



Final Event
Tuesday 23rd November 2021

spinner
next generation spine experts

Percutaneous Cement Discoplasty (PCD): Biomechanical and Clinical assessment of a Minimally Invasive Treatment of Lumbar Intervertebral Disc Disease

ESR3: Chloé Techens

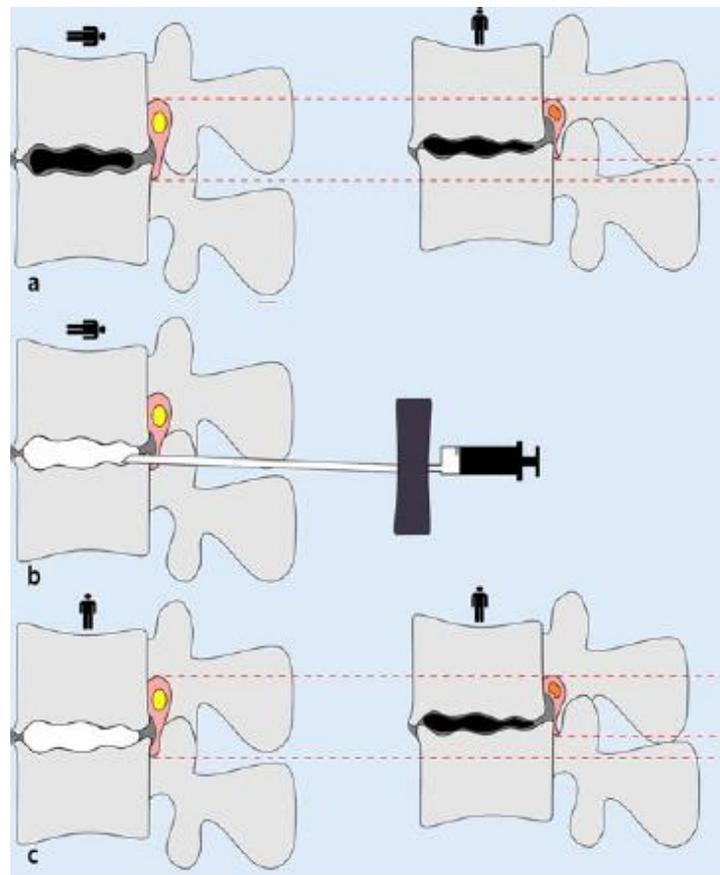
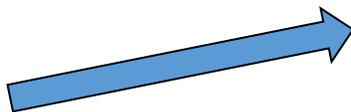
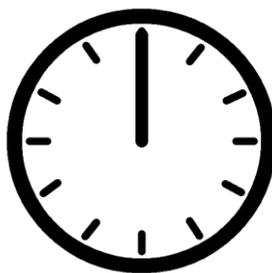
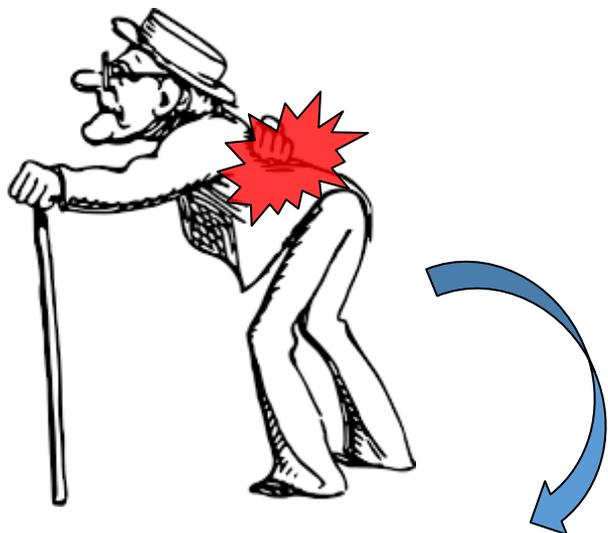
Supervisors: **Luca Cristofolini**
Peter Eltes
Aron Lazary



Final Event
Tuesday 23rd November 2021



Percutaneous Cement Discoplasty (PCD)



Varga PP and al, Experiences with PMMA cement as a stand-alone intervertebral spacer, Orthopade. 2015 Nov;44 Suppl 1:S1-7.



Final Event
Tuesday 23rd November 2021

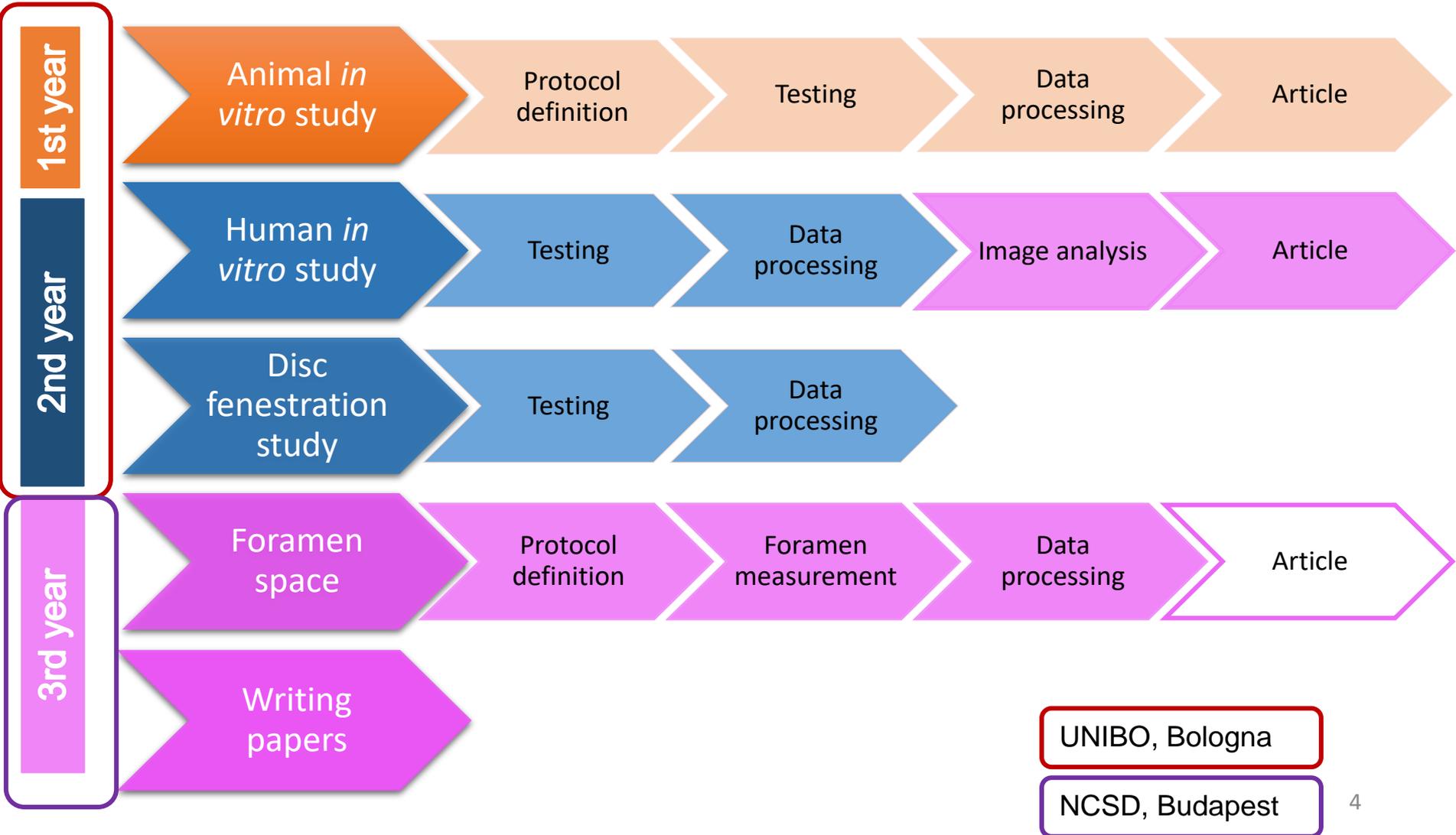
spinner
next generation spine experts

Aims of the project

- Understanding the biomechanics of the segment following discectomy
- Exploring the impact of surgery on patients to predict surgical outcome
- Detect sign of potential tissue overloading



PhD activities summary



UNIBO, Bologna

NCSD, Budapest



In vitro evaluation of PCD





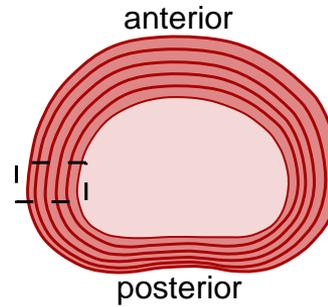
In vitro modeling of discoplasty

In vivo

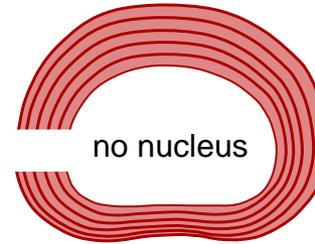


In vitro

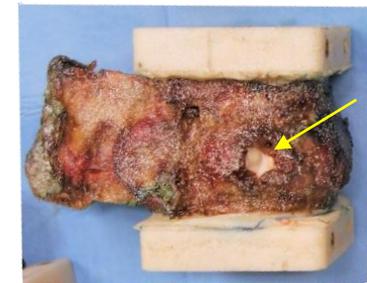
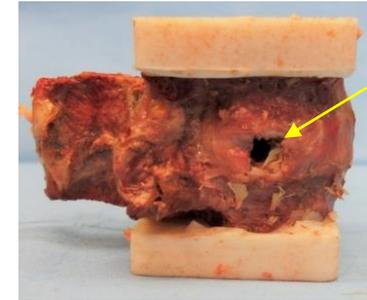
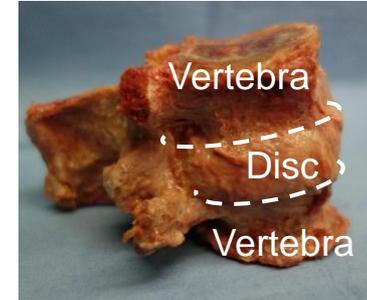
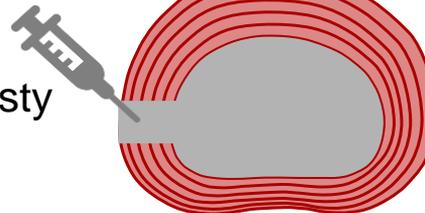
Intact



Nucleotomy (NUCL)



Discoplasty (CD)





Final Event
Tuesday 23rd November 2021

Y1

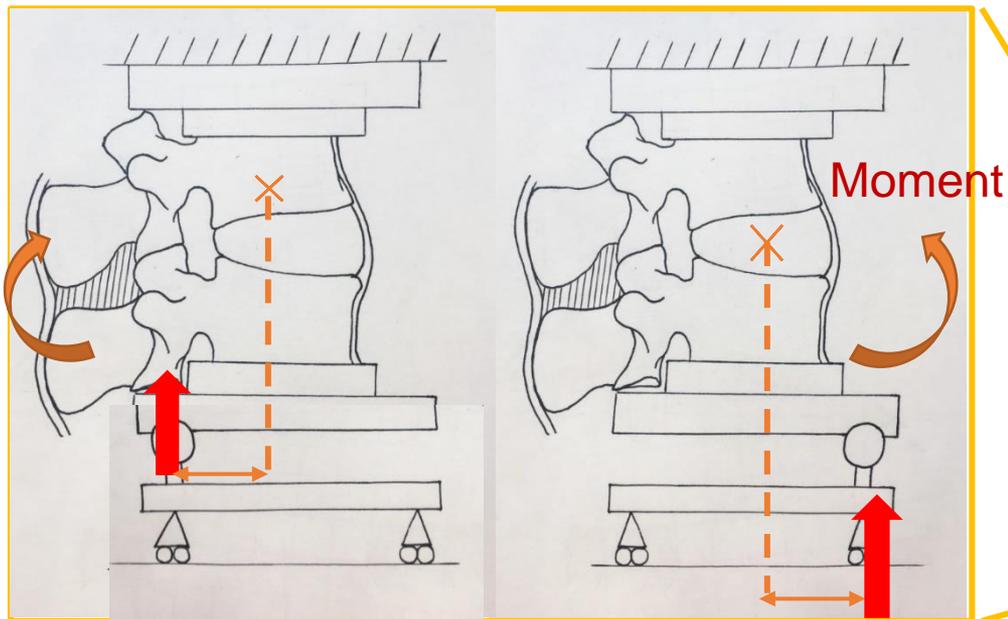
Y2

spinner
next generation spine experts

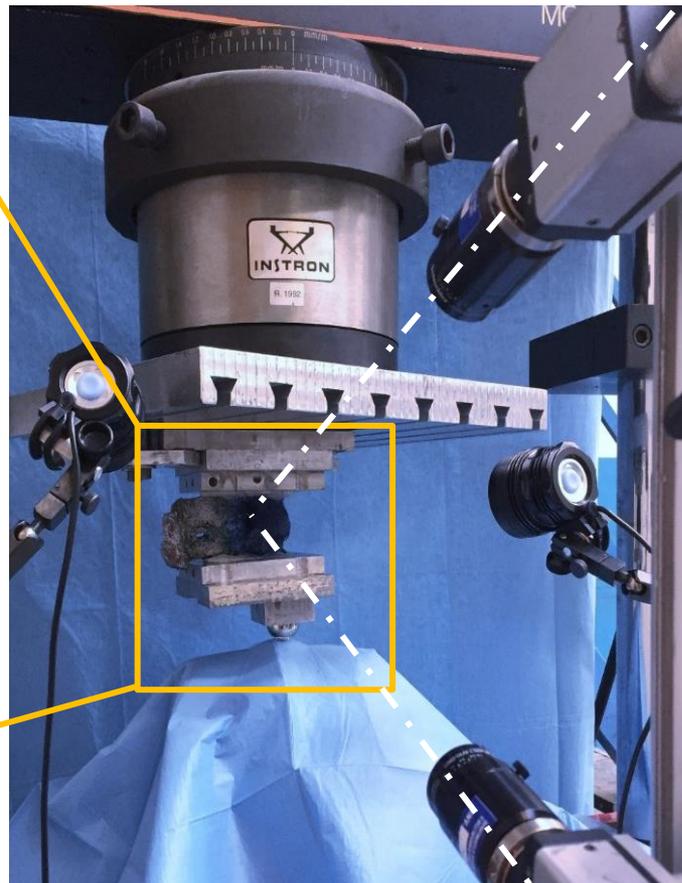
Experimental protocol for porcine spines

Extension

Flexion



Offset Force



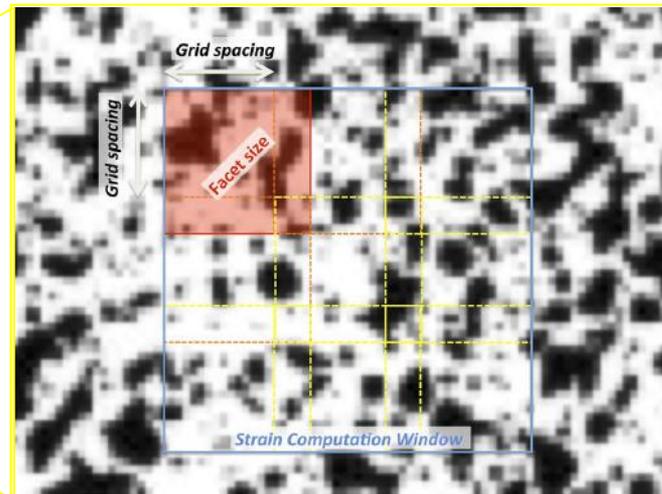
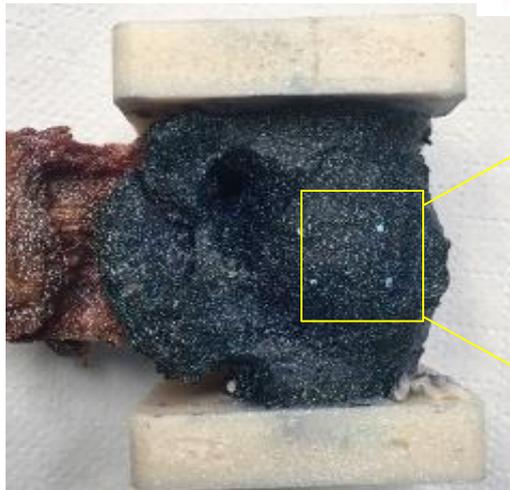
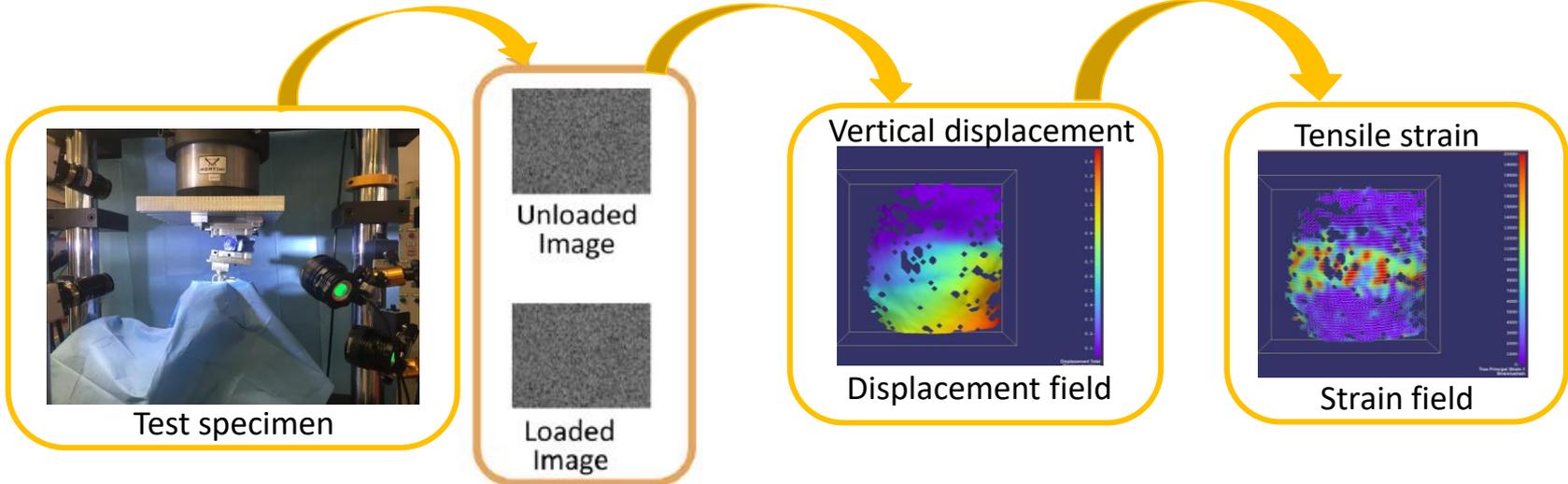


Digital Image Correlation

Acquisition of digital images

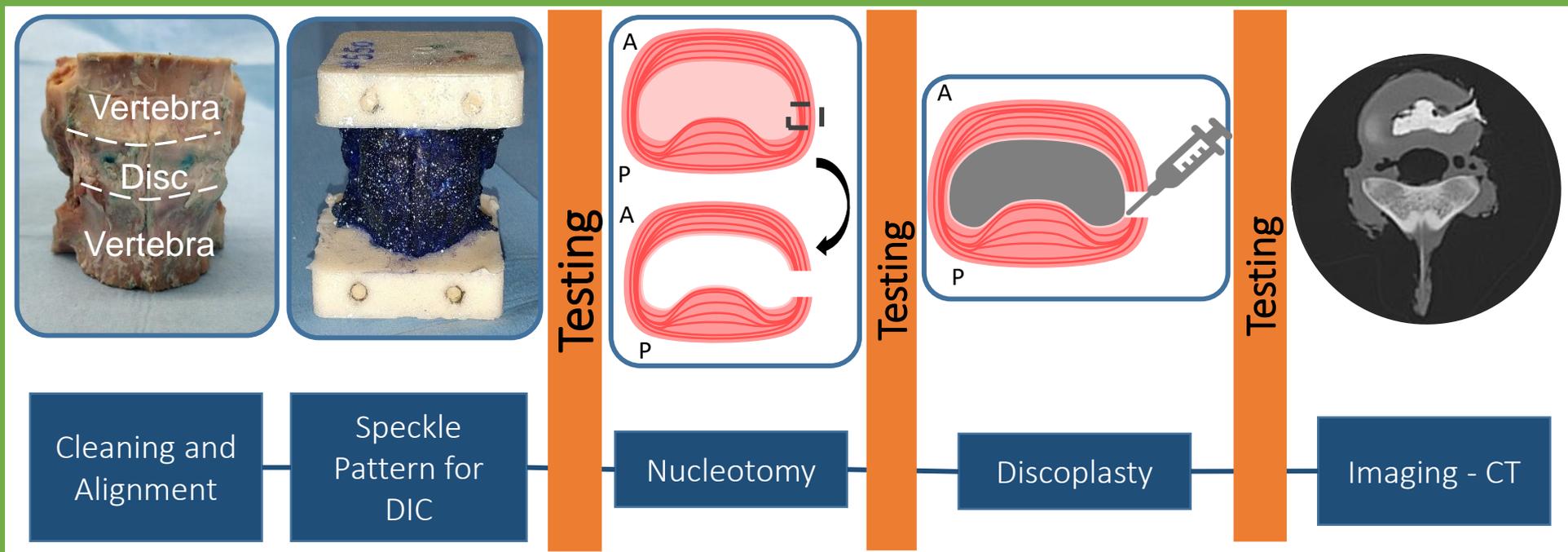
Recognition of features

Differentiation



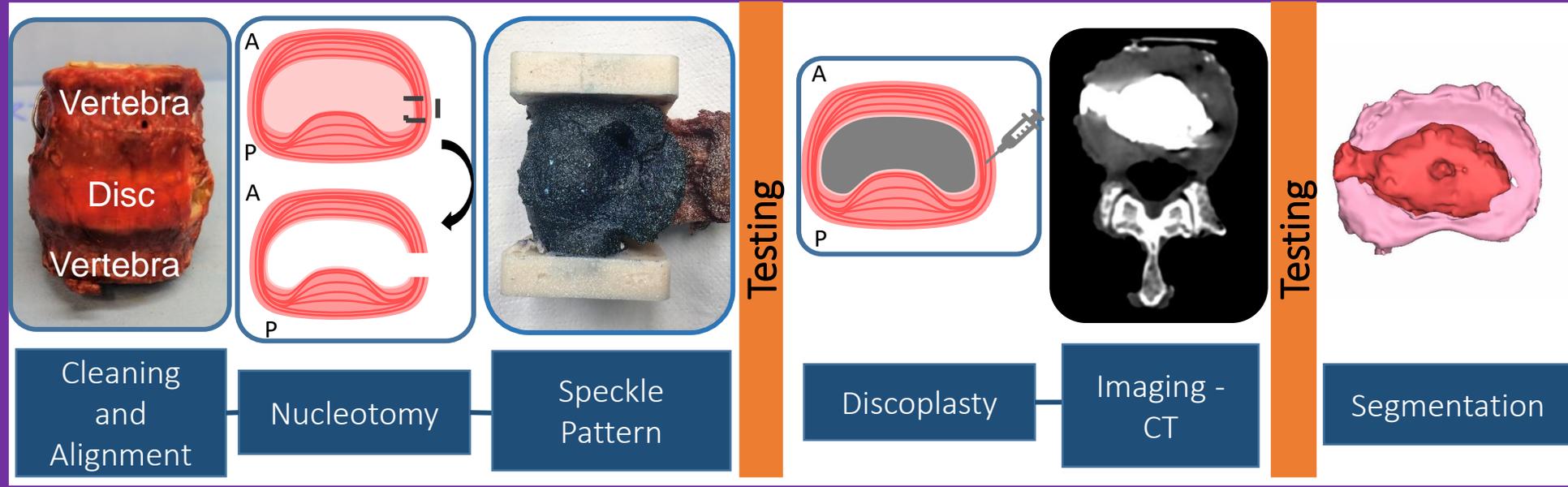


Experimental testing workflow for porcine segments



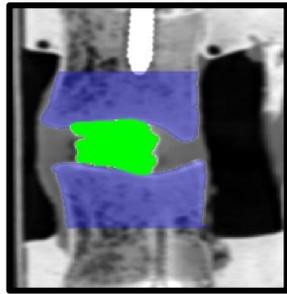


Experimental testing workflow for human segments





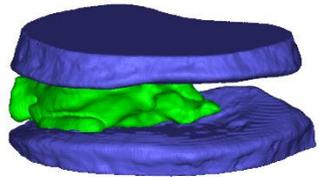
Cement distribution



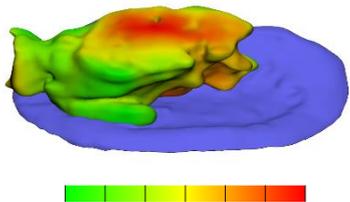
Bony elements

Cement

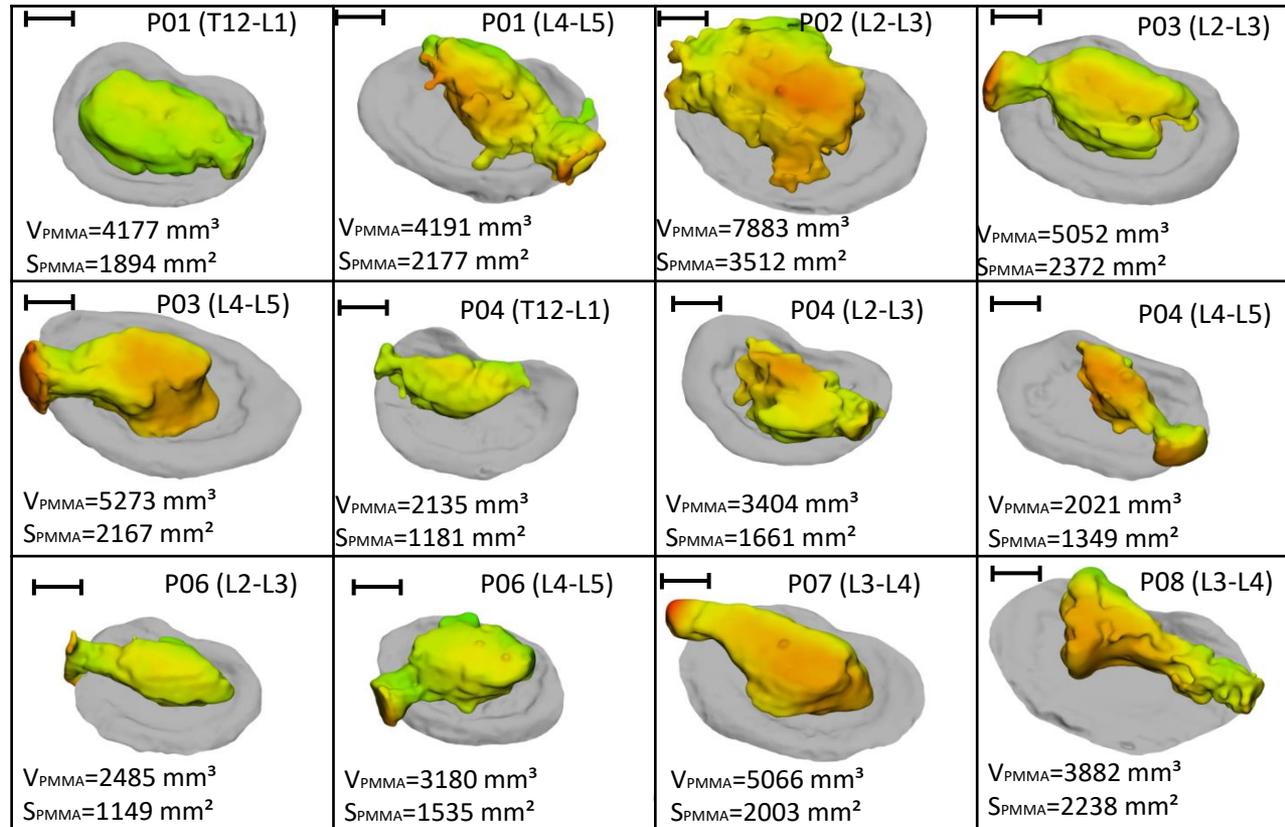
Segmentation of CT scan



Reconstructed, smoothed 3D model

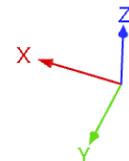


Thickness measurement



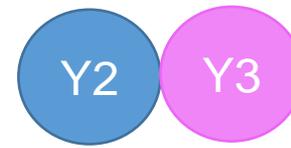
1 cm

Cement Thickness (mm)





Final Event
Tuesday 23rd November 2021

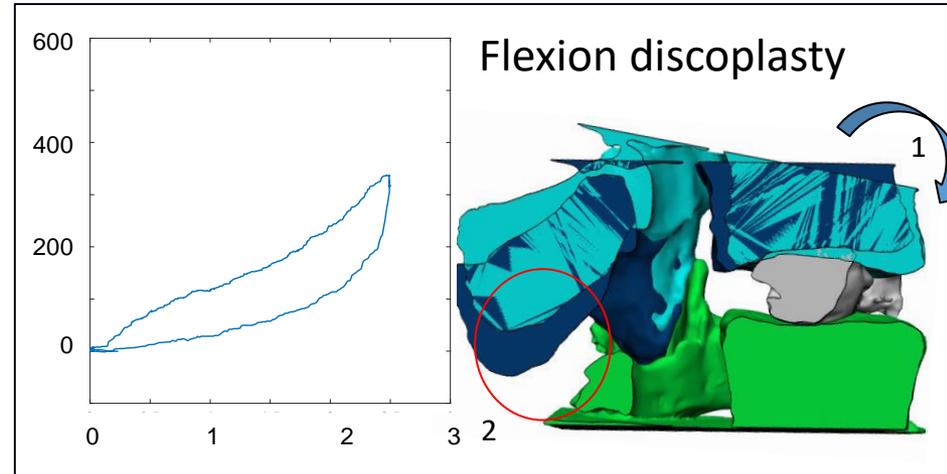
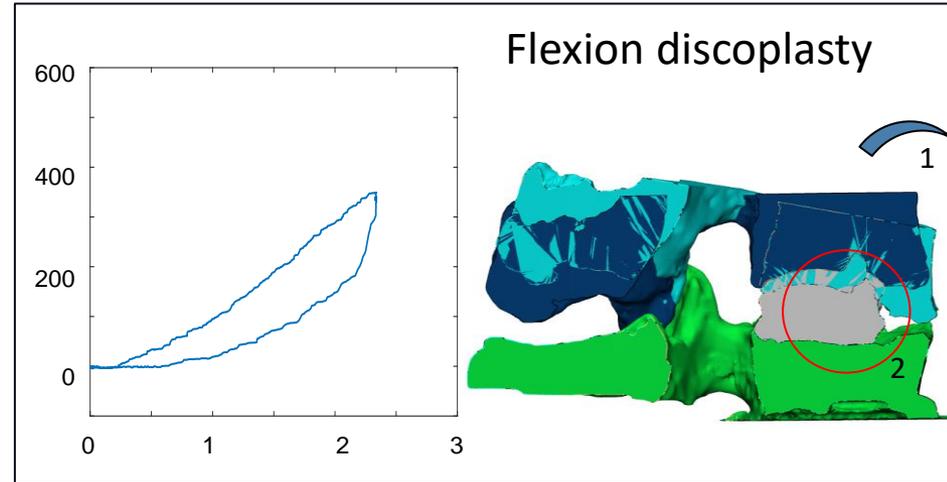
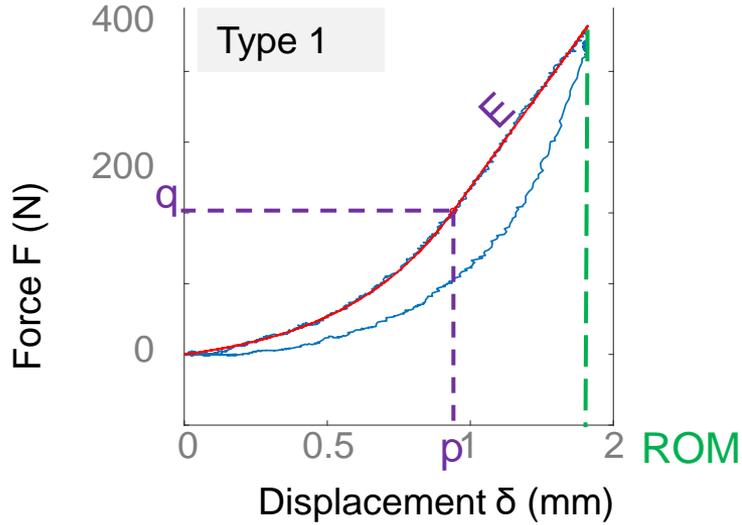


Posterior Disc Height and Cement thickness

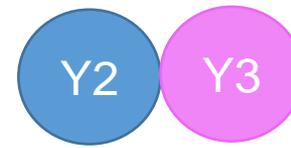
- Significant increase of disc height after discoplasty
- No impact of spine level on the change of Posterior Disc Height
- Correlation between the Disc height and the cement distribution main feature



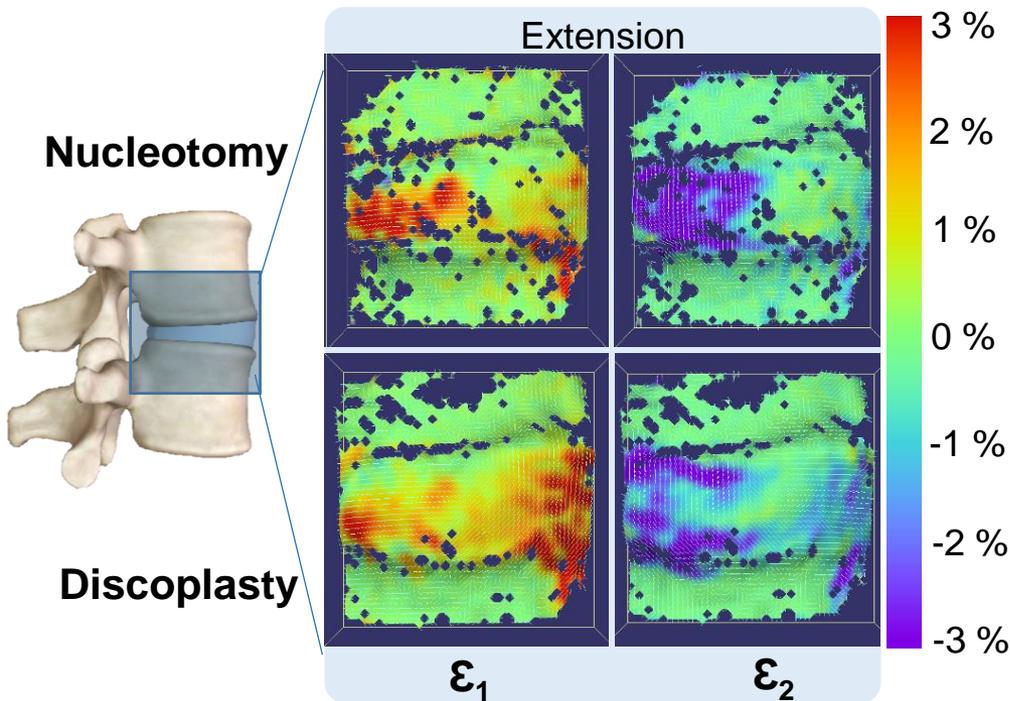
ROM & stiffness



- Increase of the stability in Flexion
- Reduction of the mobility in Flexion
- Reduction of the laxity zone for both motions



Strain distribution



- Reduction of the peak strains over the surface
- Strain distribution smoothed after discoplasty
- No sign of abnormal strain concentrations after discoplasty

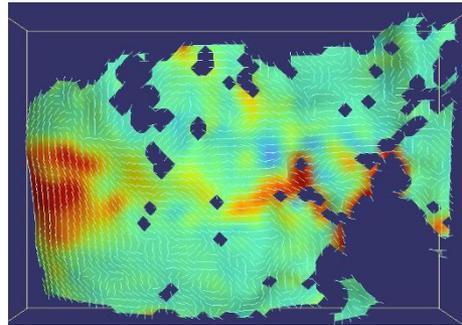


Analysis of the foramen space

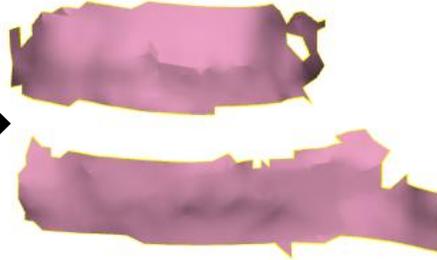




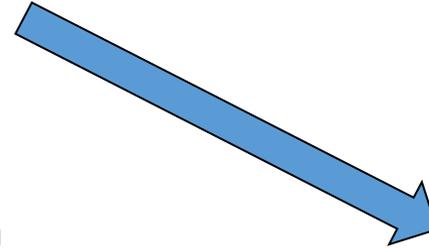
3D segment geometry in loaded pose



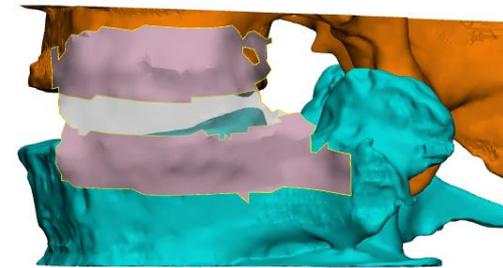
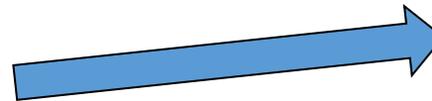
DIC correlation (*peak load*)



Vertebra identification



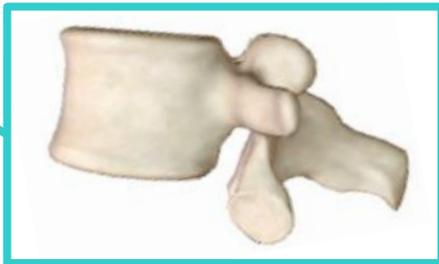
REGISTRATION
(Hausdorff Distance)



Reconstruction of the segment
(*peak load*)



CT scan
(*zero load*)



Segmentation of the vertebrae



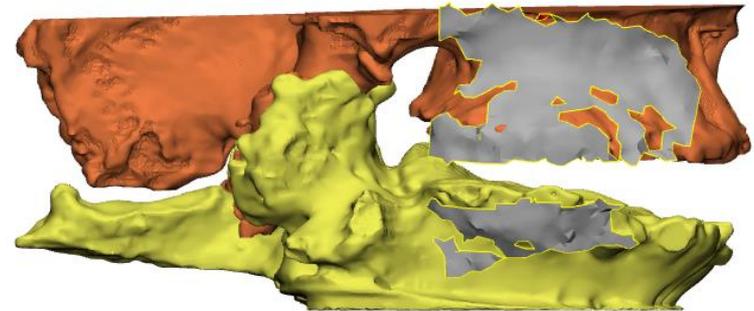
Discussion: Accuracy of the workflow

Intra- and inter-rater accuracy of the registration:

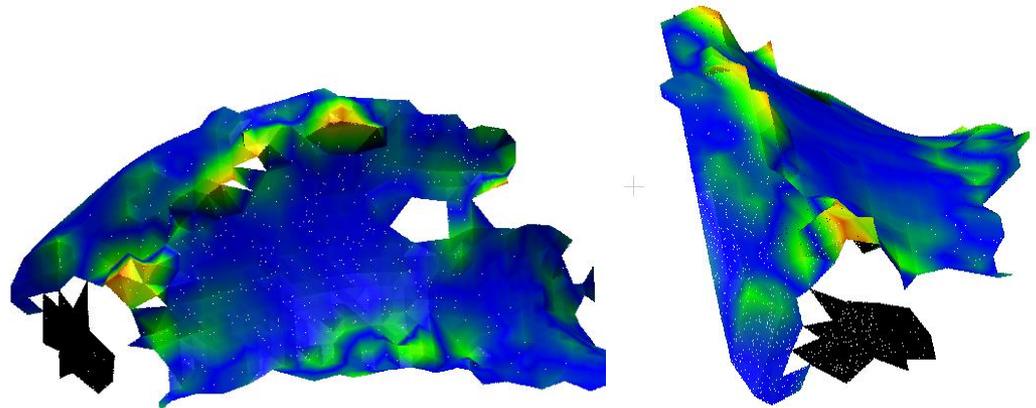
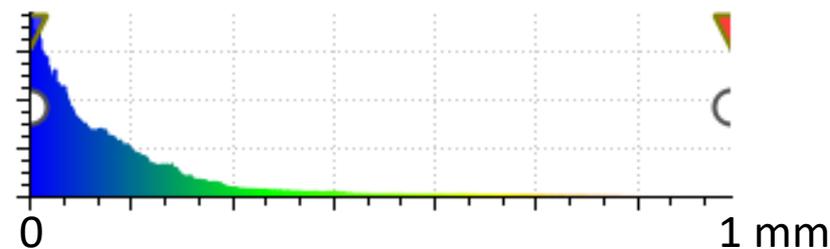
- Hausdorff Distance between repetitions of the registration for each DIC mask

Limiting factors for accurate registration:

- DIC mask surface



- DIC mask roughness (size and number of asperities)





Final Event
Tuesday 23rd November 2021



spinner
next generation spine experts

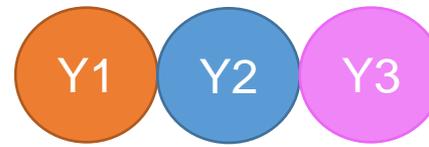
Conclusion

Aim 1: Understanding the biomechanics of the segment following discectomy

- Confirmation of the disc height increase after discectomy
- Increase of the segment stability after discectomy specially for the small motion angle
- More significant limitation of motion in flexion than extension
- Recovery of the strain distribution on the disc surface similar to healthy condition



Final Event
Tuesday 23rd November 2021



Conclusion

Aim 2: Exploring the impact of surgery on patients to predict surgical outcome

- Cement thickness has a direct impact on the disc height recovery and the ROM
- Similar cement distribution characteristics were found for similar biomechanical behaviours → restriction of the potential surgical outcome
scenari analysing the initial vacuum and the injection during surgery
 - Better surgical planning (site of injection, future stabilization...)
 - Integration of the patient limitations (endplate weakness, scoliosis...)



Final Event
Tuesday 23rd November 2021



spinner
next generation spine experts

Conclusion

Aim 3: Detect potential sign of potential tissue overloading

- Leakage in vertebra in 7 specimens on 27; 0 leakage in the neural canals
- Strain on the disc did not show any abnormal distribution
- Local strain extrema generally reduced, so no sign of potential disc tissue damage, although some specimens exhibited higher strain values



Final Event
Tuesday 23rd November 2021



Publications

Journal papers until now:

C. Techens, M. Palanca, P. E. Eltes, A. Lazary, et L. Cristofolini, « Testing the impact of discoplasty on the biomechanics of the intervertebral disc with simulated degeneration: an in vitro porcine study », Med. Eng. Phys., juill. 2020, doi: 10.1016/j.medengphy.2020.07.024.

Peter Endre Eltes, Laszlo Kiss, Ferenc Bereczki, Chloe Techens and al., « A novel three-dimensional volumetric method to measure indirect decompression after percutaneous cement discoplasty », J. Ortho. Trans., 2021, 10.1016/j.jot.2021.02.003

Under review, Europ Spine J: C. Techens, S. Montanari, F. Bereczki, P. E. Eltes, A. Lazary, et L. Cristofolini, « Biomechanics of degenerated intervertebral discs after treatment with discoplasty: an in vitro study »



Final Event
Tuesday 23rd November 2021

spinner
next generation spine experts

Dissemination

- ESB 19
- ESB-ITA 19
- ESB 21
- 8th Hungarian Biomechanics Conference
- BioMedEng 21
- 41st SICOT Orthopaedic World Congress
- Eurospine 2021
- Global Spine 2021