Influence of clavicle midshaft fracture pattern on the superior plate stabilization

PD Dr.med. Carsten Englert*
Dr.-Ing. Sebastian Dendorfer**

*Department of Orthopaedic and Trauma Surgery, University Regensburg, Medical Center, Germany

**AnyBody Technology, Aalborg, Denmark

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Presenters

Carsten Englert
(Presenter)

Sebastian Dendorfer
(Presenter)

Arne Kiis
(Host/Panelist)

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Questions, it is ok to ask

- Launch the Q&A panel here.
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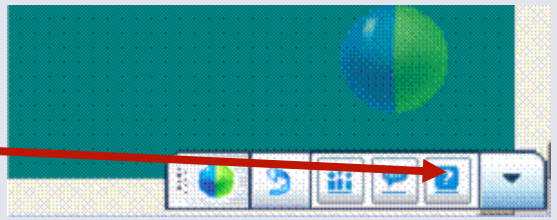
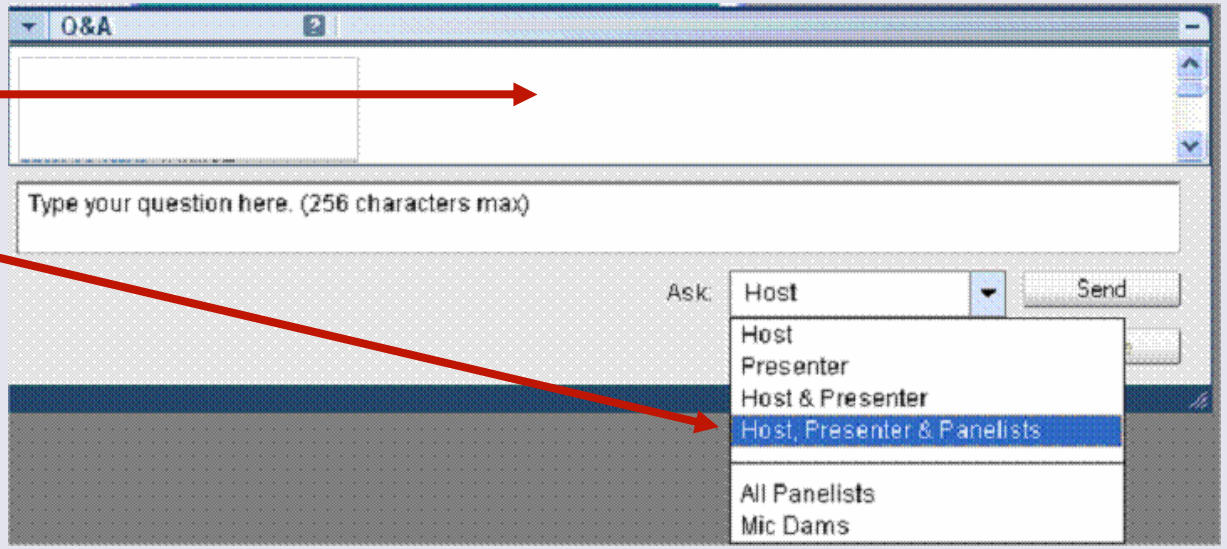
- Send the question to ”Host, Presenter & Panelists”





Notice the answer displays next to the question in the Q&A box. You may have to scroll up to see it.

Draw back‘s in clavicular fractures

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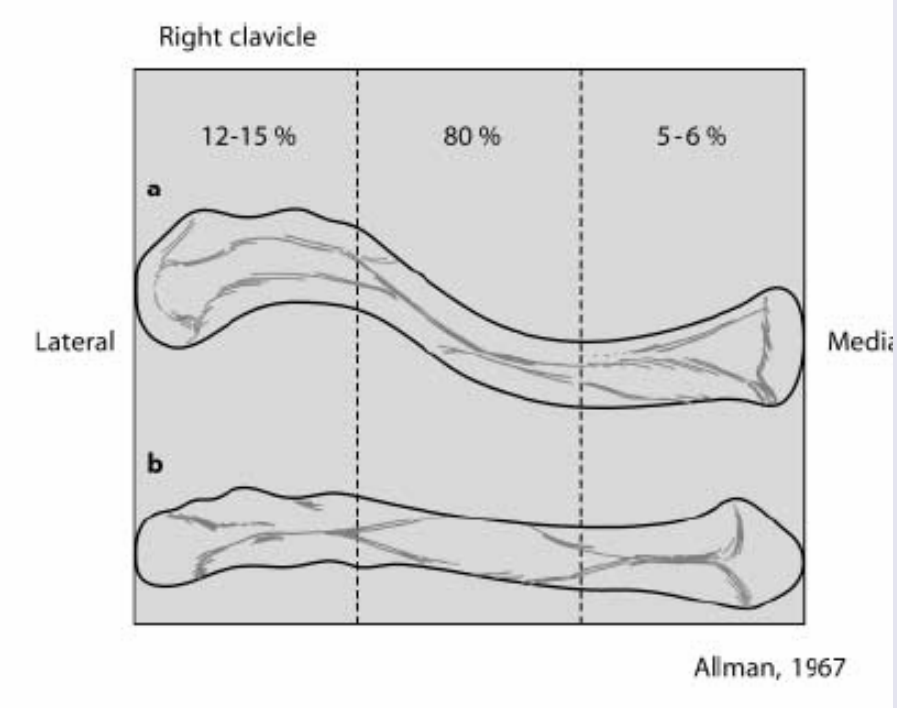
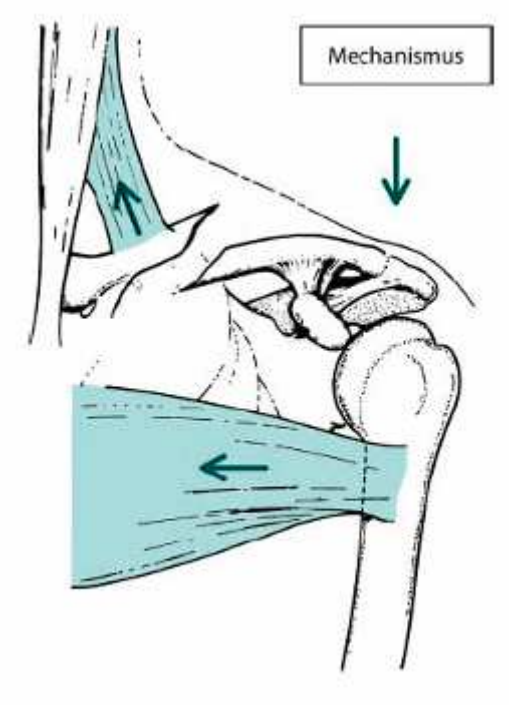
Clavicle fractures

- 4 % of all fractures
- 30% of all fractures of the shoulder





Clavicula

- S-shape
- Middle third with intramedular room
- Low soft tissue wrapping
- Important for over head positioning of the arm

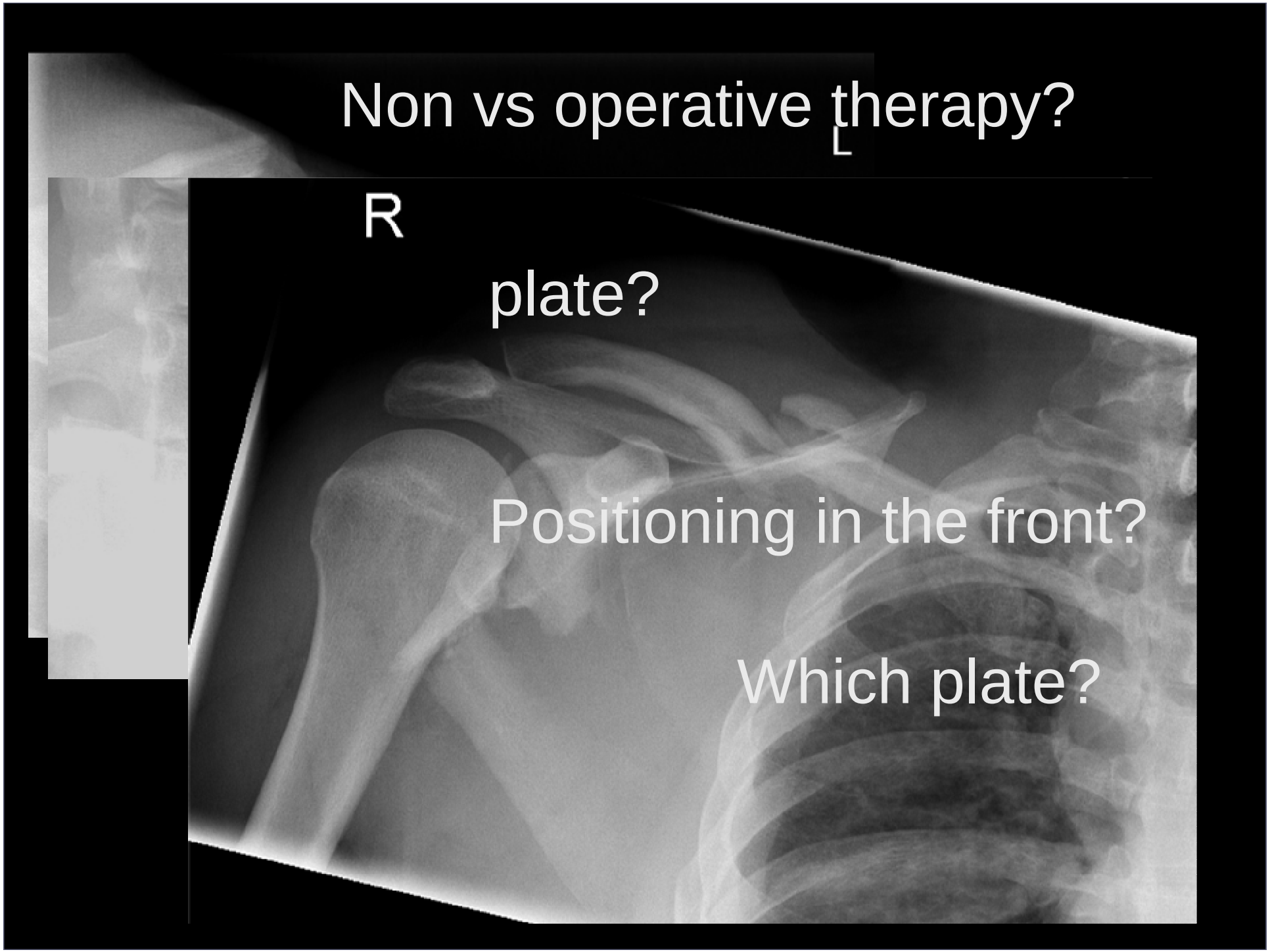
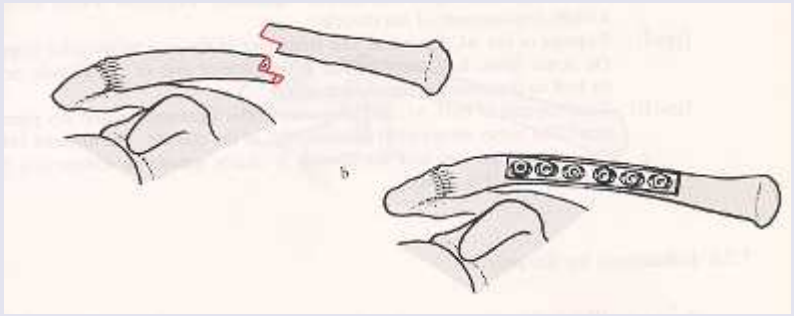
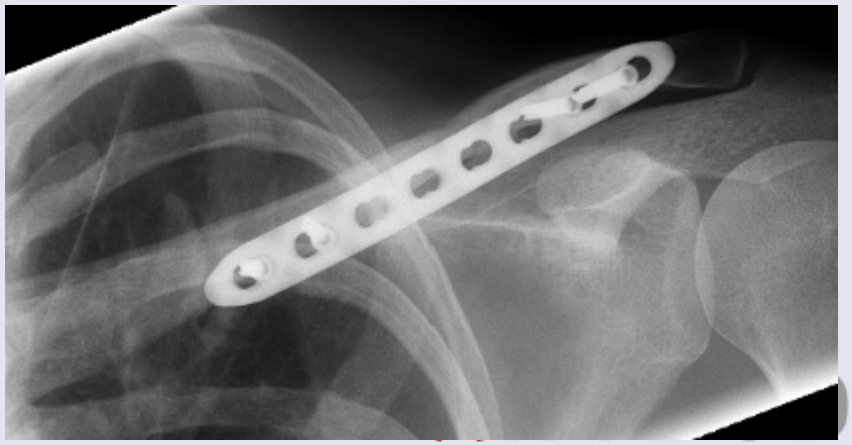

Non vs operative therapy?
L
R
plate?
Positioning in the front?
Which plate?

Plate position
superior vs anterior





Reconstruction plate

trauma

post operative

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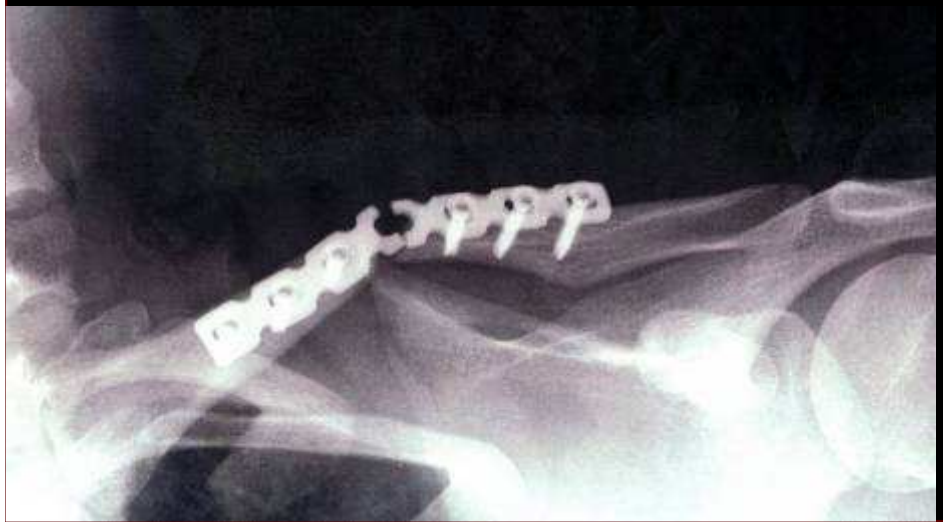
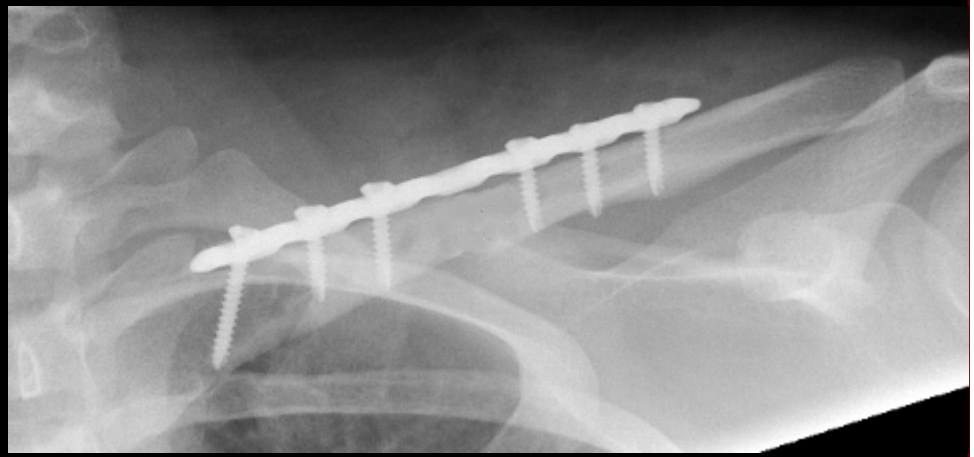
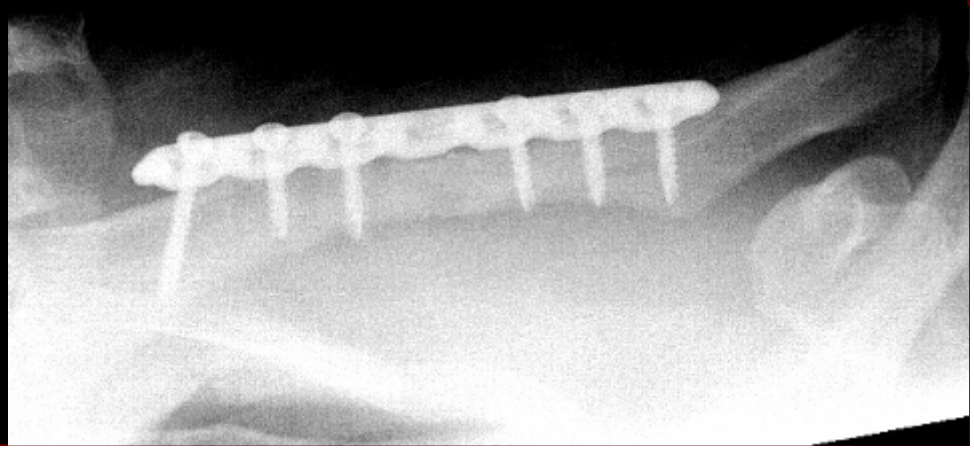
Reconst. plate vs LCP

6 weeks post Op.



revision





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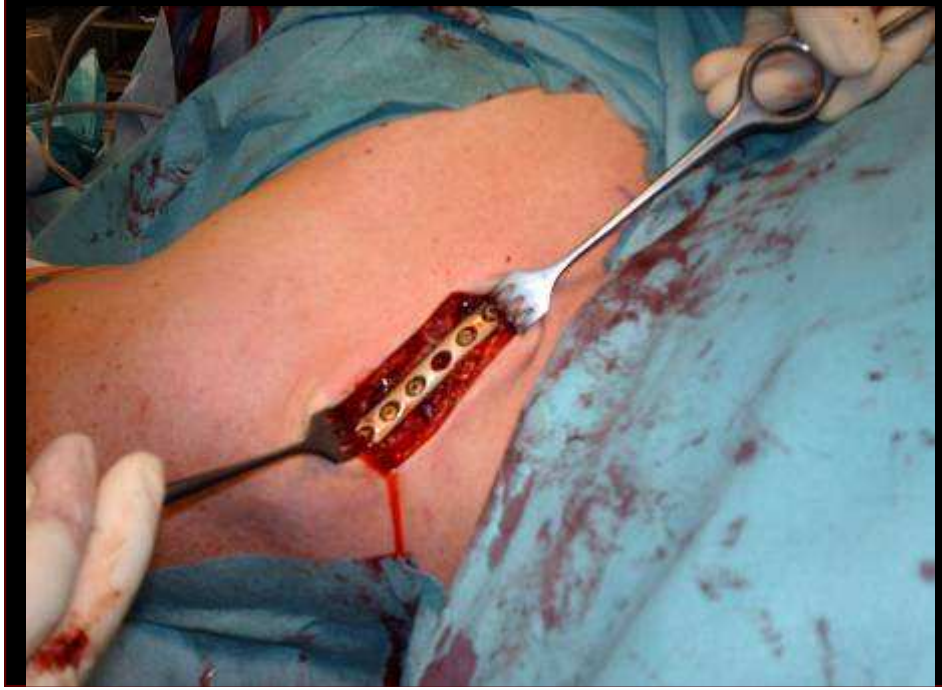
LCDCP open reduction

Pre Op

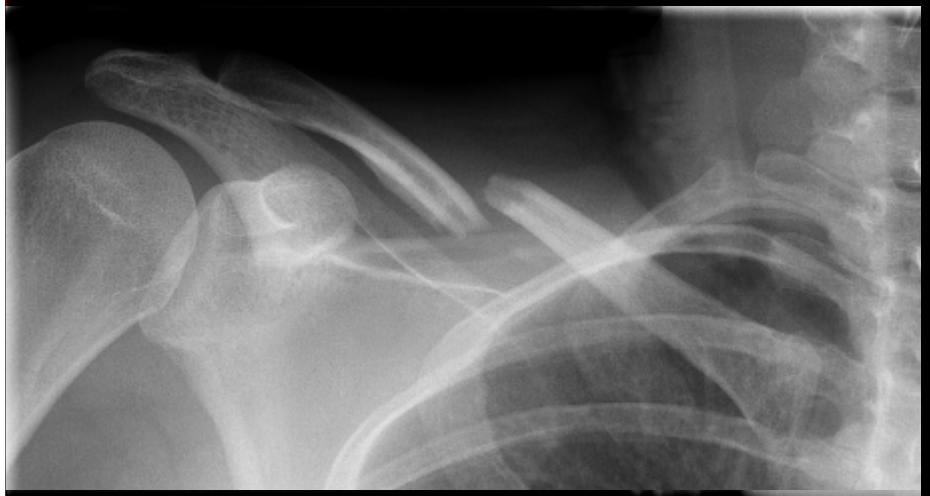


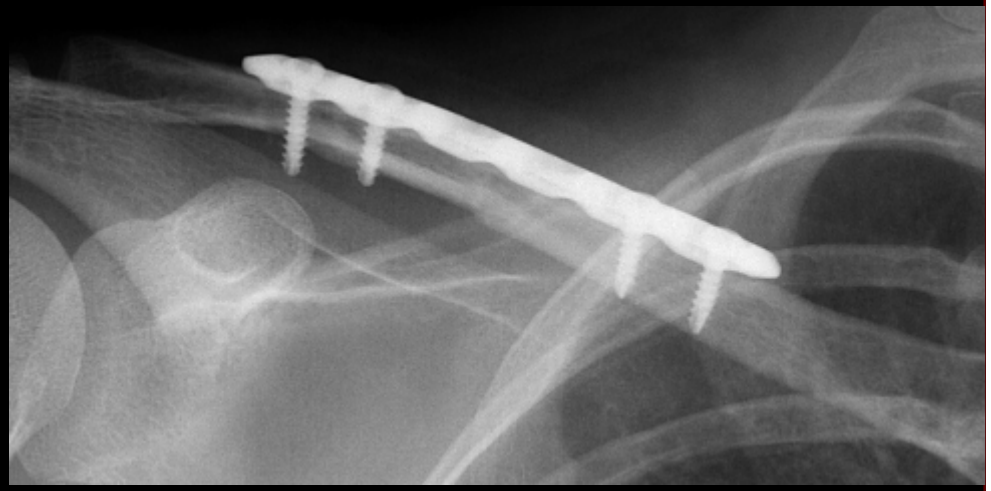
Post Op

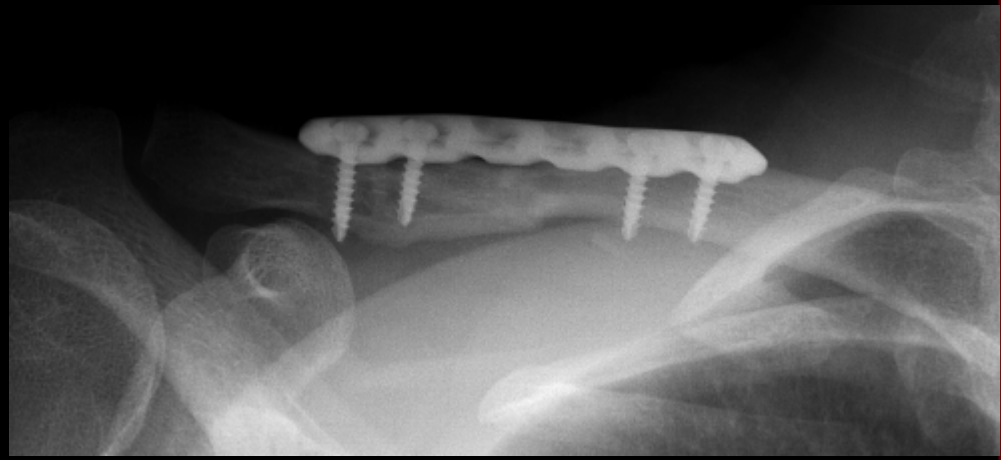
LCP in MIPO

Prae Op

Post Op

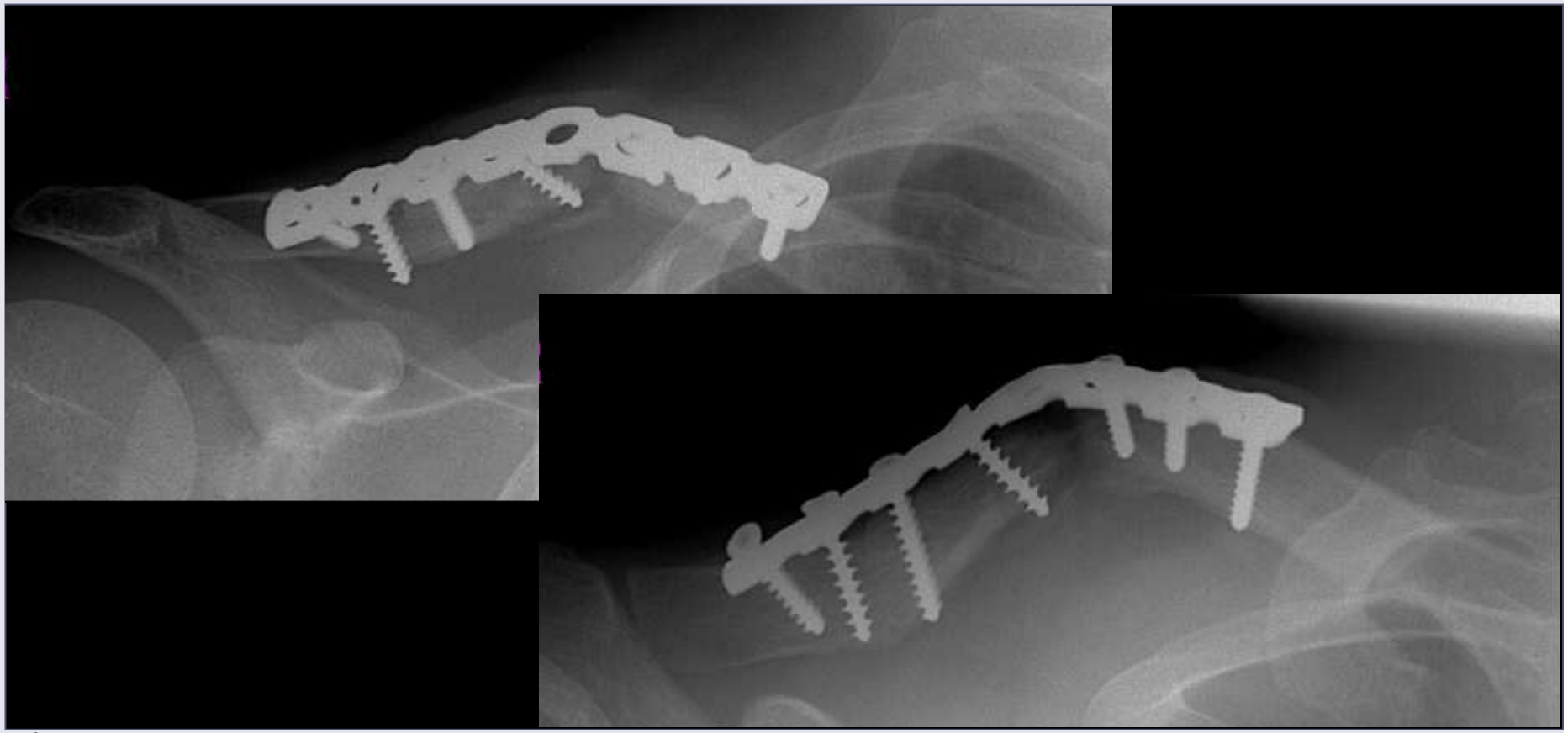






Complications

Christian D. 26 Jahre



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6 weeks post OP

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Raised questions

- Why does standard clavicular plate fixation fail?
- Do we need more specialized operative indications based on the fracture line in regard to:
  - implant choice
    - plate, nail
  - position
    - anterior, superior
  - screw choice
    - locking vs cortical screws
  - screw numbers

Objectives

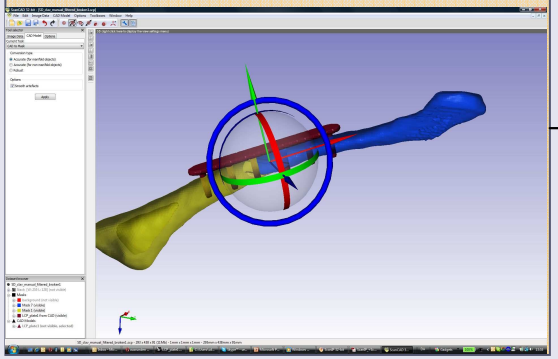
- Analyse the forces acting in the fracture during activities of daily living
- Evaluate the influence of fracture type on the stabilisation potential

From CT to FEM

CT/MRI scan

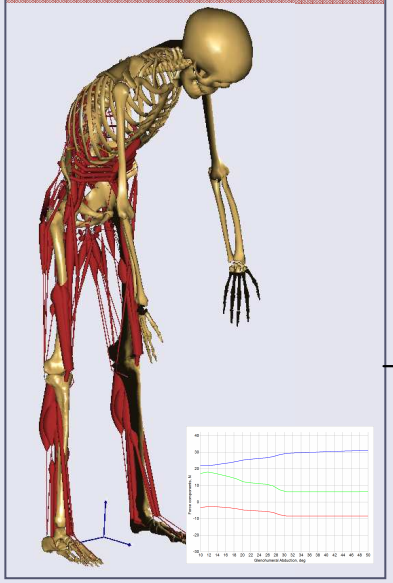
”raw” Geometry

CAD/Mesh



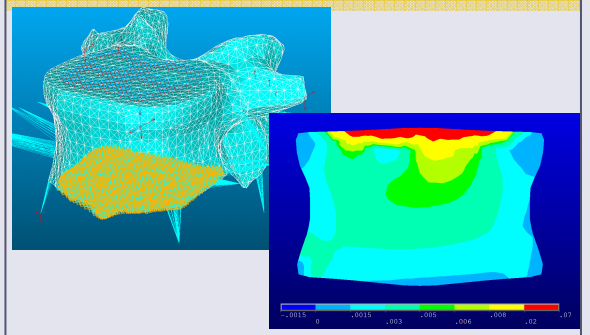
CAD and FE model for patient specific scaling

Musculoskeletal Simulation



Compute forces for activities of daily living

Finite Element Analysis



Compute tissue/material stress

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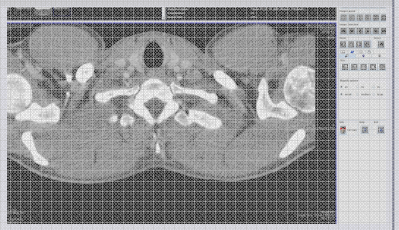
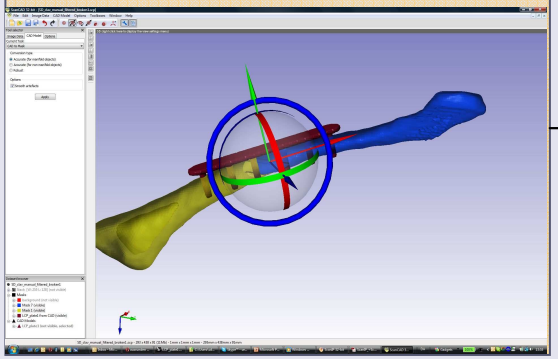
From CT to FEM

CT/MRI scan



"raw" Geometry

CAD/Mesh



CAD and FE model for patient specific scaling

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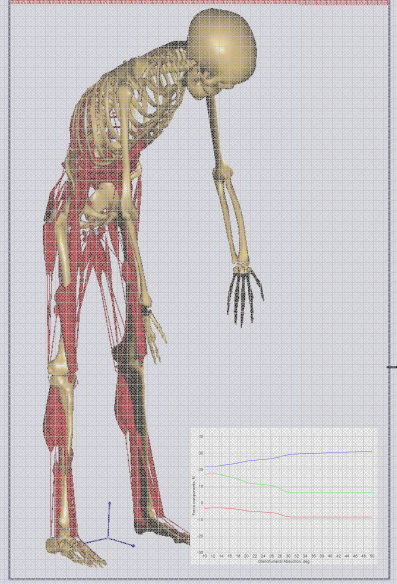
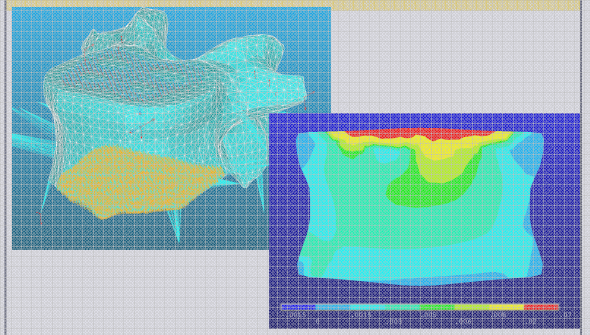
Musculoskeletal Simulation



Compute forces for activities of daily living

ANYBODY TECHNOLOGY

Finite Element Analysis



Compute tissue/material stress

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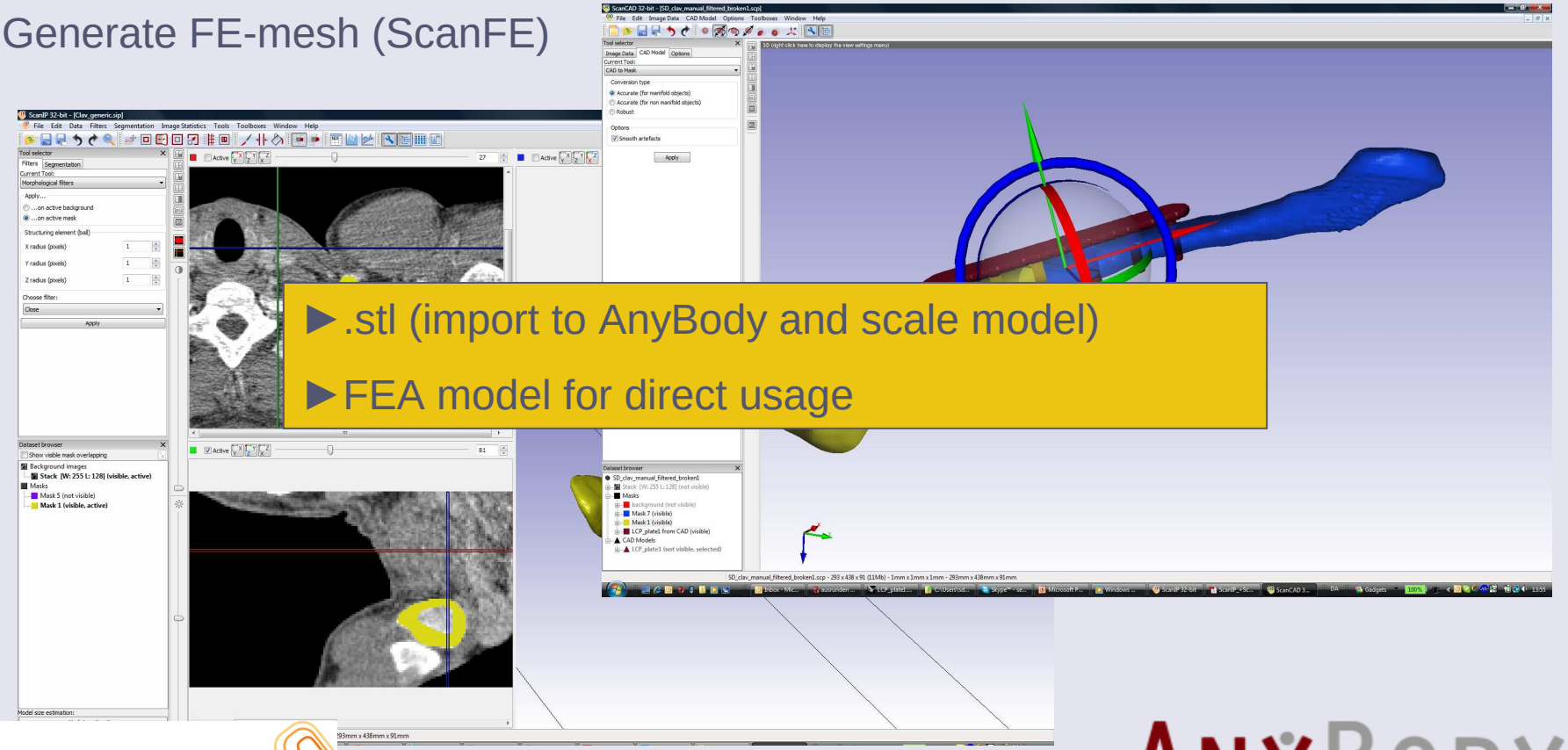
Generate CAD and FEA models

- Generate model from CT data (ScanIP)
- Insert implant (ScanCAD)
- Generate FE-mesh (ScanFE)



► .stl (import to AnyBody and scale model)

► FEA model for direct usage

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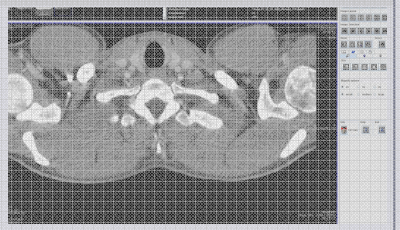
ANYBODY TECHNOLOGY

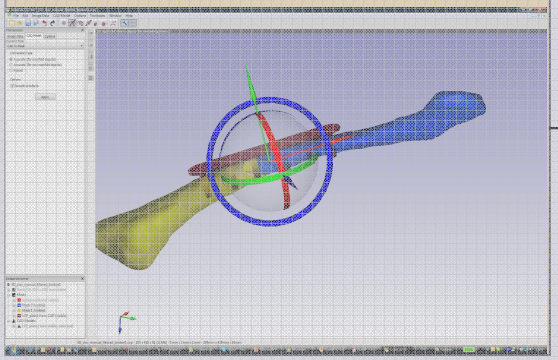
From CT to FEM

CT/MRI scan



"raw" Geometry

CAD/Mesh



CAD and FE model for patient specific scaling

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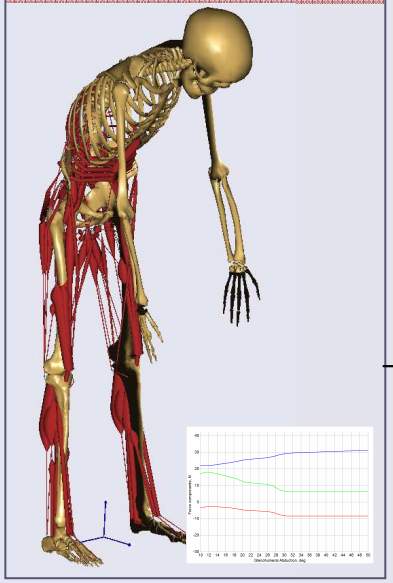
Musculoskeletal Simulation



Compute forces for activities of daily living

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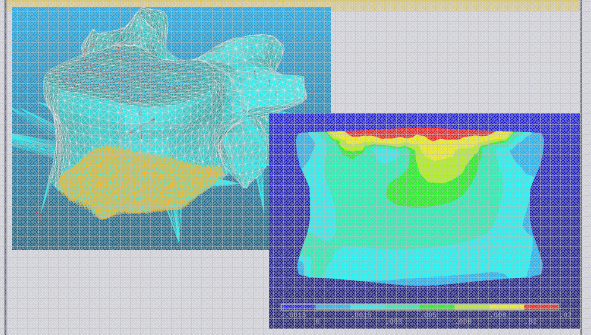
Finite Element Analysis



Compute tissue/material stress

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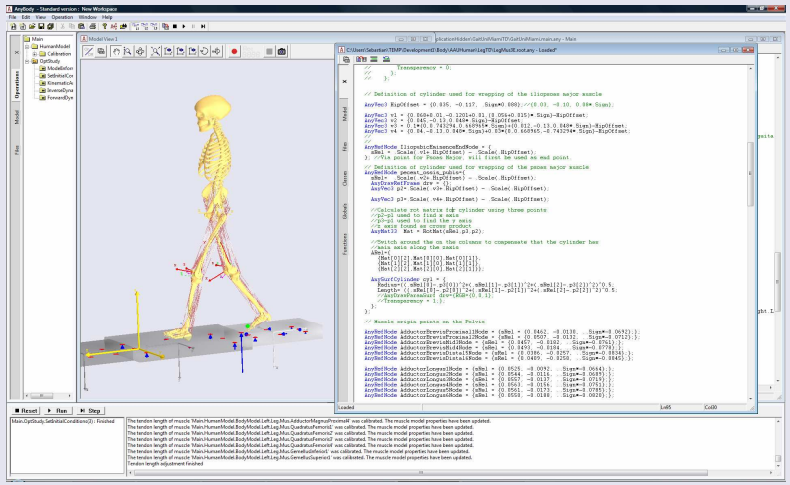
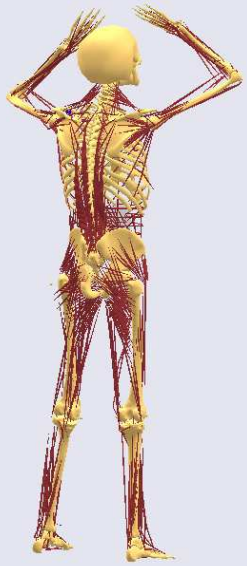
What is AnyBody?

- **The AnyBody Modeling System**
  - Musculoskeletal simulation software
  - AnyScript



- **The Model Repository**
  - Body models and applications
  - Available at www.anyscript.org



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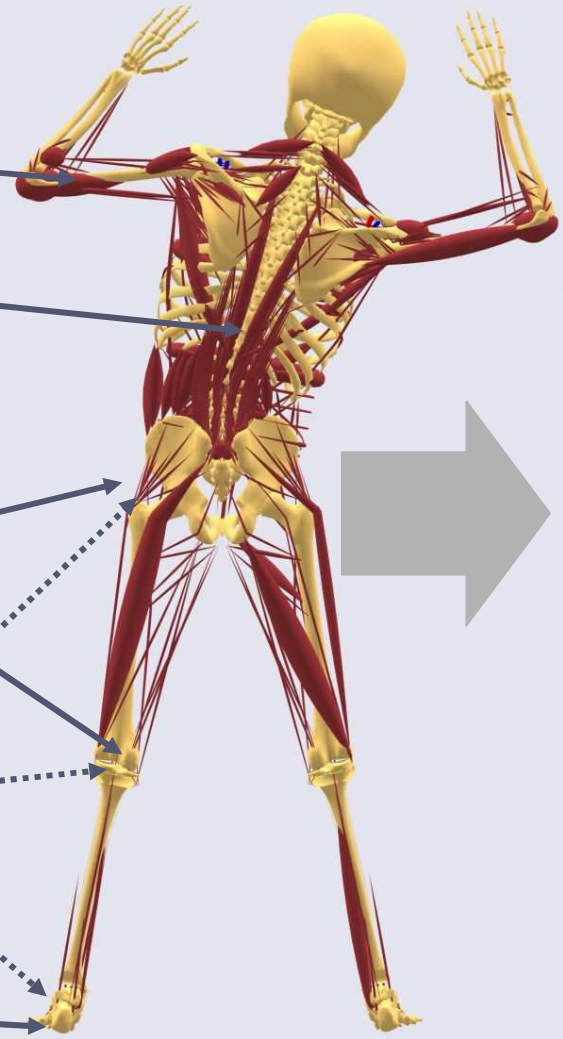
Inverse Dynamic Analysis

Input

- Bones
- Joints
- Muscles
- Ligaments
- Motion of joints or markers
- Loading on model boundary conditions



Output

- Muscles: forces, activity, power
- Joints: reaction forces, motion

Biomechanical model

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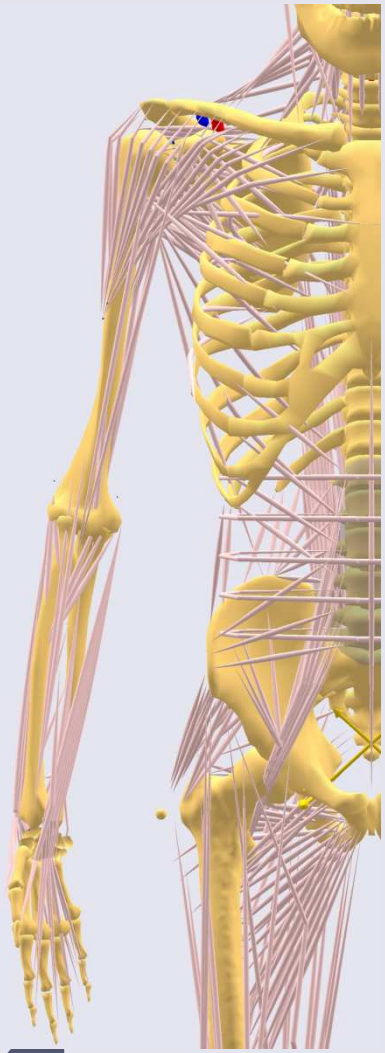
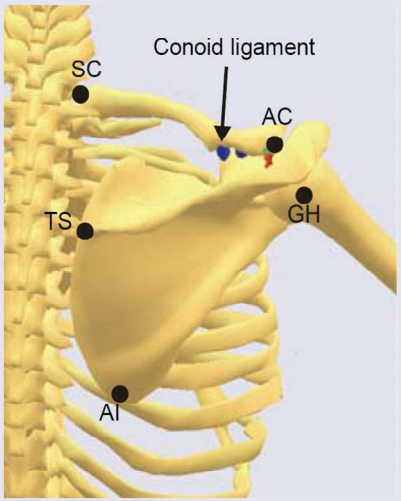
Shoulder

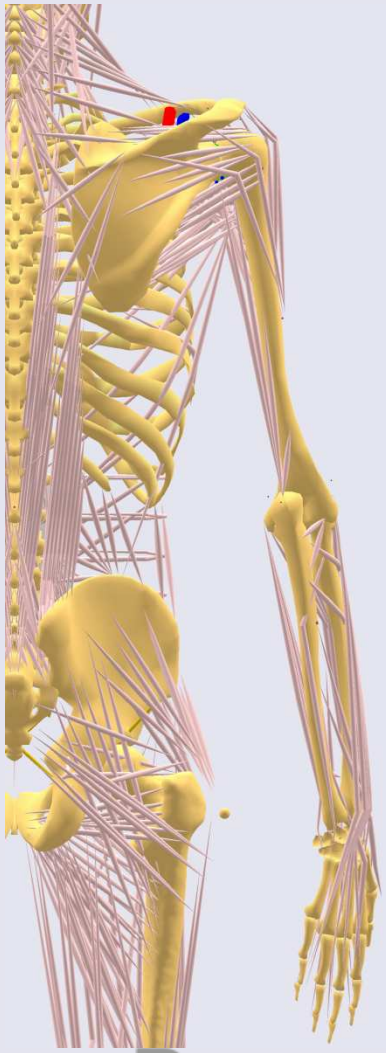


- 118 muscle fascicles on each side
- Wrapping of muscles by contact mechanics
- Contact criterion in the GH joint

Veeger et al. 1991: J. Biomech. 24, 615-29
Van der Helm 1994: J. Biomech. 27, 551-69
Veeger et al. 1997: J. Biomech. 30, 647-52



AC Spherical joint
GH Spherical joint
SC Spherical joint
TS Scapula thoracic gliding plane, ellipsoid
AI Scapula thoracic gliding plane, ellipsoid



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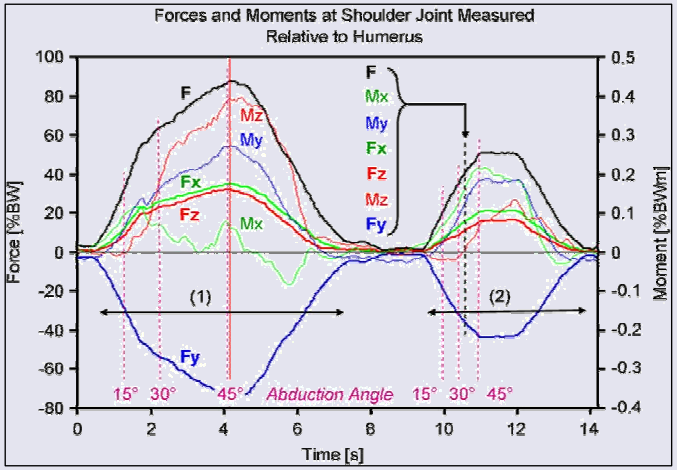
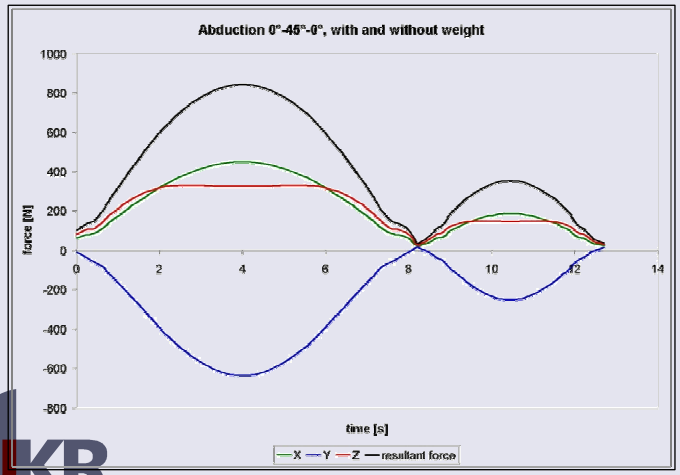
GH reaction validation

Bergmann*

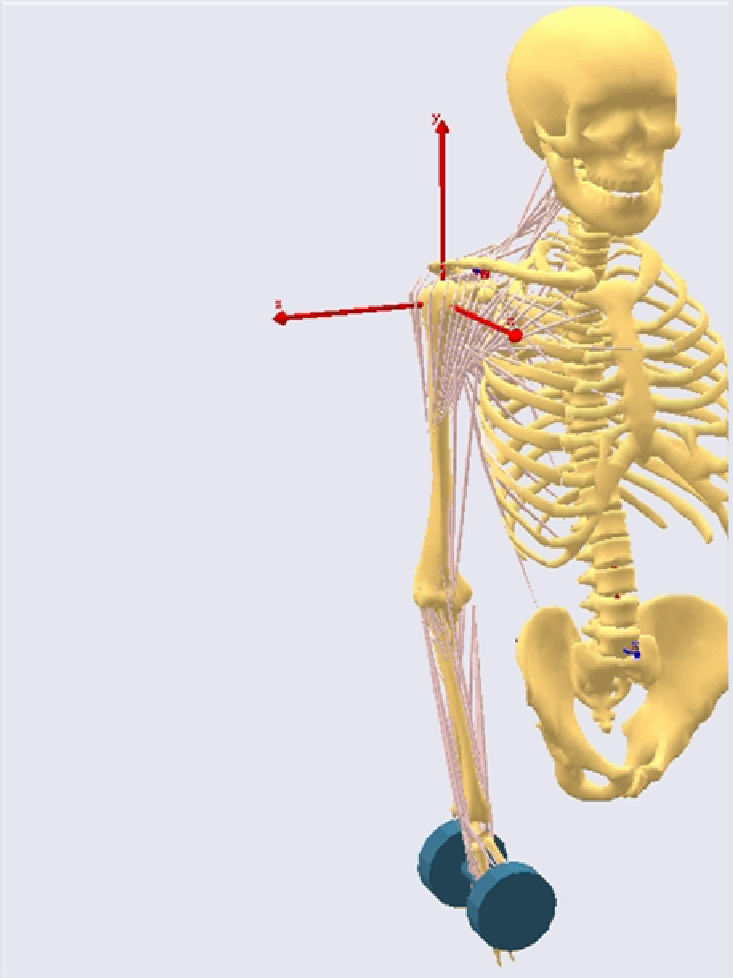


Measured peak GH force = 863 N

Model



Simulated peak GH force = 850 N



***In vivo glenohumeral contact forces—Measurements in the first patient 7 months postoperatively .**
Bergmann et al. 2007: J. Biomech. 40, 2139 - 49

Nolte et al. 2008: J. Biomech. 41, S492
Dubowsky et al. 2008: J.Biomech. 2008, 41, 2981-2988

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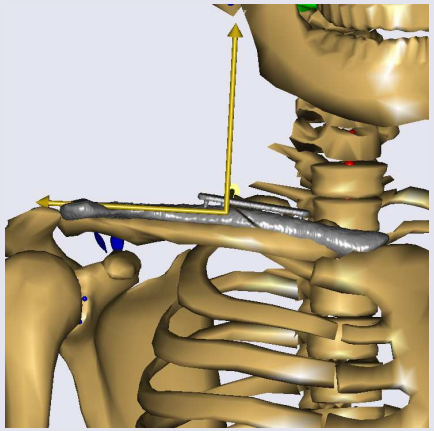
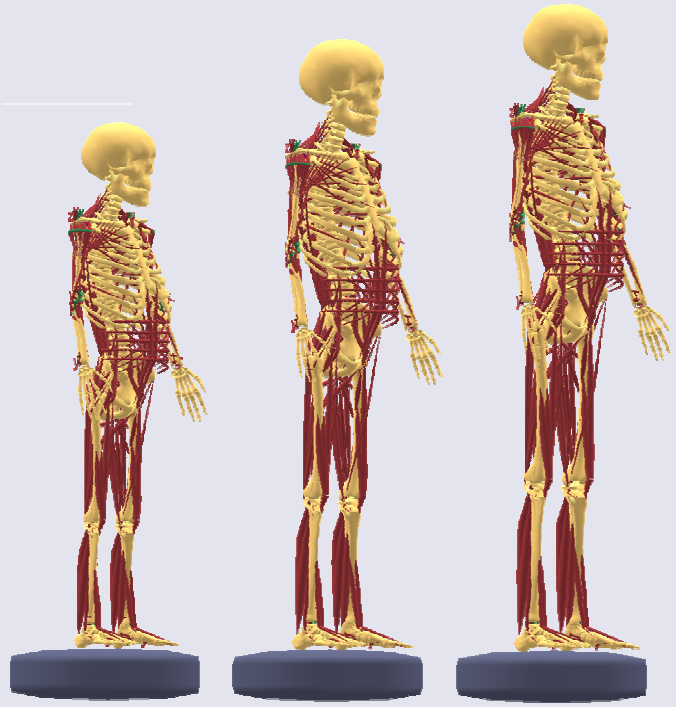
Customize model

- Import .stl from Simpleware
- Scale model to fit bone
- Analyse activities of daily living





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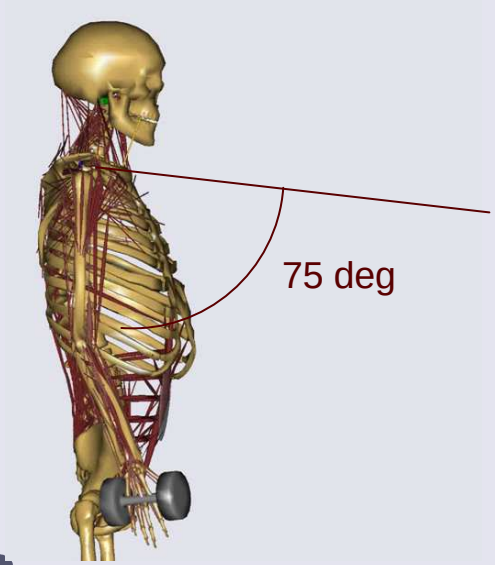
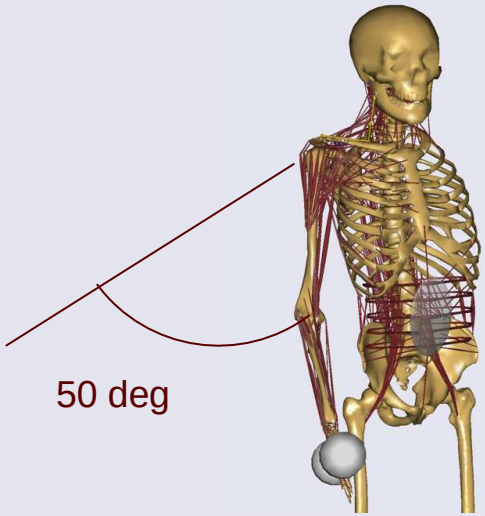
Analysed models

- Lifting 1 kg in Glenohumeral Flexion 0 – 75 degree
- Lifting 1 kg in Abduction 10 - 50 degree
- Forces in the fracture line
- All individual muscle and joint forces for FEA





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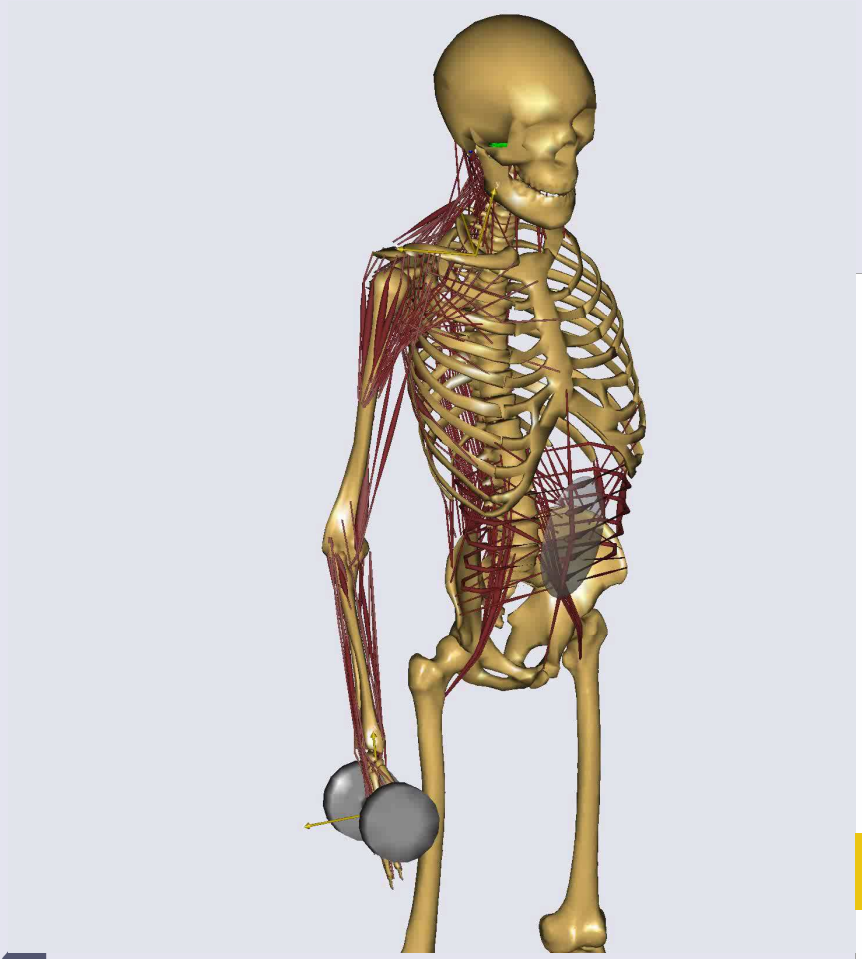
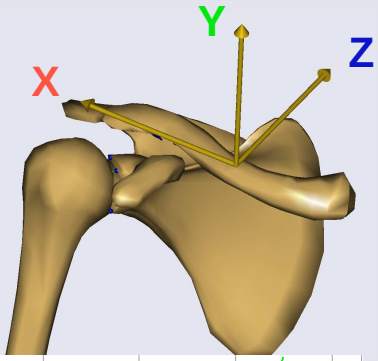
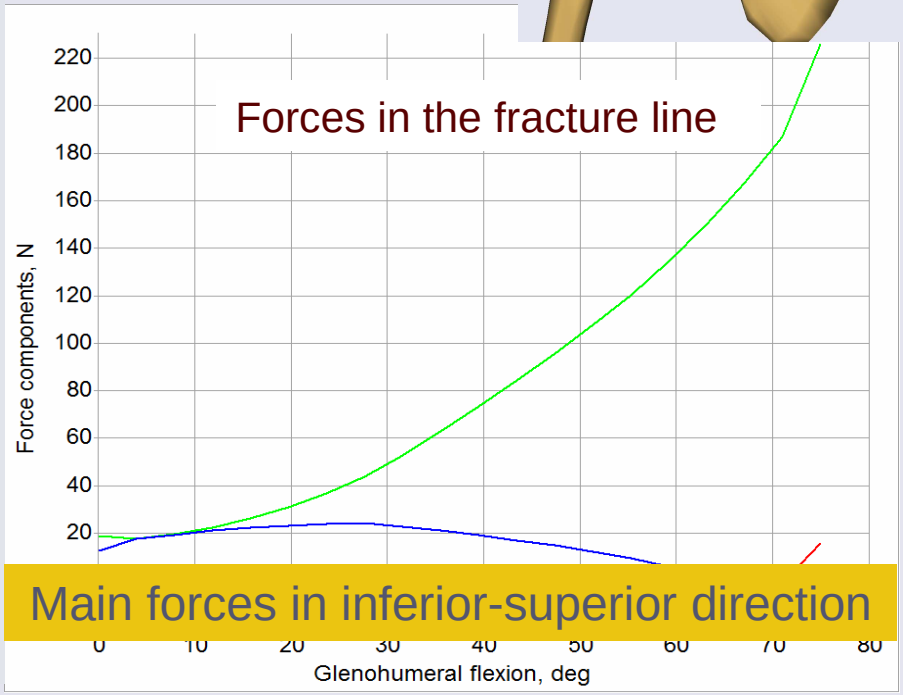
Forces in fracture - Flexion



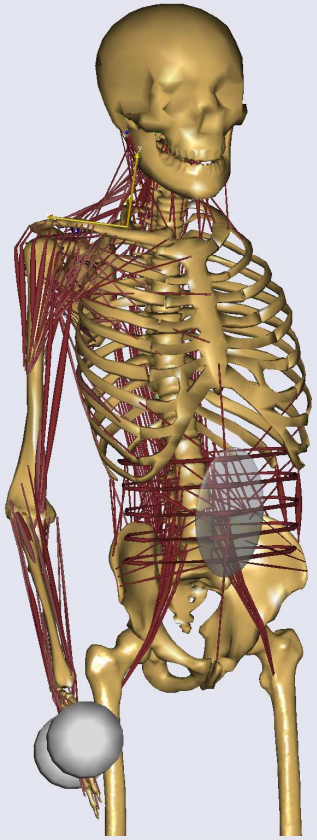
Lifting a weight of 1kg

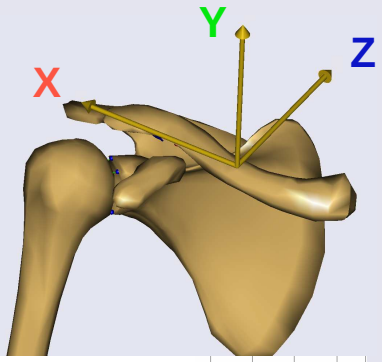


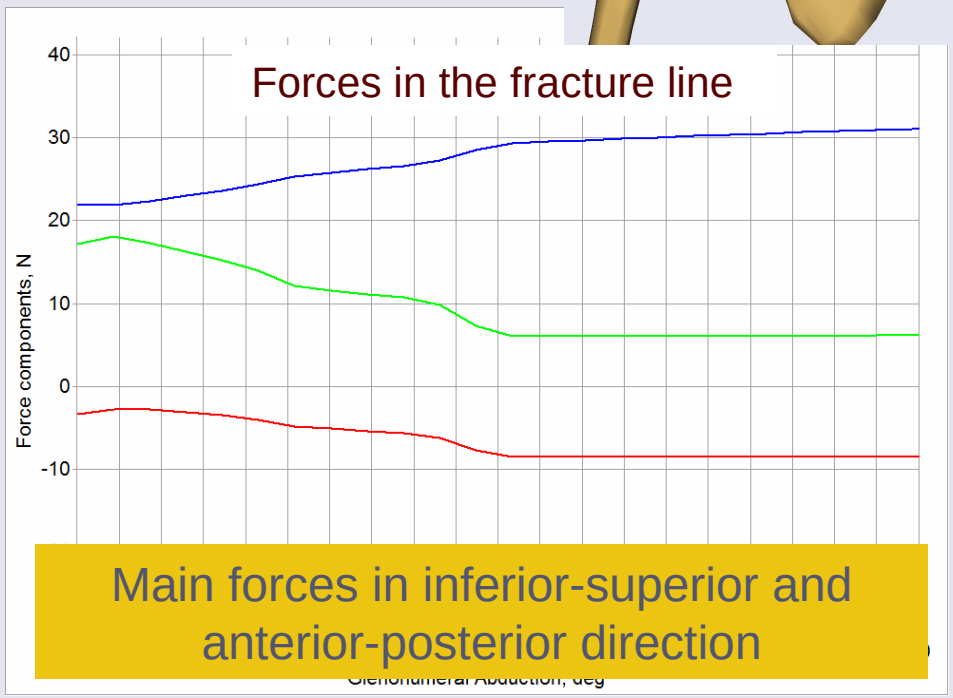


Forces in fracture - Abduction

Lifting a weight of 1kg



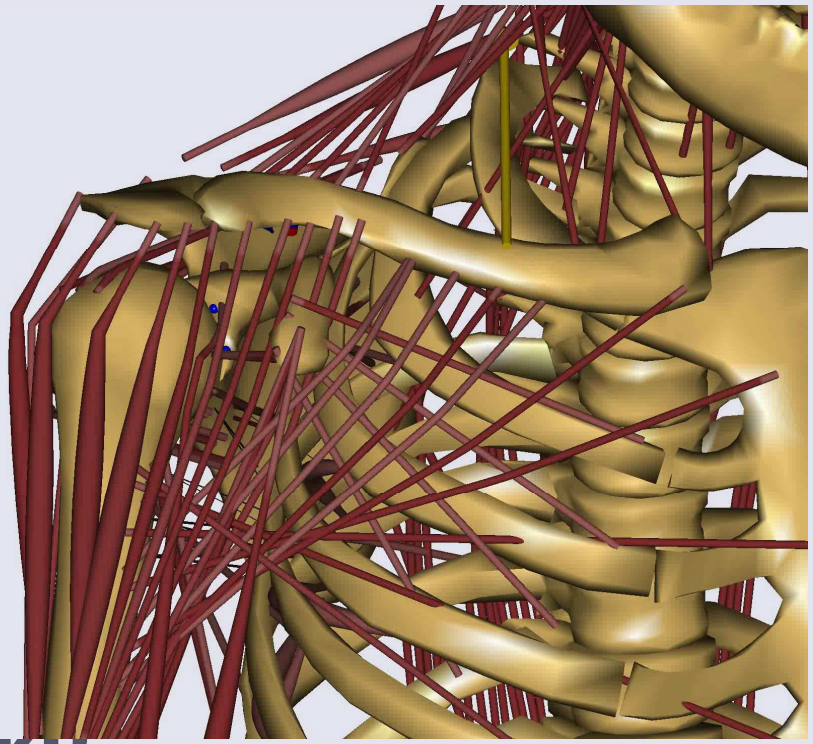


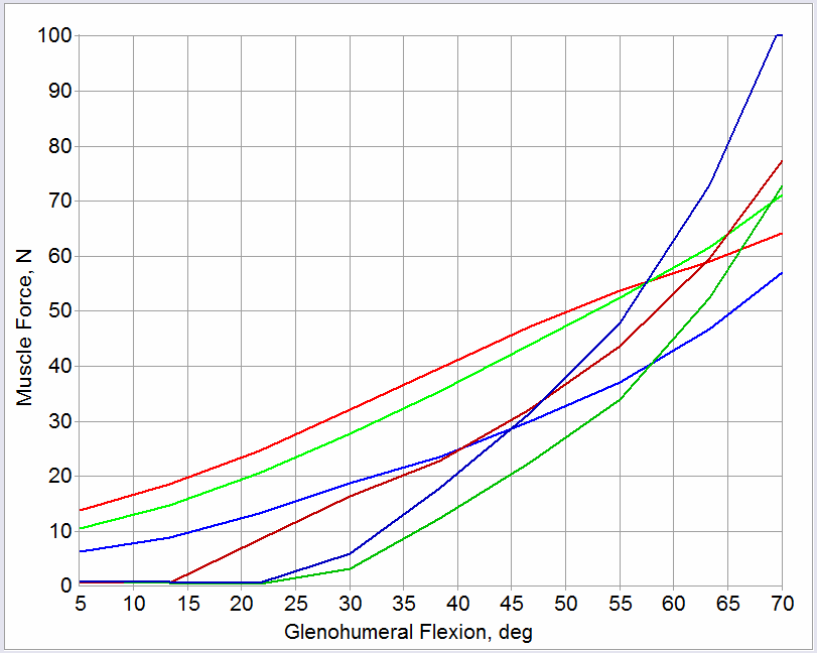


Main forces in inferior-superior and anterior-posterior direction

Muscle forces

Example: Deltoideus (pars clavicularis)

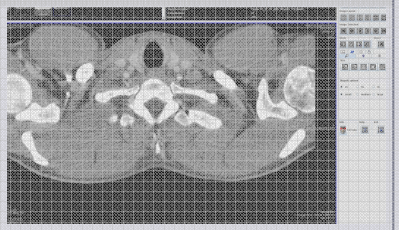




Branches of the muscle

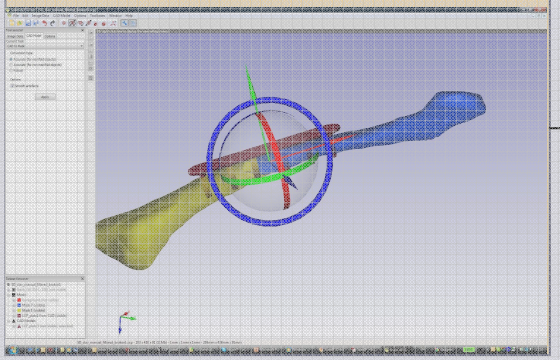
From CT to FEM

CT/MRI scan



"raw" Geometry

CAD/Mesh



CAD and FE model for patient specific scaling

simpleware

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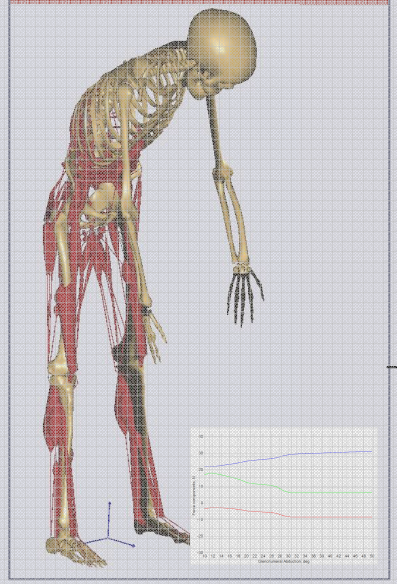
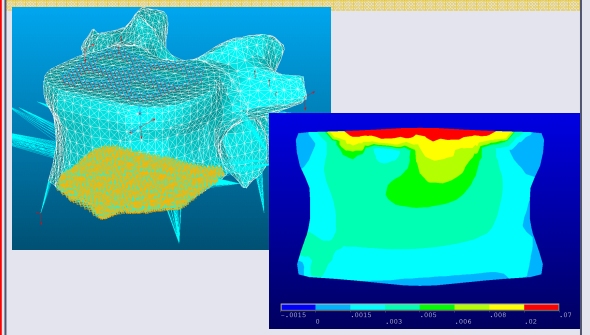
Musculoskeletal Simulation



Compute forces for activities of daily living

ANYBODY TECHNOLOGY

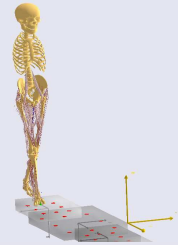
Finite Element Analysis



Compute tissue/material stress

ANSYS®

AnyBody and FEA - workflow



- Analyse forces and moments in AnyBody

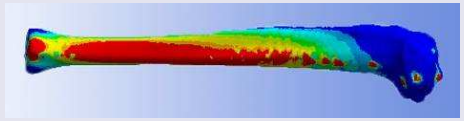
Create model with activity of daily life

Manual procedure

- Export function for all forces acting on a segment
- Export of scaled bone geometry (.stl)

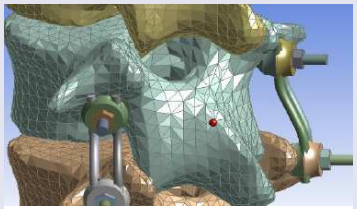
FE analysis

Free choice of FE package



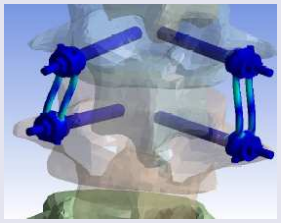
Automated

Any2Ans, *Ozen Engineering Inc.*
Interface between AnyBody and Ansys



Any2Ans
Link Dynamics & Create FE Model

ANSYS FE analysis



ANSYS
Structural Analysis

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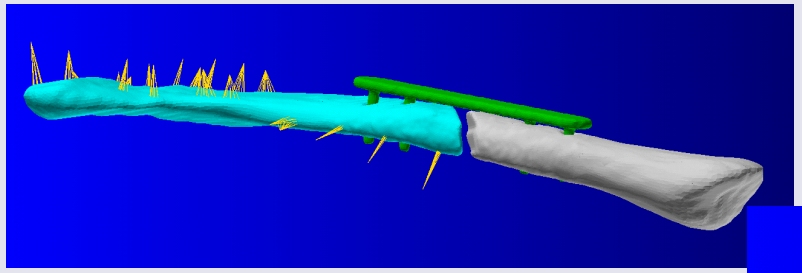
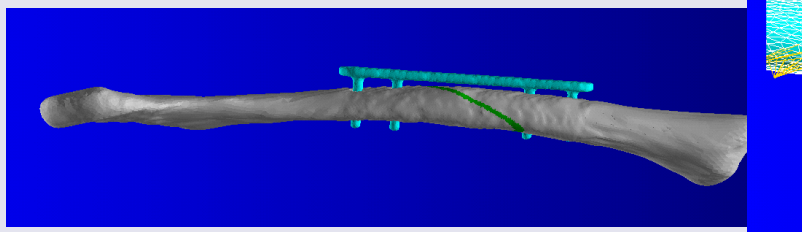
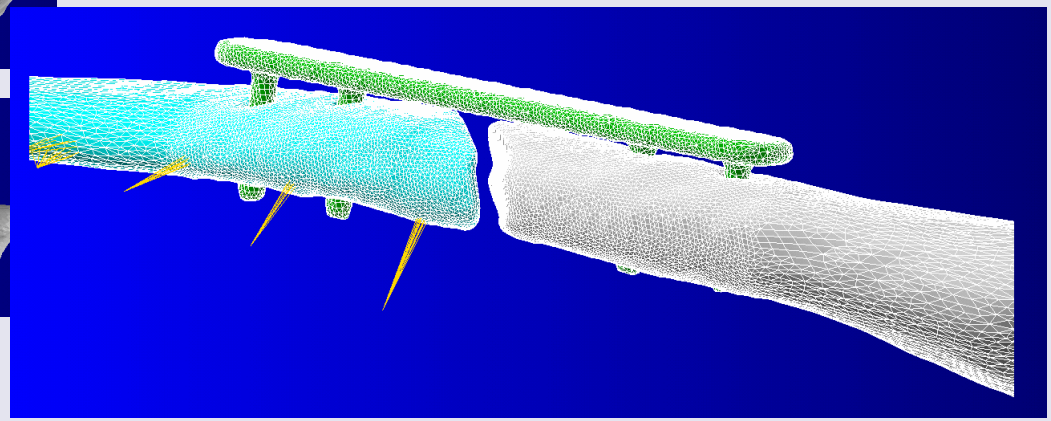
ANYBODY TECHNOLOGY

Finite Element Model

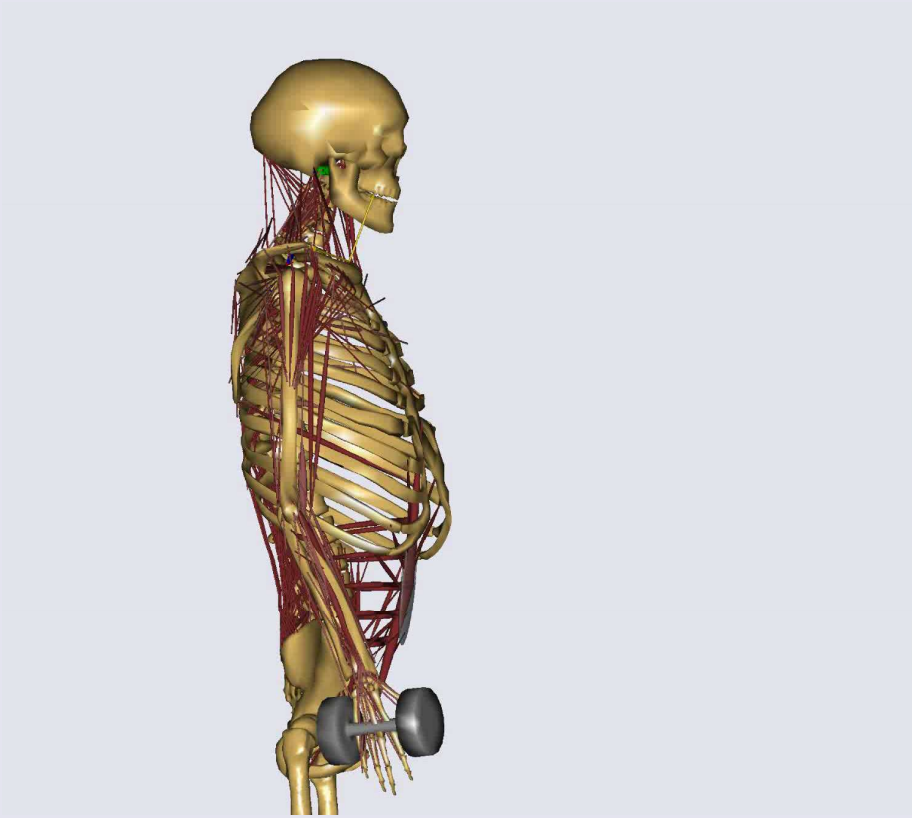
- Models generated in ScanFE
- Two different models:
    - Transverse fracture – no force transmission in fracture
    - Oblique fracture – limited force transmission
- All muscle and joint forces applied

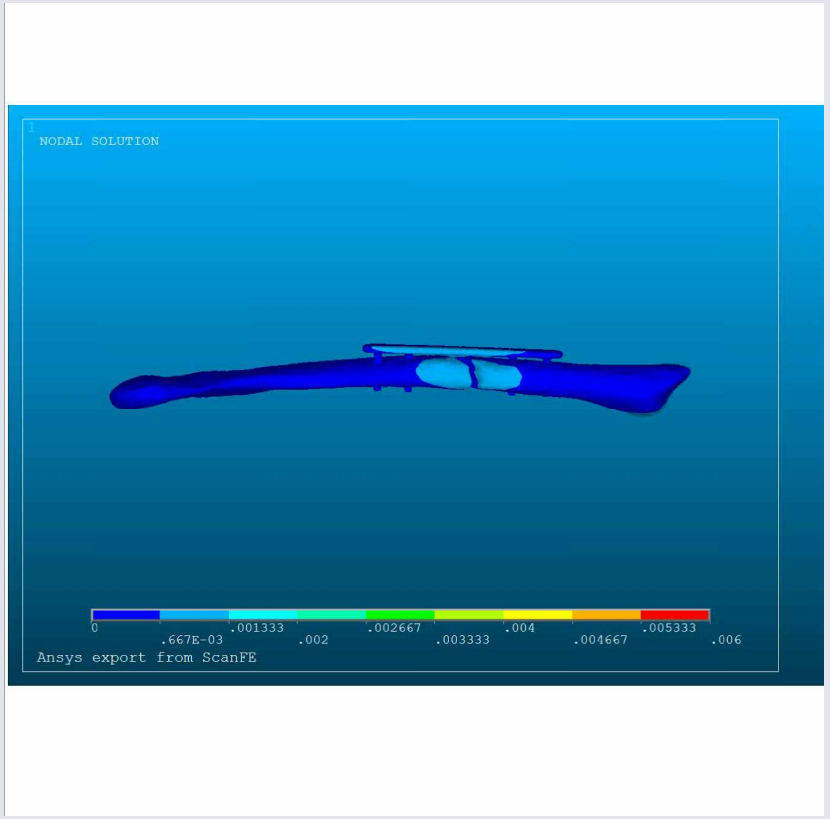






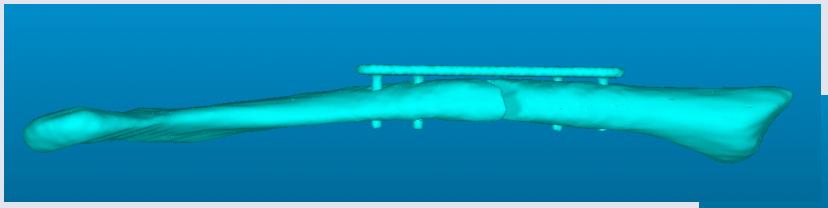
Deformation mode during flexion



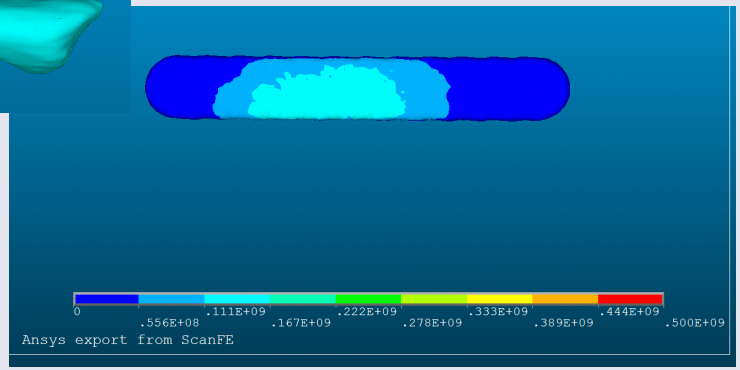


Clavicle deformation

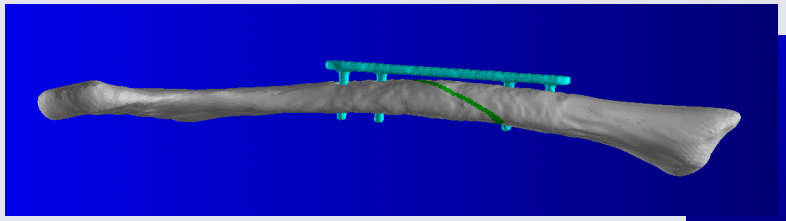
Stress in implant



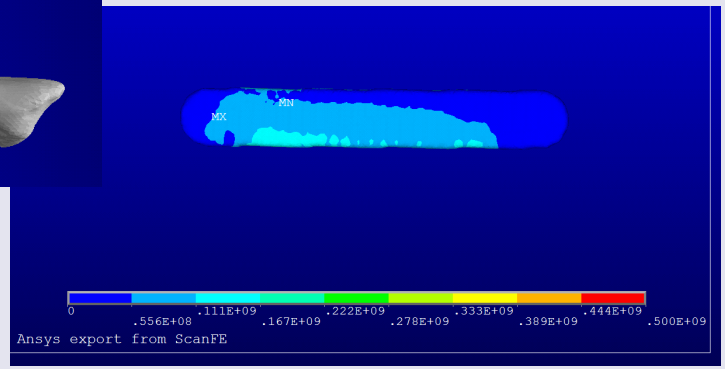
Transverse fracture, no force transfer in the fracture



Von-Mises stress



Oblique fracture limited force transmission



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AnyBody Technology

Discussion

- Main loading directions in the fracture line are i-s and a-p
- During flexion mainly downwards bending of implant
- Scew fractures are more likely to participate in load transfer
- Capability to transfer forces in the fracture line reduces loading on implant
- Even very limited load transfer will help (investigation of influence)
- An ideal implant position would be a combination of i-s and a-p placement