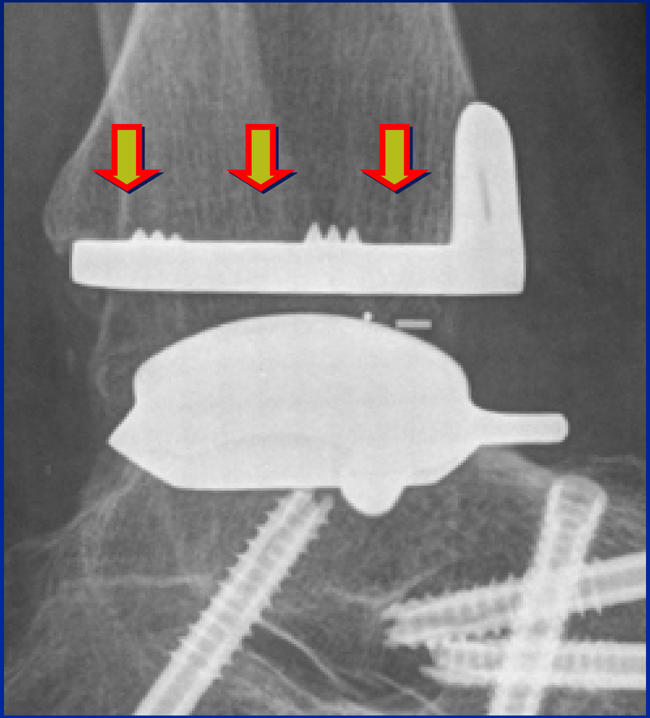
HINTEGRA

Tibial Bone-Implant Interface

Bone-Implant Stability

- Primary
  → sufficient
- No stress-shielding





HINTEGRA

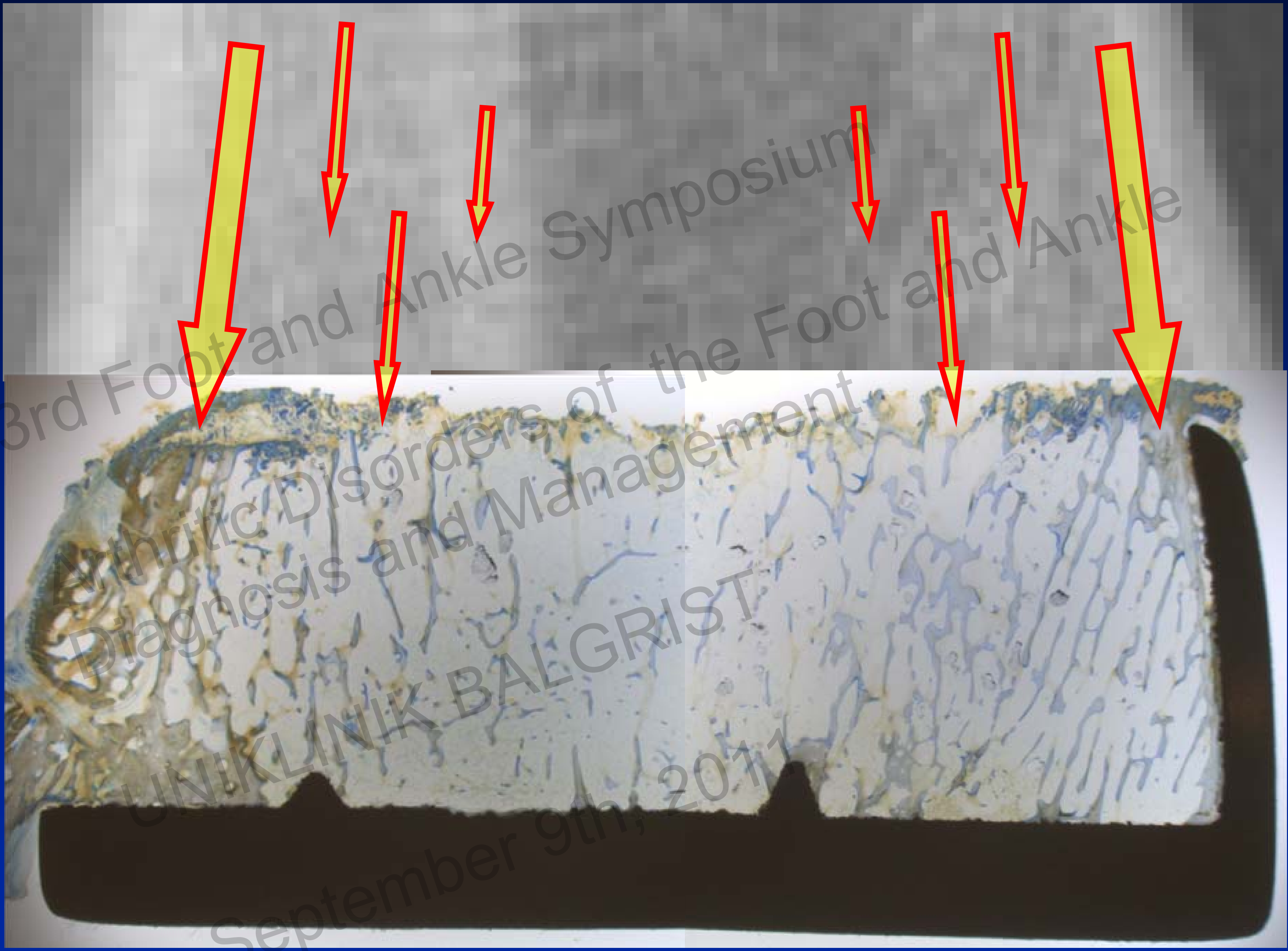
Tibial Bone-Implant Interface

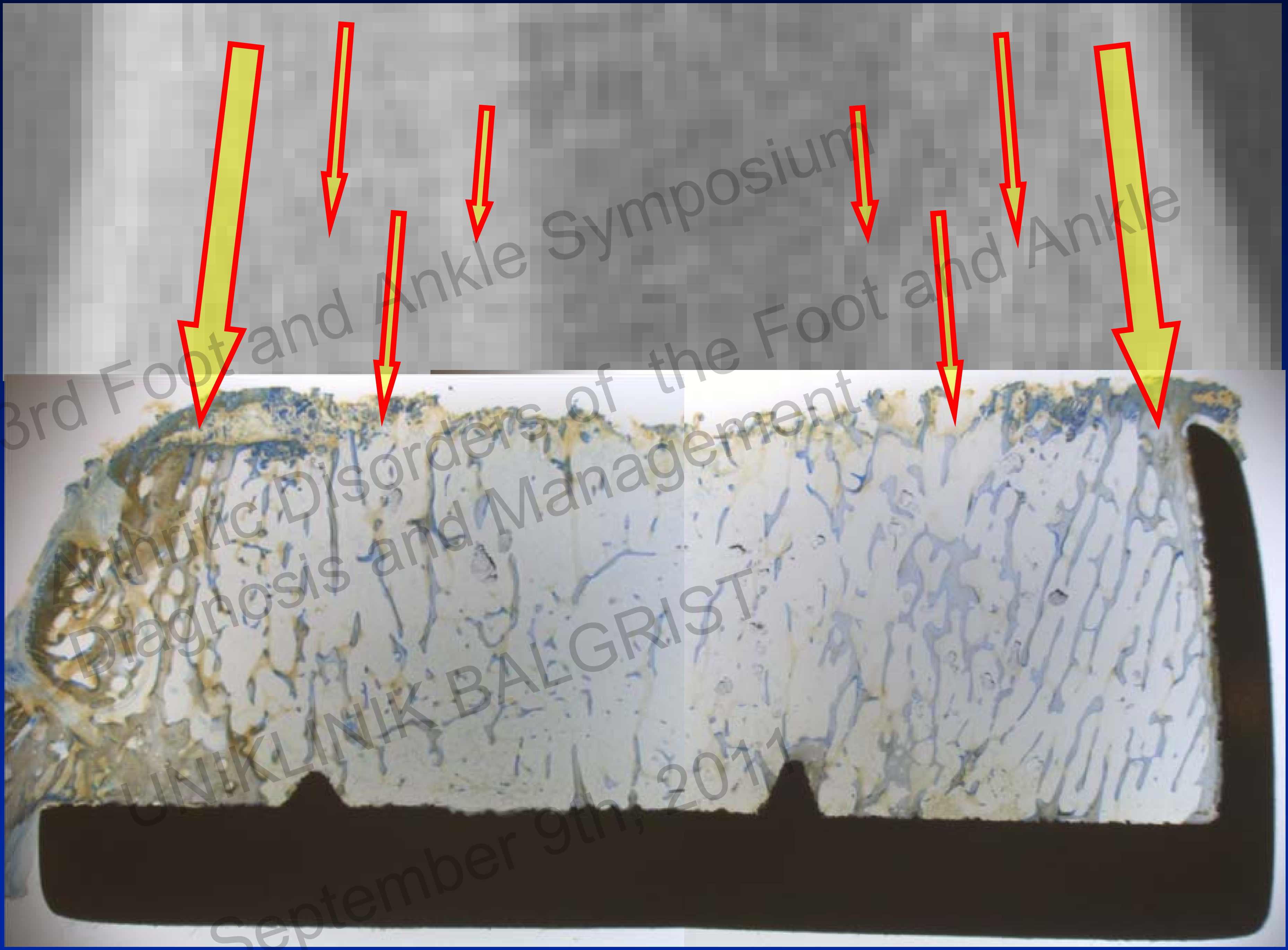
Long-Term Stability ?

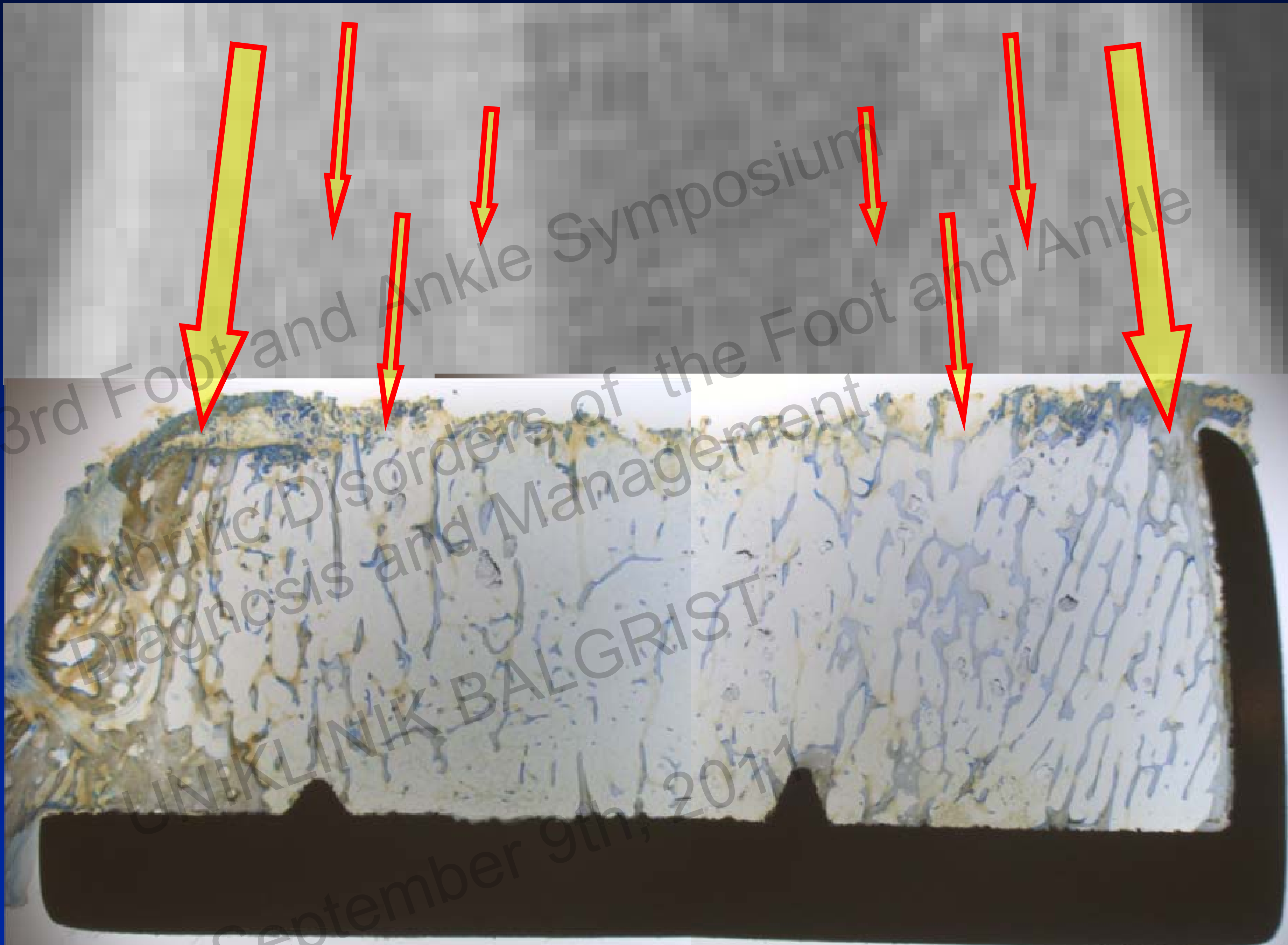
- Bone-implant interface
  - → stable ?
  - → stress-shielding ?

f, 48 y

- chronic pain syndrome
  - → 2 x mosaicoplasty
  - → 2 x osteotomy med mall
- stiffness
  - → equinus 3°
- refused proposed fusion



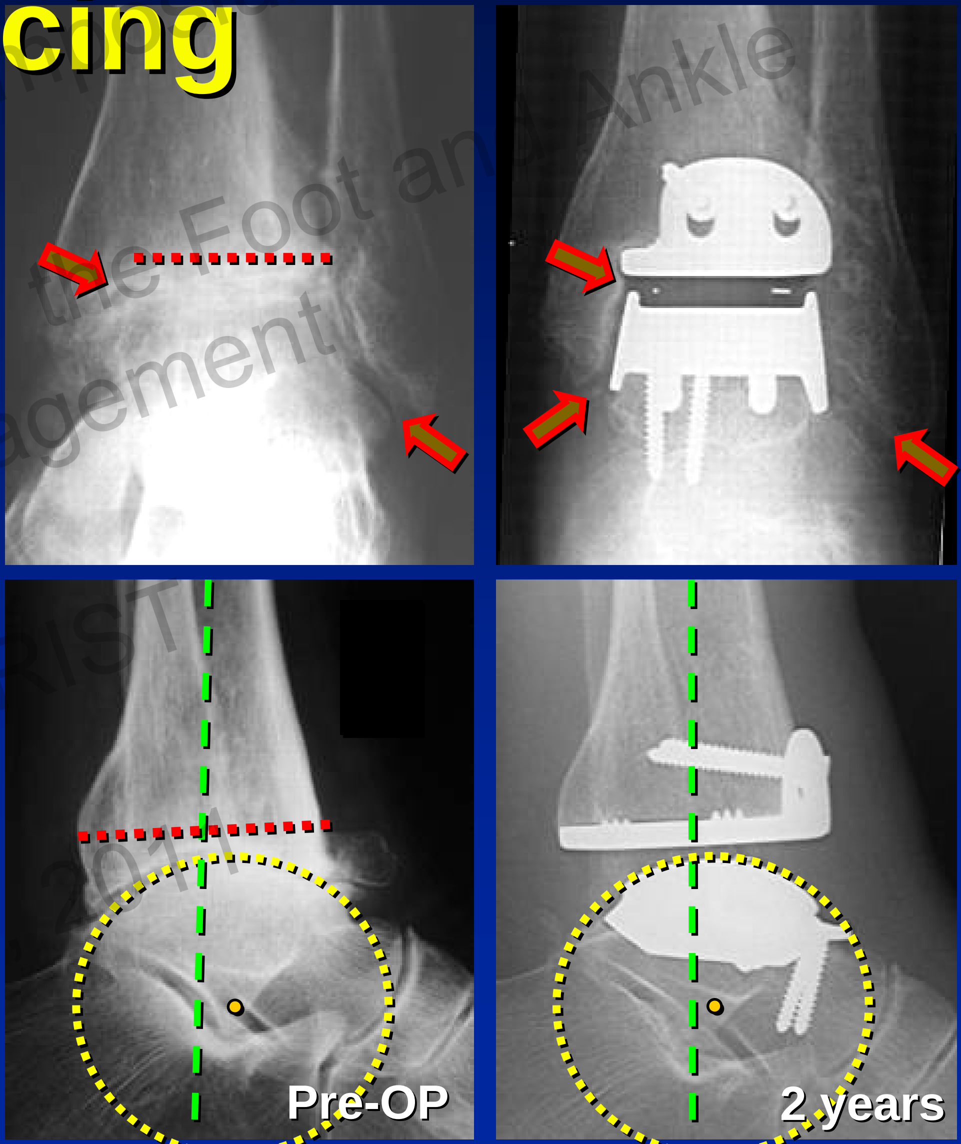




Ligament Balancing

Goals

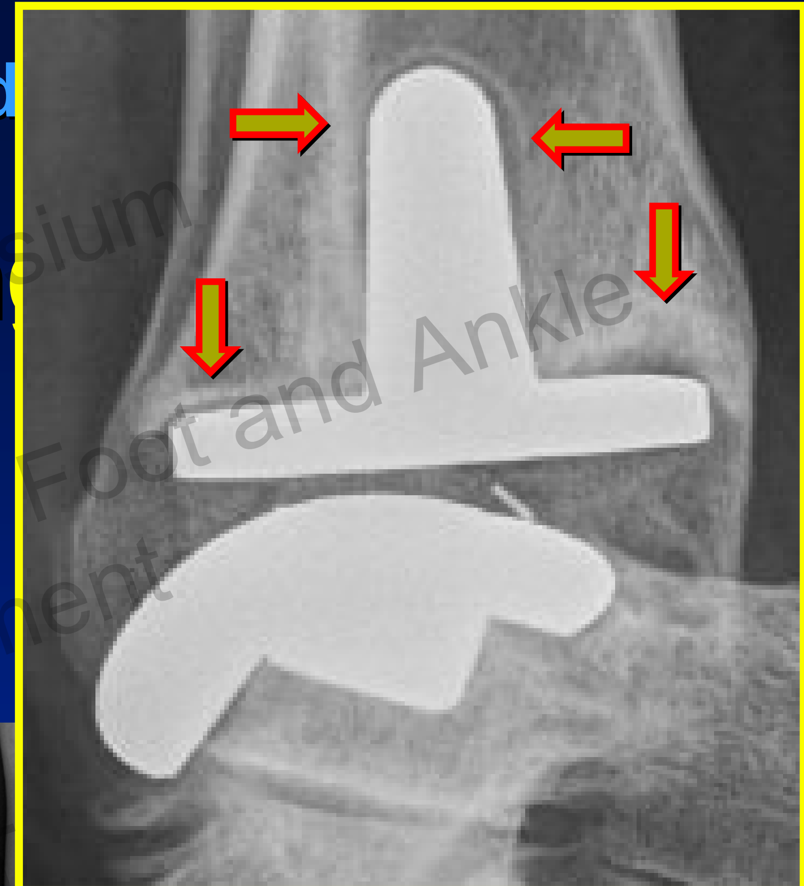
- AP-view
  → alignment of tibia
  → ligament tensioning
- Lateral view
  → tibiotalar alignment
  → center of rotation

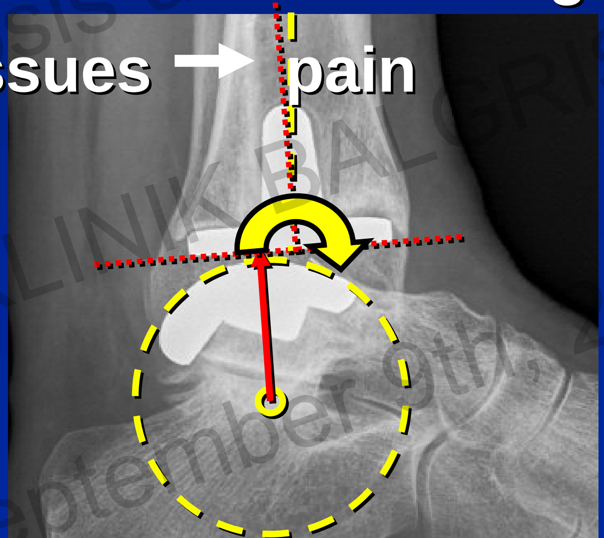


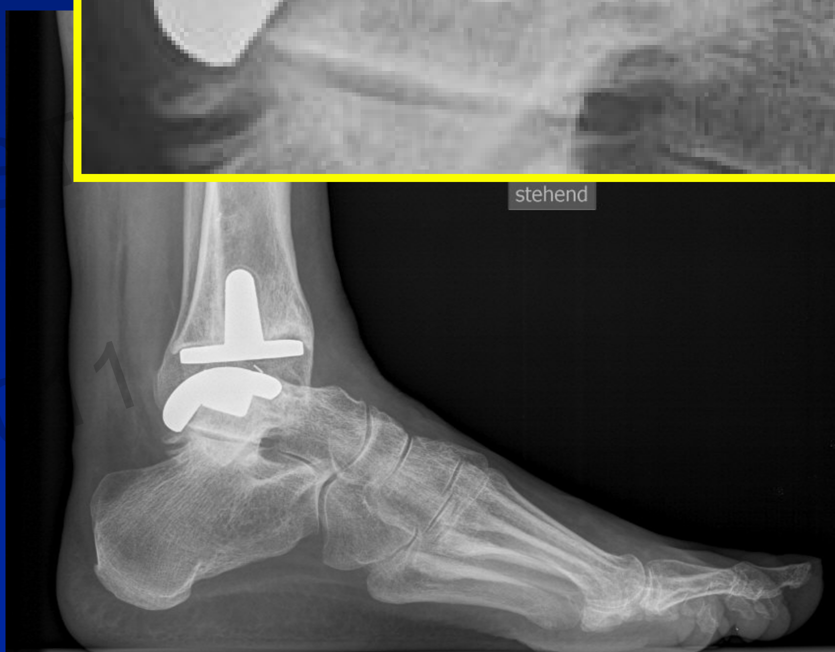
Ligament Balancin

Not Balanced …

- Asymmetric Load
  - ➞ implants ➞ PE wear
  - ➞ loosening
  - ➞ soft tissues ➞ pain



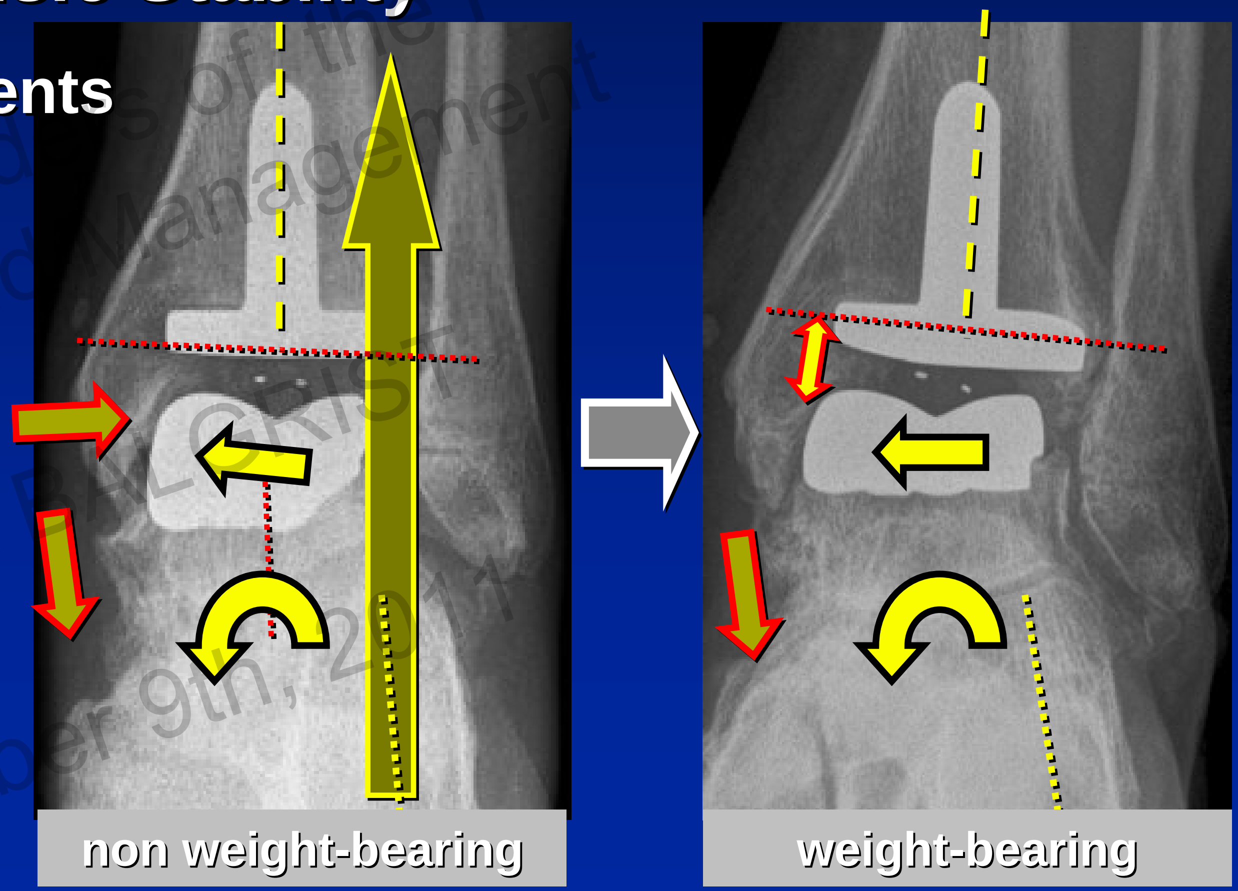




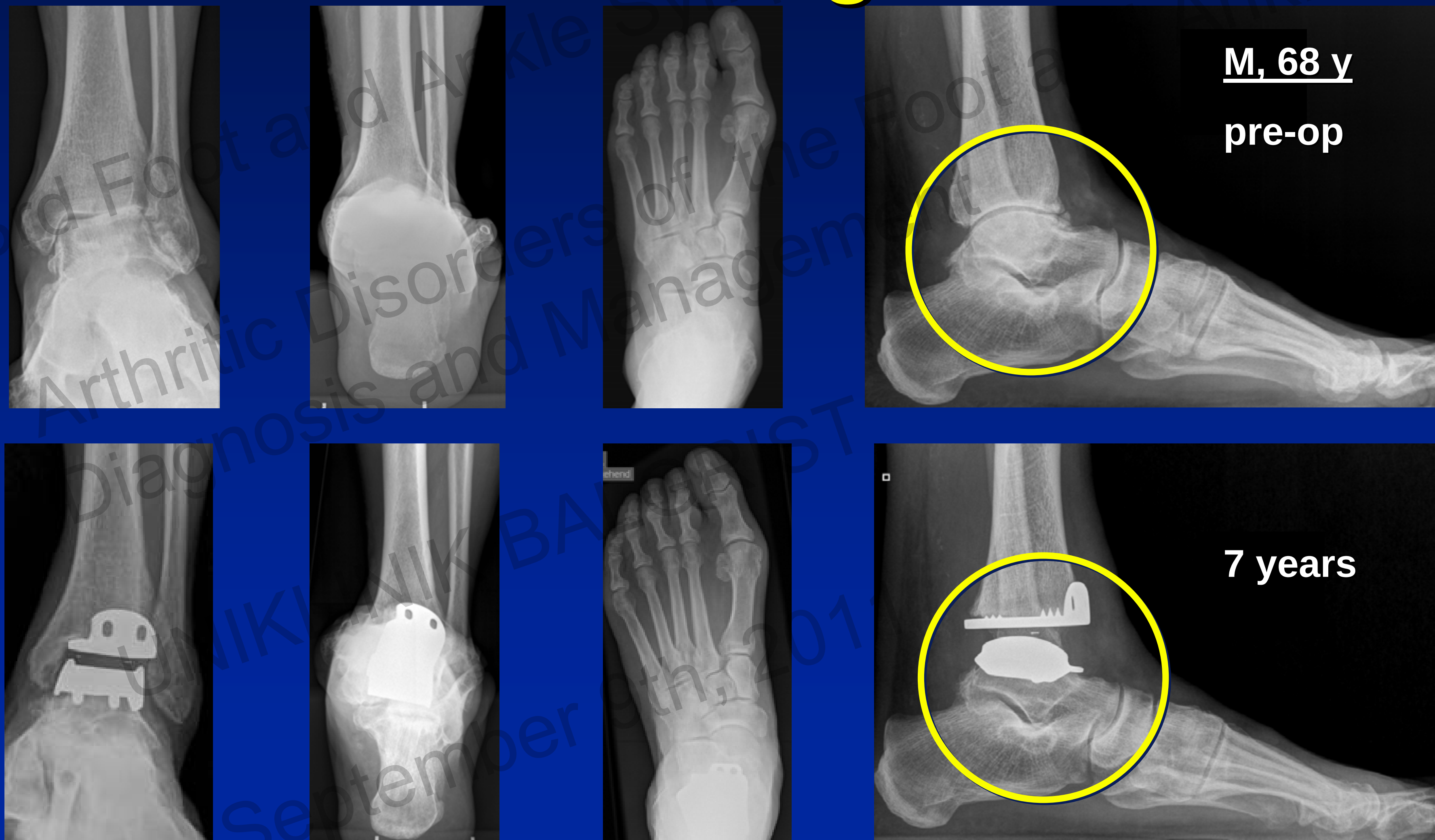
Ligament Balancing

Insufficient Intrinsic Stability

- Overload of ligaments
  - → progressive instability
  - → impingement
  - → pain

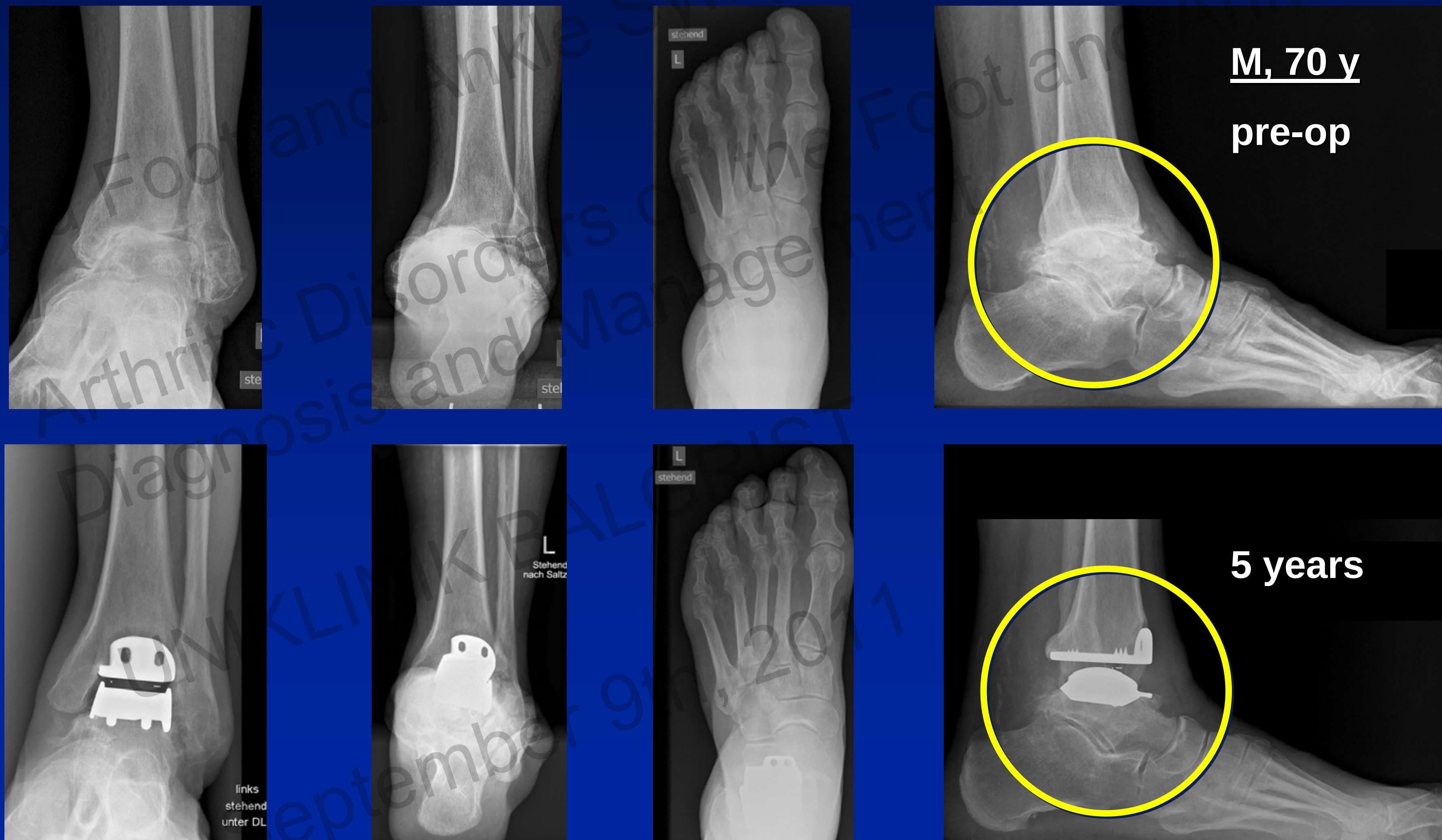


Clinical Case - Valgus

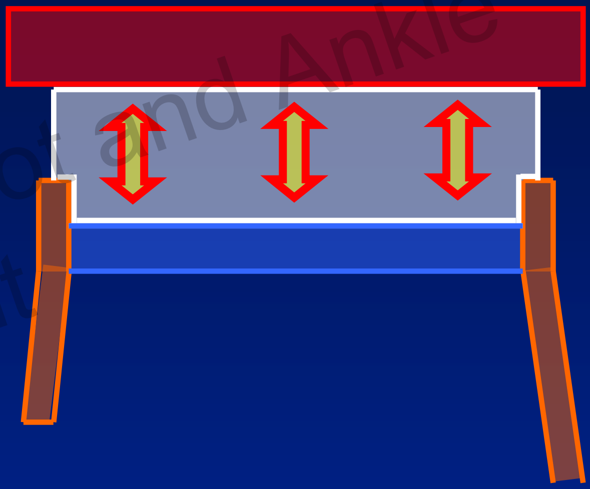


Clinical Case - Valgus

Clinical Case - Varus

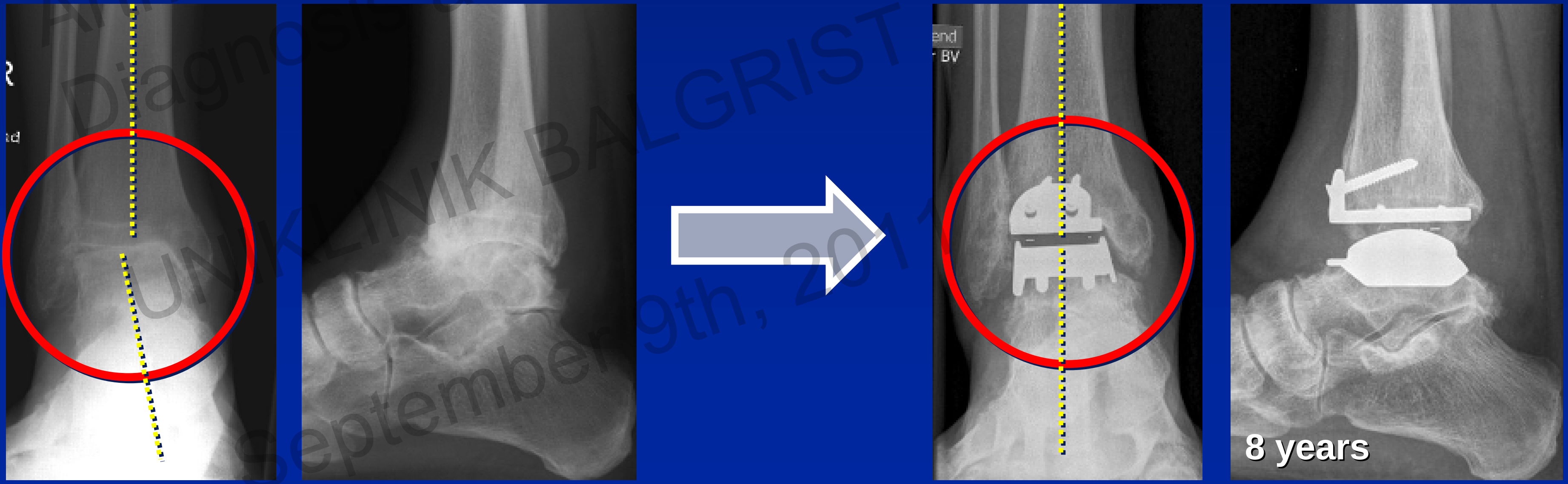


Ligament Balancing



My Believe → Proven…

- **Coronal plane stability**
  → **mandatory for instrinsic stability of the ankle**

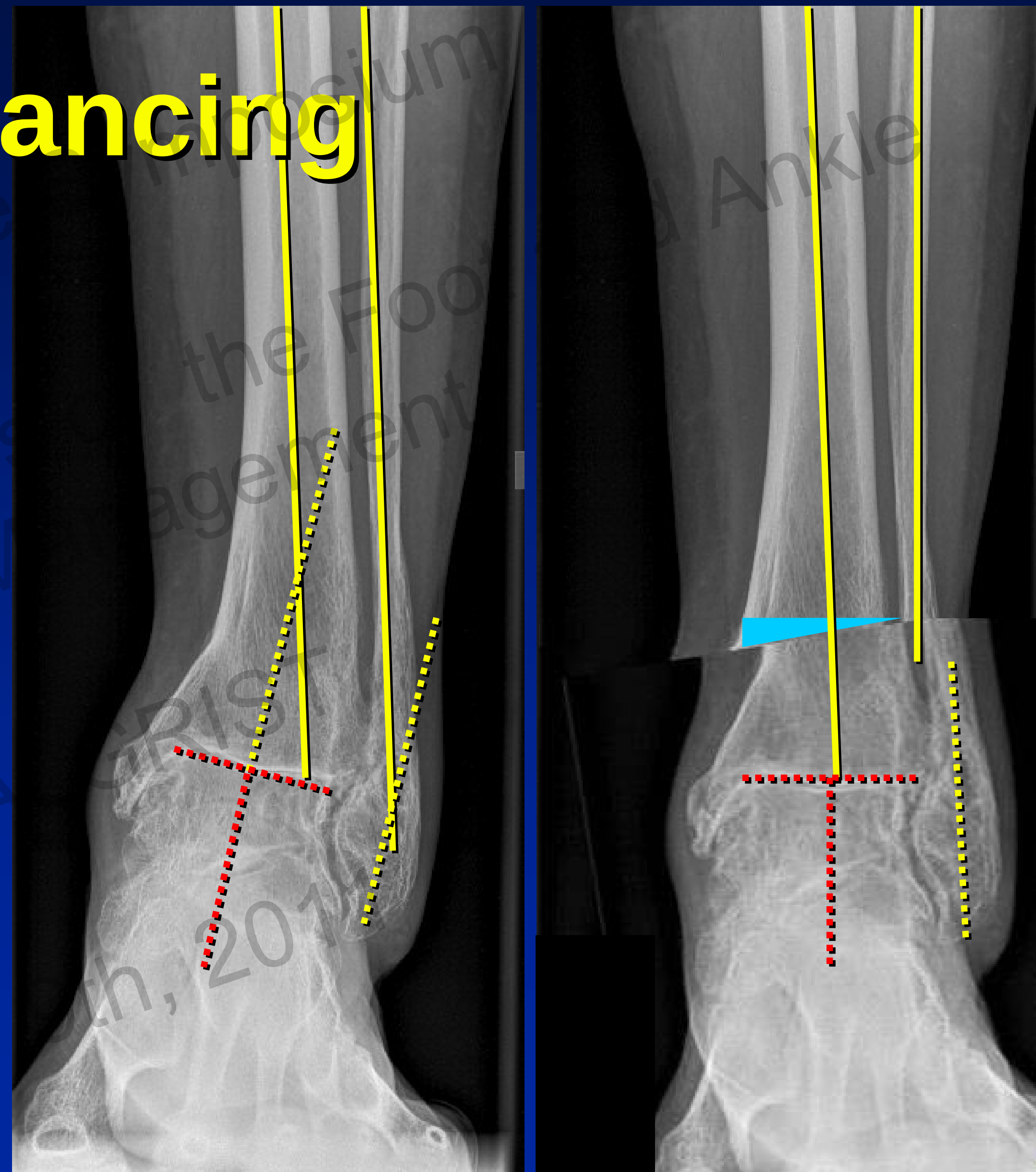


Osseous Balancing

Misaligned ankle

- Tibial osteotomy
  - → valgisation
  - → lateral translation
- Fibular osteotomy
  - → valgisation
  - → lateral translation
- Tibiotalar joint
  - → resurfacing

frontal plane

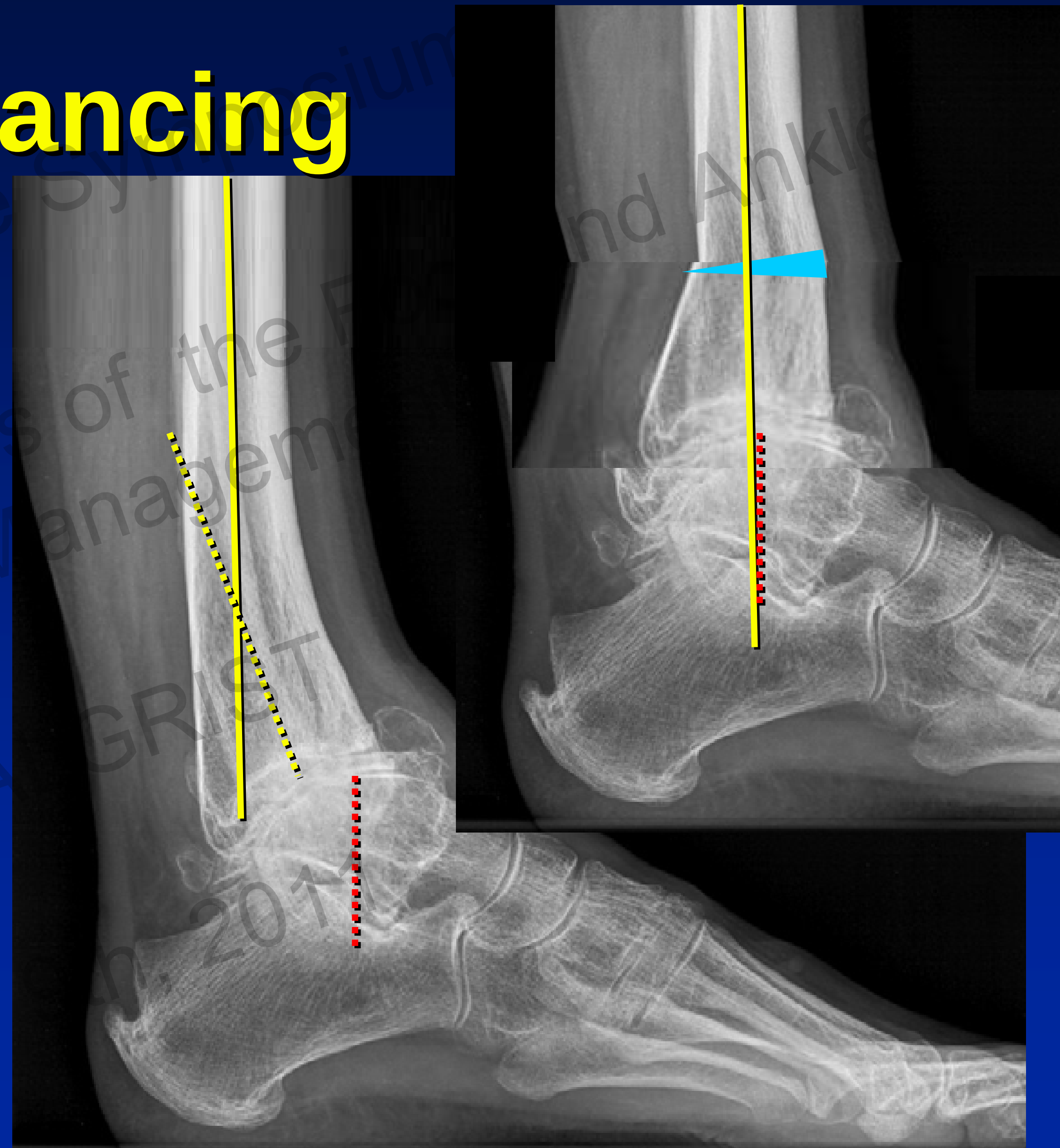


Osseous Balancing

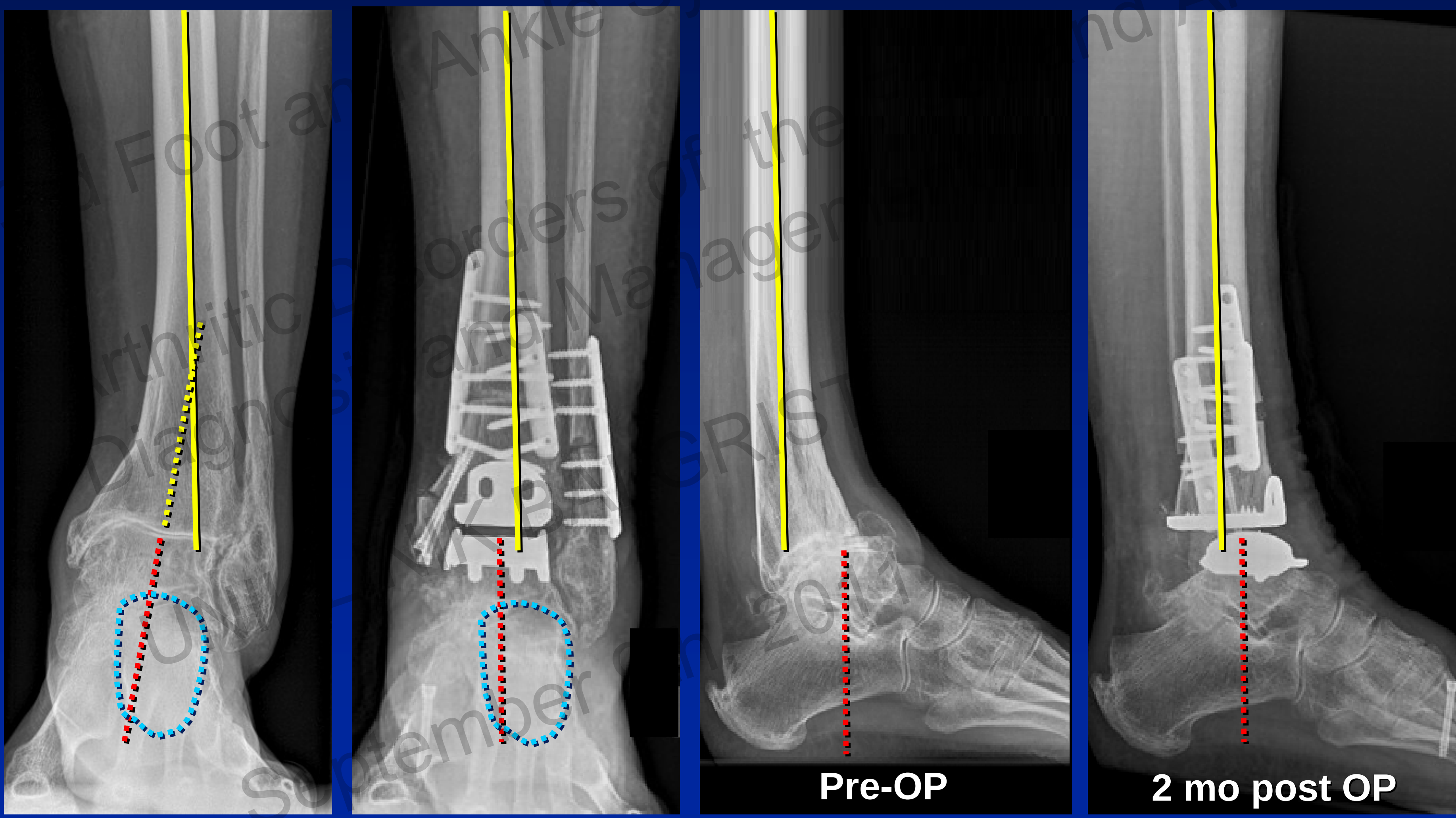
Misaligned ankle

- Tibial osteotomy
  → extension
- Fibular osteotomy
  → extension
- Tibiotalar joint
  → resurfacing

sagittal plane



Osseous Balancing



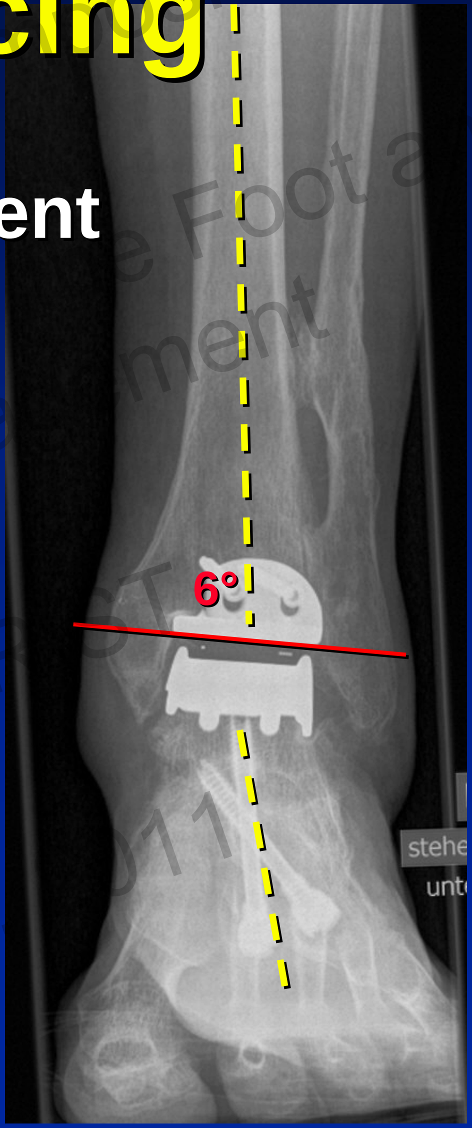
Osseous Balancing

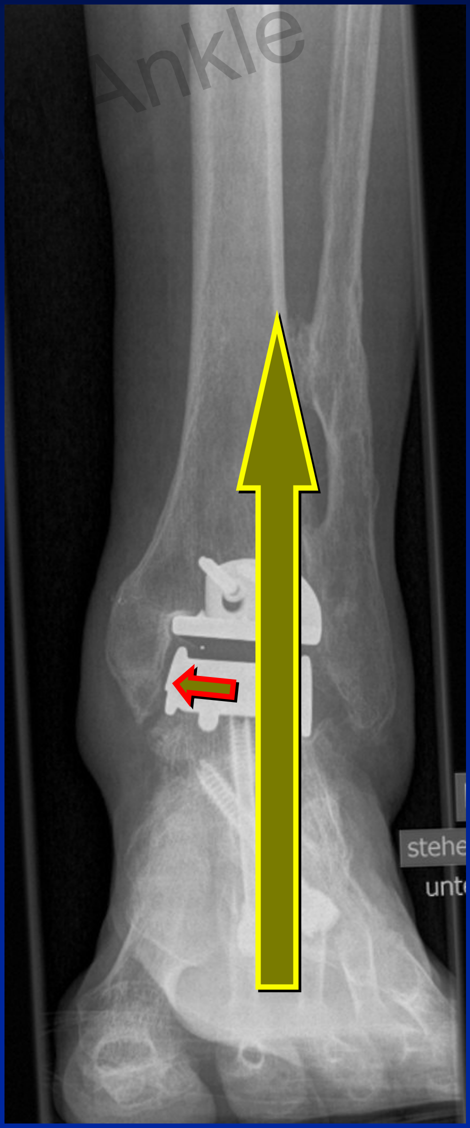
Varus-Valgus-Misalignment

- Medial shift of talus
  → medial pain syndrome

<u>f, 73 y</u>

- Posttraumatic OA
  → TAR 26 months
- Pain
  → medial malleolus
- Limited load tolerance
  → walking distance < 1 h

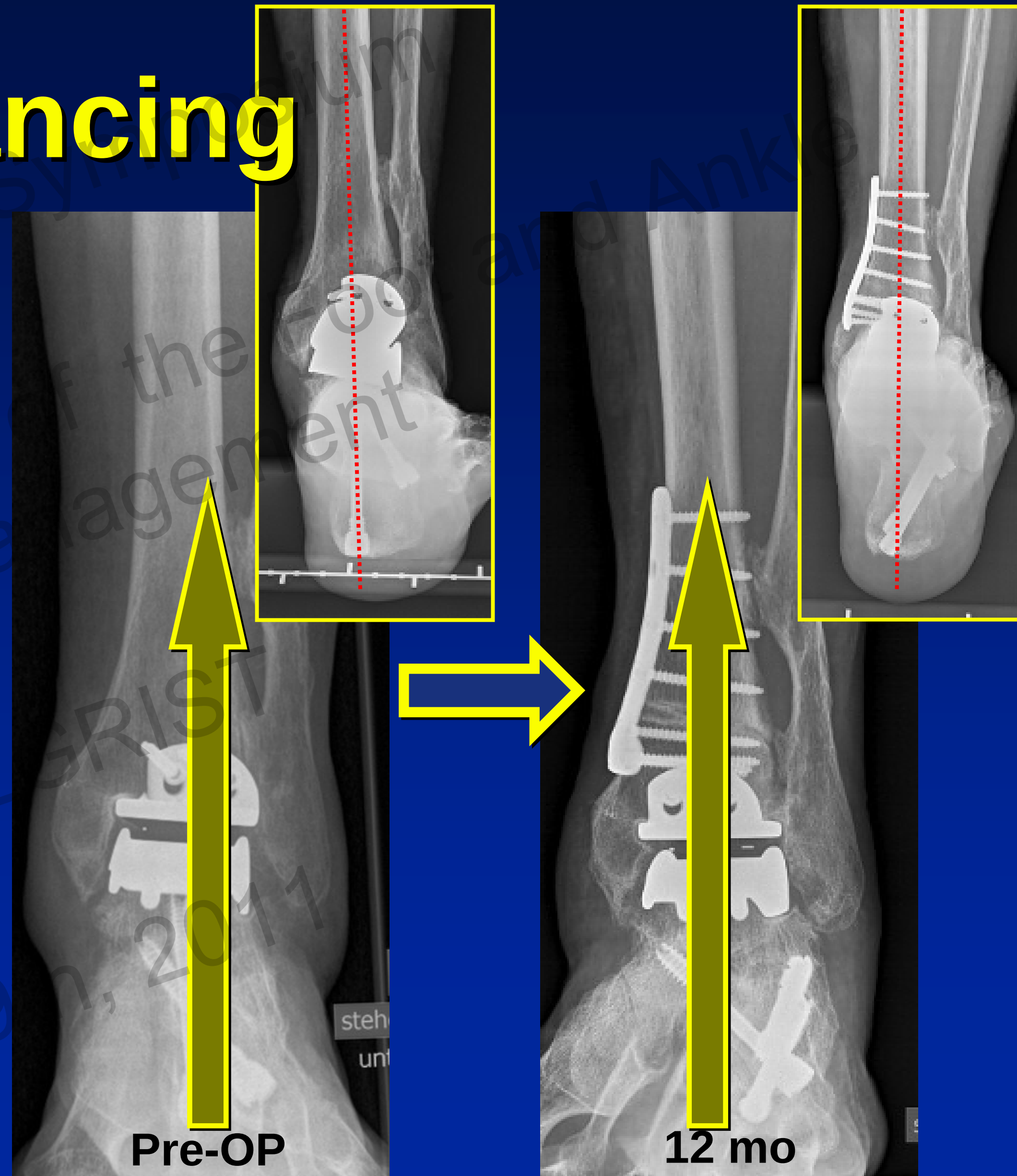




Osseous Balancing

After **Osteotomies**

- **Decompressed medial ankle joint**
  → **regular position of talar component**
- **Decreased stress**
  → **soft tissues**
- **Patient**
  → **pain relief**
  → **better feeling**



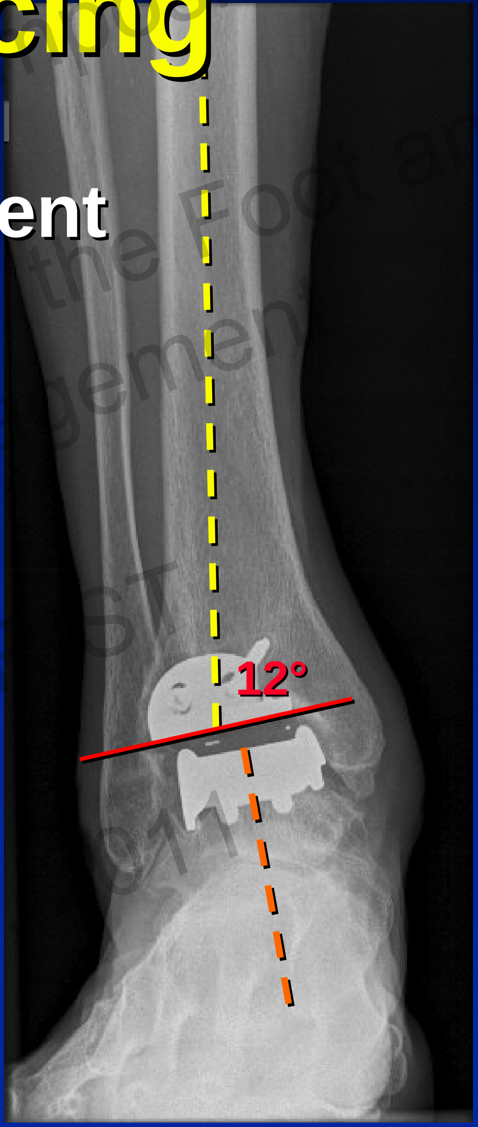
Osseous Balancing

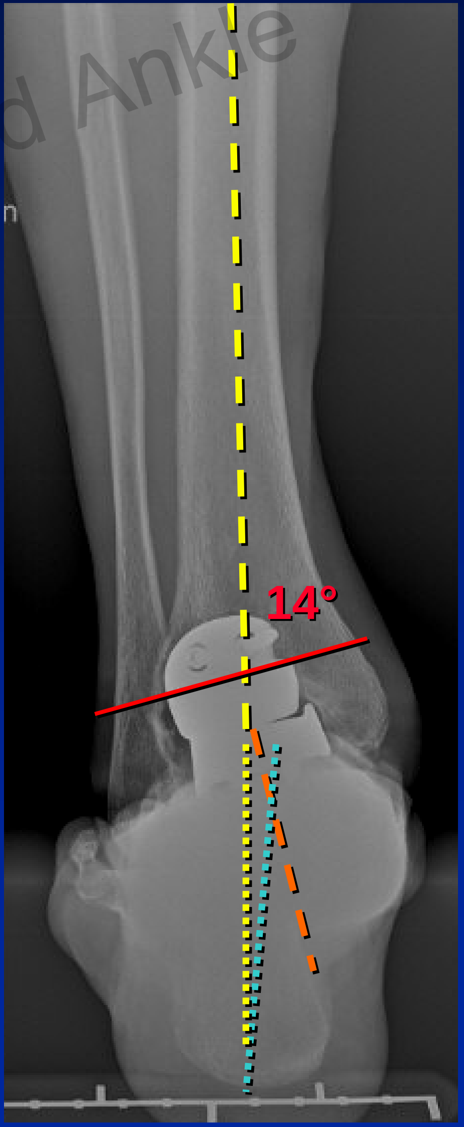
Varus-Valgus-Misalignment

- Medial shift of talus
  → medial pain syndrome

f, 58 y

- Posttraumatic OA
  → TAR 20 months
- Pain
  → medial malleolus
- Limited load tolerance
  → walking distance < 1 h





Osseous Balancing

Osseous Balancing

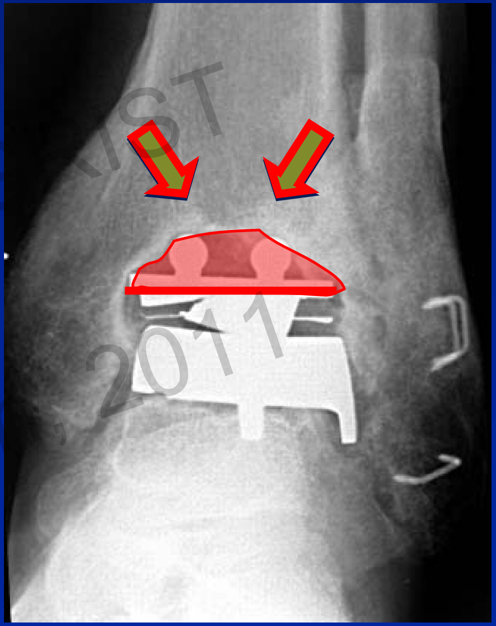
Usable as a Revision Ankle ?

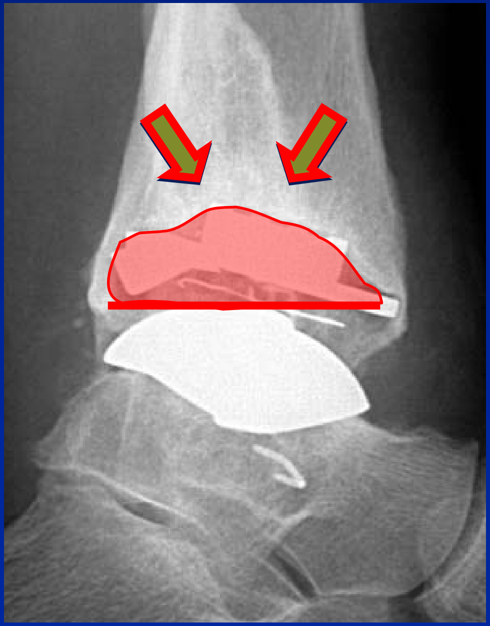
Challenges

- Bone defect
  → stable anchorage of implants ?

f, 52 y

- posttraumatic ankle OA
  → ankle fracture 5 years
- S.T.A.R. ankle 5.6 years
  → some pain
  → strange feeling
- problems
  → bone loss

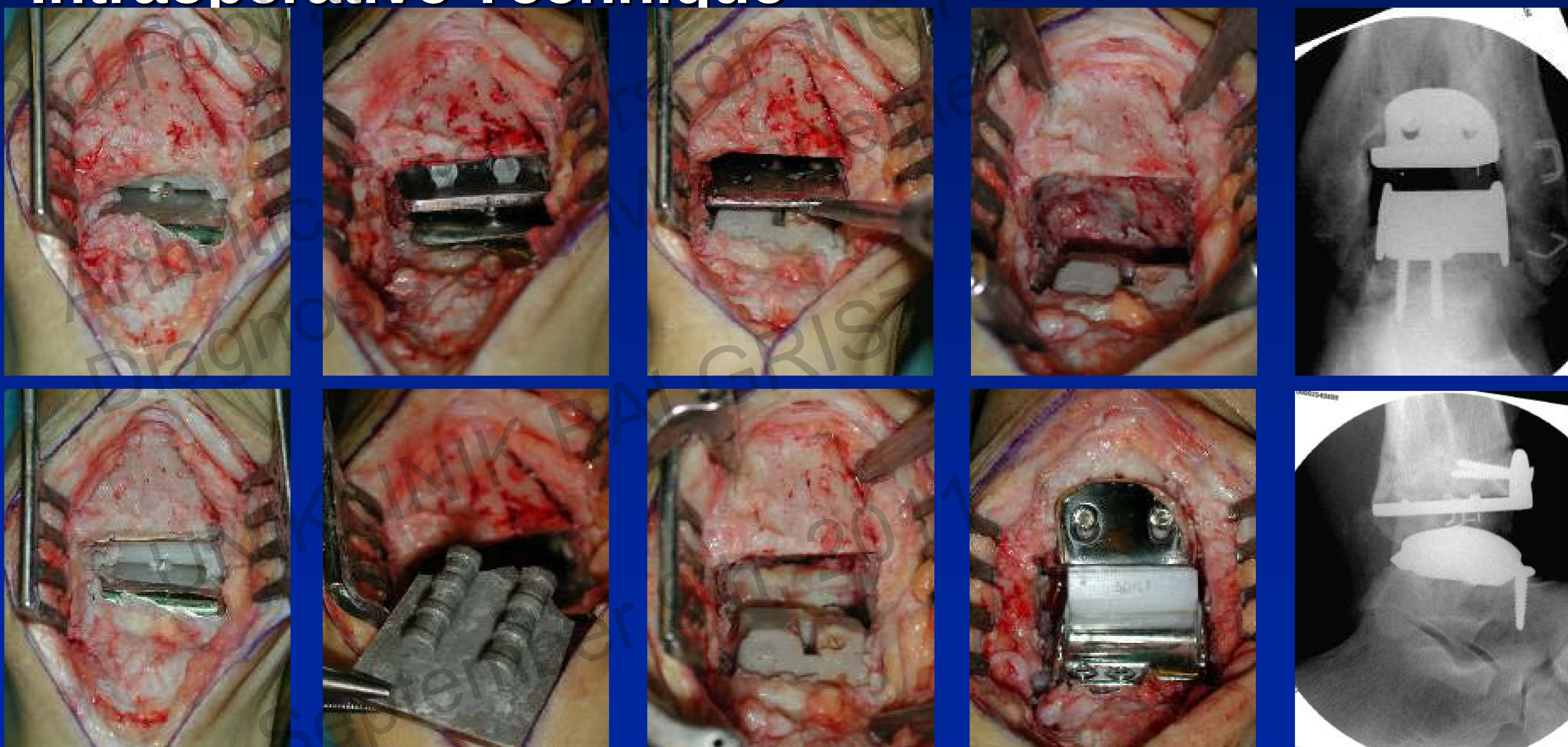




TAR – History, Technique and Outlook

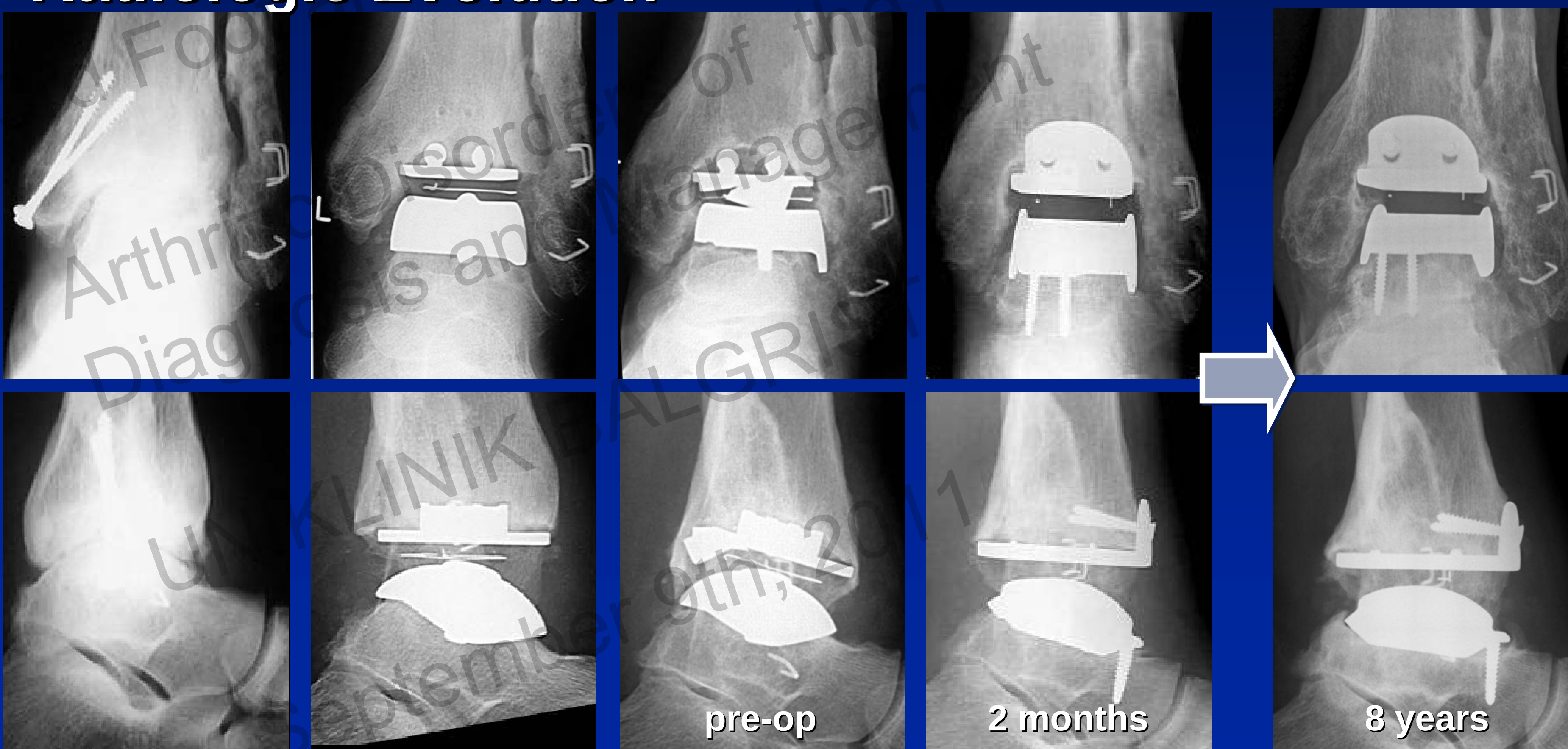
Usable as a Revision Ankle ?

Intraoperative Technique



Usable as a Revision Ankle ?

Radiologic Evolution



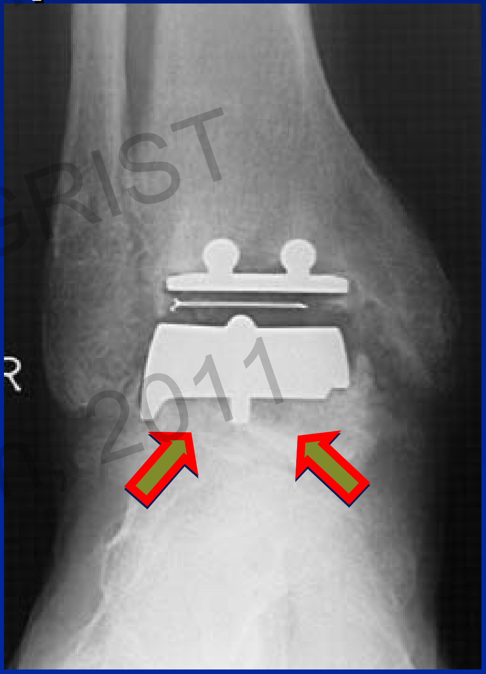
Usable as a Revision Ankle ?

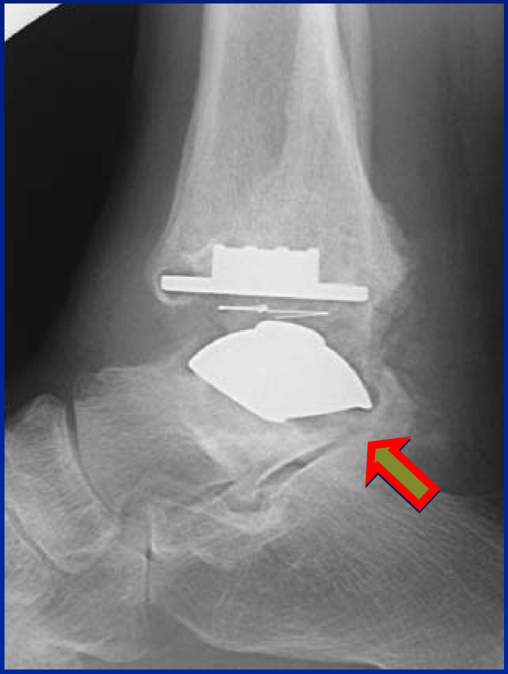
Challenges

- Bone defect
  → stable anchorage of implants ?

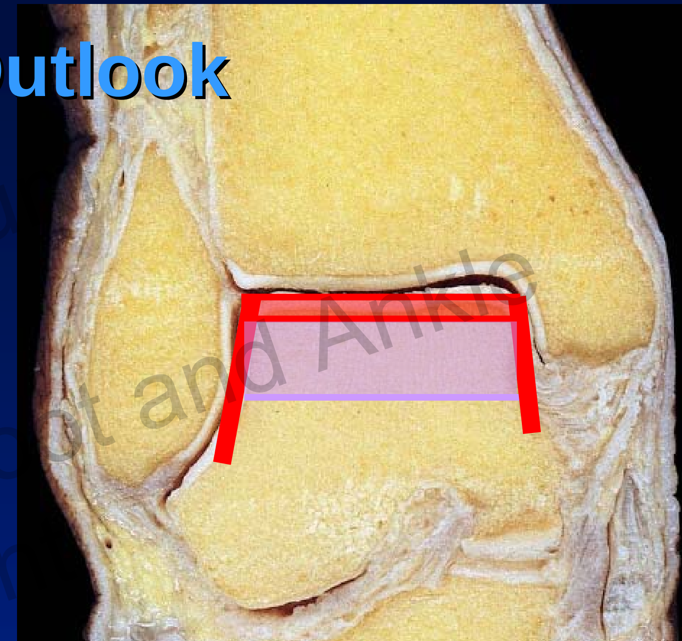
f, 49 y

- posttraumatic ankle OA
  → ankle fracture 22 years
- S.T.A.R. ankle 6 years
  → asymptomatic
- problems
  → bone loss
  → cyst formation





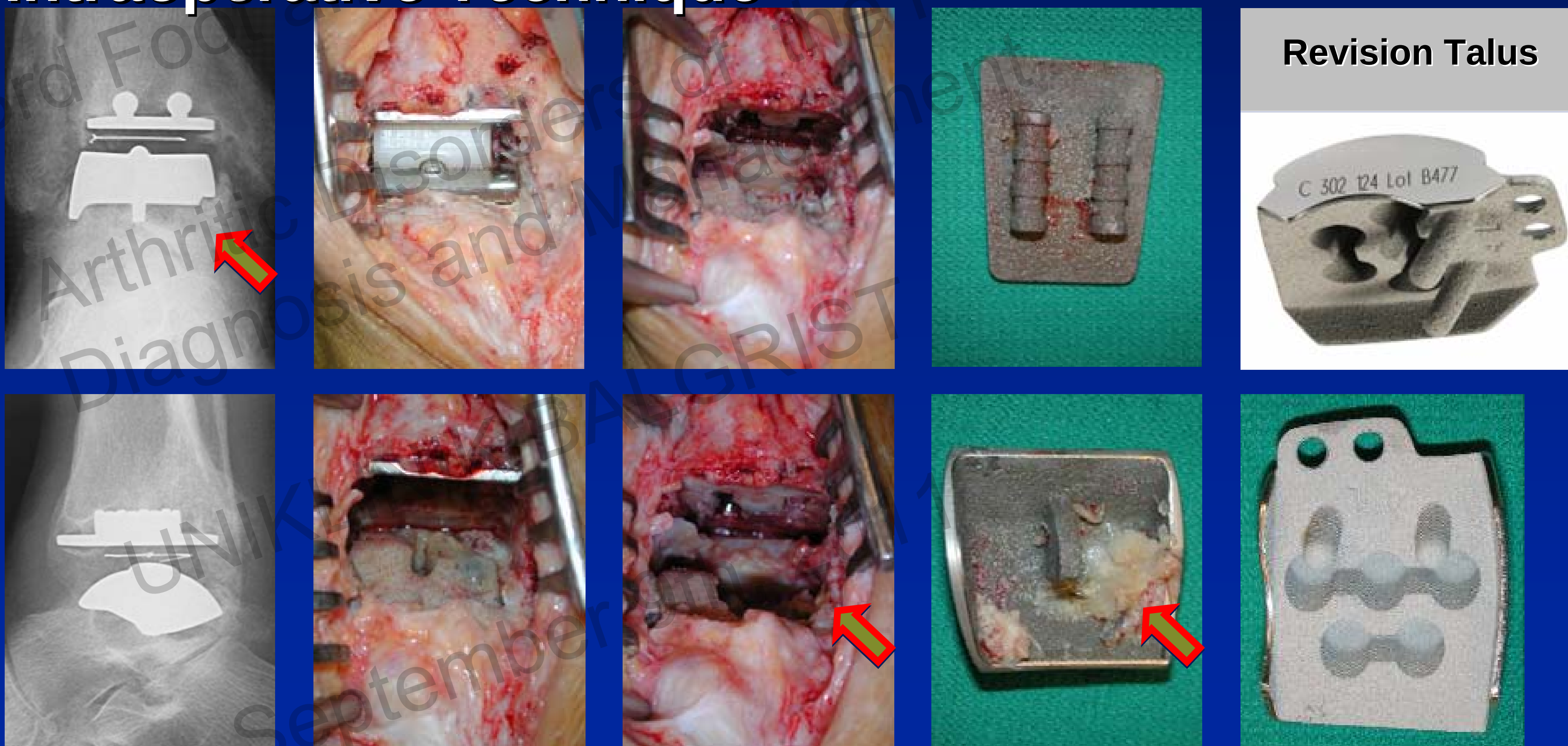
Revision Talus



TAR – History, Technique and Outlook

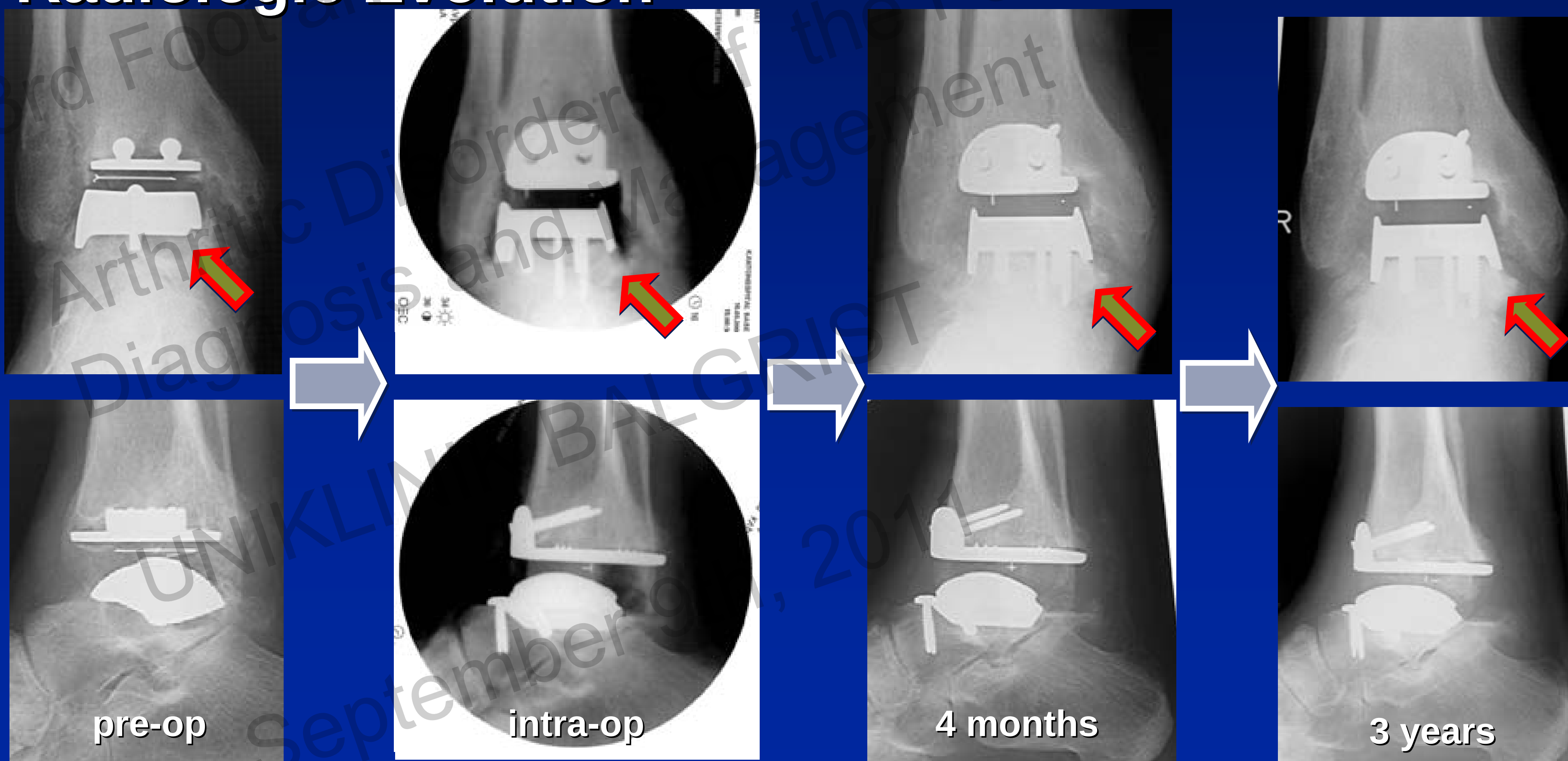
Usable as a Revision Ankle ?

Intraoperative Technique



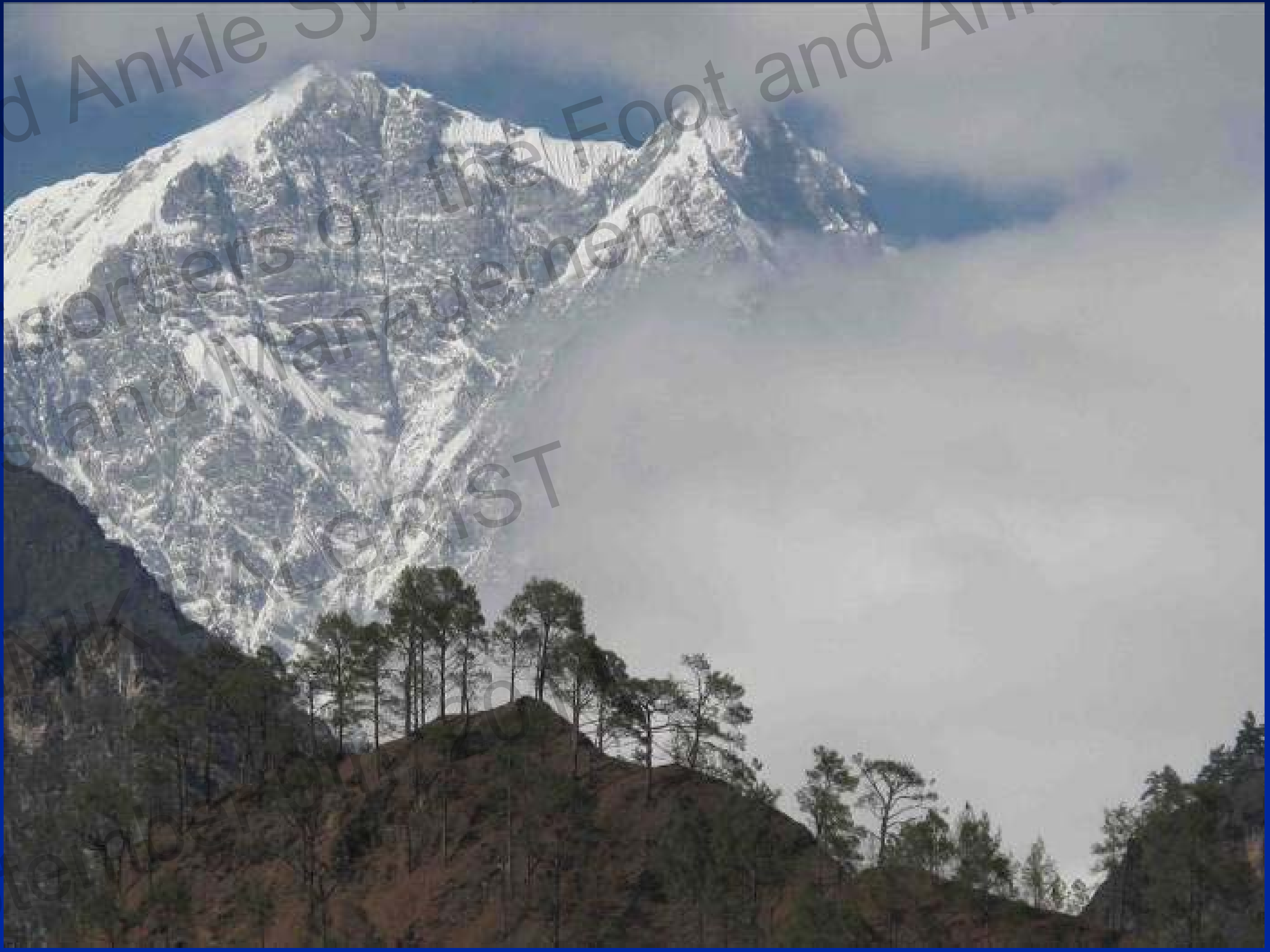
Usable as a Revision Ankle ?

Radiologic Evolution



TAR – History, Technique and Outlook

At the End …



Not at All !

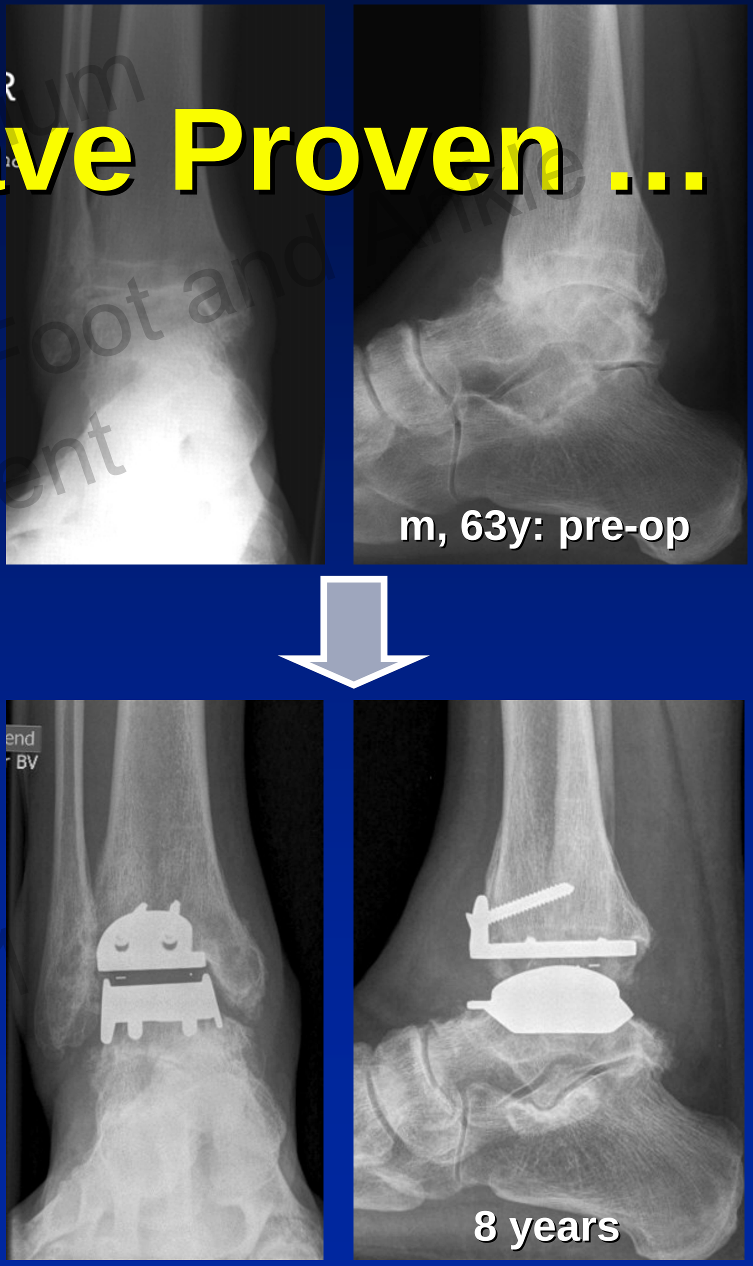
There is Need for …

- Ongoing longitudinal observation of patients
  - → long-term stability of interface
  - → wear of PE insert
- Improved techniques
  - → safe and reliable implantation
  - → use the prosthesis as a part of hindfoot reconstruction
- Controlled studies
  - → indications / contraindications
  - → limit of the procedure

But the 11 Years have Proven …

We are on the Way !

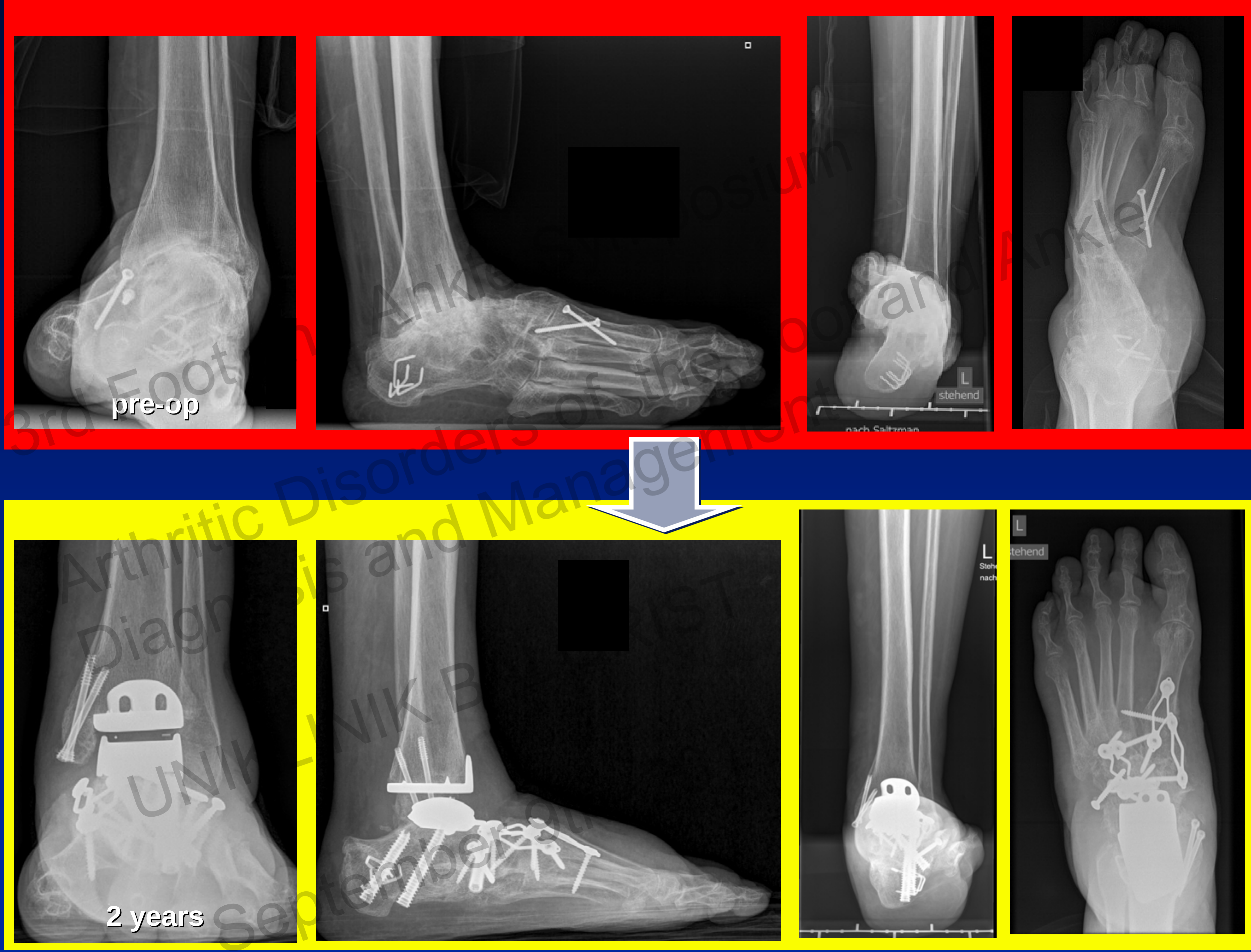
- Successful tool
  → to replace the ankle



But the 11 Years have Proven …

We are on the Way !

- **Successful tool**
  - → to replace the ankle
  - → **to restore hindfoot function**


pre-op
L
stehend
nach Saltzman
2 years
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But the 11 Years have Proven ...

We are on the Way !

- **Successful tool**
  - → to replace the ankle
  - → to restore hindfoot function
  - → **to make the patient happy**

f, 55 y: 22 y after arthrodesis - preop

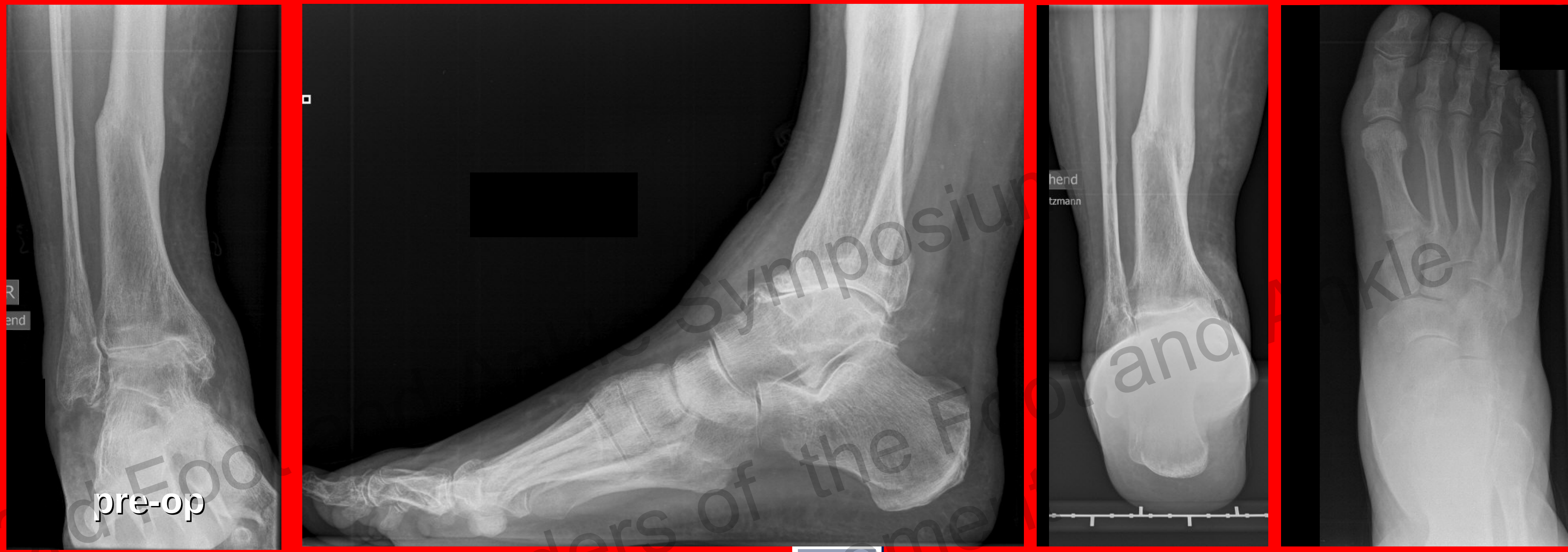

pre-op
4 months

But the 11 Years have Proven …

We are on the Way !

- **Successful tool**
  → to replace the ankle
  → to restore hindfoot function
  → to make the patient happy
  → **to make the surgeon happy**

m, 67 y: pre-op



Thank you !

Summary

TAR

- Rarely simple surgery
- Mostly part of it
  → reconstruct the hindfoot
- Challenges me
  → every day !
- I am still on the way
  → discovering more
  → getting more insight

Summary

Why do Use Another Prosthesis ?

- More bone resection
  → difficulties to revise
- Not anatomic
  → difficulties to balance
- No intrinsic stability in frontal plane
  → ligament overstress
- Intramedullar fixation
  → not physiologic load transfer
- ………………..


Thank You !