ISTB – Institute for Surgical Technology and Biomechanics
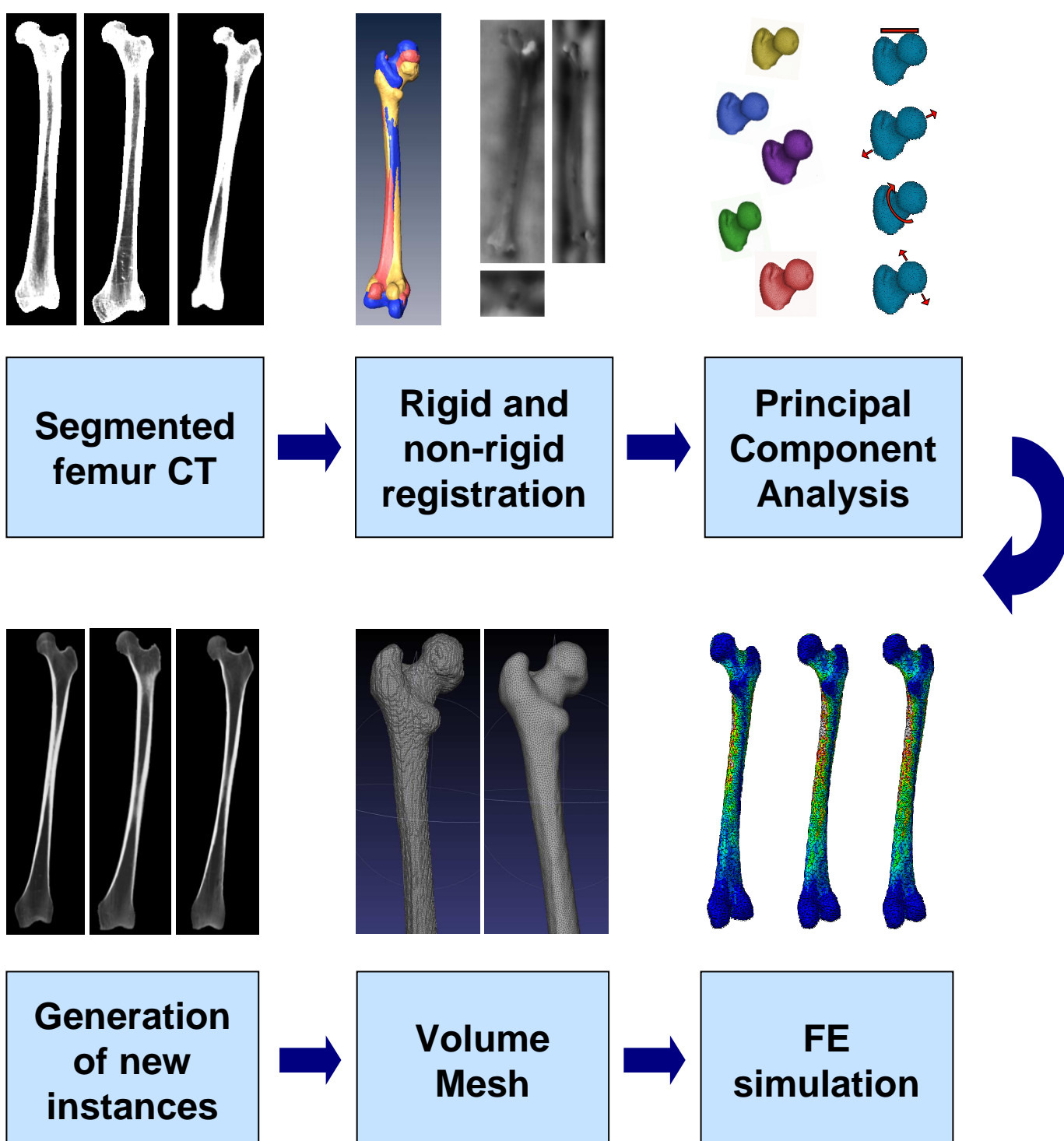
Project Id: 5 – The Virtual Skeleton Database
Workpackage: 3 – Statistical Finite Element Modeling for the VSD
Name: Serena Bonaretti

CO-ME
COMPUTER AIDED AND IMAGE GUIDED
MEDICAL INTERVENTIONS

Project Description

Finite element models developed from CT data are commonly used to evaluate the mechanical performance of bones without taking into account variations of bone geometry and material properties. Using Statistical Shape Modeling bone anatomical variations can be included in mechanical simulations.

Segmented femur CT → **Rigid and non-rigid registration** → **Principal Component Analysis**

Generation of new instances → **Volume Mesh** → **FE simulation**

Results

Assessment of Bone Stiffness

- Caucasian femur CT images
  57 for males; 80 for females

- Statistical Shape Model
  4 modes - 40 instances for each gender

- 10-node tetrahedral mesh
- Bone: E = 6.85ρ1.49 GPa; v = 0.3
- L = 800 N; distal part constrained

- No statistical difference between male and female
  Limitation: same length and density for all bones
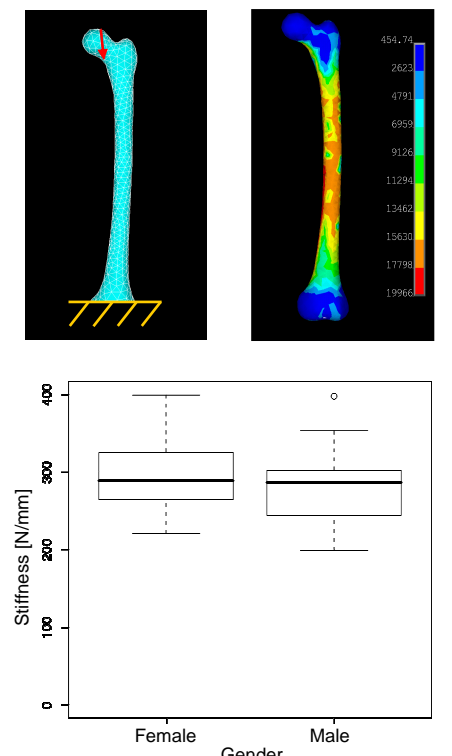
Implant Design

- 43 Caucasian tibia CT images
- 47 Asian tibia CT images

- Statistical Shape Model
  2 modes - 13 instances for each ethnic group

- 10-node tetrahedral mesh
- Bone: E = 15.52ρ1.93 GPa, v = 0.3
- Implant: E = 110 GPa, v = 0.3
- L = 1600 N; distal part constrained

- Bone-implant average distance higher for Asian
- Stress in the plate statistically higher for Asian (p<0.05)
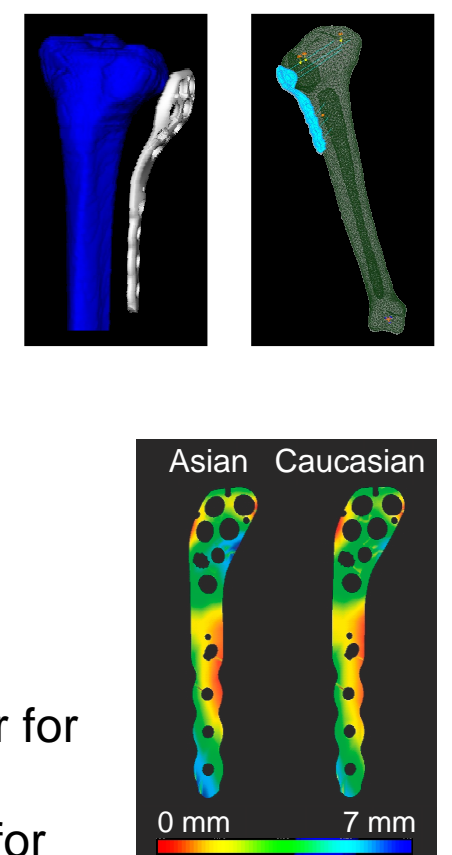
Summary

Motivation: To exploit the mechanical information available in medical images and to establish tools to integrate biomechanical information into the Virtual Skeleton Database

Algorithms: Demons Registration, Principal Component Analysis, Finite Element Analysis

Materials: ITK, VTK, MRFSurface, NetGen, Abaqus

Datasets: CT images

Output: CT images of virtual bones and their mechanical evaluation

Needs: More mechanical simulation on shape and shape-intensity new instances

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