Application of a Calibration Method Provides More Realistic Results for a Finite Element Model of a Lumbar Spinal Segment

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Aim: Validation of a finite element model of a single spinal motion segment

Determination of the geometry of bony structures

CT

Philips MX 8000IPT®

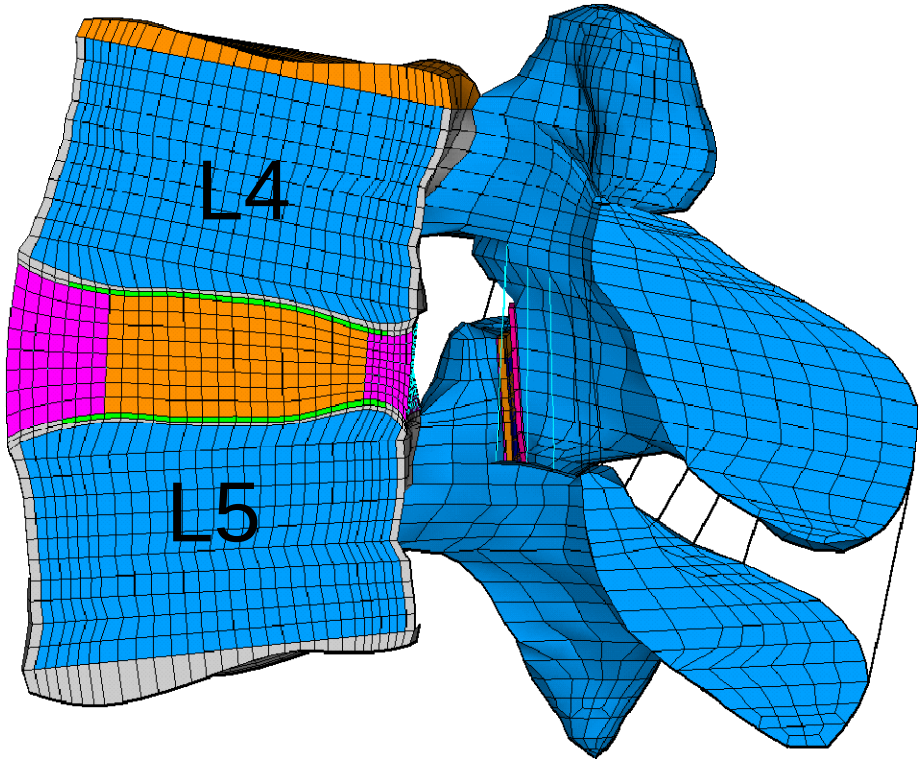
3D

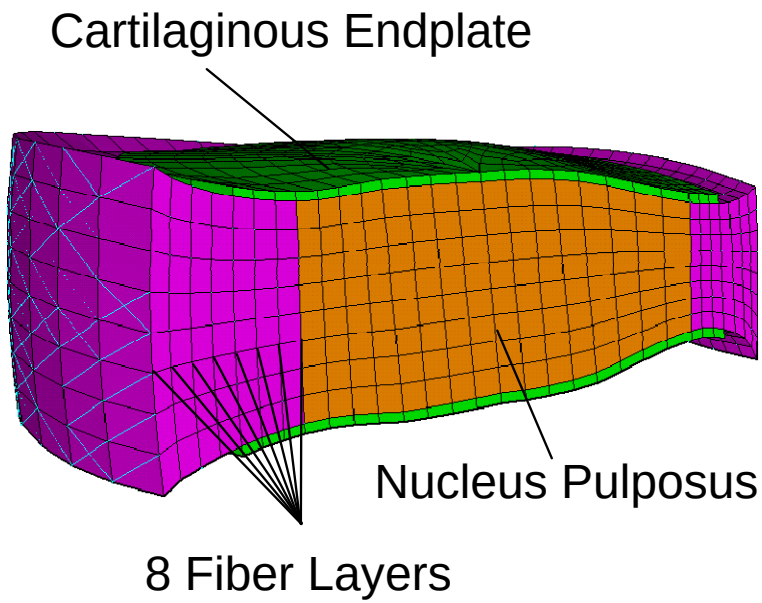
amira® 3.0

Determination of the geometry of soft tissue

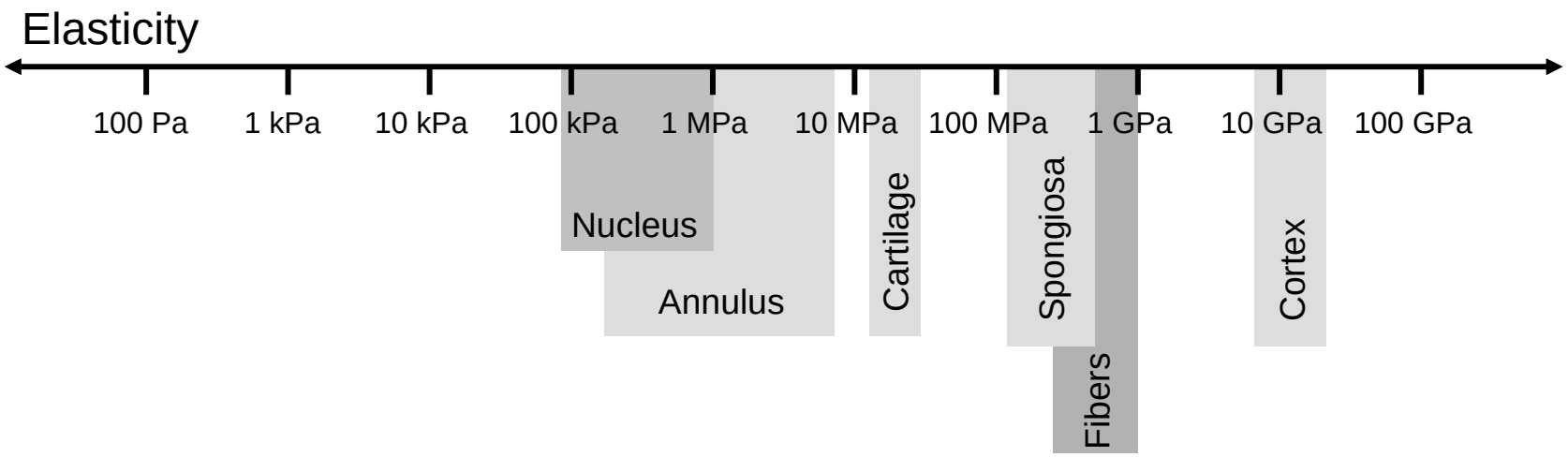
MRI-Slices

macroscopical frozen cuts

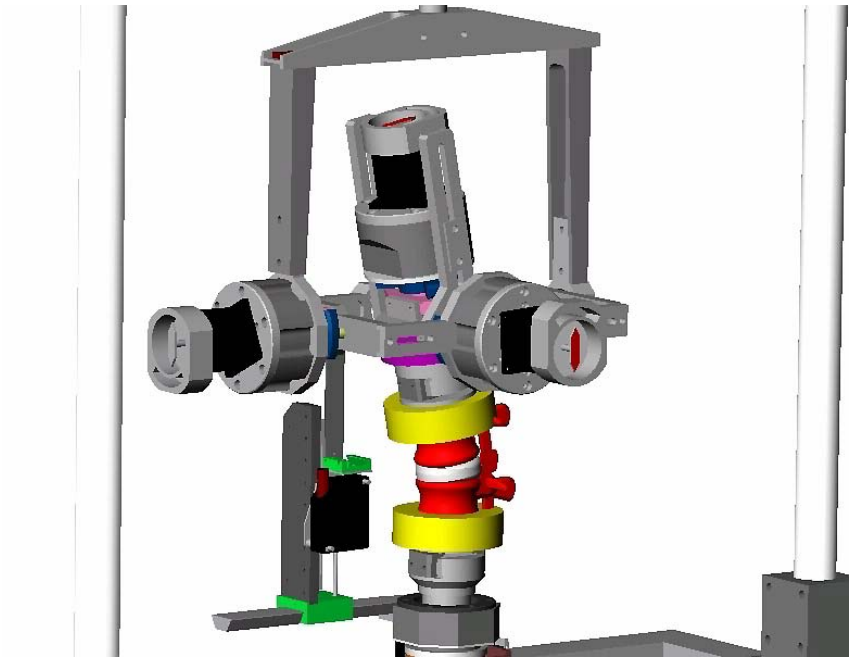

L4
L5


Cartilaginous Endplate
Nucleus Pulposus
8 Fiber Layers

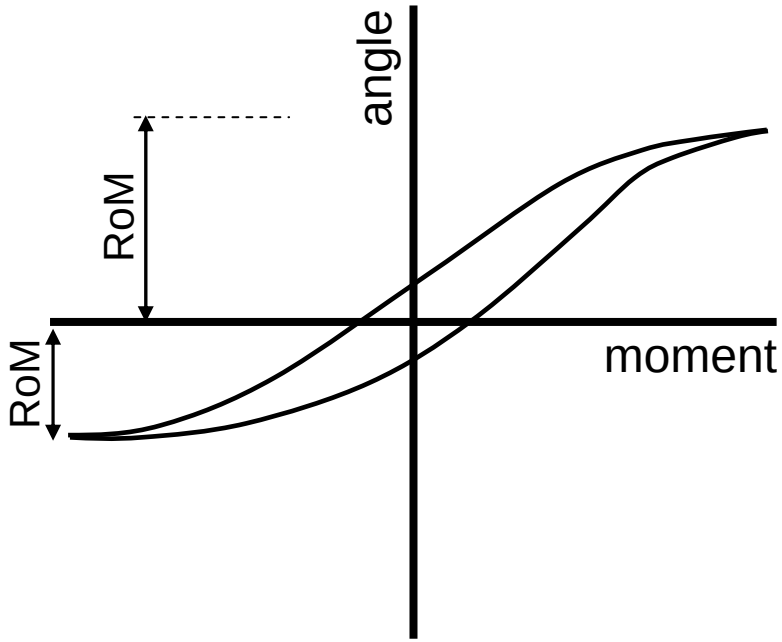
Material properties of different biological structures



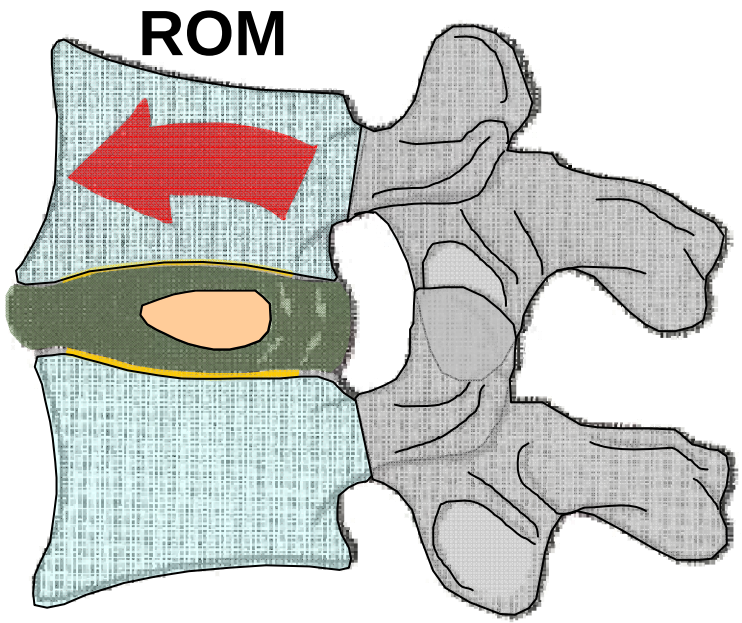
Validation parameter

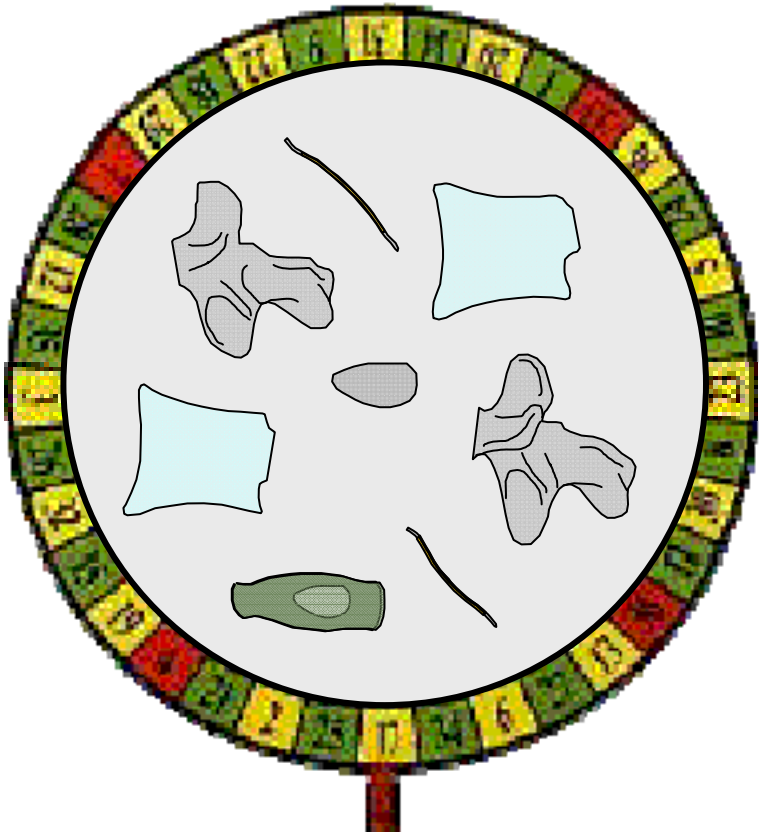


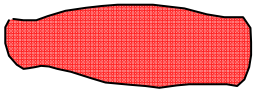
Range of Motion



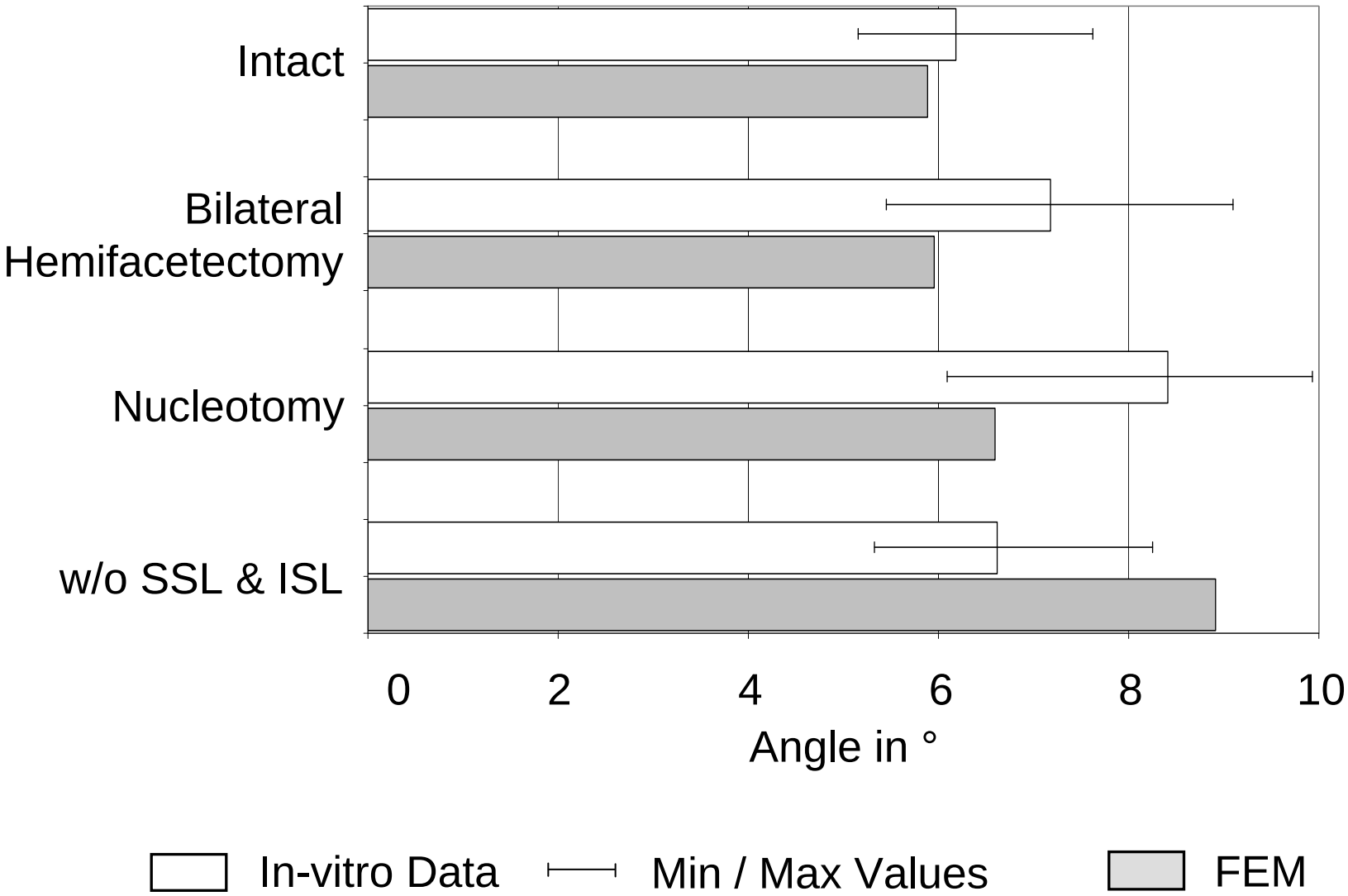
Often performed validation procedures







Material modification


Intact
Bilateral Hemifacetectomy
Nucleotomy
w/o SSL & ISL
0
2
4
6
8
10
Angle in °
In-vitro Data
Min / Max Values
FEM

Marco Viceconti, Clinical Biomech, 2005

“I have a question and I am sure you don‘ t like it:

How did you validate your finite element model?”

M. Viceconti, S. Olsen, L. Nolte, K. Burton

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CLINICAL BIOMECHANICS

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Editorial

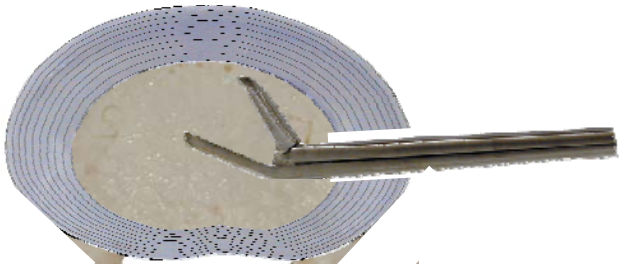
Extracting clinically relevant data from finite element simulations

1. Introduction

The present editorial is the conclusion of a consensus

sional community, and also the rather simple materials that are considered in most industry applications. In biomechanics and related research our biggest challenge

In-vitro Studies



Intact

w/o SSL

w/o ISL

w/o FL

w/o FC

w/o VA

w/o PLL

w/o ALL

w/o Nucl

Load application

Flexion

Extension

Lateral bending

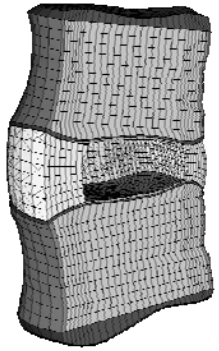
Axial rotation

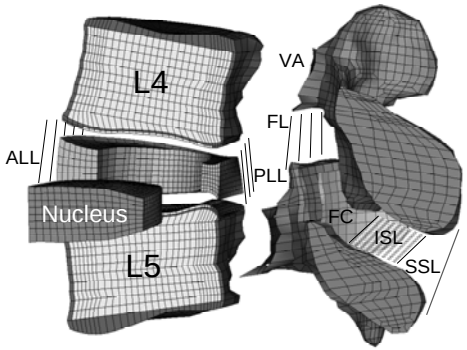
Load magnitudes

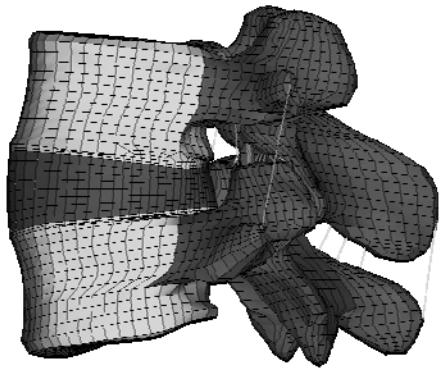
1, 2.5, 5, 7.5, 10 Nm

$$\sum = 180$$

Calibration
of the
Finite Element Model







Annulus

with ALL
with PLL

with VA

with FC
with FL
with ISL

Intact

<u>Load application</u>

Flexion

Extension

Lateral bending

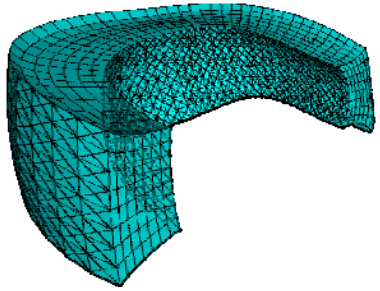
Axial rotation

<u>Load magnitudes</u>

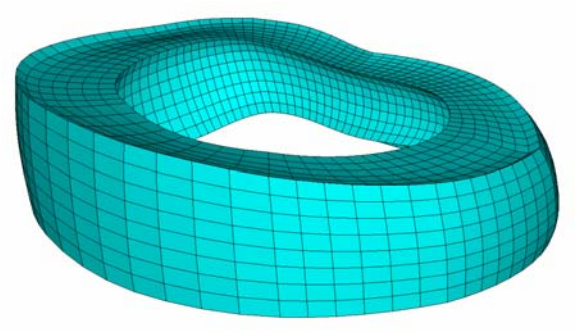
1, 2.5, 5, 7.5, 10 Nm

$$\sum = 180$$

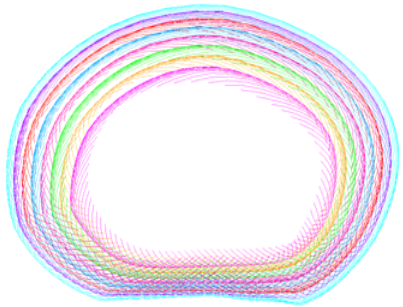
Annulus fibrosus

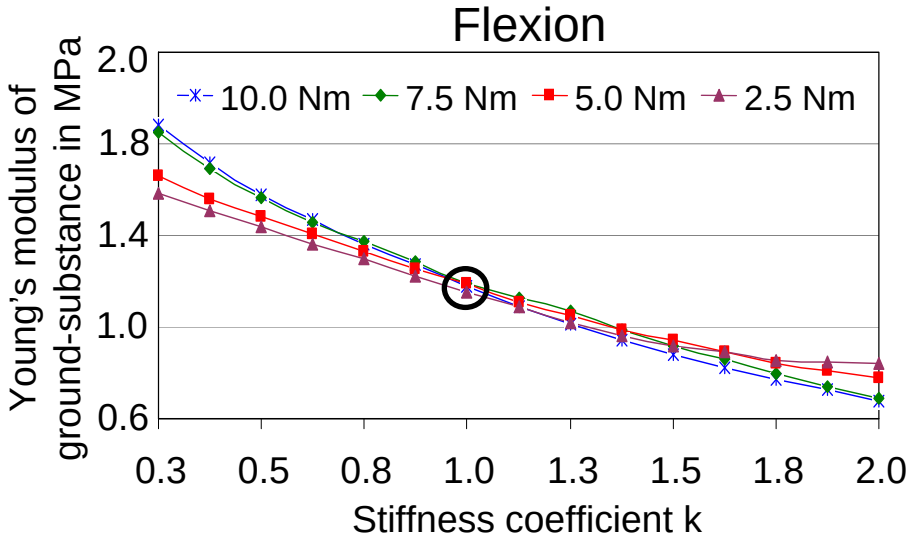


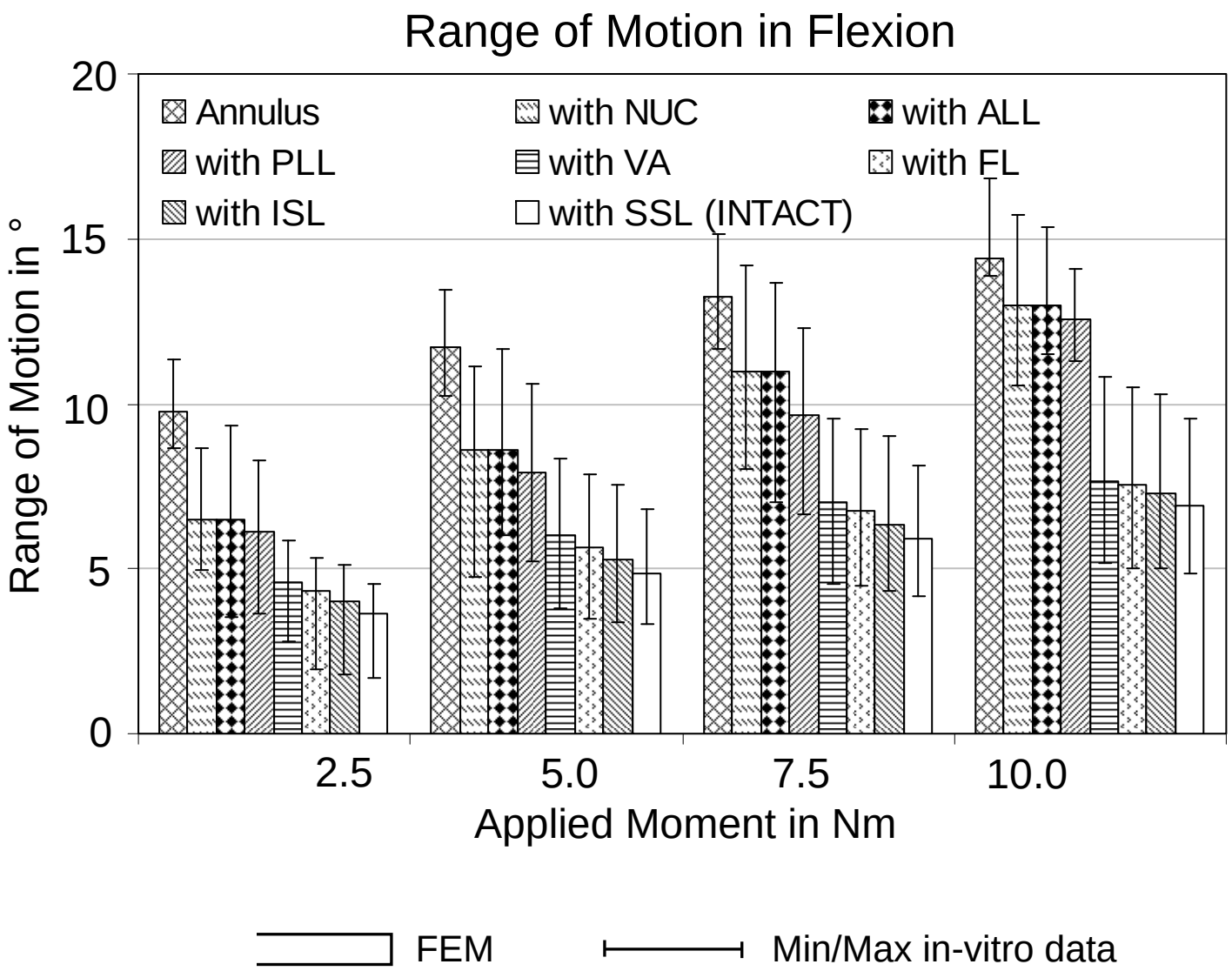
Ground substance



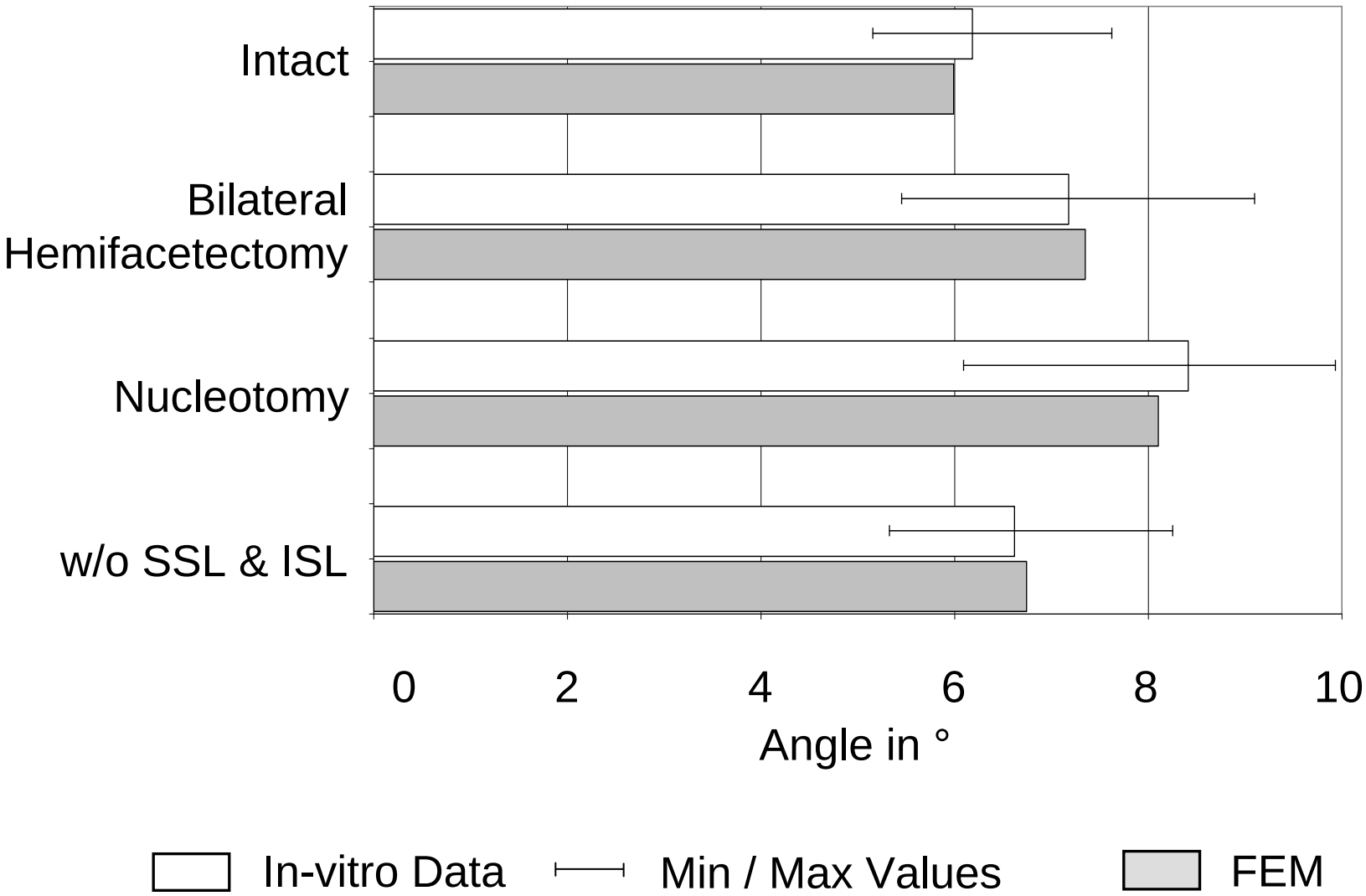
Fibers






Range of Motion in Flexion
Annulus
with NUC
with ALL
with PLL
with VA
with FL
with ISL
with SSL (INTACT)
Range of Motion in °
20
15
10
5
0
2.5
5.0
7.5
10.0
Applied Moment in Nm
FEM
Min/Max in-vitro data

Accuracy of the calibrated FE-model


Intact
Bilateral Hemifacetectomy
Nucleotomy
w/o SSL & ISL
0
2
4
6
8
10
Angle in °
In-vitro Data
Min / Max Values
FEM

Conclusion

•Only the calibrated FE-model showed a good agreement to all defect situations

but

•The current model is only suitable for quasi-static load application

Validation is “a never ending” process!!!

Thank you for your Attention!