ABAQUS Project
Analysis of Human Body
Stress Field in Femur

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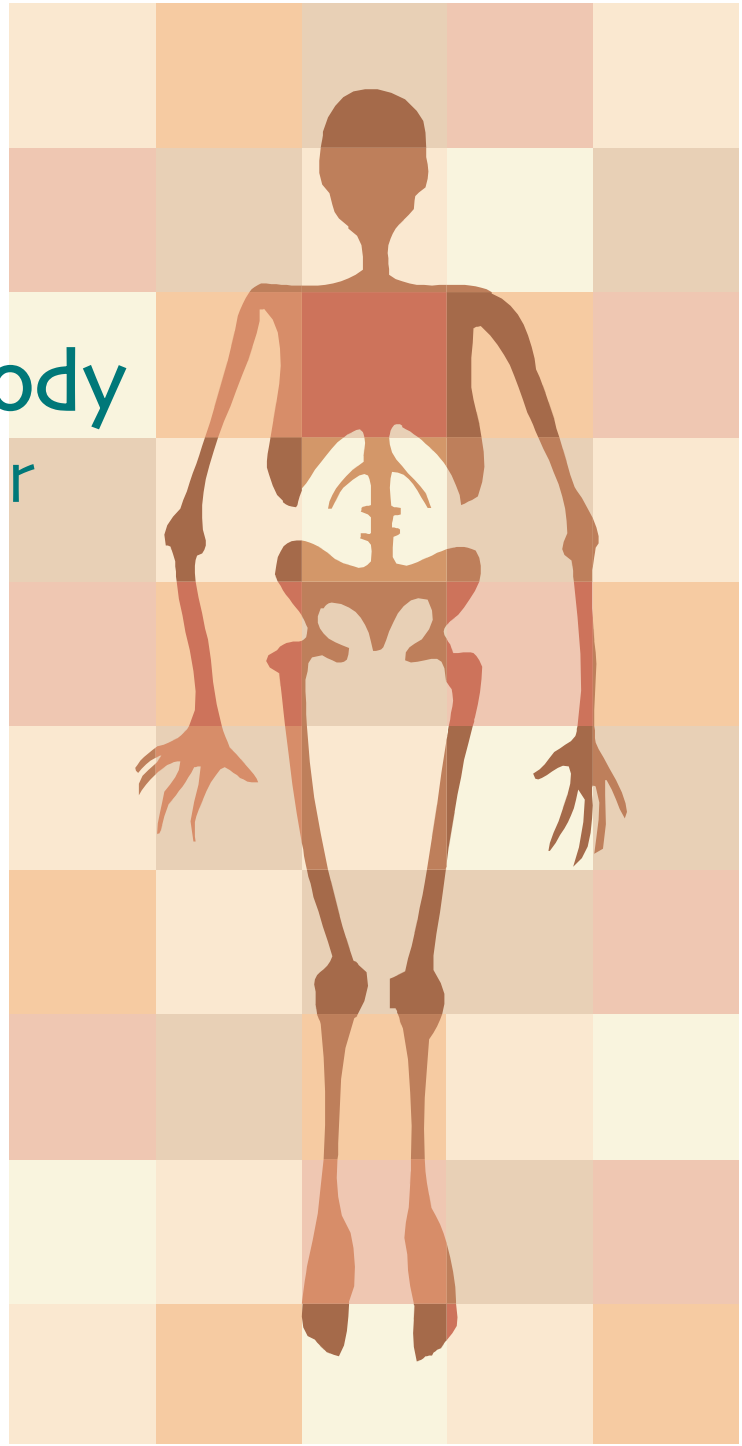
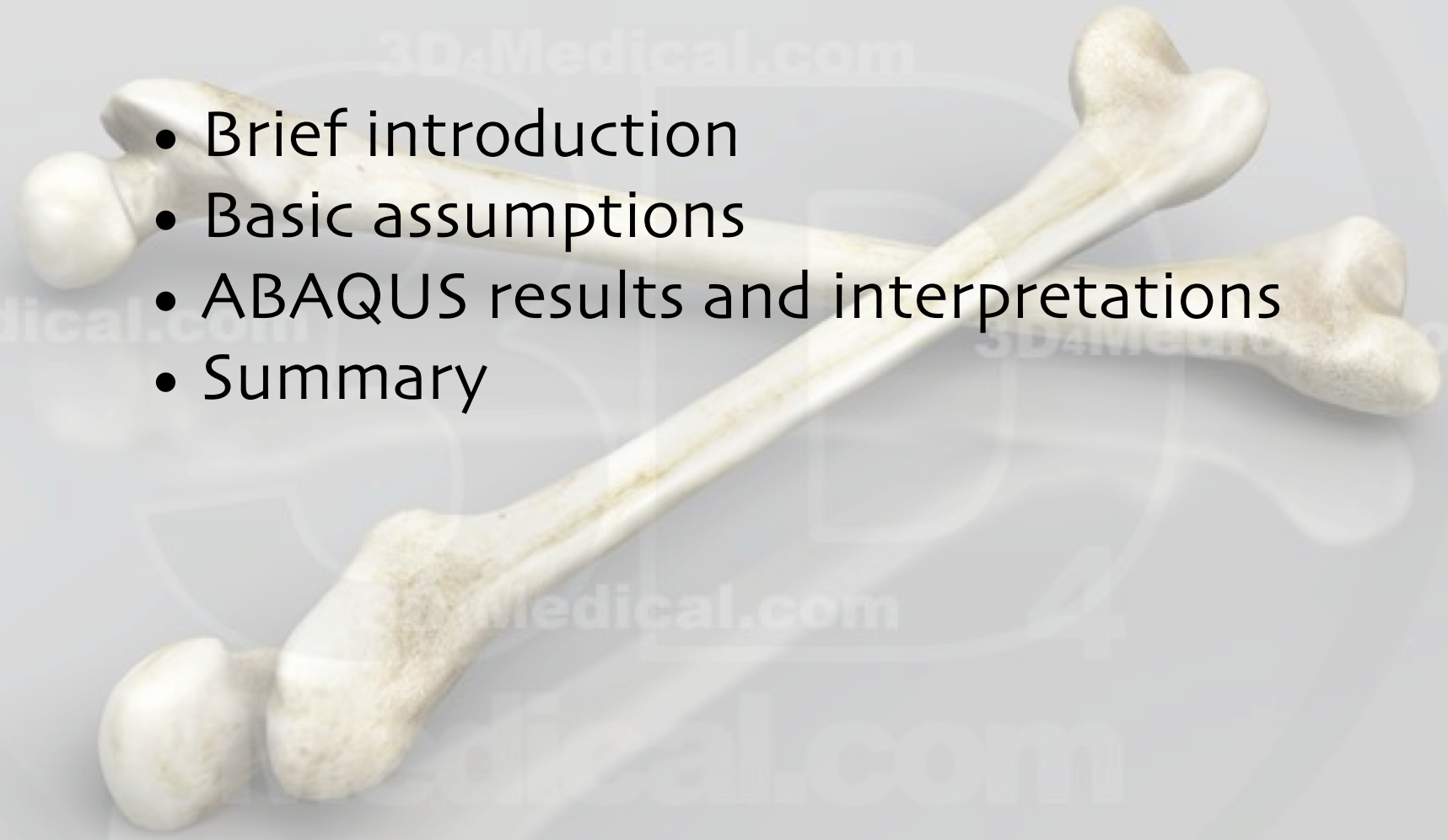
12/12/06



Outline

- Brief introduction
- Basic assumptions
- ABAQUS results and interpretations
- Summary



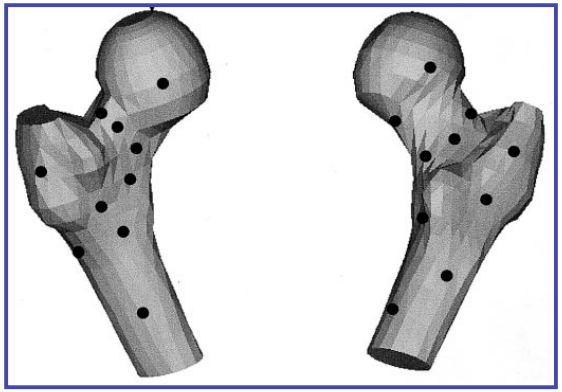
http://www.3d4medical.com/view_rm_horizontal_image~aid~000009910.htm

Introduction

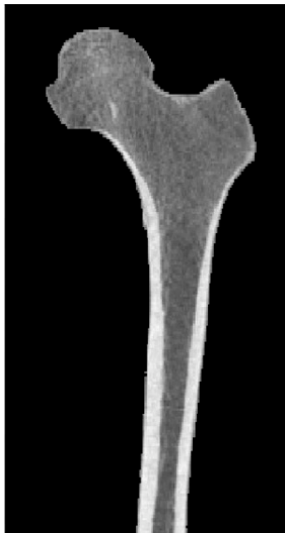
- Build a homogeneous & an inhomogeneous model
  - *Bone density*
- Investigations of stress within femur bones
  - Relations of *loading and cracking* on the bone
  - Comparisons between the 2D and 3D model

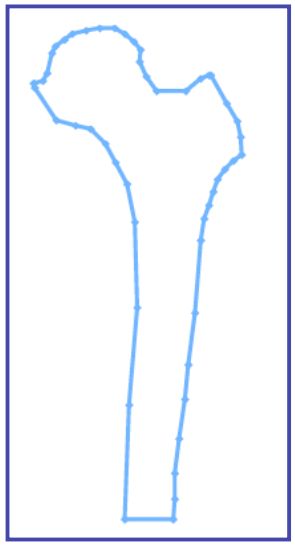
Assumptions

- Human body is complicated
  Commercial package - 3D model
  Use a simple 2D model

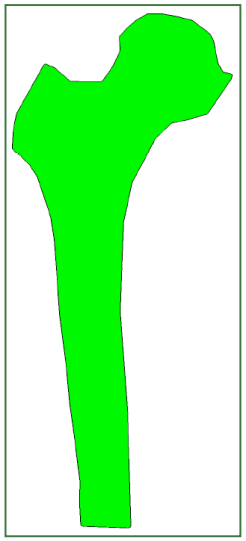


- Femur bone shape was sketched from a CT image
  Roughly the same as femur bone





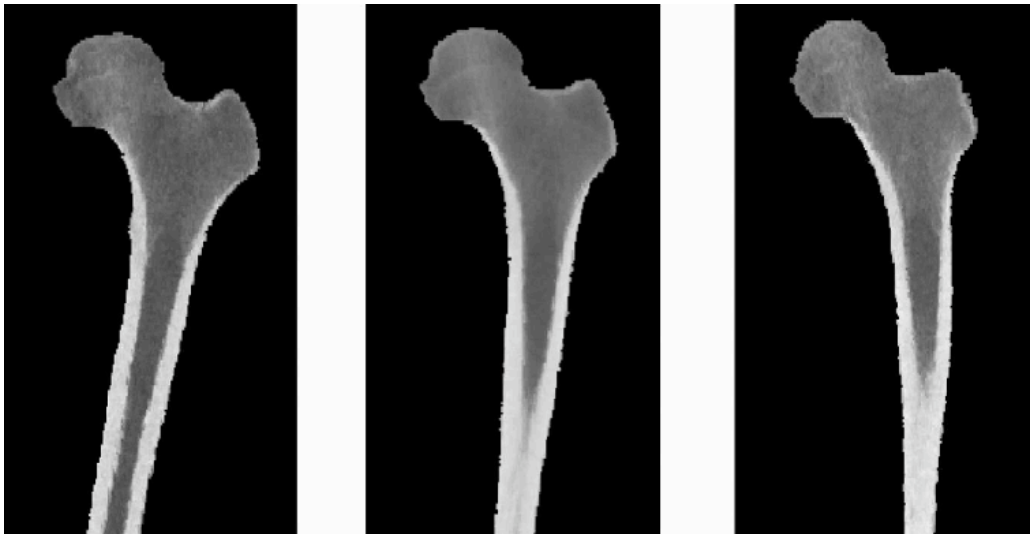
by photoshop

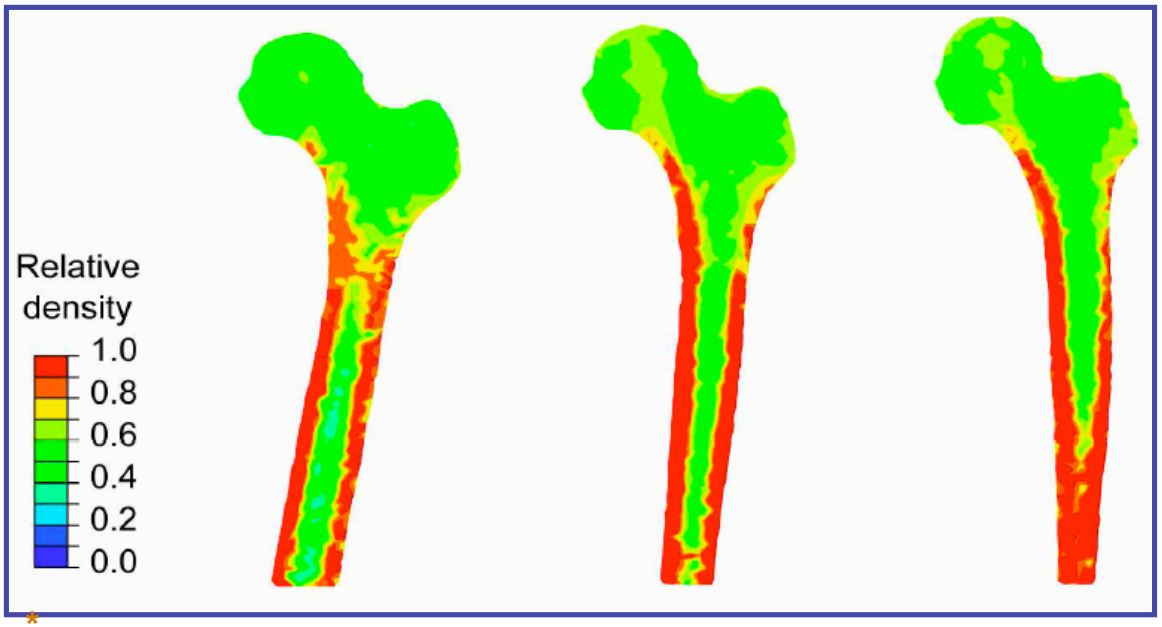


by ABAQUS

Assumptions

- Bone density is estimated





ABAQUS Results - Femur

2D Homogeneous Model

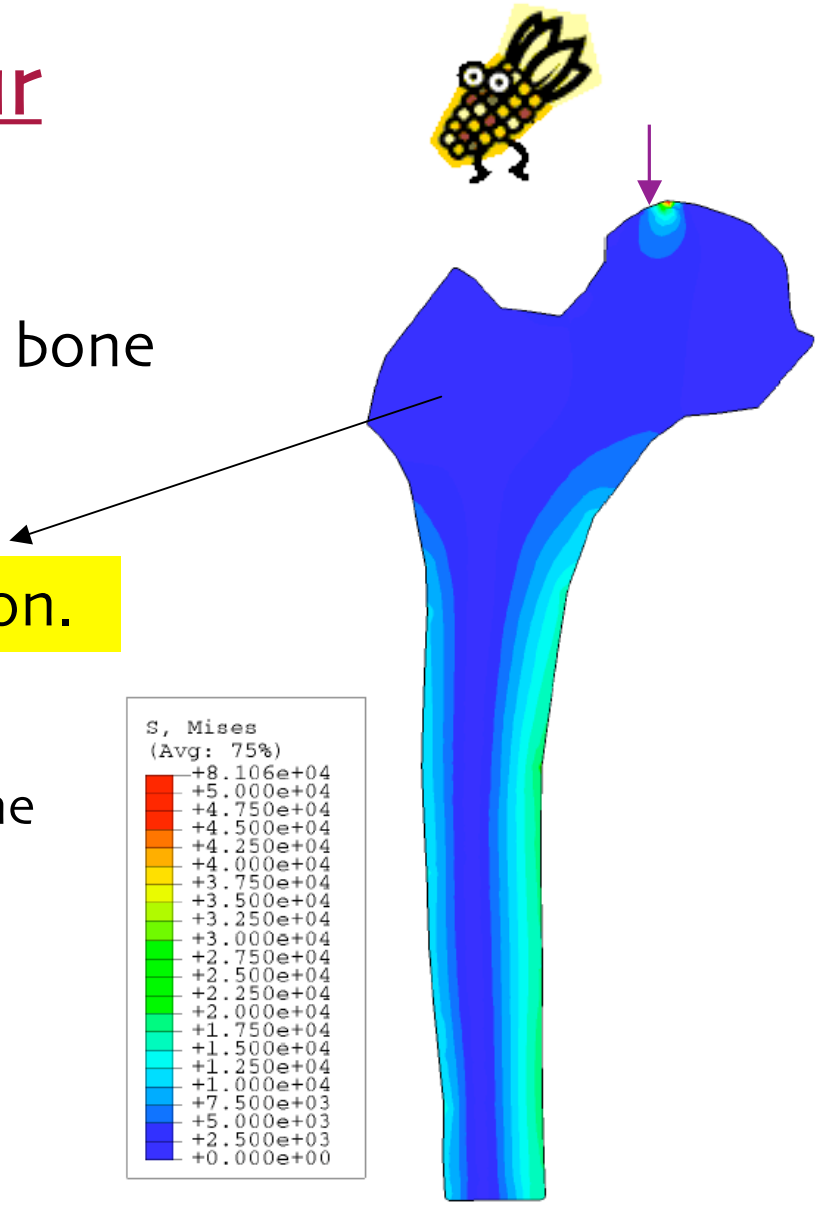
Homogeneous femur model

density is the same inside the bone

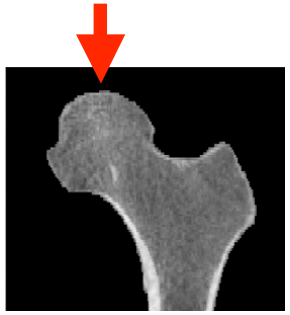
$E_{bone} = 2875\rho^3$; $\rho=1$

$\nu = 0.3$ [1]

Stress is relatively low in this region.



- Apply a *concentrated force* on humeral head while the diaphyseal part of the bone remains fixed.



[1] L. B. Querol *et al.*, J of Biomechanics 36 897 2003

ABAQUS Results - Femur

2D Inhomogeneous Model

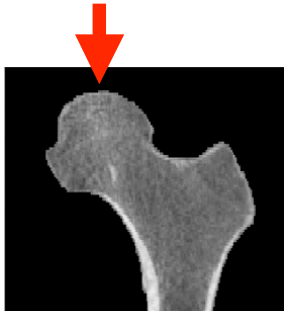
- Inhomogeneous model, E depends on bone density [1]

$E_{bone} = 60+900\rho^2$, $\rho<0.46$ (g/cm³) [MPa]

Or $E_{bone} = 2875\rho^3$, otherwise [MPa]

$\nu = 0.3$

- Apply a *concentrated force* on humeral head while the diaphyseal part of the bone remains fixed.



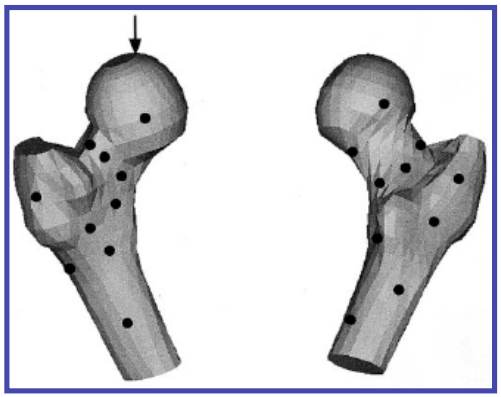
- Bone relative density is roughly divided into 3 segments.

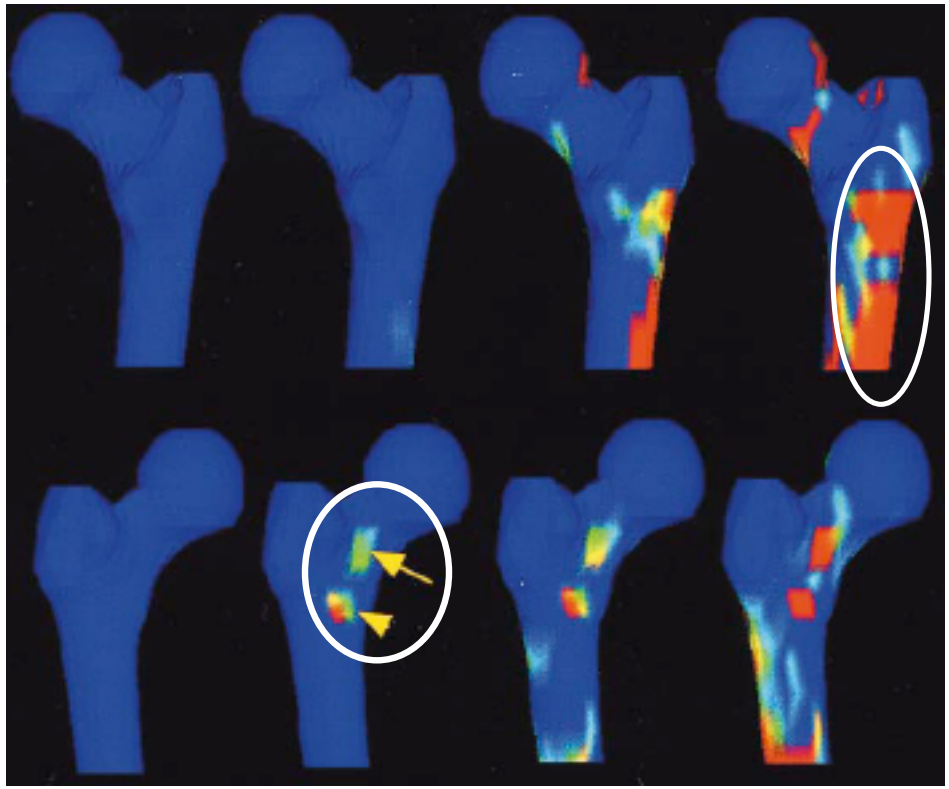
$\rho=1$	E=2875 MPa
$\rho=0.8$	E=1472 MPa
$\rho=0.5$	E =359.4 MPa

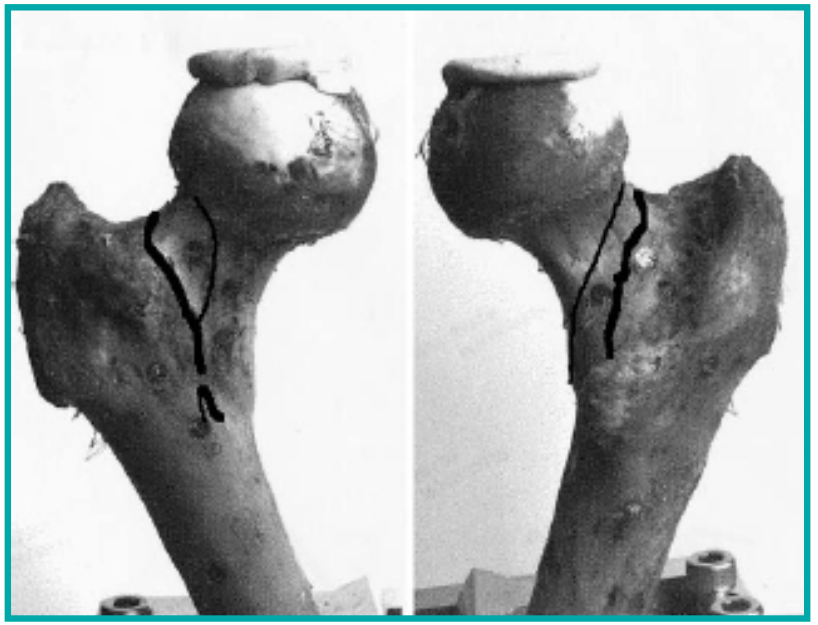
[1] L. Belenguer *et al.,* Statistical Finite Element Model for Bone Shape and Biomechanical Properties, 405 2006

ABAQUS Results - Femur

Loading and Crack 3D Model-1



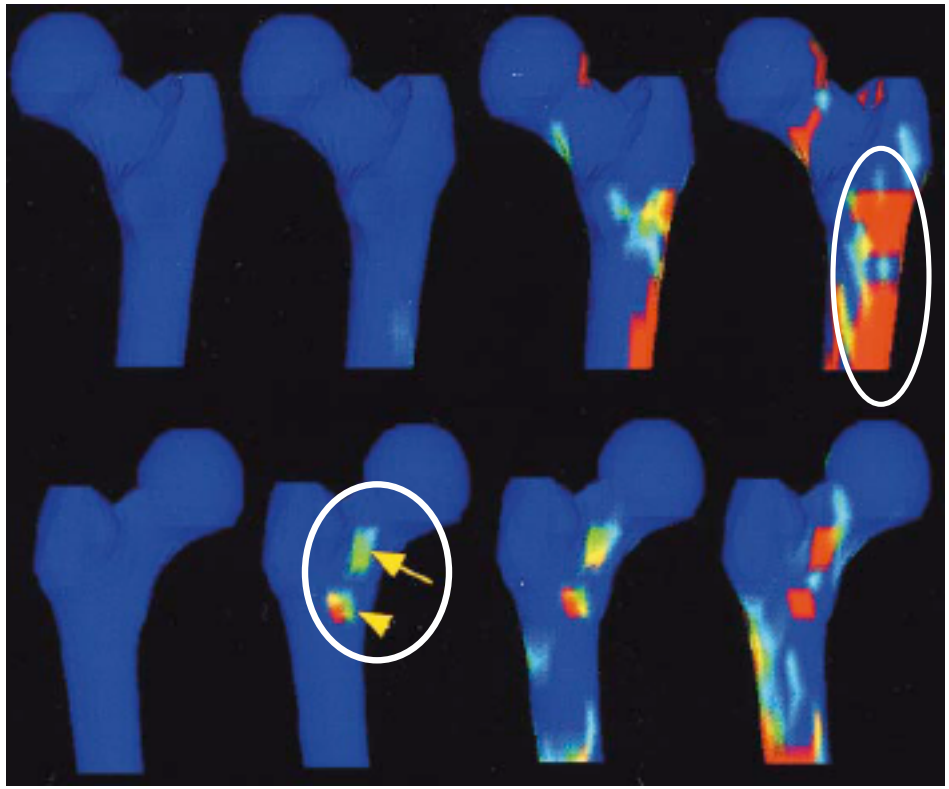


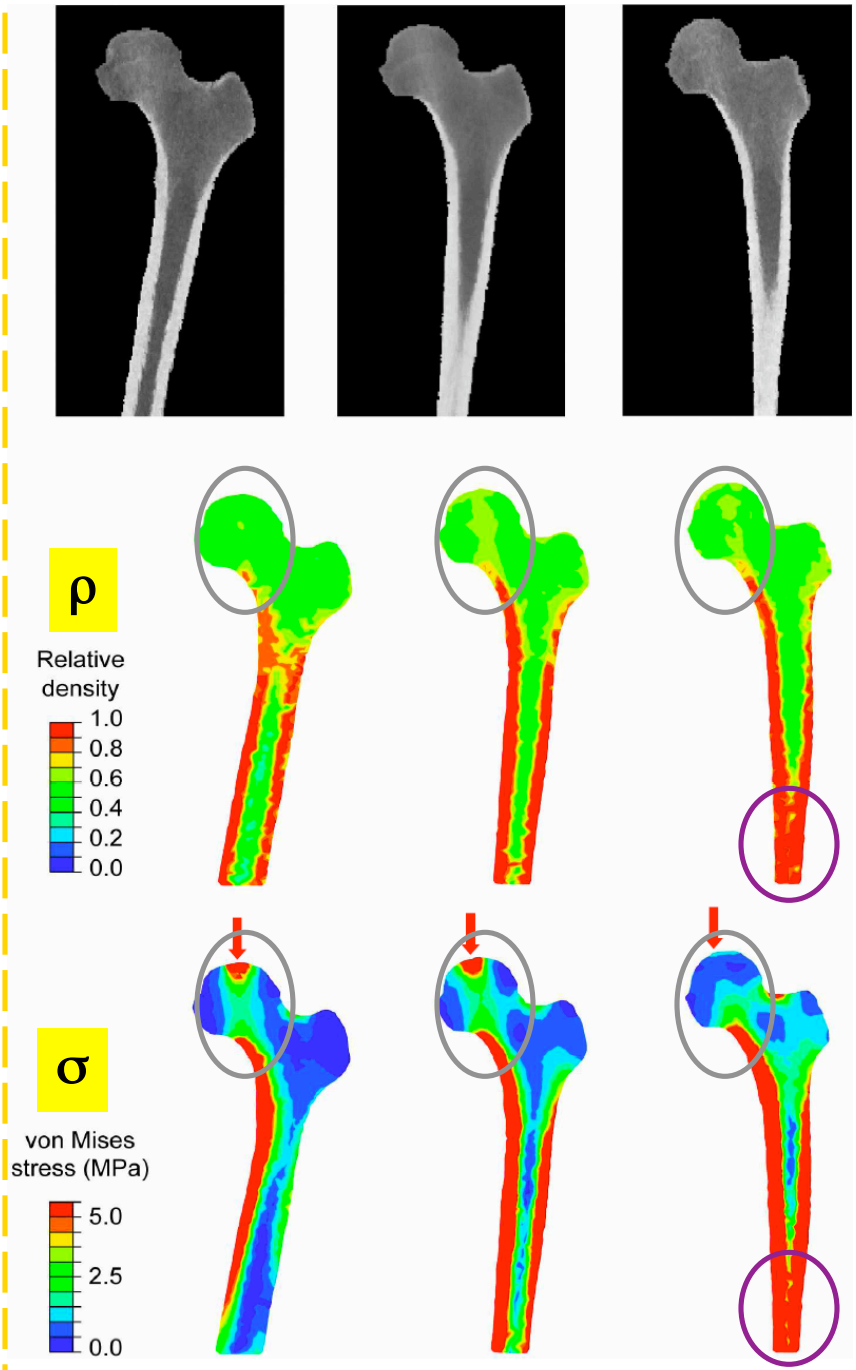


ABAQUS Results - Femur

Loading and Crack 3D Model-2

① ρ↑, E↑
② ρ↑, σ↑
③ ρ<0.4; σ is very small
④ Results are not quite the same

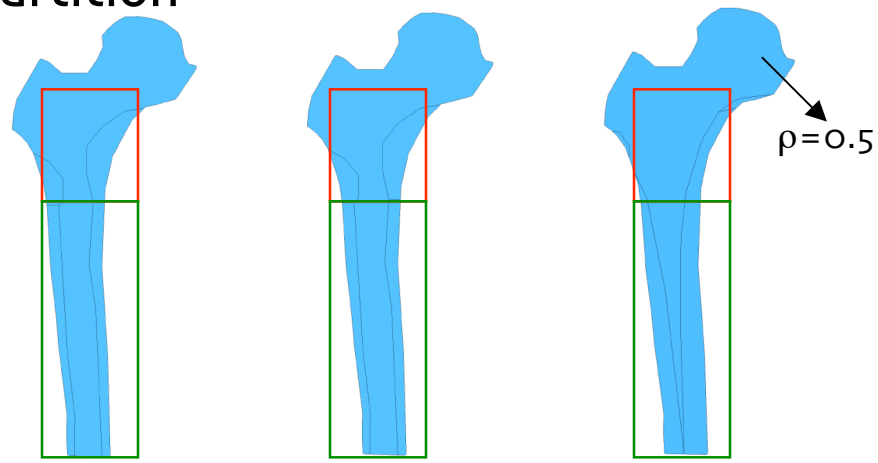




ABAQUS Results - Femur

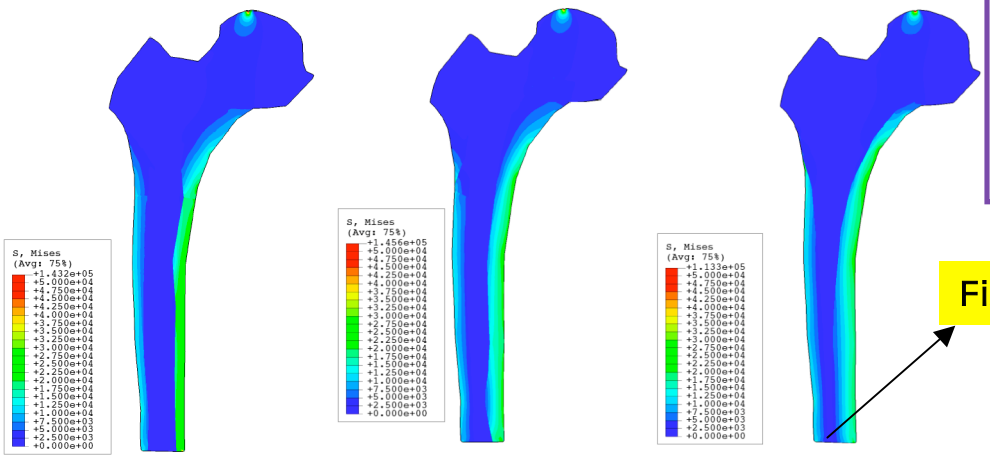
Cracking and Loading 2D Model

Partition



ABAQUS

ρ=0.8 ρ=1.0



①ρ≈0.5, σ is very small

② As ρ=1 area increases, high σ region expands.

③σ is highly dependent on ρ

④ Femur is estimated to fracture at the fixed end.

⑤3D model would give a better simulation prediction.

Summary

- Build a simple 2D model
- Comparison between a 2D model and a 3D one
- Predict cracking

Ackowledgement

Hongtao Wang