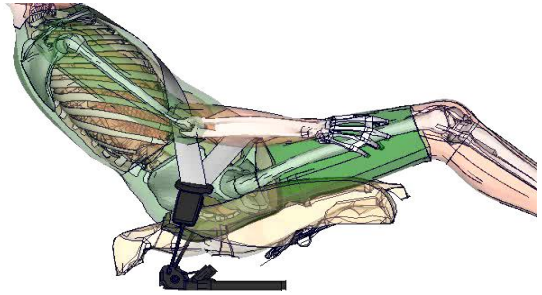
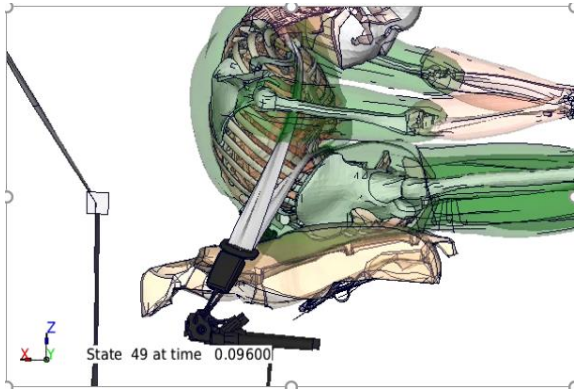




Summary of FFI - Pelvis and spine injury predicting models for women and men in a variety of sitting postures in future autonomous cars (I-HBM step 4)

Autoliv: **Bengt Pipkorn**, ***Leila Jaber***

VCC: **Lotta Jakobsson**, **Katarina Bohman**, **Jonas Östh**

Chalmers: **Johan Davidsson**, **Johan Iraeus**, **Erik Brynskog (PhD Student)**

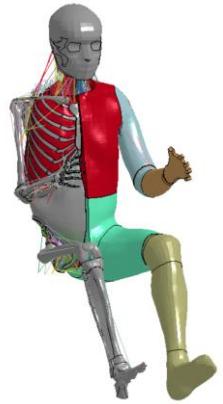
Sahlgrenska: **Olle Bunketorp**

I-HBM Projects Over Time

V8

V9

V10



V11

Injury HBM, step 1

Injury HBM, step 2

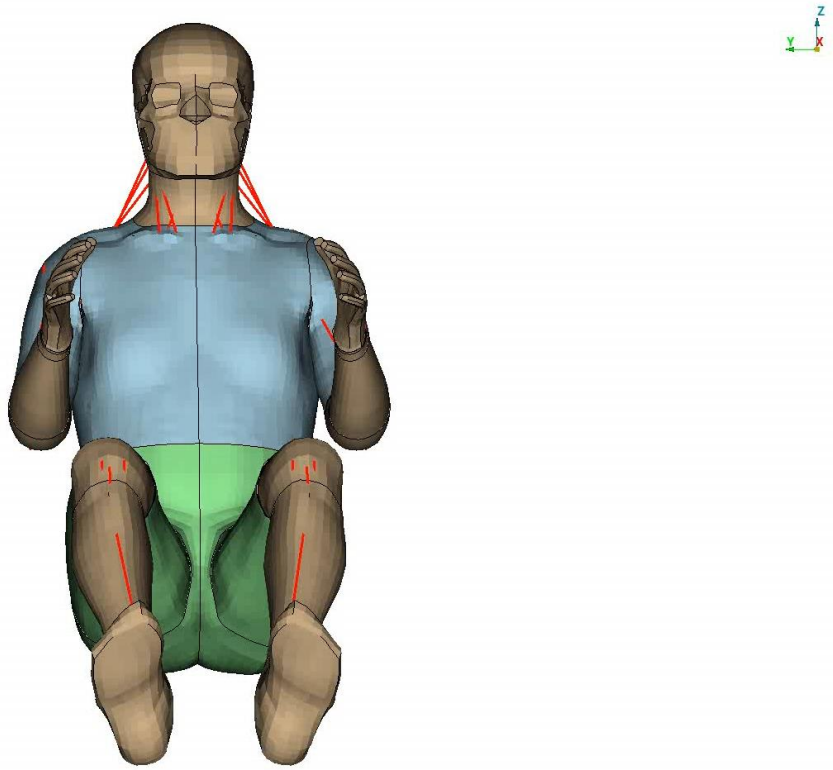
Injury HBM, step 3

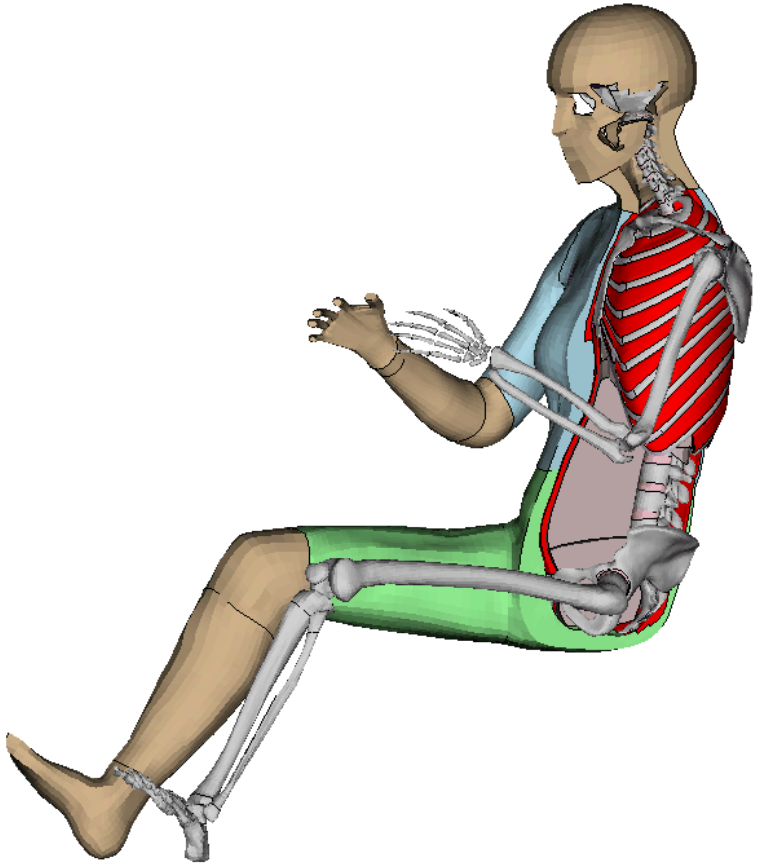
Injury HBM, step 4

Injury HBM, step 5

2010 2012 2014 2016 2018 2020 2022 2024

Introduction to SAFER HBM





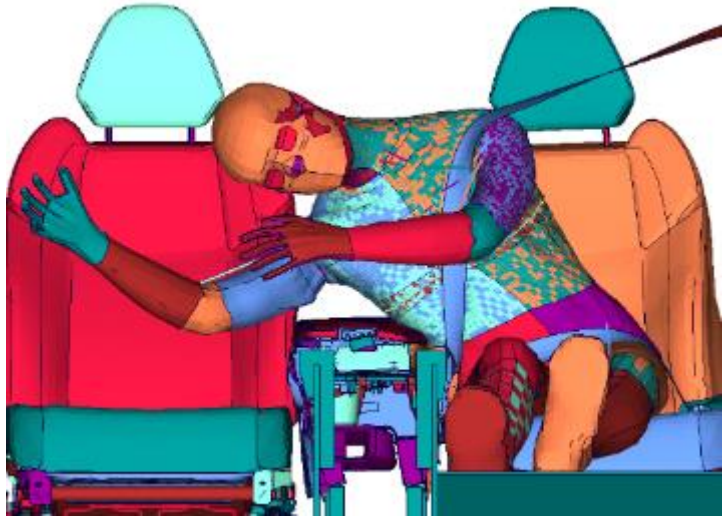
“Omnidirectional”, tunable and scalable human body model capable of injury risk and biofidelic kinematics prediction in high-g as well as low-g events”.

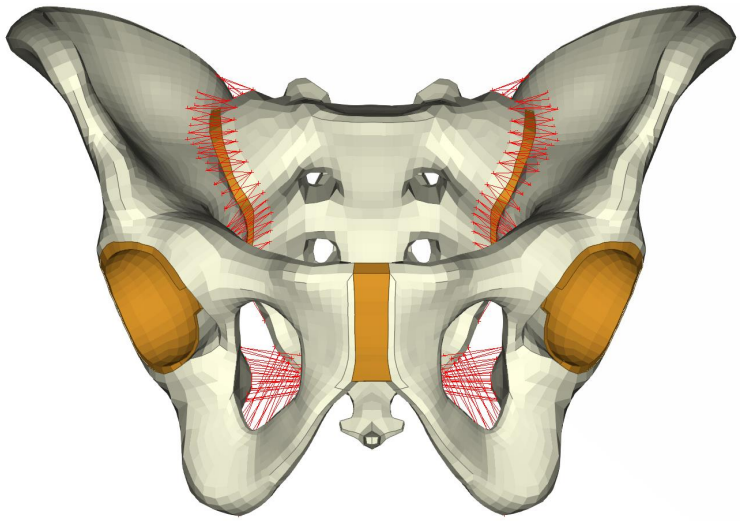
Morphed based on sex, age, height, and weight to represent women and men of various anthropometries

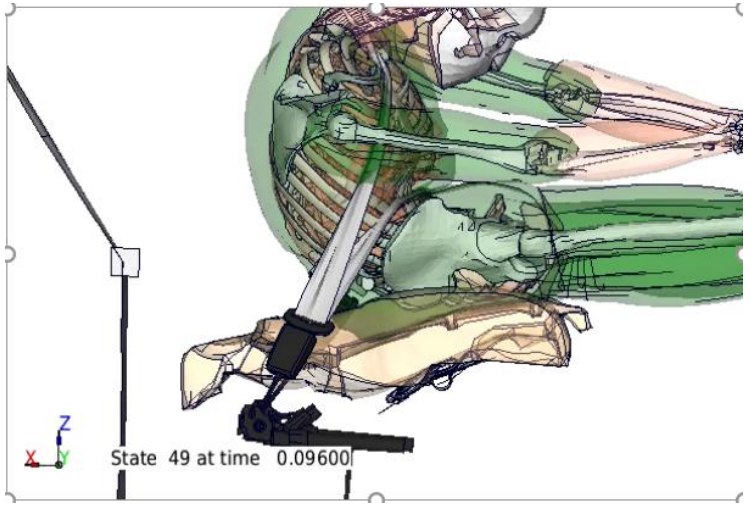
I-HBM step 4

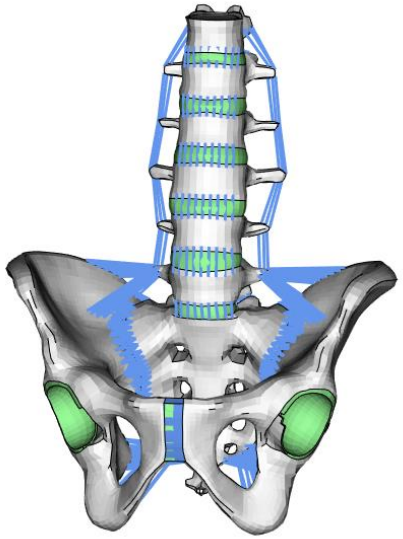
Research questions:	How do the belt interact with the pelvis? How can pelvis and lumbar spine injury risks be predicted for the population of vehicle occupants?
Objective:	Develop and validate pelvis and spine injury prediction capabilities for the morphable human body model SAFER HBM
Duration:	2019-04-01 to 2023-06-30 (2022-03-31)
Financer:	FFI Trafiksäkerhet och automatiserade fordon
Budget:	12.4Mkr
Partner:	Autoliv, Volvo Cars, Chalmers, SU
PhDs/ Postdocs:	1 PhD student

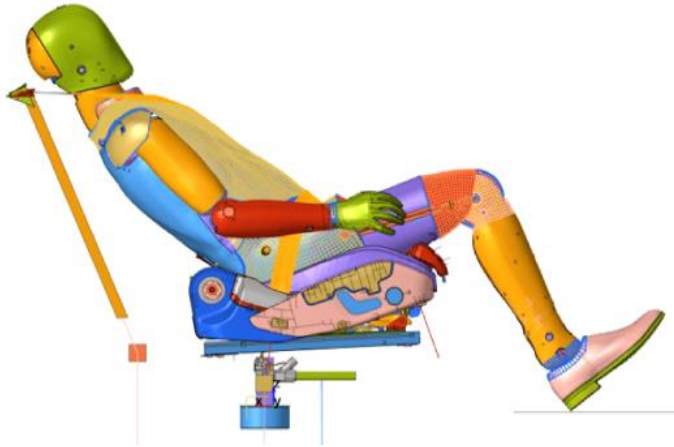
I-HBM IV Project Content





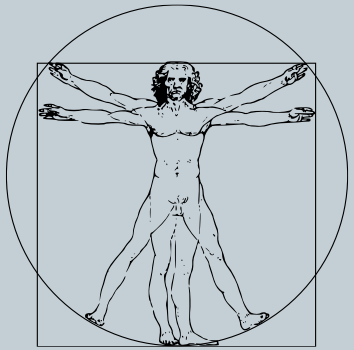






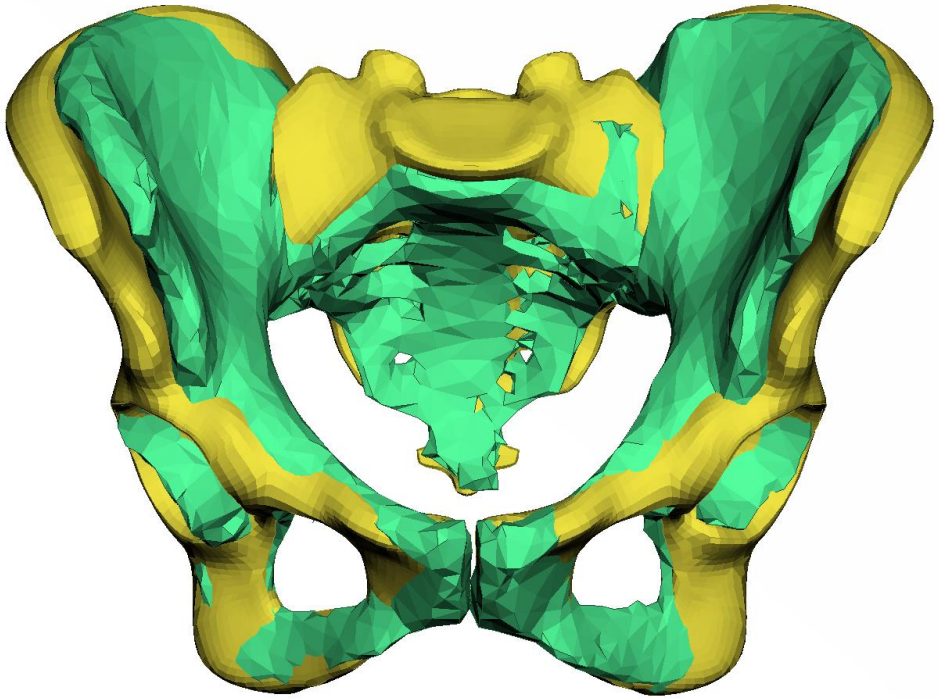
Development of Statistical Model

Sex
Age
Stature
BMI



Representation of pelvic shape variation

Statistical model



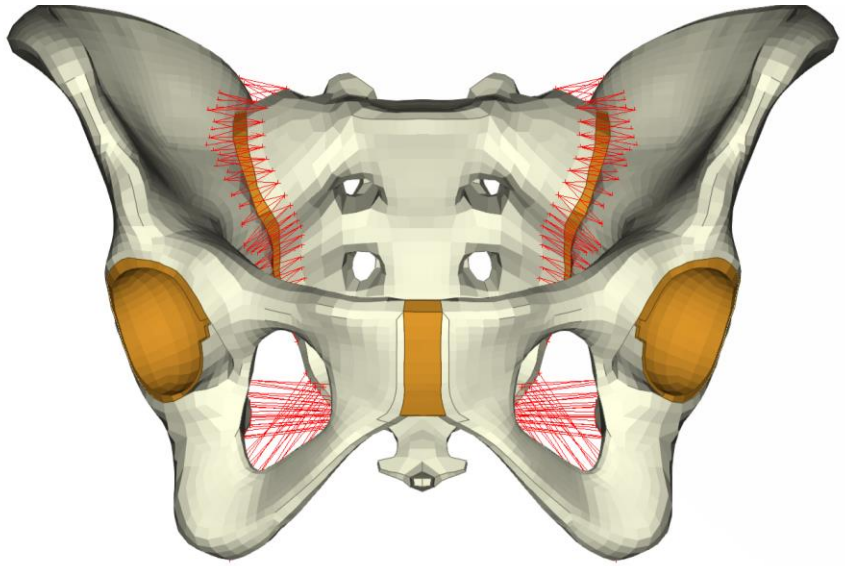
90% of shape variance

Capturing 29% of shape variance

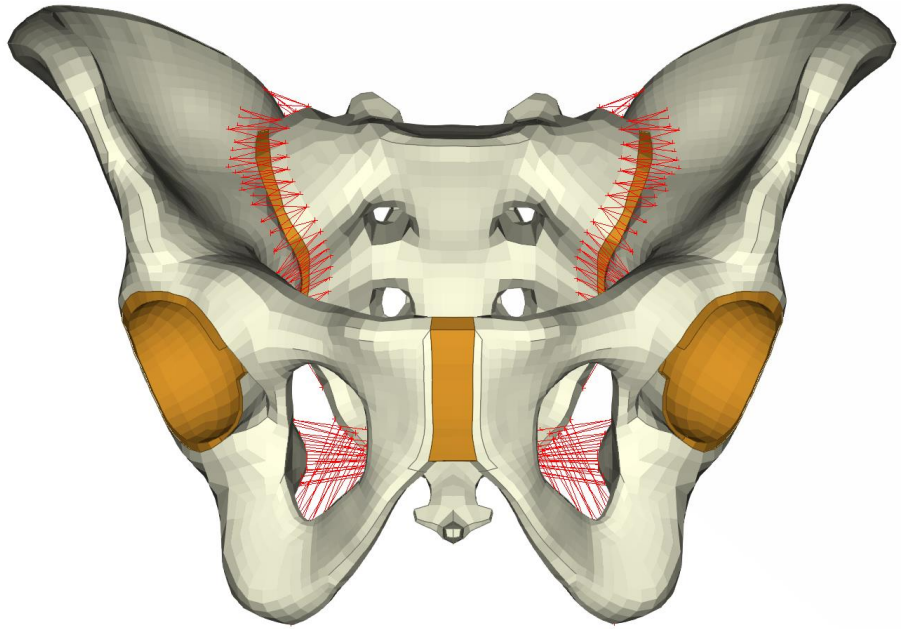
Brynskog E., et al. (2021)

Morphable Finite Element Pelvis Model

Morphable based on population shape variance



50th percentile female

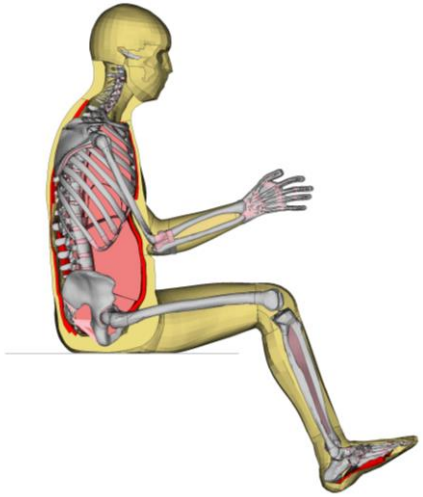


50th percentile male

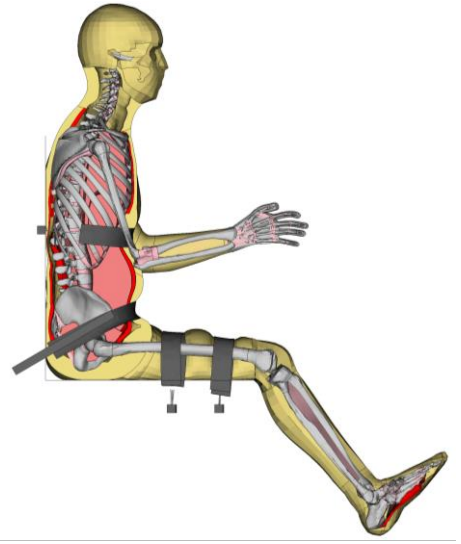
23 926 hexahedral solids
10 984 quadrilateral shells
318 1-D cable elements

Development of Submarining Prediction Capability

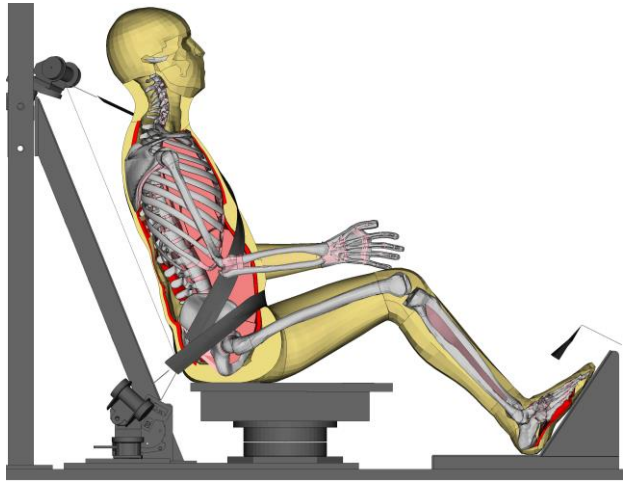
The development version SAFER HBM v10.1.x with the updated pelvis model generally showed agreement with the published experiments, in the validation scenarios



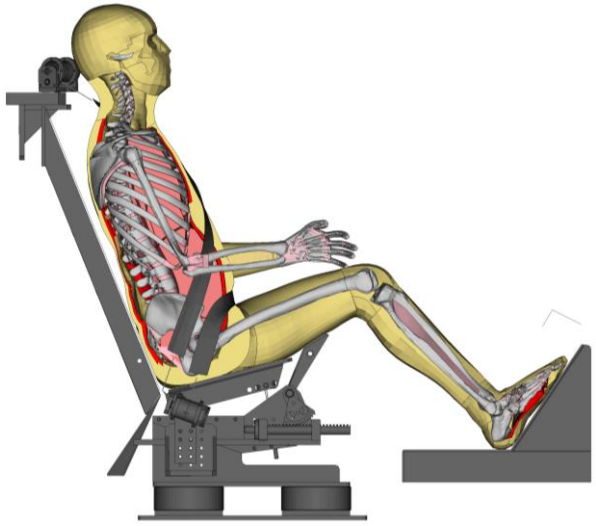
Free-back, mid-abdomen, rigid-bar impact



Pelvis seatbelt loading



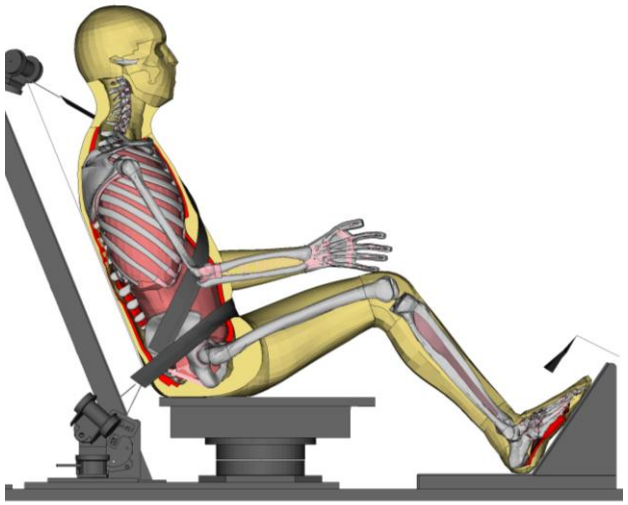
Sled test with rigid seat



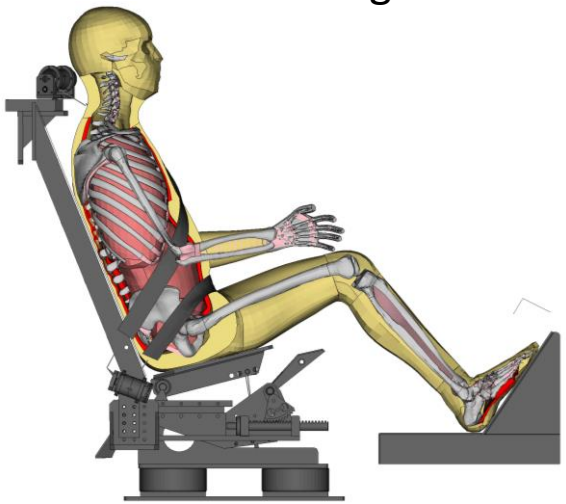
Sled test with semi-rigid seat

Next step to develop the capability of the model to predict the submarining variability for 50%ile male
The SAFER HBM v10.1.x modifications will be included in SAFER HBM V11

Evaluation of Submarining Prediction Capability
SAFER HBM V10.1.x



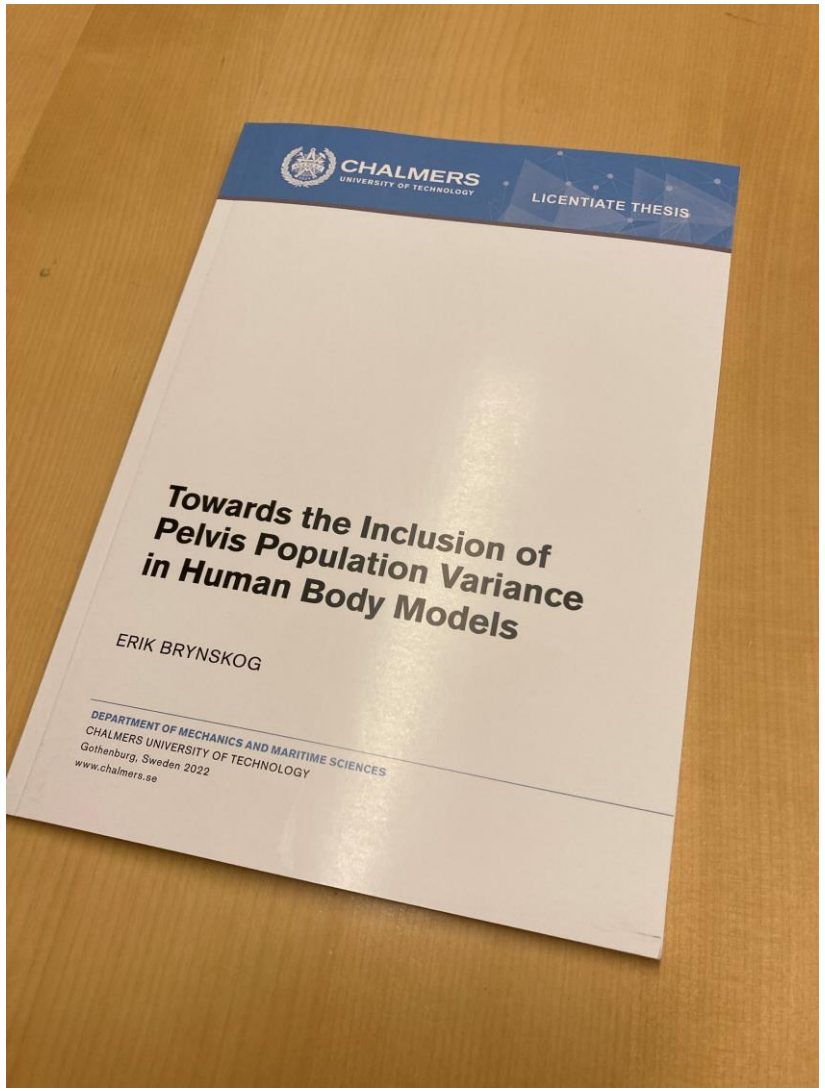
Submarining



Not Submarining

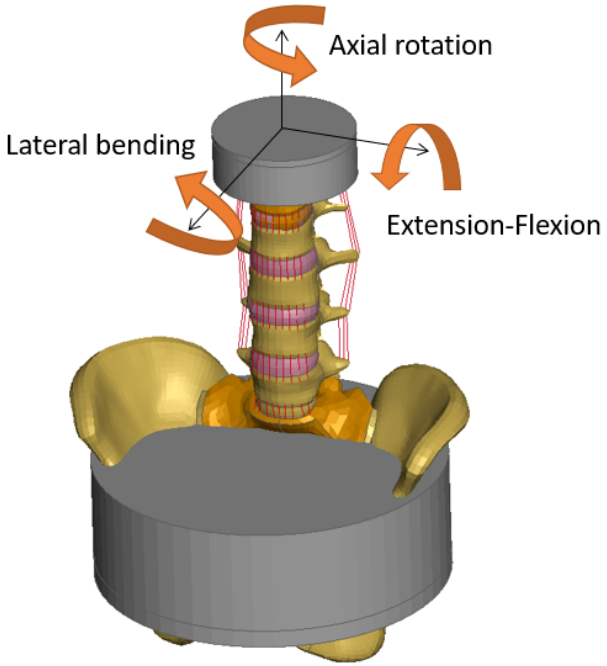
Reference	Case	Submarining outcome	Submarined in simulation?
Luet *et al.* (2012)	Conf. 1	3 of 3 submarined	Yes
Luet *et al.* (2012)	Conf. 2	1 of 3 submarined	Yes
Luet *et al.* (2012)	Conf. 3	3 of 3 submarined	Yes
Uriot *et al.* (2015b)	Front seat	0 of 4 submarined	No
Uriot *et al.* (2015b)	Rear seat	4 of 4 submarined	Yes

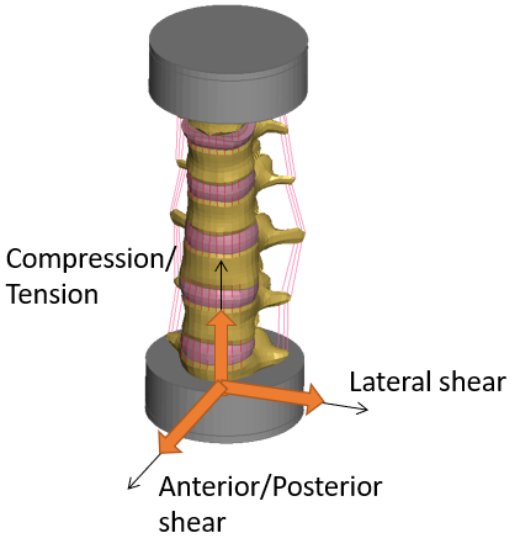
Licentiate Thesis Presentation 22-04-29



Lumbar Spine Model Development and Validation

The orange arrows show the directions of the displacements applied.





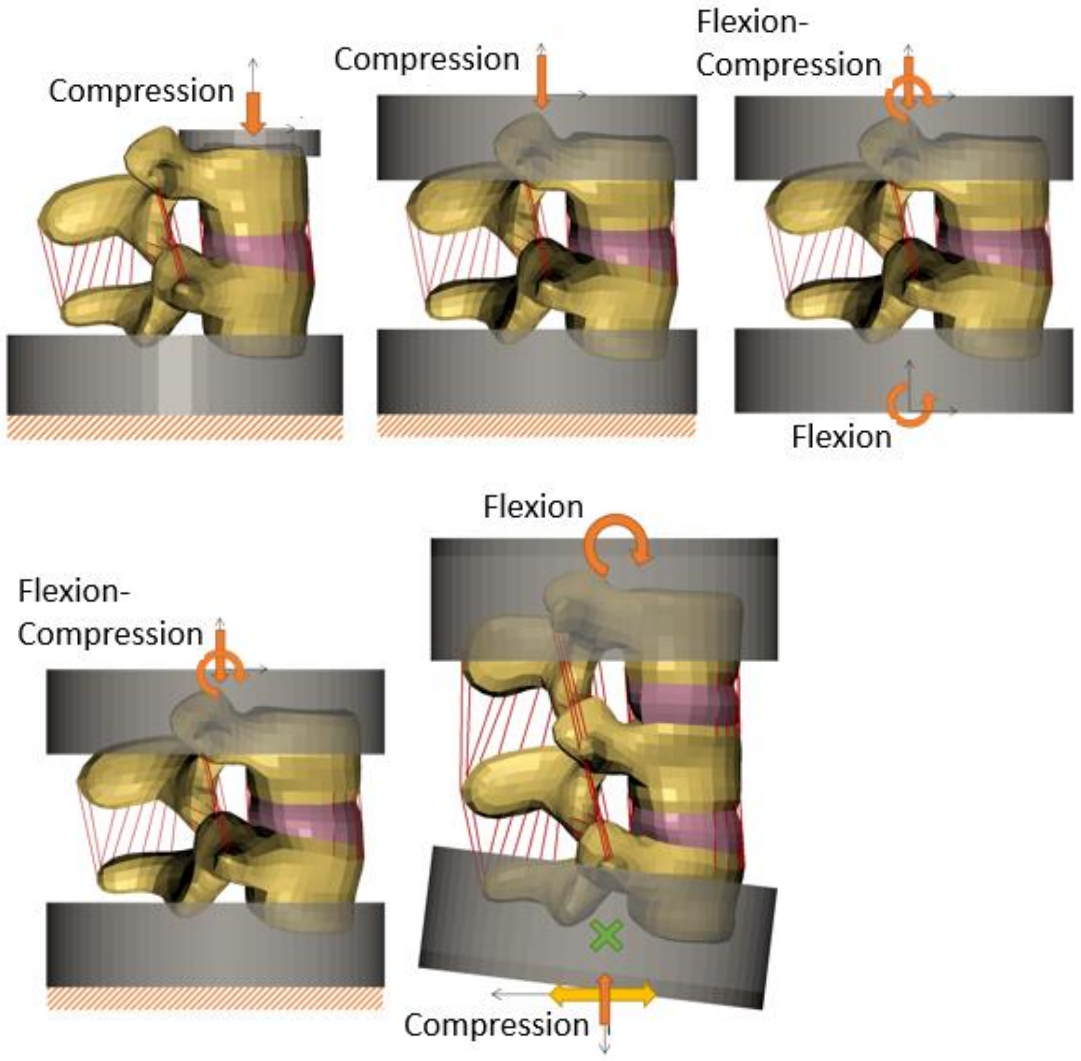
Left: Yamamoto et al. (1989).

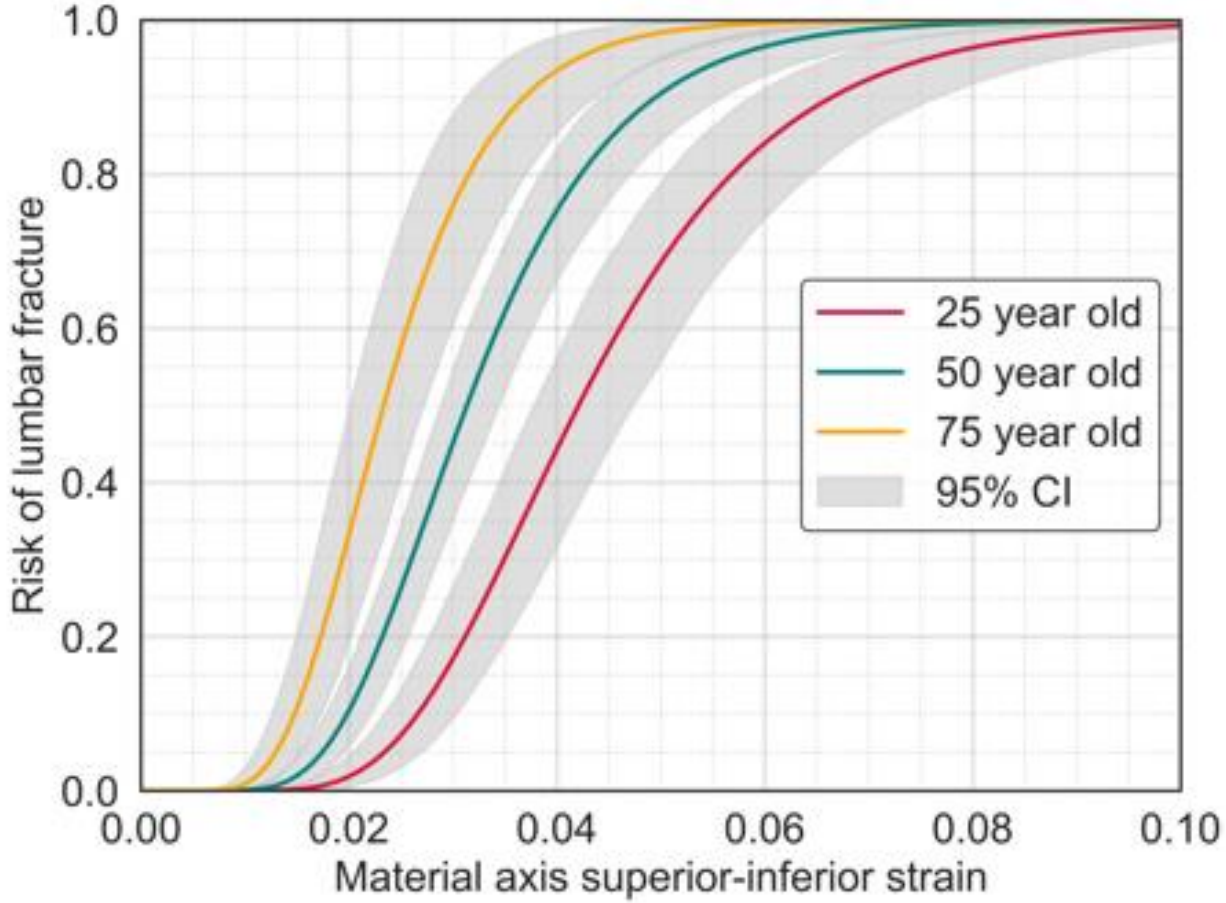
Right: Demetropoulos et al. (1998).

The kinematic and kinetic whole lumbar spine validation - showed model predictions were reasonably close to the test results

Major deviation for the posterior shear,

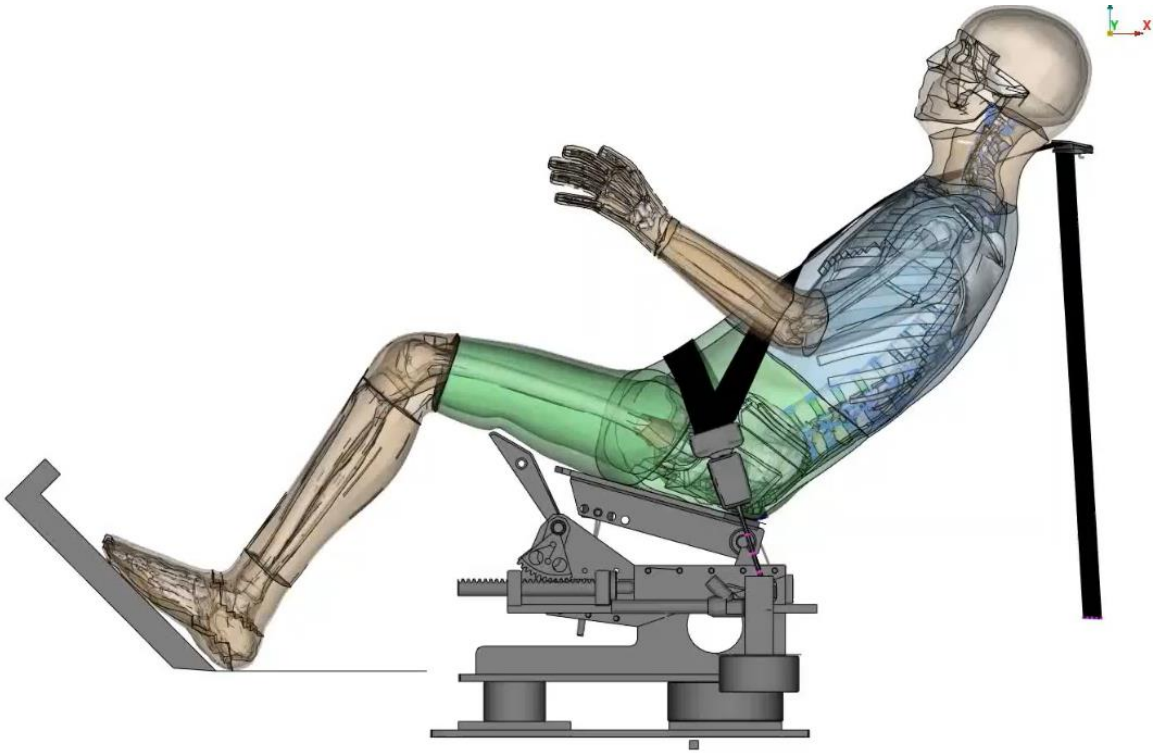
Reconstructions of FSU Tests to Create Lumbar Spine Vertebra Fracture Risk Functions

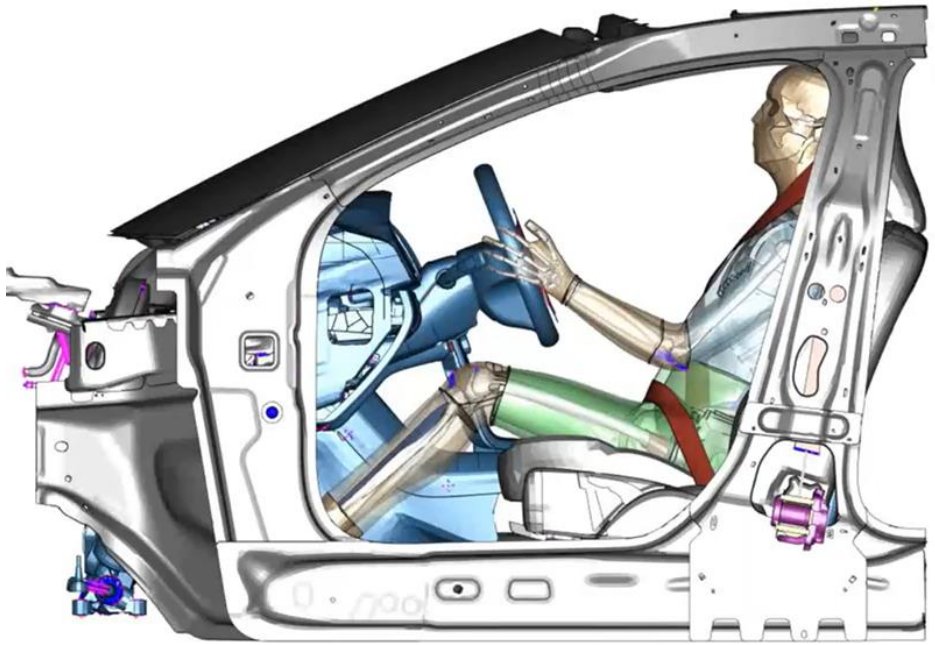




Brinkman et al. (1989), Duma et al. (2006), Granhed et al. (1989), Hutton and Adams (1982), Tushak et al. (2022).

Evaluation of Lumbar Spine Vertebra Fracture Risk Function
SAFER HBM V10.1.x





Reconstruction of testing with recline subjects

In recline testing 3 out 5 subjects sustained L1 fractures

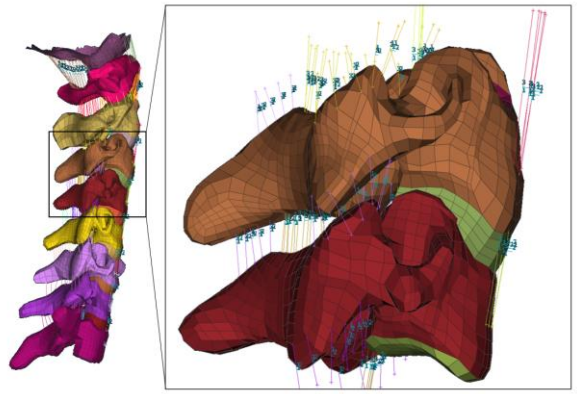
93% risk of L1 fracture was predicted

Reconstruction of accident, Volvo V40 – Renault Bipper

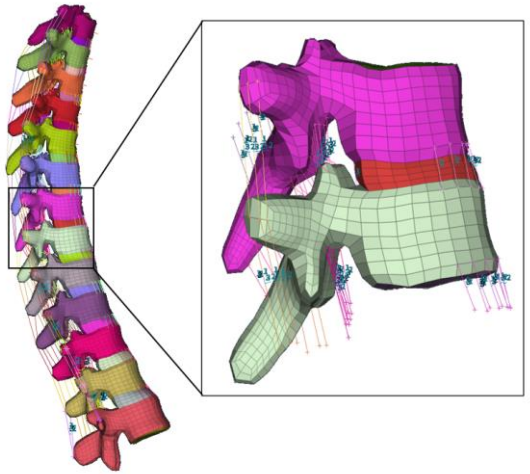
Volvo driver sustained compression fracture at L5

70% risk of L5 fracture was predicted

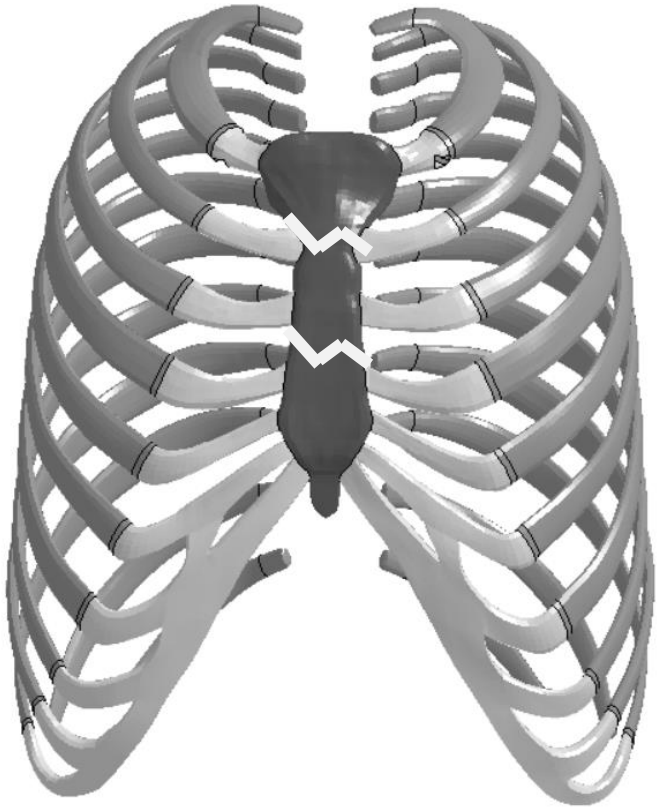
Next Steps and Future Challenges



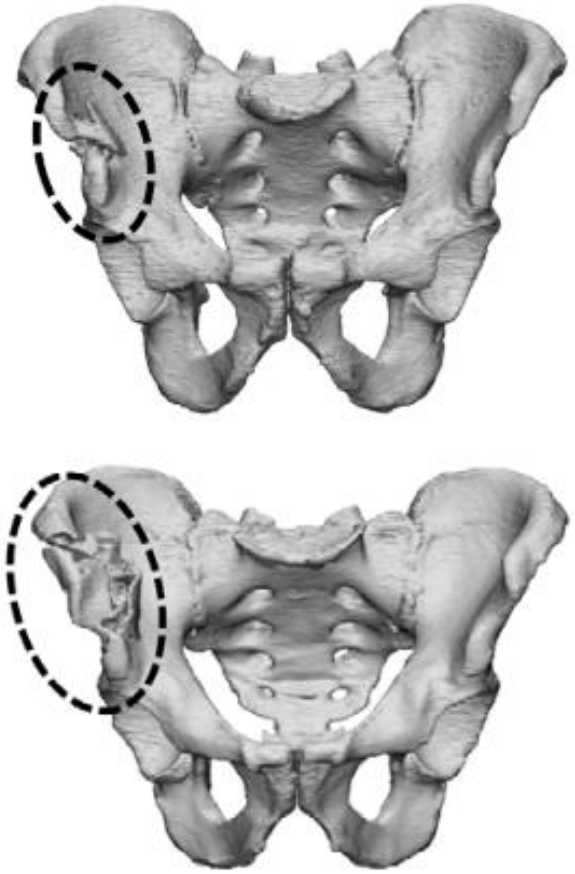
Cervical spine injury prediction



Thoracic spine injury prediction

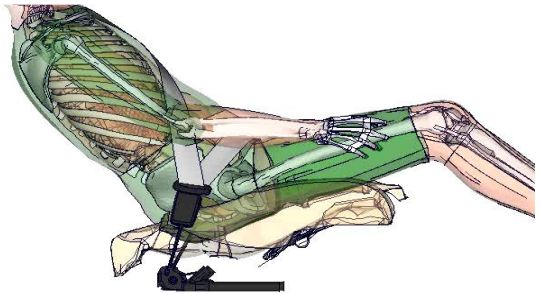


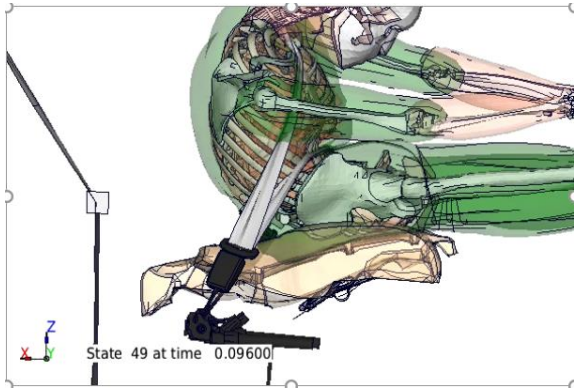
Sternum fracture prediction



Iliac wing fracture prediction

VÄSTRA GÖTALANDSREGIONEN
SAHLGRENSKA UNIVERSITETSSJUKHUSET





Thank You


Saving More Lives