ANYBODY™
POWERFUL BODY SIMULATIONS

Welcome to a presentation hosted by AnyBody Technology

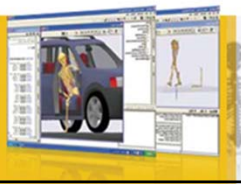
...Public webcasts on AnyBody-related topics are regularly hosted by AnyBody Technology. The web-casts typically address research projects, related technologies and workflows, or instructions on how to use and benefit from the AnyBody Modeling System™.

This presentation will begin shortly...

We hope you will have a good experience. Please take time to respond to the poll after the presentation - it only takes a few seconds. Thank you!

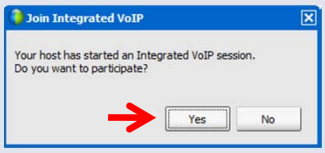
The AnyBody Modeling System™

- Full-body musculoskeletal simulations for activities of daily living
- Muscle and joint force computation + many other features
- Unprecedented model detail and validity

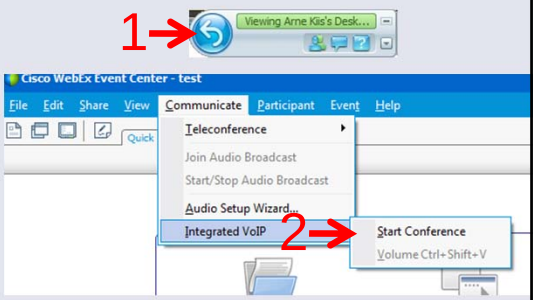


Audio set-up:

During logon



During session

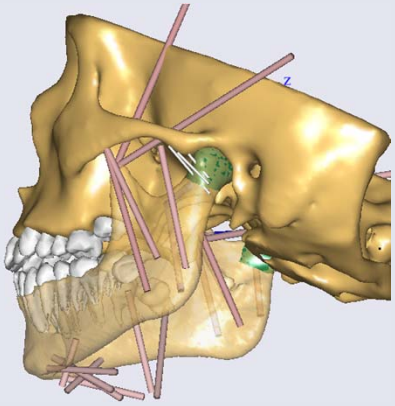


Screen set-up
Select “Sharing” menu (upper right corner) ->View ->Autofit

The web cast will start in a few minutes….

ANYBODY TECHNOLOGY

Modeling and analysis of non-conforming joints in AnyBody - Part II



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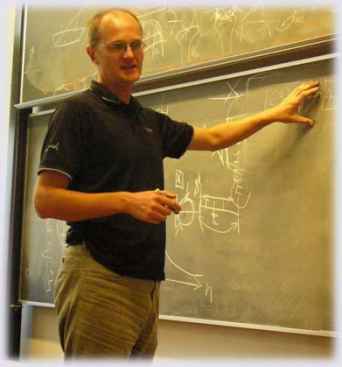
People



John Rasmussen
(Presenter)

Arne Kiis
(Host)

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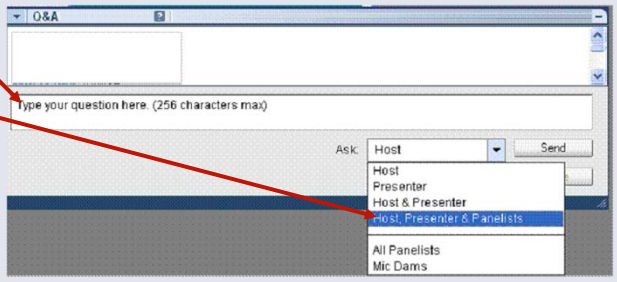
Q&A Panel

- Søren Tørholm
- Launch the Q&A panel here.
- Type your questions in the Q&A panel.
- 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.



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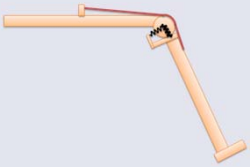
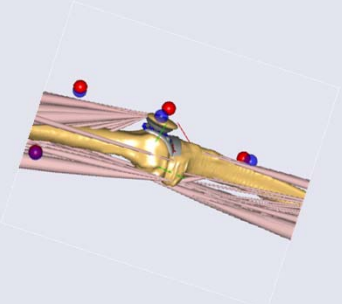
Progression

Part I of this webcast on September 8th about the basic technology.

Part II today about anatomically realistic models.





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General application field

- Non-conforming joints.
- Small motions depending on (internal) forces.
- Nonlinear elastic passive structures stabilizing the model.
- Prediction of elastic deformations loaded by muscle forces.
- Models that are both active and passive.

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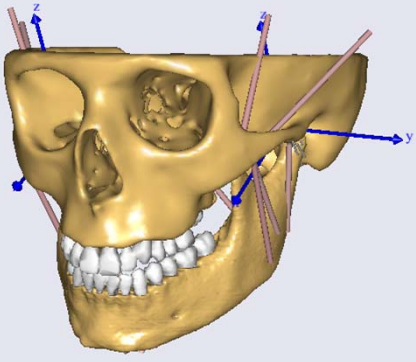
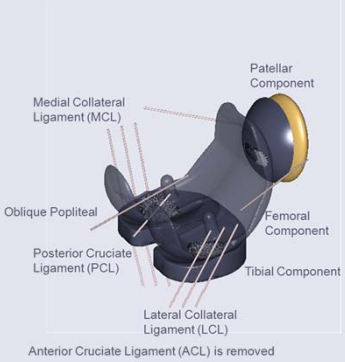
Two examples

The mandible



Total knee arthroplasty (TKA)



Anterior Cruciate Ligament (ACL) is removed

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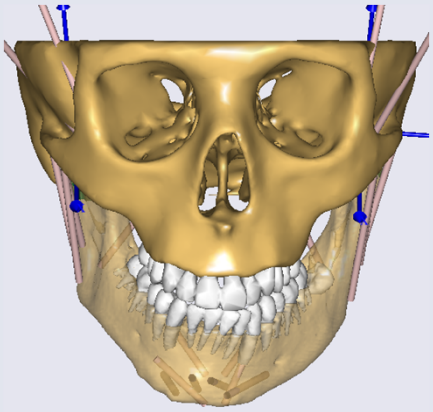
The mandible model



- Asymmetrical mandible with difference in ramus lengths.
- 150 N bite force perpendicular to the occlusal plane.
- Mission: Compute joint forces and directions.
- Work by Mark de Zee and Michael Skipper Andersen.

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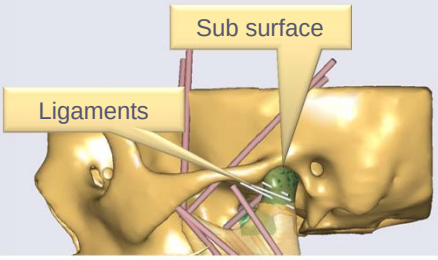
The temporo-manibular joint



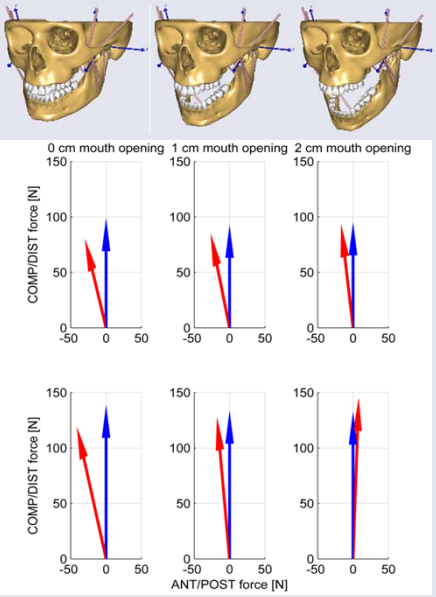
- A loose joint
- S-shaped joint surface.
- Master: The entire skull surface
- Slave: A sub set of

```
AnyForceSurfaceContact TMJ_JntR_Contact =
{
  AnySurface &sMaster = ..Seg.Skull.SurfSkull;
  AnySurface &sSlave = ..Seg.Mandible.SurfMandibleContactRight;
  PressureModule = 1e9;
  ForceViewOnOff = On;
  MeshRefinementMaster = 3;
  MeshRefinementSlave = 3;
  SingleSidedOnOff= Off;
};
```

TECHNOLOGY

Results

Red: FDK
Blue: Non-FDK



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Conclusions

- Agreement between FDK and simple joints on the magnitude of joint forces in this case.
- Improved prediction of the direction of the joint forces by FDK.
- The simple joint was a cylinder-on-plane and could only provide forces perpendicularly to the plane.

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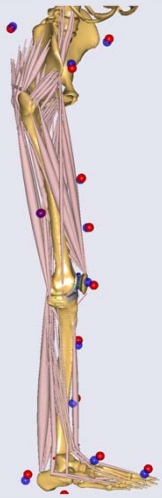
The knee



- Complex and multiple joint surfaces.
- Stabilized by cartilage, meniscus and multiple ligaments.
- The target of frequent joint replacement.
- Work by Michael Skipper Andersen.

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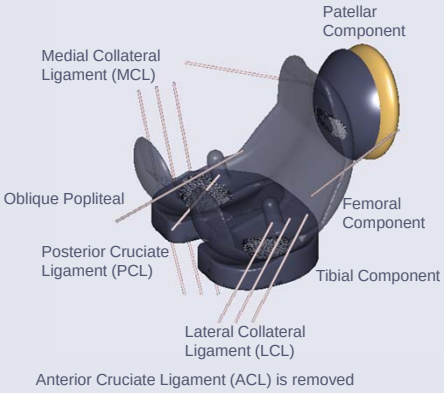
Modeling principles

- Modeling of TKA.
- Based on the Grand Challenge data set (Fregly, d'Lima et al.).
- PCL-retaining.
- Joints:
  - Lateral condyle
  - Medial condyle
  - Patello-femoral
- Triangulated surfaces imported from CAD on STL format.



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Preliminary results

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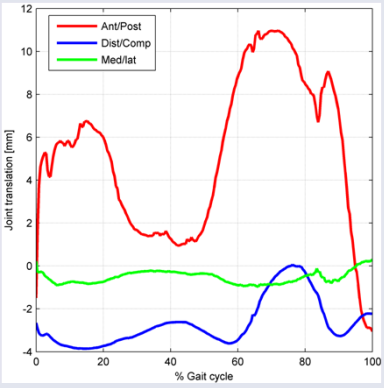
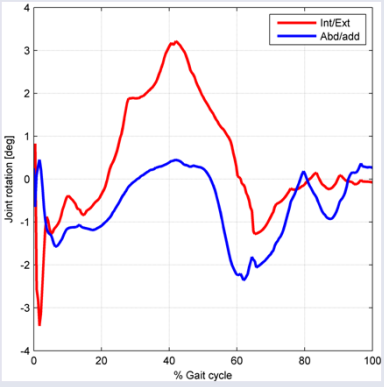
Kinematics





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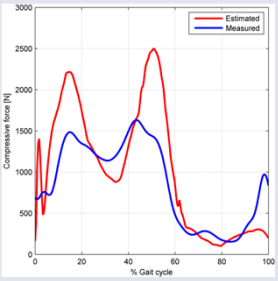
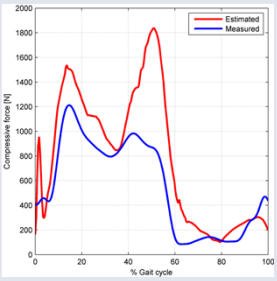
Condyle forces

Total compressive force



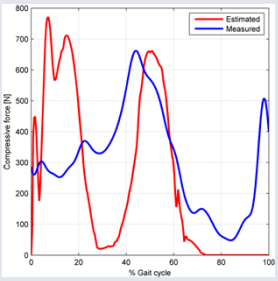
RMS error: 454N

Medial force



RMS error: 350N

Lateral force



RMS error: 250N

Captures the trends, but over predicts the peaks.
Over-prediction is not related to FDK but to muscle moment arms.

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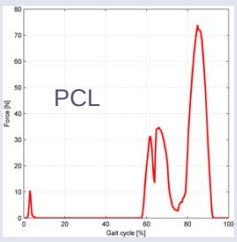
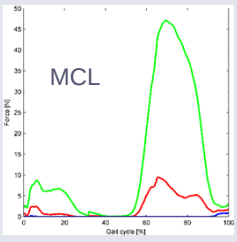
Ligament forces





- Ligaments are some of the elastic elements stabilizing the joint.
- Therefore, ligament forces are computed as an integrated part of the FDK analysis
- The ACL is sacrificed in the implantation
- The analysis shows very little LCL force (omitted)

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Contact analysis

- Contact based on penetration volumes.
- This analysis has used relatively soft materials = larger contact volumes.
- Harder materials require refinement of the surface mesh.
- How do the results depend on this?
- “Convergence” test!

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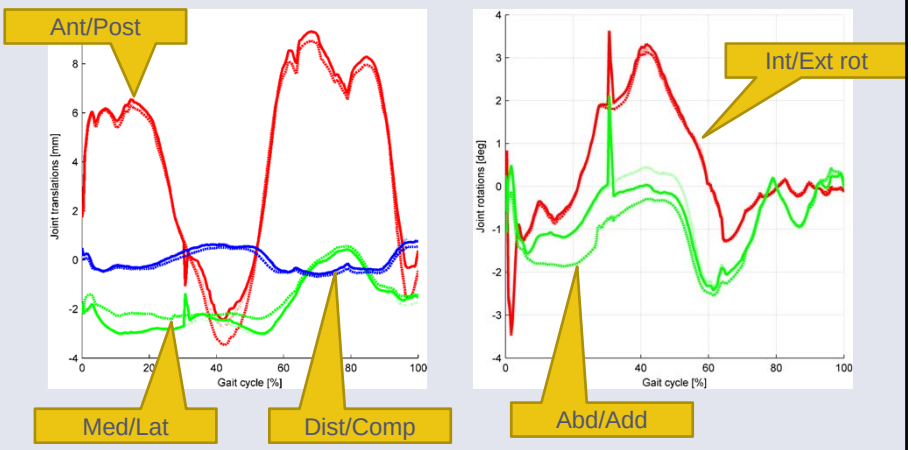
Kinematics
soft/crude, soft/refined and hard/refined



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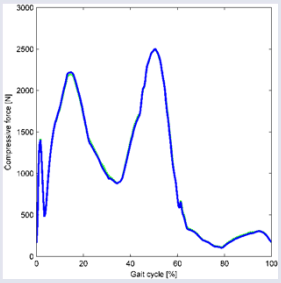
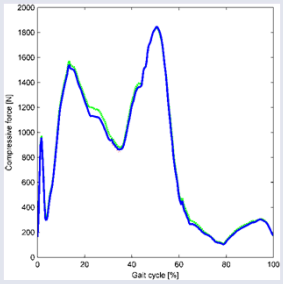
Condyle forces, soft/crude, soft/refined and hard/refined

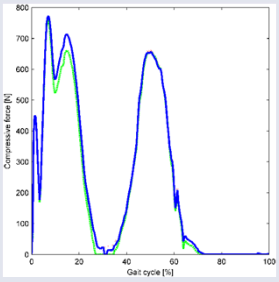
Total compressive force



Medial force



Lateral force



Only small differences between original (soft/crude), soft/refined and hard/refined.

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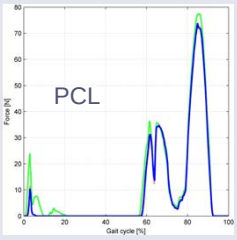
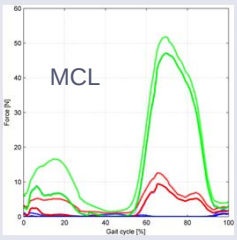
Ligament forces soft/crude, soft/refined and hard/refined





Rather small influence of model parameters on ligament forces.

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General experiences with FDK

- The ability to handle
  - Many muscles
  - Passive-elastic structures
  - Kinematics depending on forces

  } Unique for FDK!
- Computes contact forces but not credible pressure distributions
- Dependency on surface
  - Hardness
  - Smoothing
  - Mesh refinement
  - Softened materials are easier to use.
  - Small dependency of result on material hardness.
- Knee forces
  - are too large
  - have correct trends
  - are probably too large because of muscle moment arms.

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Plans with models

Knee model

- Will go into the repository (www.anyscript.org) when finished.
- Still a work-in-progress under AnyScript.org.
- Get in touch with MSA if you want access to an Alpha version.

Mandible

- THE example for a FDK publication.
- Data acquisition for an individualized model under way.

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Online resources

- www.anybodytech.com
  - Free demo license for the AnyBody Modeling System
  - Sign up for the future webcasts
- www.AnyScript.org
  - Discussion forum
  - Wiki
  - Model repository
- www.anybody.aau.dk
  - Homepage of the research group

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Q&A Panel

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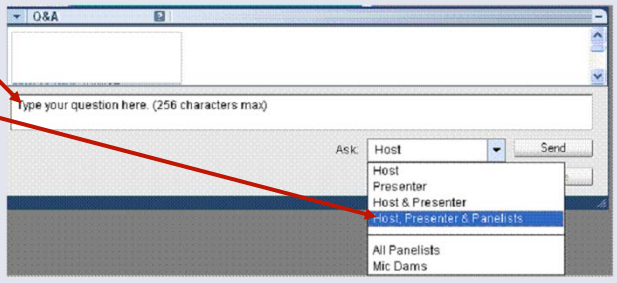

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