Marie Skłodowska-Curie Actions (MSCA)
Innovative Training Networks (ITN)
H2020-MSCA-ITN-2017

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SPINe: Numerical and Experimental Repair Strategies
Management Meeting
Friday, 23rd October 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 766012

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Modelling for spinal surgeries

ESR5: Marco Sensale

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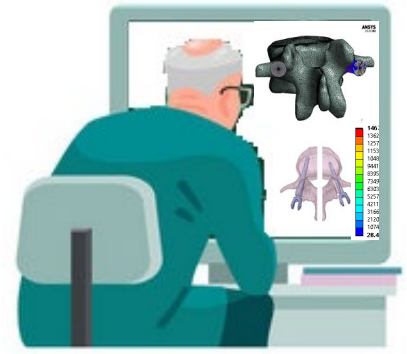
Modelling for spinal surgeries

Vertebral fracture

CT-scan images



The goal of the project is to develop CT-based **efficient planning** and **intra-operative tools** to be used by surgeons to improve the outcomes of spinal surgeries

Thoracolumbar burst fractures (TBF)

[2]

- Societal burden of vertebral fractures exceeded only by hip fracture [1]
- TBF 30 % of total share[2]
- Falls, motor or sport accidents [3]
- Typically at lumbar spine [3]

[1] Schousboe 2015, [2] Magerl et al. 1994, [3] Oprel et al. 2010, [4] Kumar et al. 2005, [5] Wang et al. 2017

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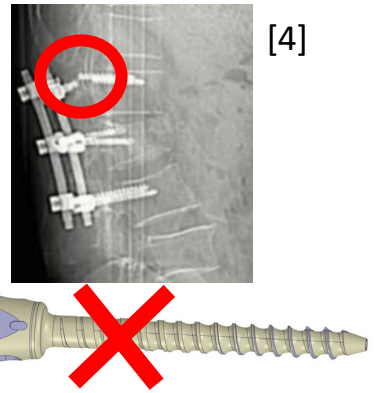
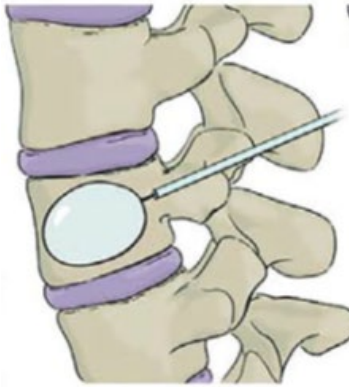
Minimally invasive techniques

Posterior fixation

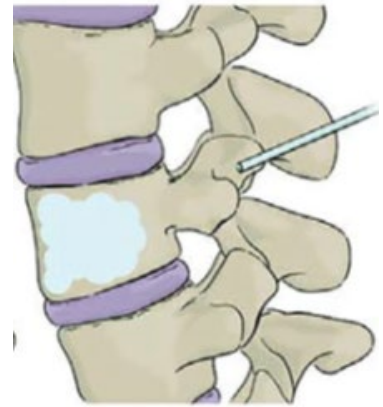


[4]

Kyphoplasty



[5]



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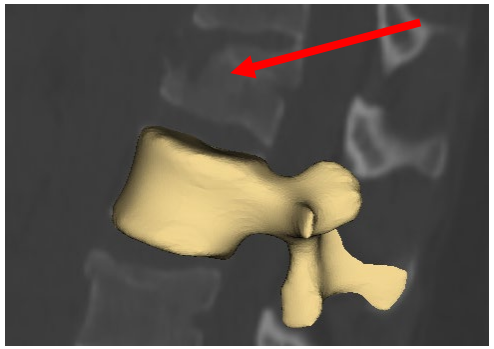
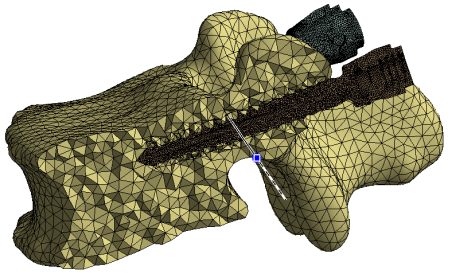
Two modelling approaches

Biomechanical modelling

Goal: to optimize the outcomes of posterior screw fixation



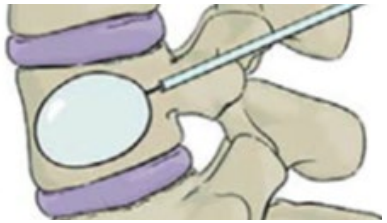


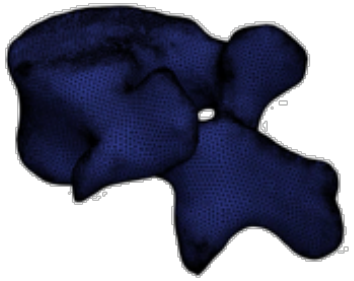
- Sensitivity analyses of FE models
- RBF Morphing
- Reduced order modelling

Statistical shape modelling

Goal 1: to predict the pre-fracture shape of a lumbar verterbra to optimize kyphoplasty

Goal 2: pre-processing of FE pipeline





- Gaussian free form deformation models
- RBF Morphing
- Machine learning techniques

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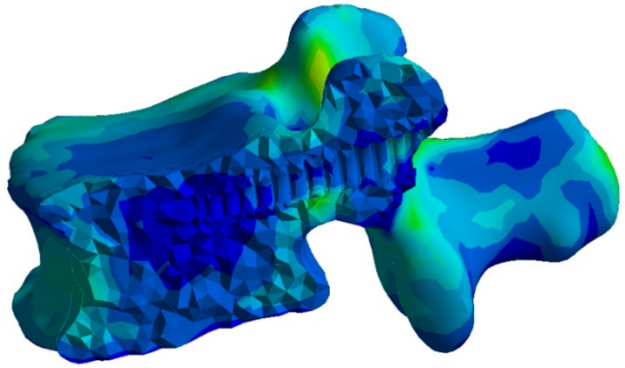
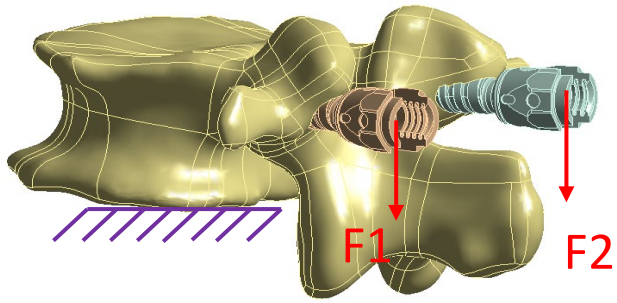
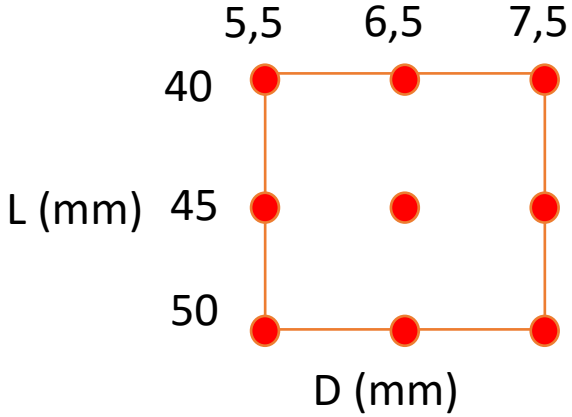
Methods

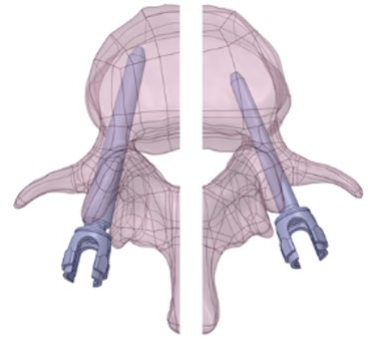
FE model of one instrumented lumbar vertebra with heterogeneous material properties subjected to body weight



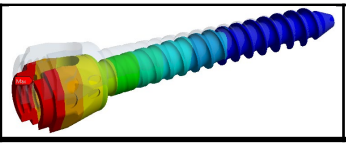
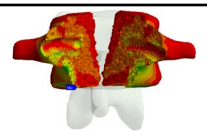


Verification and sensitivity analyses





Metrics

Max deflection Screw		Max σ_{VM} Screw		Min ε_{p3} Bone	

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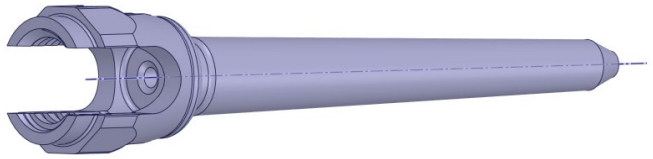
Results

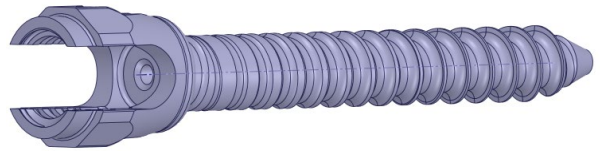
Sensitivity analysis

Max σ_{VM} Screw

		Diameter		
		7.5 mm	6.5 mm	5.5 mm
Length	40 mm	-	=	+
	45 mm	-	REF	+
	50 mm	-	-	+

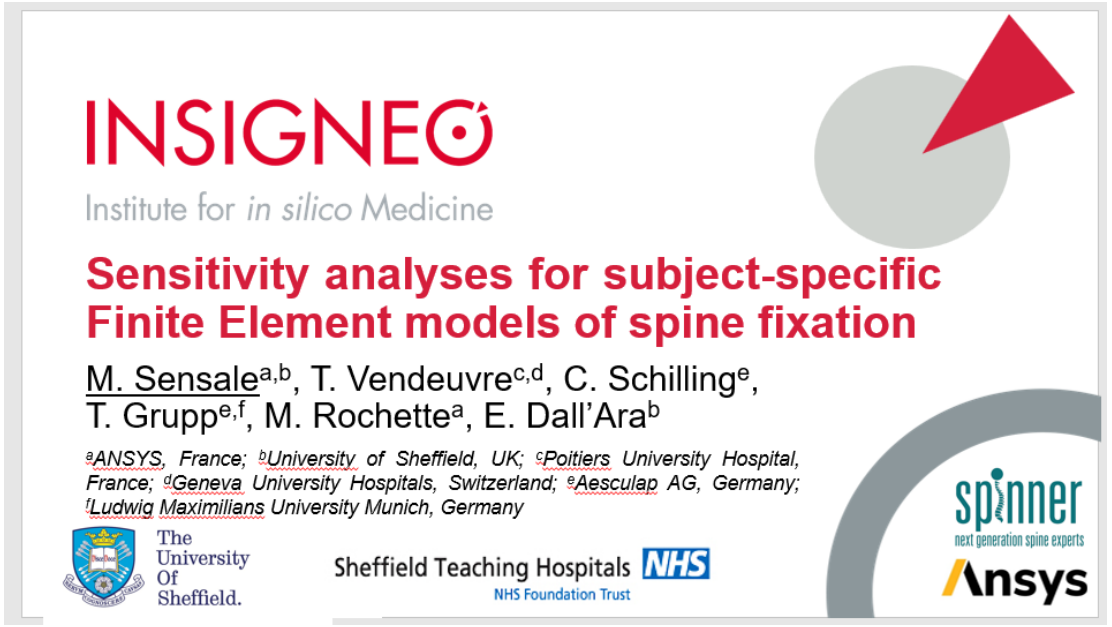
		Diameter		
		7.5 mm	6.5 mm	5.5 mm
Length	40 mm	-	+	+
	45 mm	-	REF	+
	50 mm	-	-	+





Scientific outcomes

Oral presentation at an international conference



Submission to international journal:

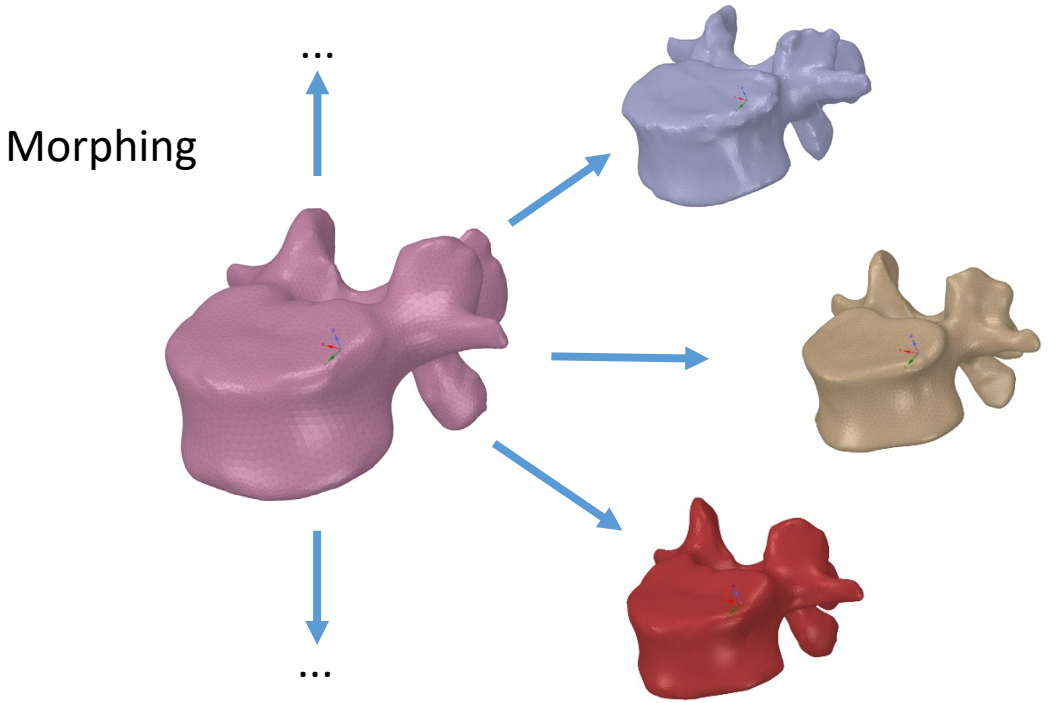
Sensale, M., Vendeuvre, T., Schilling, C., Grupp, T., Rochette, M., Dall'Ara, E.. Tentative title: *"Sensitivity analyses for patient-specific Finite element models of posterior fixation"*

Special research topic of Frontiers in Bioengineering and Biotechnology (Biomechanics)

frontiers in Bioengineering and Biotechnology

Statistical Shape Modelling

- Morphing techniques to obtain an iso-topological population of vertebrae
- Singular Value Decomposition (SVD) analysis to summarize the variability of the dataset in deformation modes



Challenge: avoid the sliding of nodes to preserve the topology-anatomy correspondence

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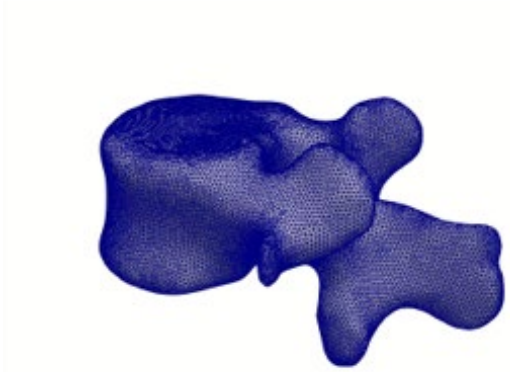
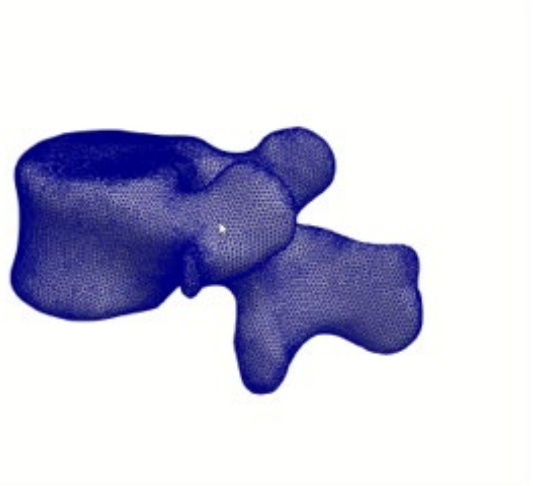
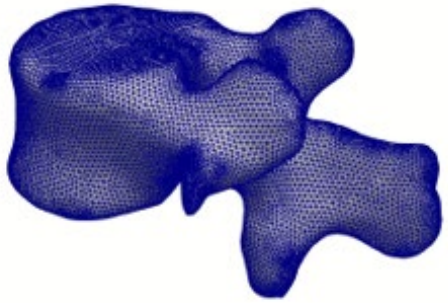
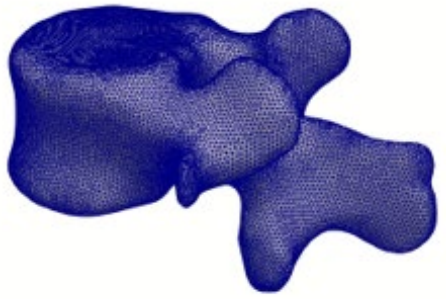
Statistical Shape Modelling

- Same number of nodes
- Same number of elements
- Same connectivity
- Preserved topology-anatomy correspondence









Application of two implemented tools by:

(rbf-morph)™

scalismo

Current works

Biomechanical modelling

- Development of a model with non-linear contact mechanics
- Application of a ROM-based Ansys approach
- Application to different patients

Statistical shape modelling

- Morphing of T12, L1 and L2
- Development of an SSM of T12, L1 and L2
- Machine learning techniques to predict the shape of L1 from the shape of T12 and L2

Acknowledgments

Tanguy Vendeuvre
Marco Biancolini

Supervisors:
Michel Rochette
Enrico Dall'Ara

Thomas Grupp
Christoph Schilling

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