



Centre for Health Engineering CNRS UMR 5146 – INSERM IFR 143

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Identification of the material parameters of soft tissues in the compressed leg



Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

Conclusion

Prospects

Acknowledgements



Introduction

Context

- Calf: a peripheral heart
- Different types of treatments by compression
- Towards patient-specific compression

FE model

- Geometry and meshing
- Model specifications
- Constitutive equations
- Identification
- Identification results
- Results
- Results
- results

Conclusion

- Prospects
- Acknowledgements



Veinous diseases



Sportspeople





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

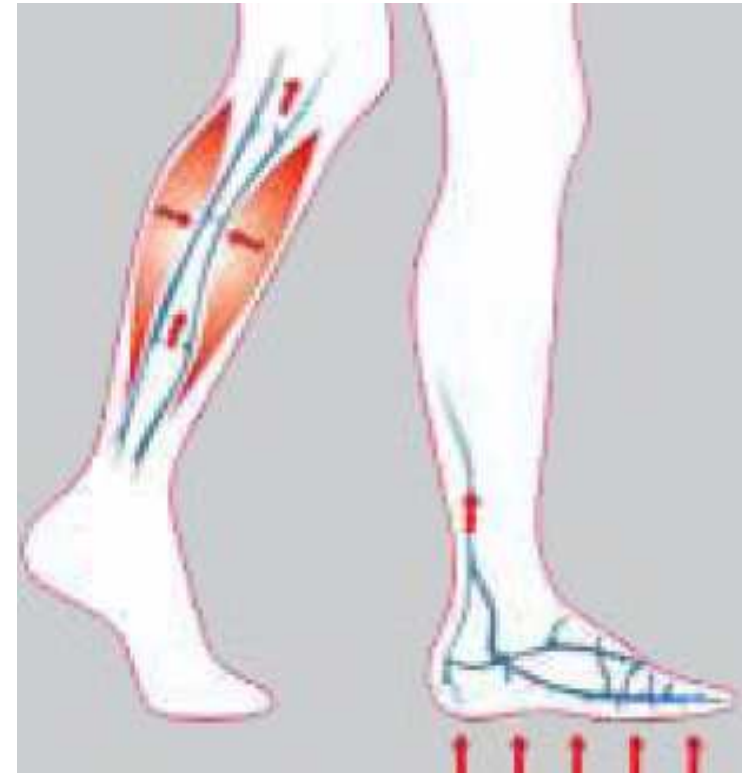
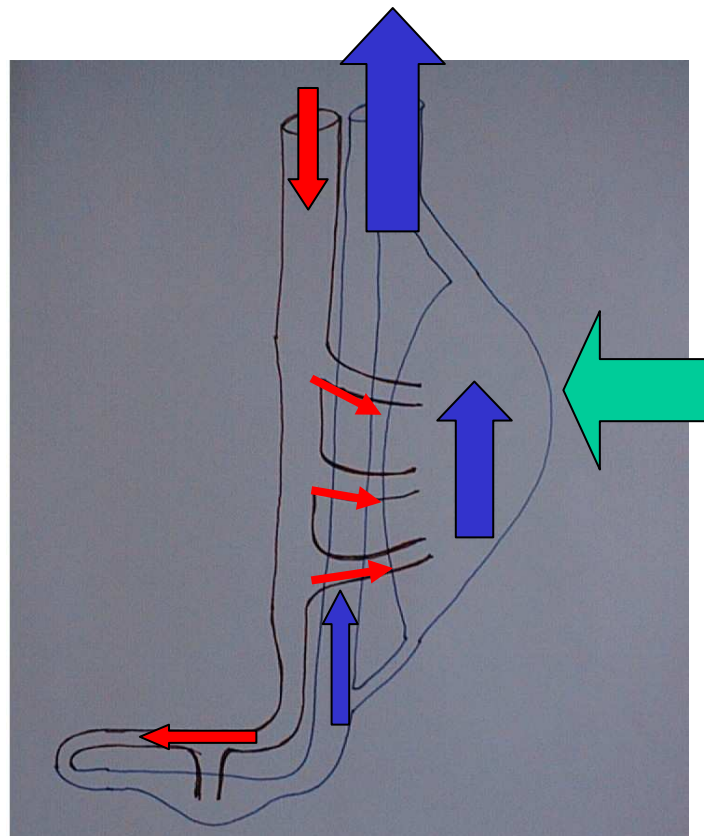
Results

results

Conclusion

Prospects

Acknowledgements



[P. Ducrozet. *Booster study*. PhD thesis, Université Jean Monnet, Saint Etienne, 2004]

[S. Couzan, P. Mismetti, S. Laporte, J.F. Pouget, E. Gauthier, D. Brisot, I. Quere, A. Leizorovicz. *CE-Prog study*. Saint-Étienne, 2009]



Introduction

Context

Calf: a peripheral heart

Different types of treatments by compression

Towards patient-specific compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

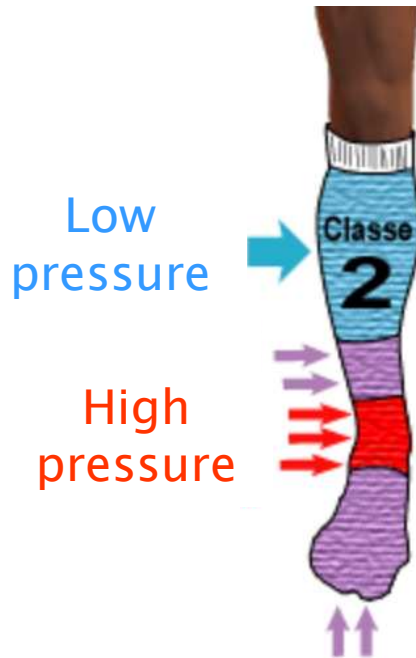
results

Conclusion

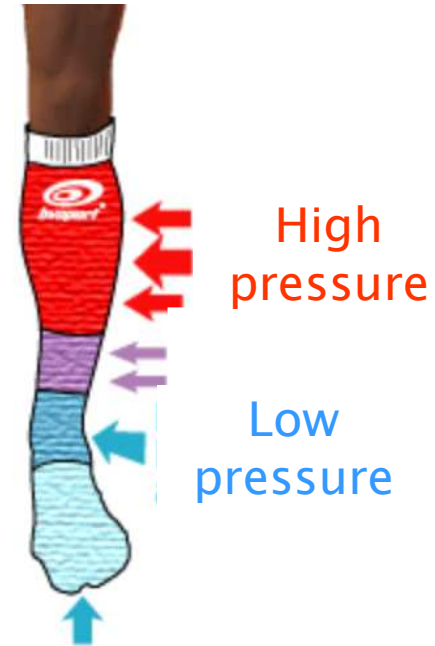
Prospects

Acknowledgements

Conventional compression (compression stockings) (1956)



Progressive compression (BVSport patent) (1997)





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

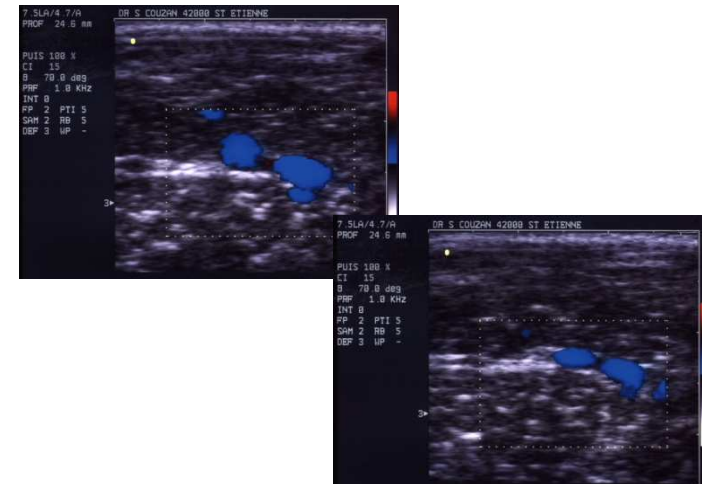
Conclusion

Prospects

Acknowledgements

➤ Device for veinous pressure measurements

➤ Compressionmeter for custom compression



→ Raises mechanical issues:

- Pressure transmission from stockings to soft tissues?
- Mechanical properties of these tissues?
- Pressure field in tissues?



Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

Conclusion

Prospects

Acknowledgements



Introduction

Context

Calf: a peripheral heart

Different types of treatments by compression

Towards patient-specific compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

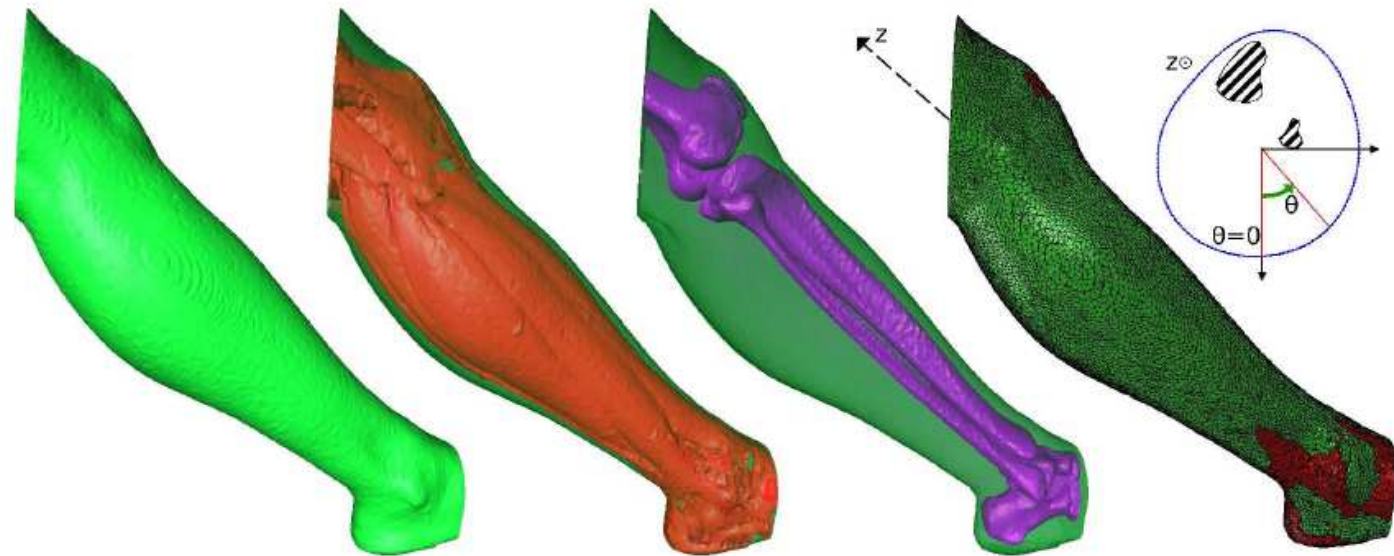
Results

results

Conclusion

Prospects

Acknowledgements



Exterior surface

Muscle surface

Bone surface

FE Mesh



Introduction

Context

Calf: a peripheral heart

Different types of treatments by compression

Towards patient-specific compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

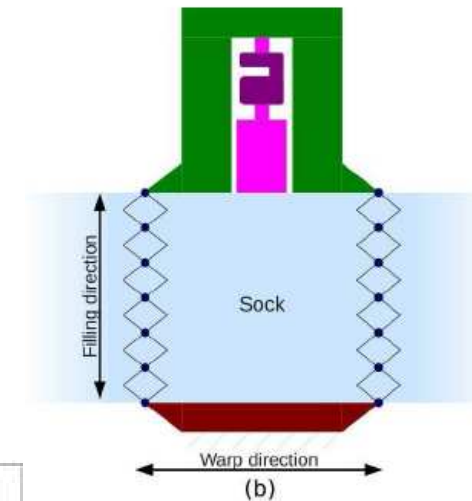
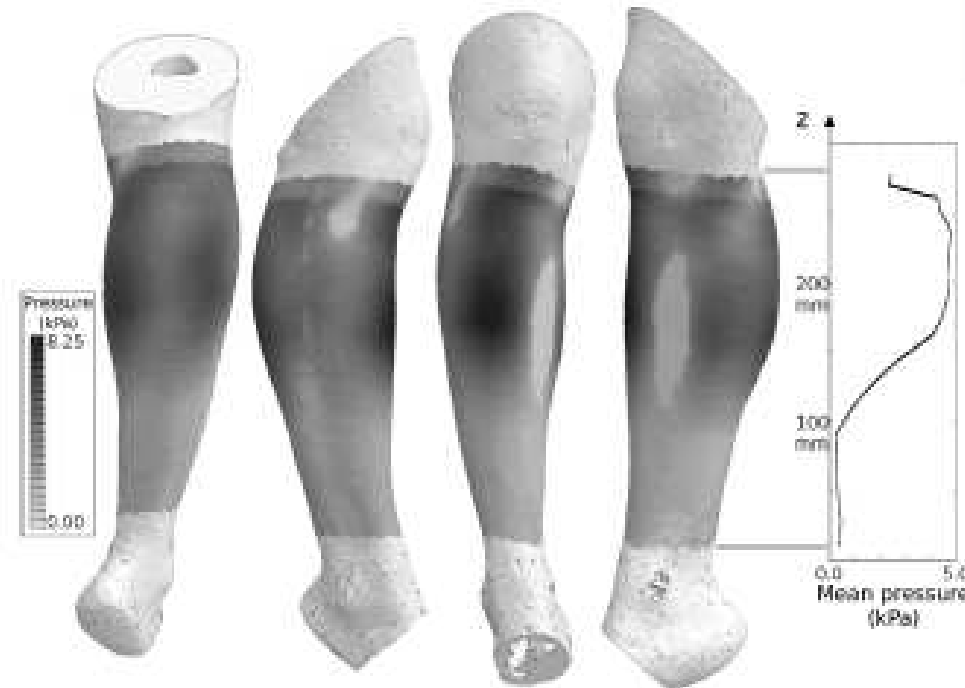
Conclusion

Prospects

Acknowledgements

➤ Boundary conditions

- Bones clamped
- Pressure applied by the stocking
→ Laplace law: $P = T/R_c$





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

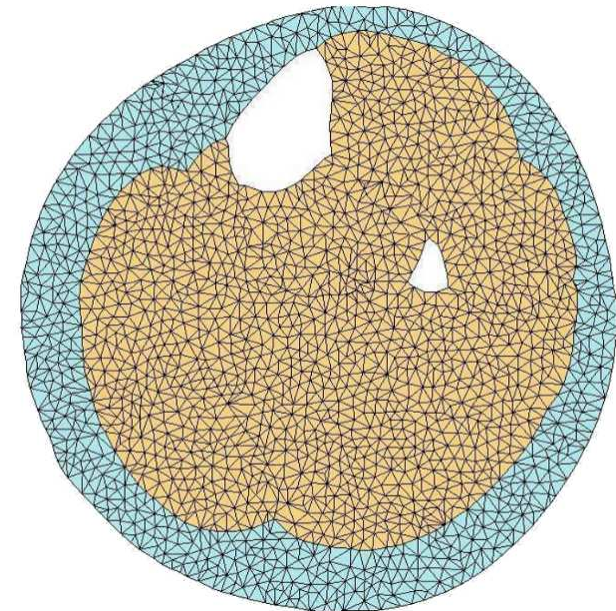
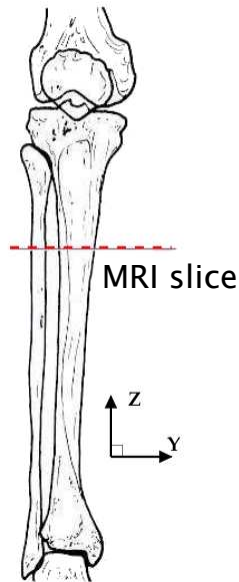
Conclusion

Prospects

Acknowledgements

► Neo-Hookean model

$$W = \frac{G}{2} (\bar{I}_1 - 3) + \frac{K_v}{2} (J - 1)^2$$



[S. Avril, L. Bouten, L. Dubuis, S. Drapier, J-F. Pouget. *Mixed Experimental and Numerical Approach for Characterizing the Biomechanical Response of the Human Leg Under Elastic Compression*. J. Biomechanical Eng. 132, 2009.]



Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

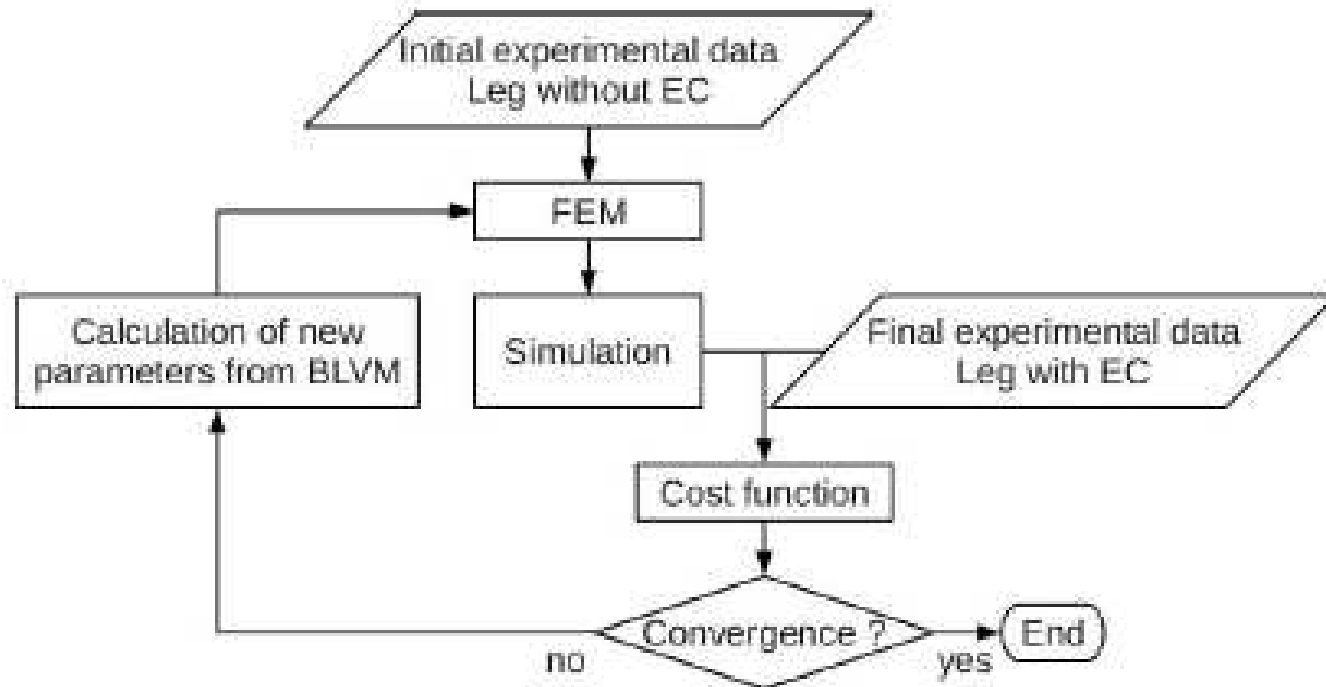
Results

results

Conclusion

Prospects

Acknowledgements





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

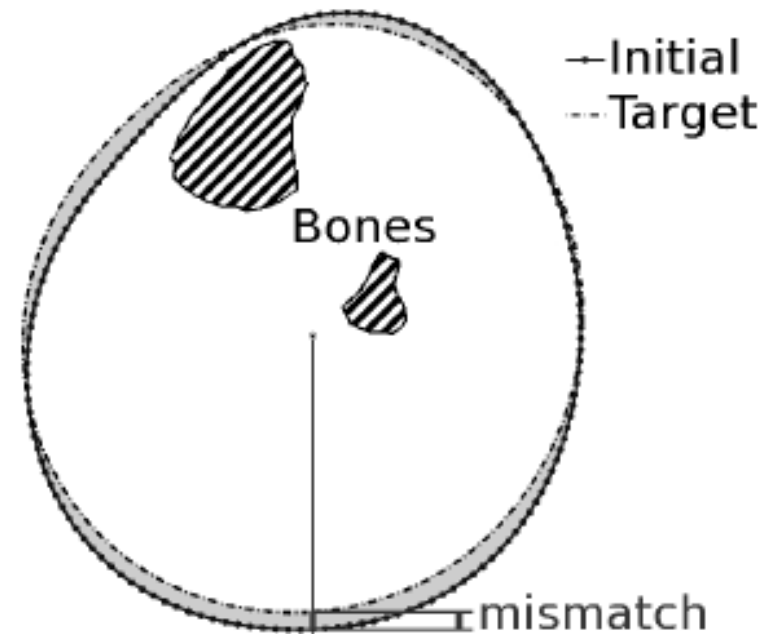
results

Conclusion

Prospects

Acknowledgements

Inverse problem: definition of the cost function





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

Conclusion

Prospects

Acknowledgements

➤ Identified constitutive parameters

Hyperelastic
Neo Hookean model

	Fat	Muscle
C_{10} (kPa)	5	11.5
K (kPa)	1060	1160



Introduction

Context

Calf: a peripheral heart

Different types of treatments by compression

Towards patient-specific compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

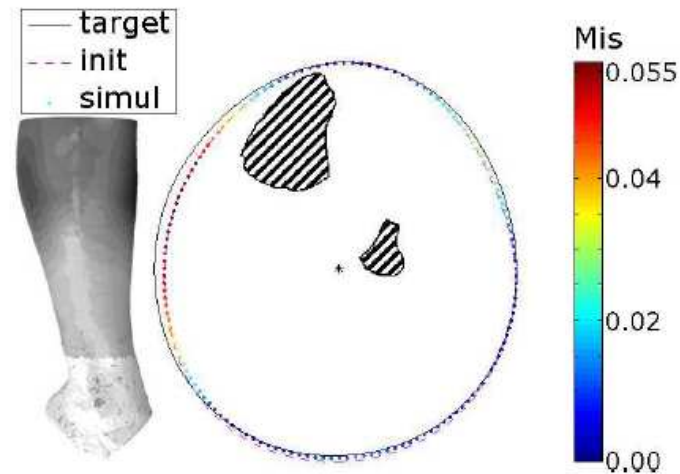
Results

results

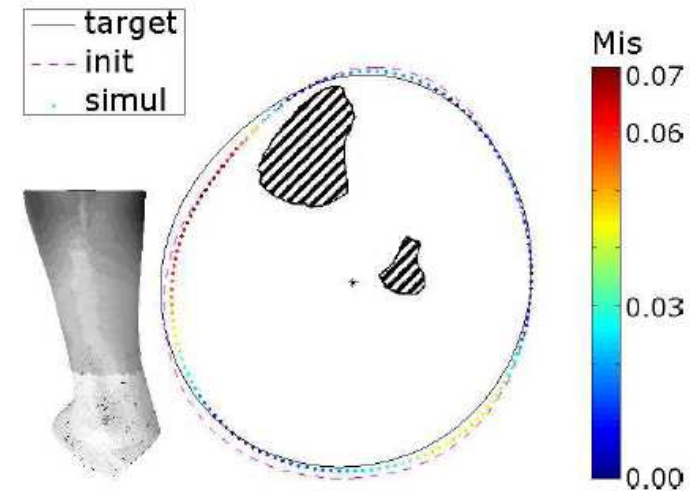
Conclusion

Prospects

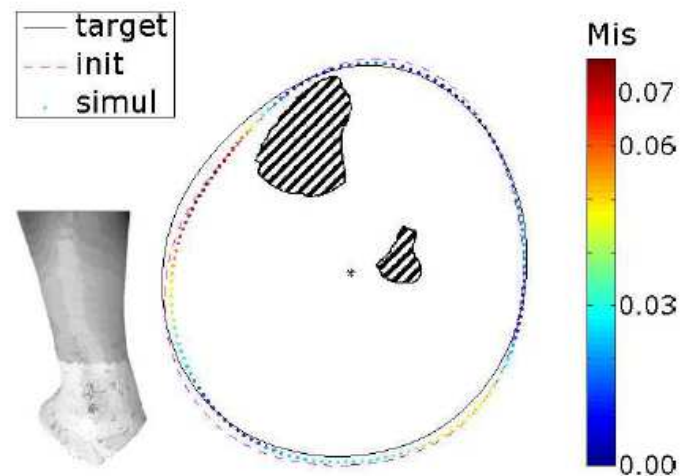
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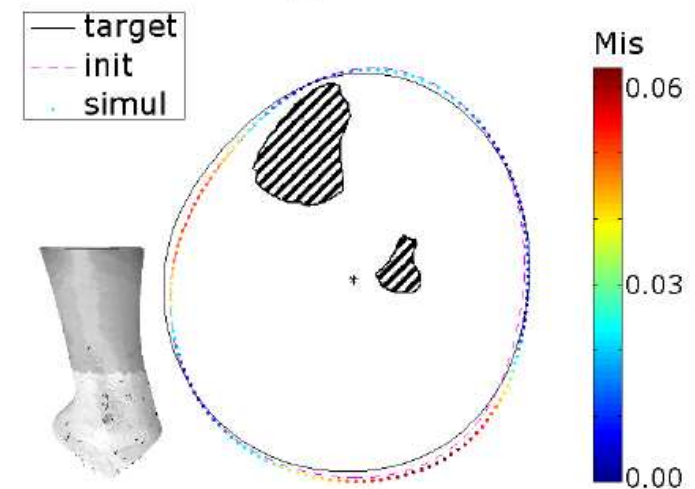
(a) 250 mm



(b) 190 mm



(c) 160 mm



(d) 130 mm



Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

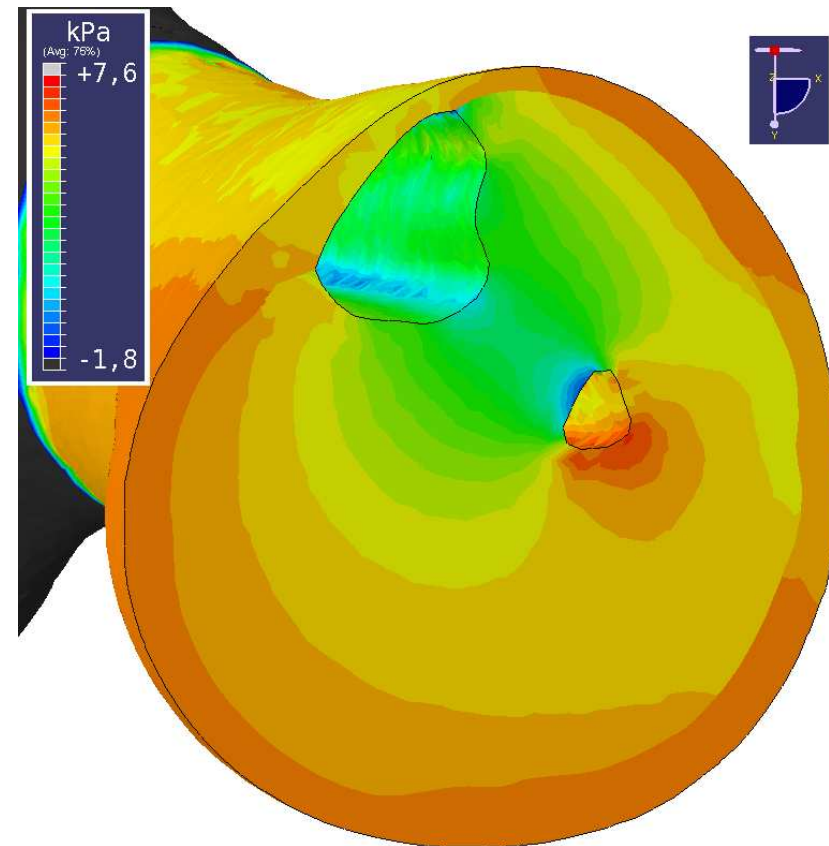
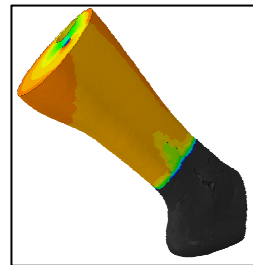
results

Conclusion

Prospects

Acknowledgements

► Hydrostatic pressure





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

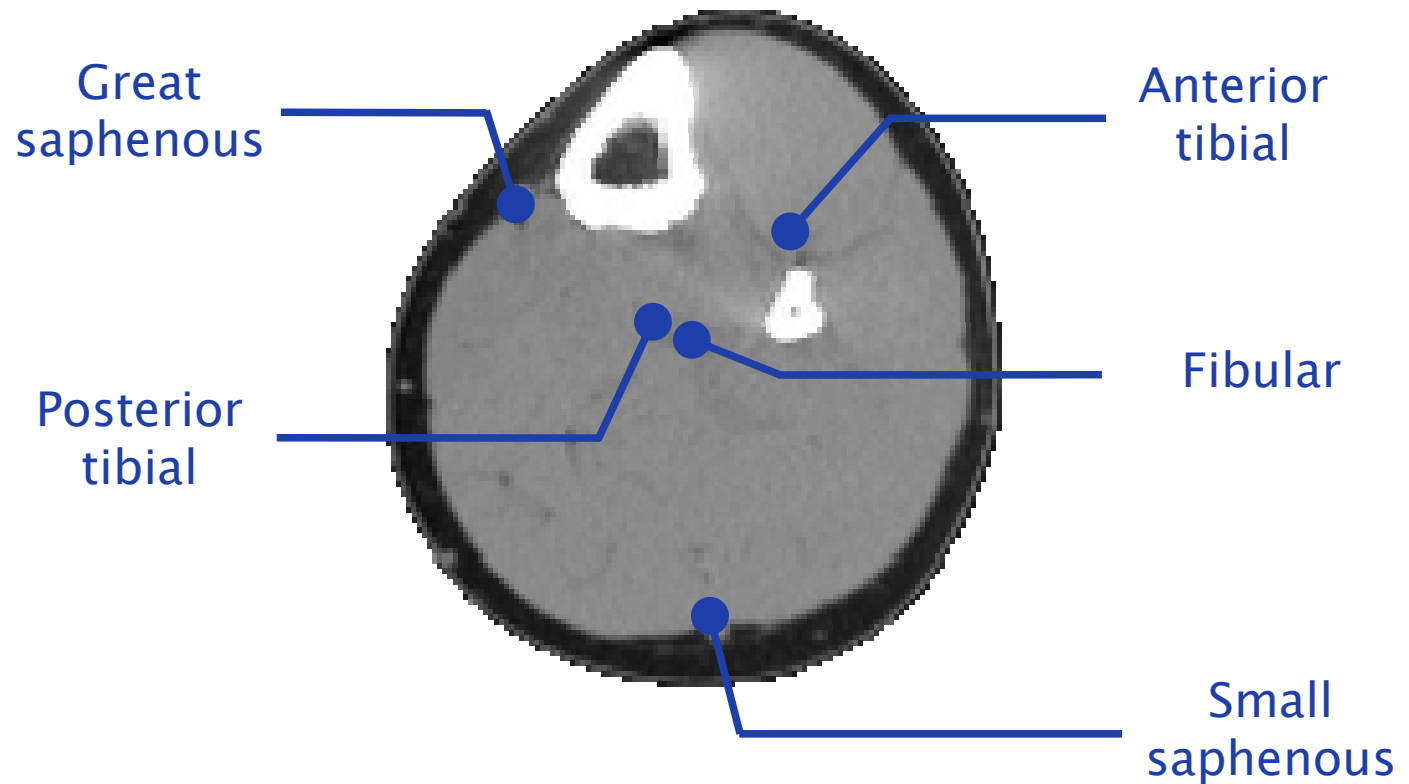
Results

results

Conclusion

Prospects

Acknowledgements





Introduction

- Context
- Calf: a peripheral heart
- Different types of treatments by compression
- Towards patient-specific compression

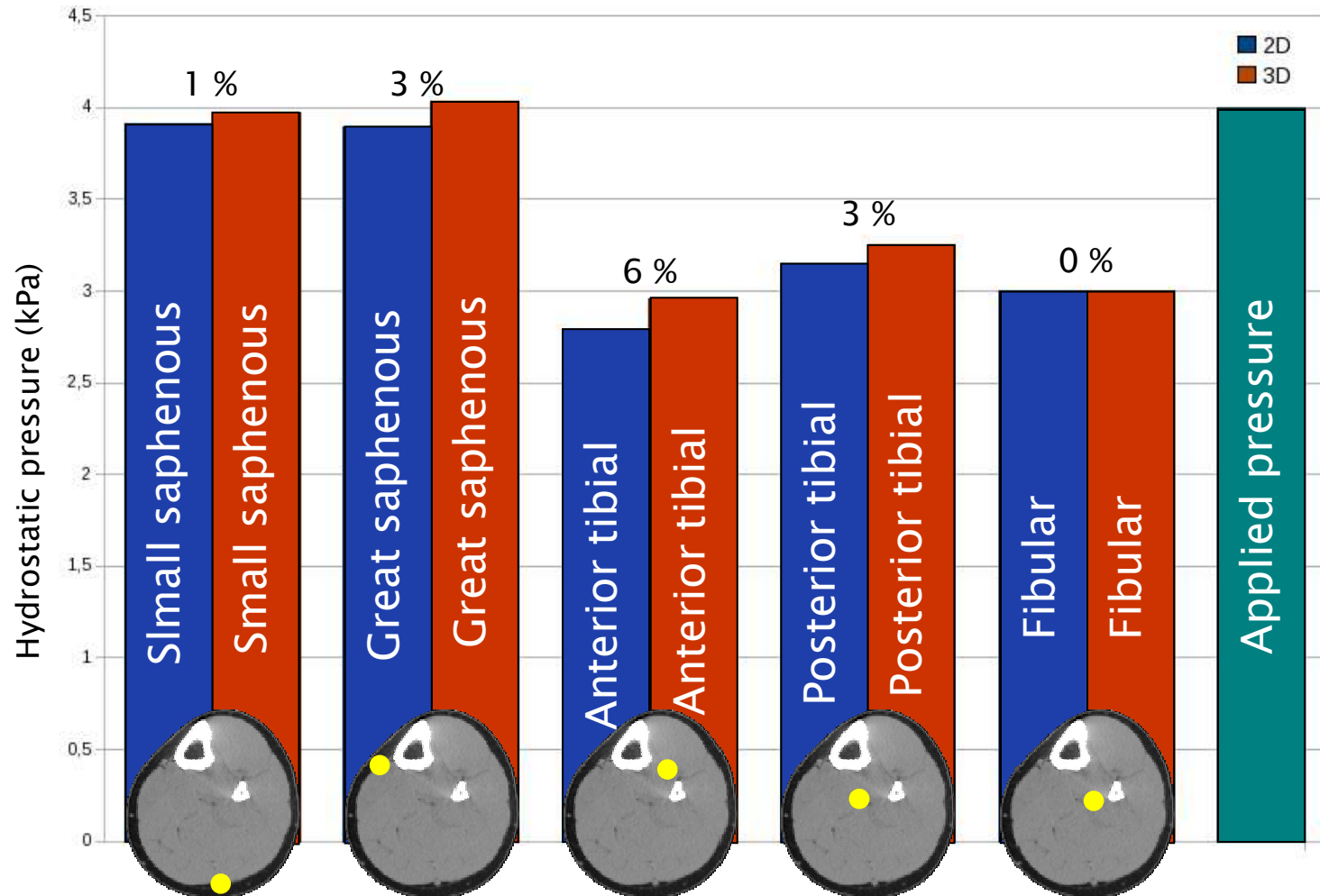
FE model

- Geometry and meshing
- Model specifications
- Constitutive equations
- Identification
- Identification results
- Results
- Results
- Results

Conclusion

- Prospects
- Acknowledgements

► Hydrostatic pressure at different locations





Introduction

Context

Calf: a peripheral heart

Different types of treatments by compression

Towards patient-specific compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

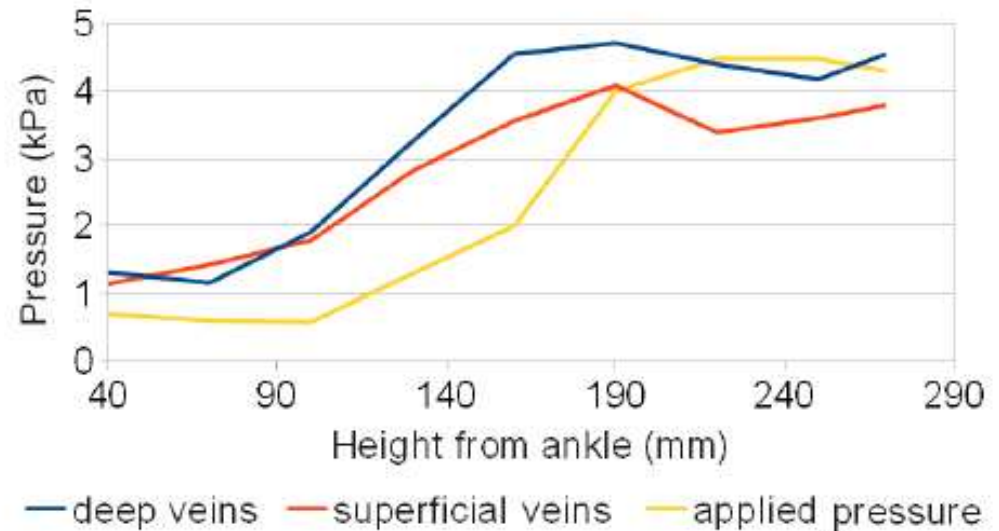
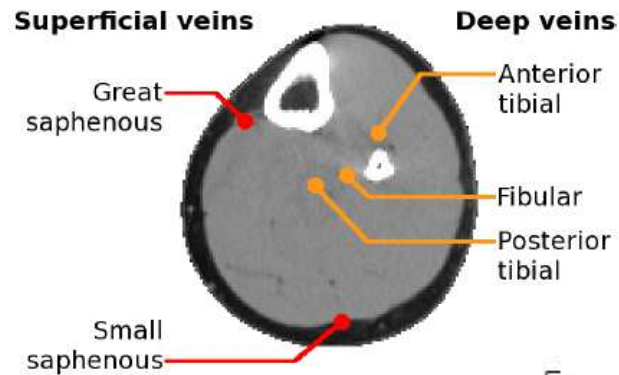
results

Conclusion

Prospects

Acknowledgements

► Hydrostatic pressure at different heights





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

Conclusion

Prospects

Acknowledgements



Introduction

Context

Calf: a peripheral heart

Different types of treatments by compression

Towards patient-specific compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

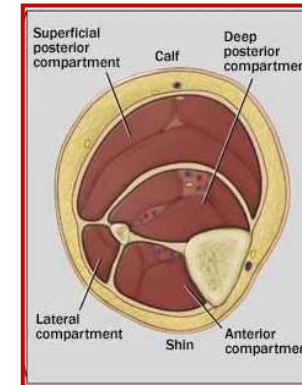
results

Conclusion

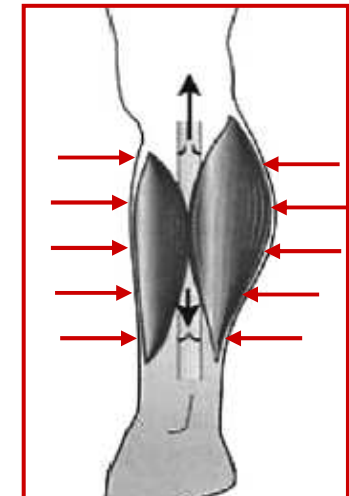
Prospects

Acknowledgements

► Compartments and aponeuroses Interactions and sliding



► Coupling with veinous blood flow Quantification of draining effect





Introduction

Context

Calf: a peripheral heart

Different types of
treatments by compression

Towards patient-specific
compression

FE model

Geometry and meshing

Model specifications

Constitutive equations

Identification

Identification results

Results

Results

results

Conclusion

Prospects

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Students: Laura Bouten & Laura Dubuis

Colleagues: Pierre Badel, Johan Debayle

Physicians: Serge Couzan, Jean-François Pouget

Support: ANR, Région Rhône-Alpes, industry

