

COMPUTER 3D MODELING for CVD & COMPRESSION

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**ICC Annual Meeting 2021
Controversies in Compression Therapy
May 14, 2022 Amsterdam**



Organisation
des Nations Unies
pour l'éducation,
la science et la culture



Chaire UNESCO en
enseignement et recherche
en anatomie numérique
Université Paris Descartes



Université
de Paris



I have no conflict of interest

Interest of 3D modeling

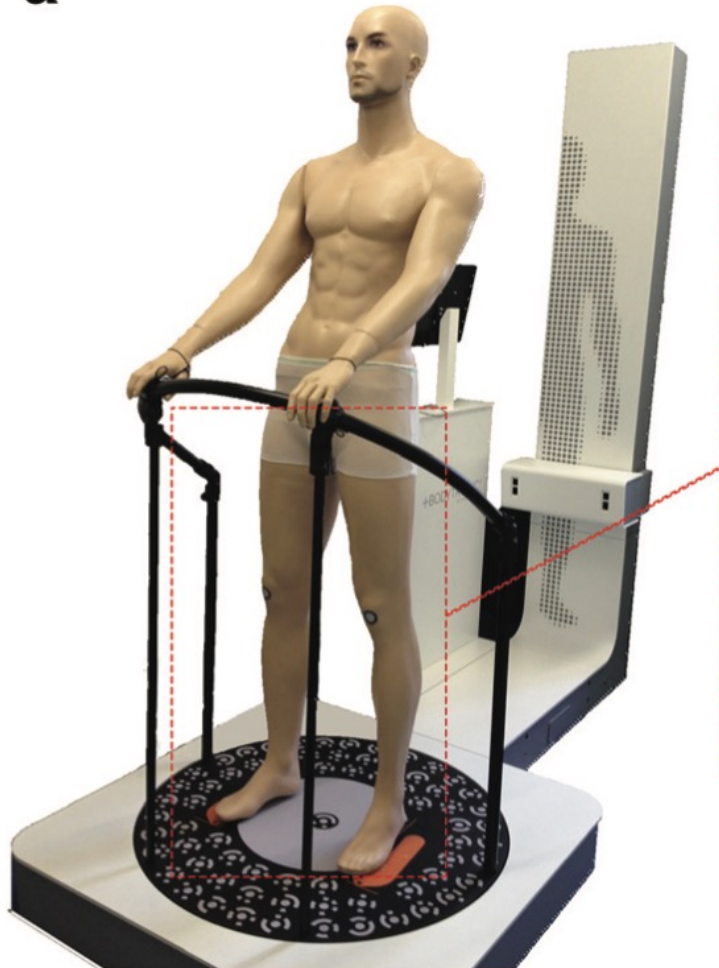
- Customized compression
- Leg volumetry
 - Quantification & topography of venous edema
 - Follow-up of lymphedema
- Venous anatomy under compression

Customized compression

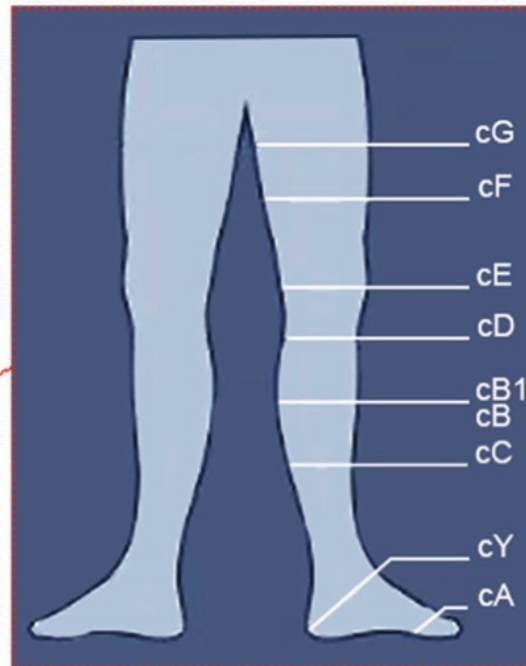
Bodytronic 600[®] (Bauerfeind)

By phogrammetry

a



b



c



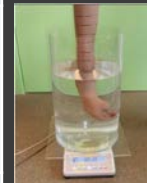
New technique of limb volumetry*

HANDYSCAN 3D (Creaform)

*C. Yahathugoda et al. Use of a Novel Portable 3D Imaging System to Measure Limb Volume and Circumference in Patients with Filarial Lymphedema. Am. J. Trop. Med. Hyg., 97(6), 2017 : 1836–1842

Reminder of leg volumetry techniques

	device	accur	Min.	drawbacks
CT scan		+++		X rays cost
Water displacement ¹	Water tank	++	15	Hygiene issue
Tape measurement ²	Leg-o-meter	+ -	20	Tedious not accurate
Photogrammetry ³	Bodytronic 600	+	2	
Opto electronic ⁴	perometer	+ -	1	Not accurate
3d scan⁵	Peel3D	++	2	-

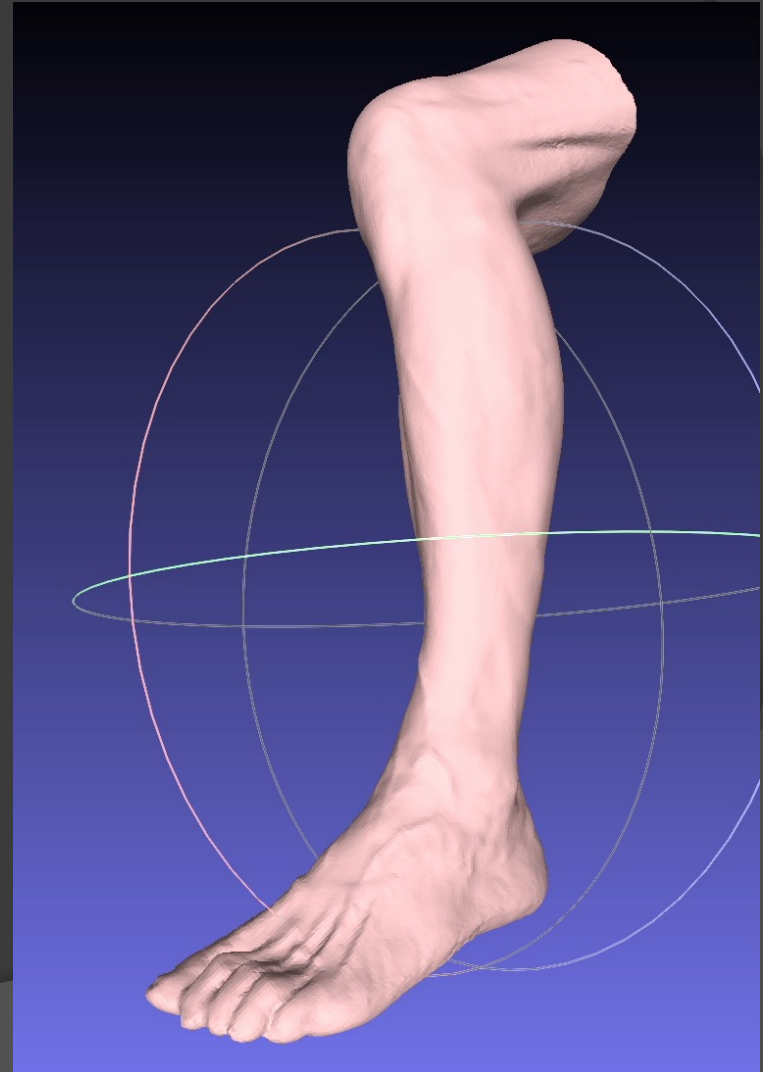


- 1- Eberhard Rabe, Markus Stücker, Bertram Ottilinger Water displacement leg volumetry in clinical studies BMC Medical Research Methodology 2010, 10:5
- 2- Berard A. , Kurz X. , Zuccarelli F. , et al, Reliability study of the Leg-O-Meter, in patients with chronic venous insufficiency of the leg. Angiology 49:169-173, 1998
- 3- Bodytronic 600® (Bauerfeind AG, Zeulenroda, Germany)
- 4- Stanton Awb , Northfield JW , Holroyd B. , et al: Validation of an optoelectronic limb volumeter (Perometer®) . Lymphology 30:77-97, 1997
- 5- Channa Yahathugoda et al. Use of a Novel Portable 3D Imaging System to Measure Limb Volume in Lymphedema Am. J. Trop. Med. Hyg., 97(6), 2017 : 1836–1842

Quantification of limb volume

By handheld 3D high resolution surface scanner

Accuracy 0.1 mm – quick - reproducible



protocole Handyscan peel3D

Targets and skin landmarks



Handyscan peel3D

device

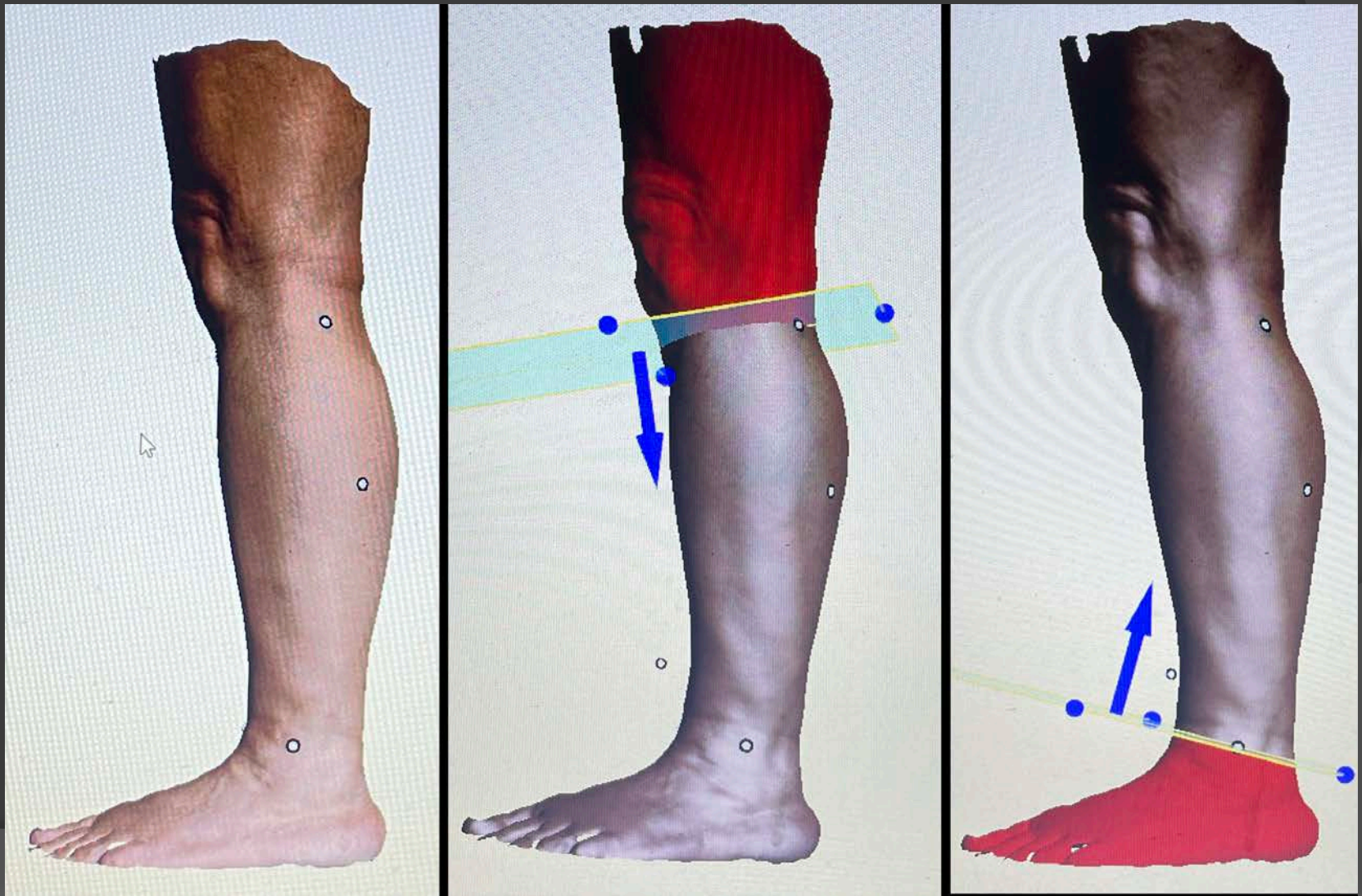


LL/UL scanning = 2 minutes



Volume computing

Cutting planes with the targets



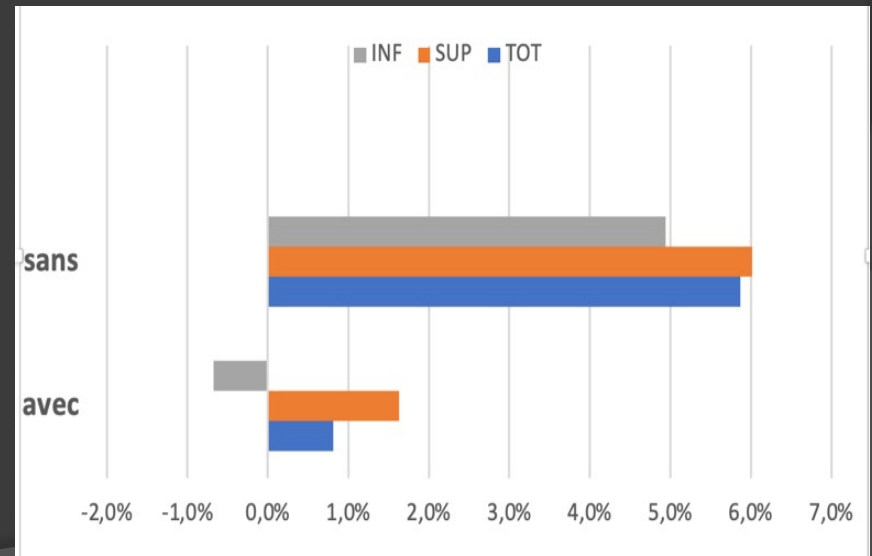
First results on leg edema

Variation coefficient between the 3 measurements of the leg volumes calculated on 222 scans and 600 volumetrics: **0.5%**

Assessment of the **vesperal edema** on 13 normal subjects: Variation between morning and evening from 10 ml to 180 ml (**0.5% to 7%**)

Effect of a 15-20 mm Hg sock vs no compression during the day (12 legs)

Volume reduction **6% vs 1%**
120 ml vs 15 ml
more seen on the **lower half** of the leg



INDICATIONS

Quantification of edema:

- Venous edema
- Lymphedema
 - Lower limb
 - Upperlimb

3D modeling of Venous anatomy

3D modeling & printing of Venous anatomy by CT venography

How to 3D print a angio-CT?

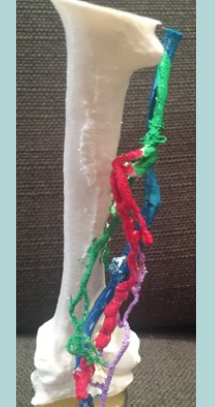
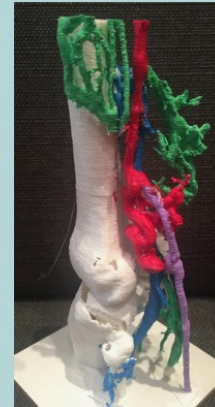
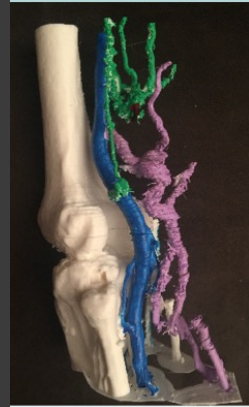
Angioscanner

Coupes DICOM

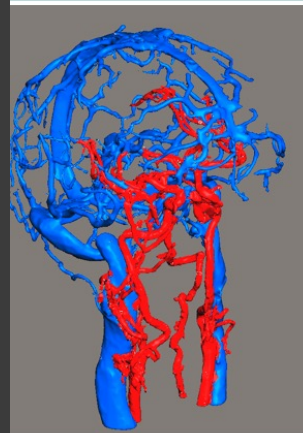
Horos[®] software
3d vectorial model

Meshmixer[®]
Cleaning repairing

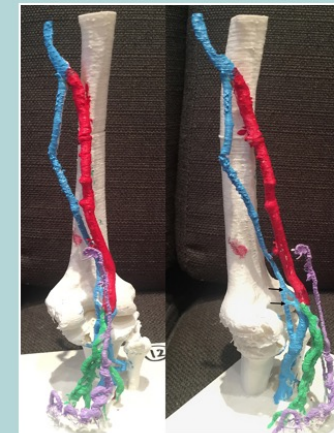
CURA[®]
3D printing



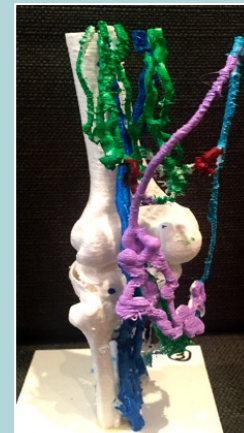
Anatomical variations of the popliteal fossa



brain vessels



Duplication of FV

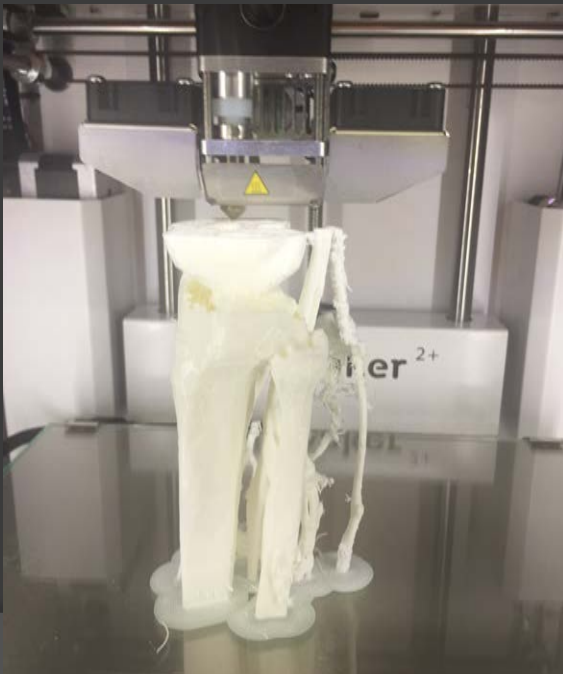


Giacomini

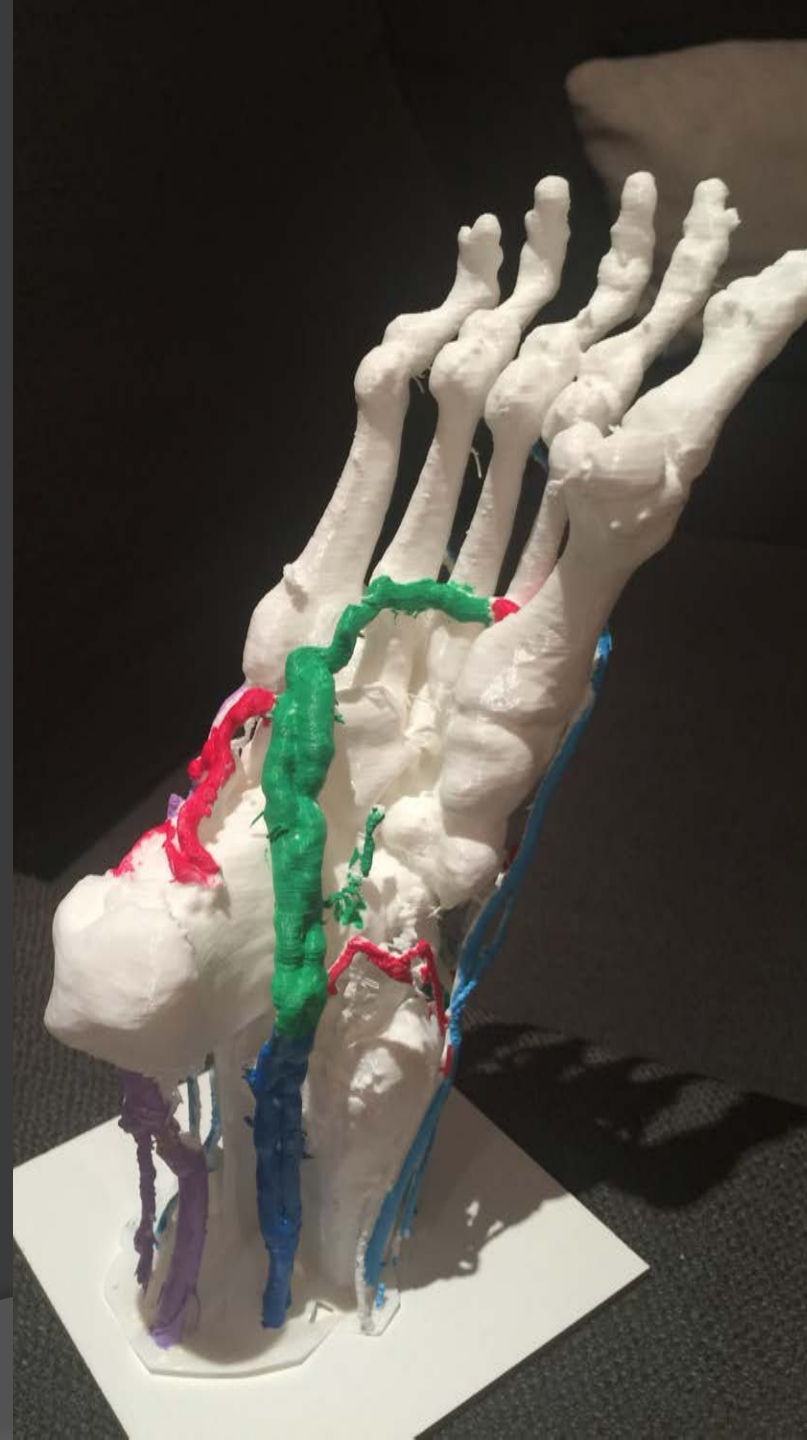
3D Printers



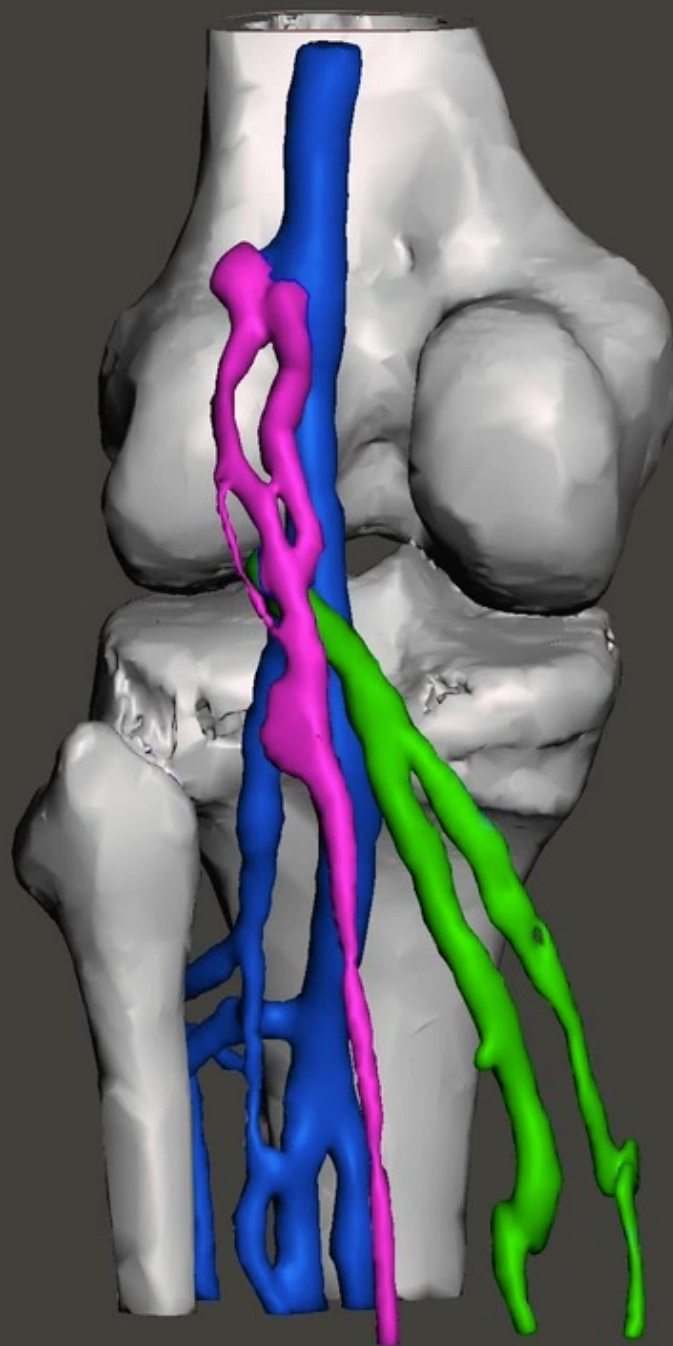
Ultimaker 2+ 1700 €



ENDER 3 Pro 250 €







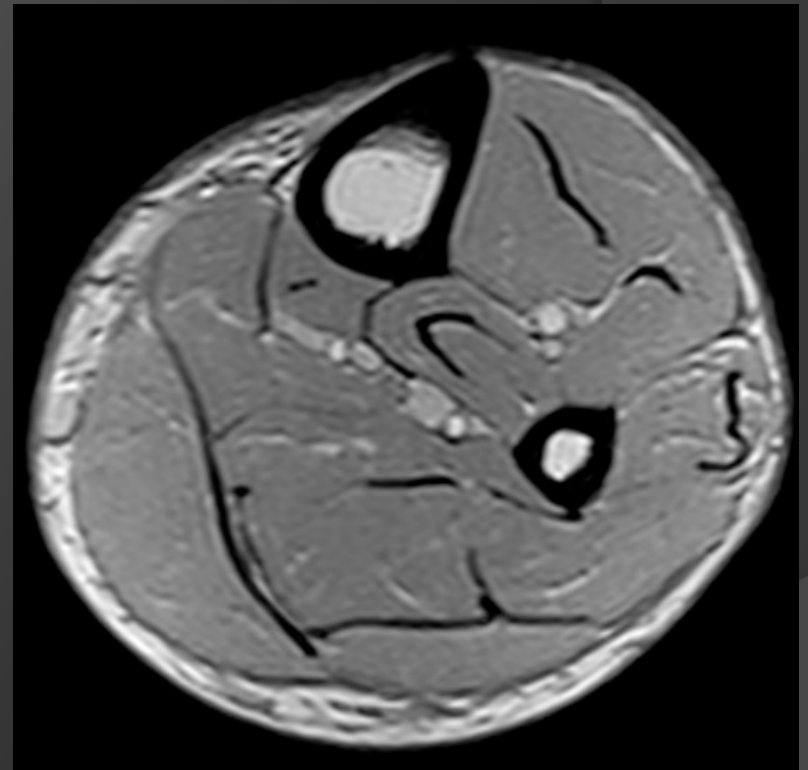
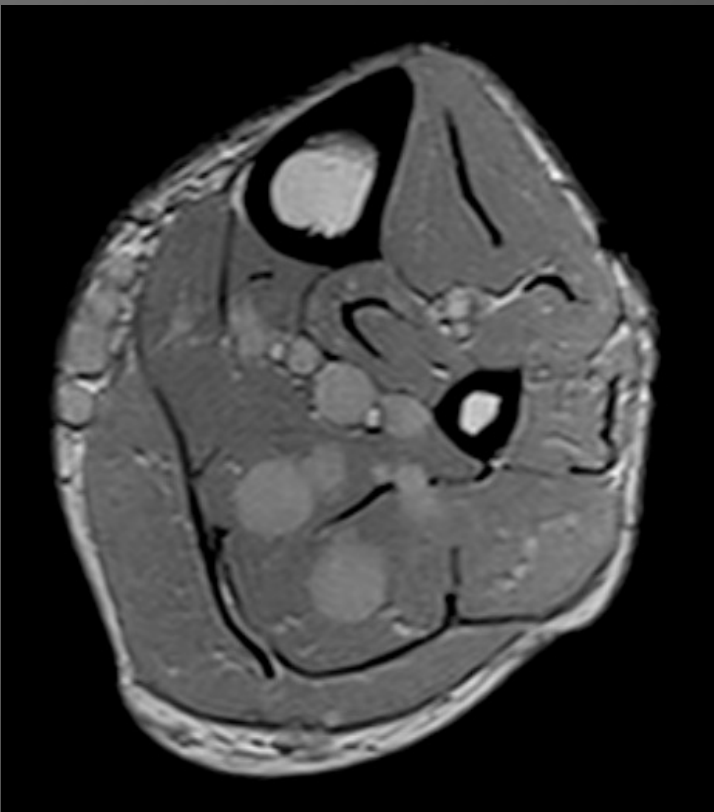
3D reconstruction by standing MRI under compression*

J.F Uhl, H. Partsch, G. Mosti

- Effect of compression therapy on leg veins anatomy: Quantification by 3D vectorial modelling from MRI slices. Uhl J.F, Mosti G., Partsch H. AVF 22-26 feb 2011
- Unexpected venous diameter reduction by compression stocking of deep, but not of superficial veins. H. Partsch, G. Mosti, J.FUhl Veins and Lymphatics 2012; 1:e3
- Relationship between medical compression and intramuscular pressure as an explanation of a compression paradox Uhl J-F, Benigni J-P, Cornu-Thenard A, Fournier J, Blin E. Phlebology 2014 March 7, 2014 DOI:10.1177/0268355514527442

EFFECTS ON THE VEINS EVALUATION BY STANDING MRI

*MRI Esaote, G-scan - bandages 22 mm Hg **

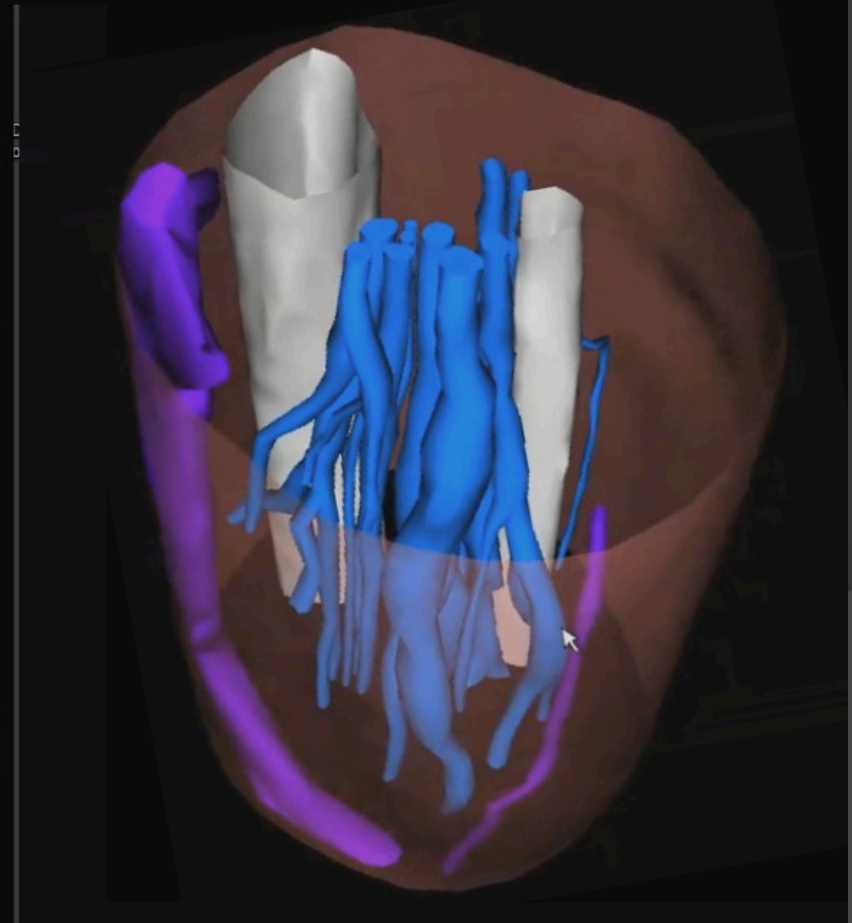
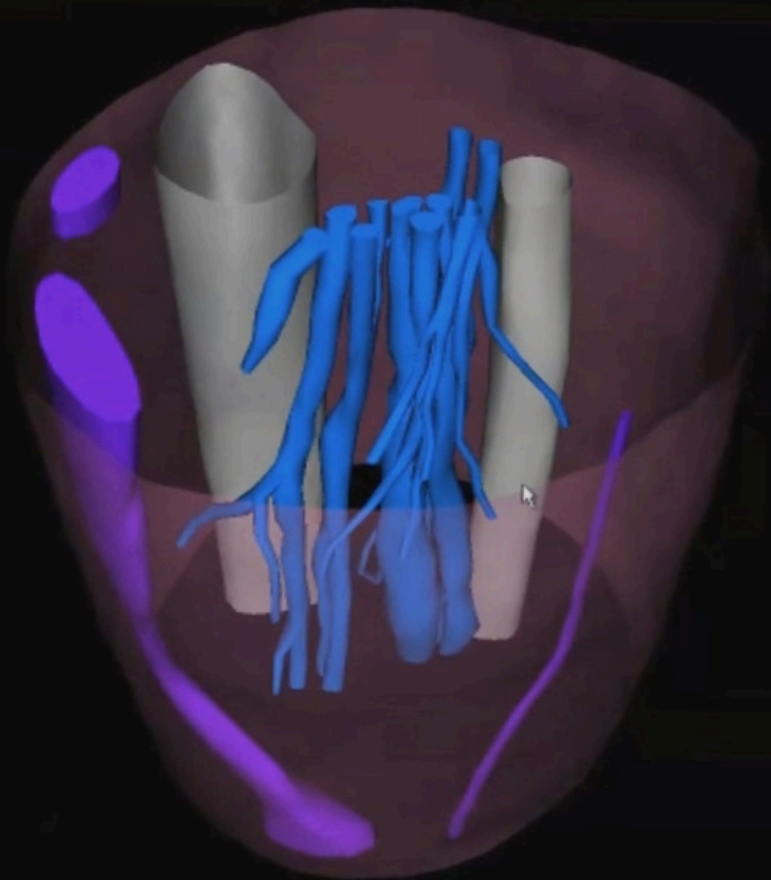


**Partsch, Mosti Abstracts of AVF 2010*

3D MODELLING OF CALF ANATOMY (MRI STANDING)

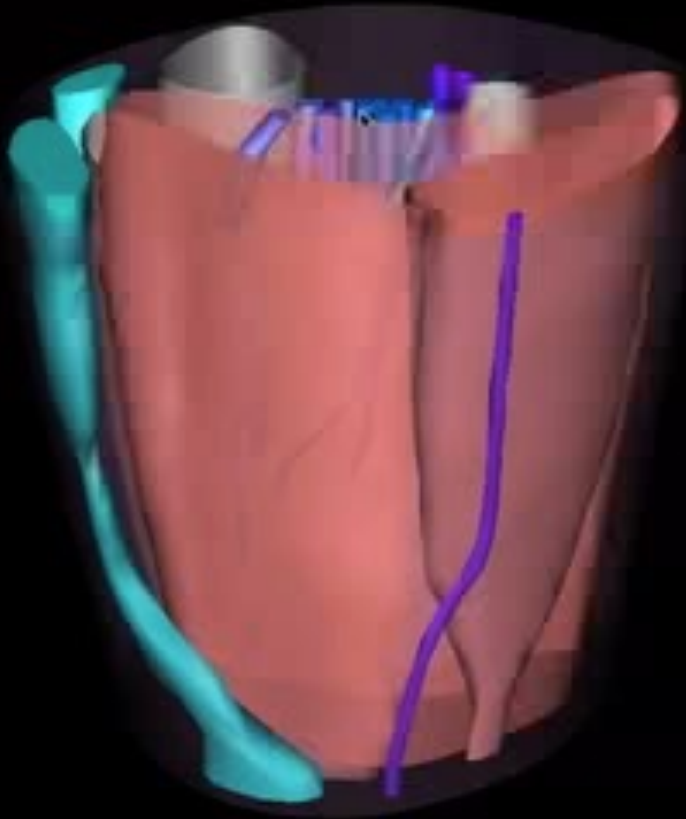
With Rosidal mobile 22 mm Hg

Without compression

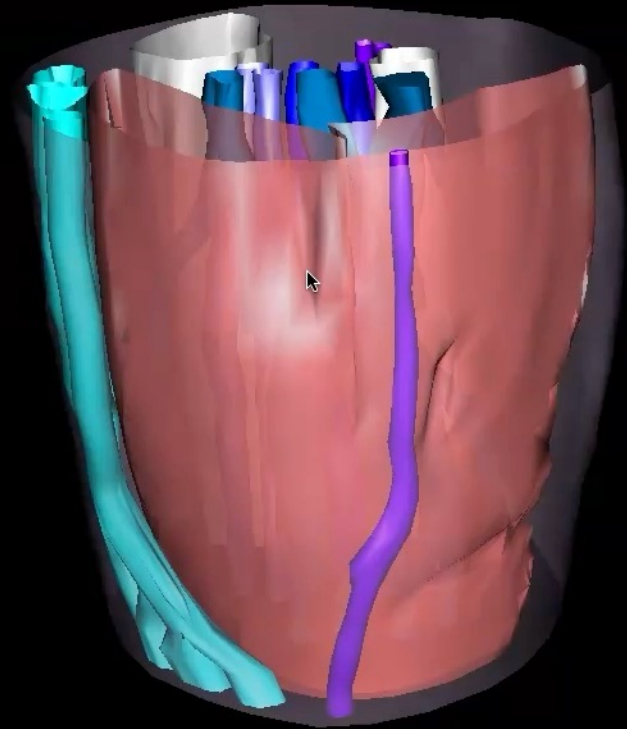


3D MODELLING OF CALF ANATOMY (MRI STANDING)

With Rosidal mobile 22 mm Hg

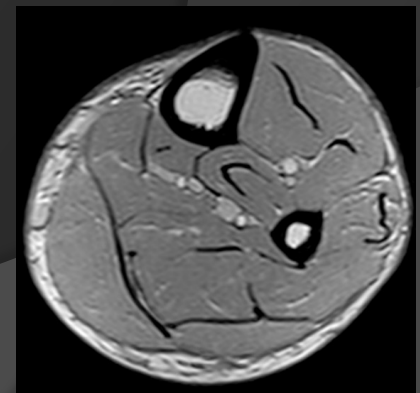
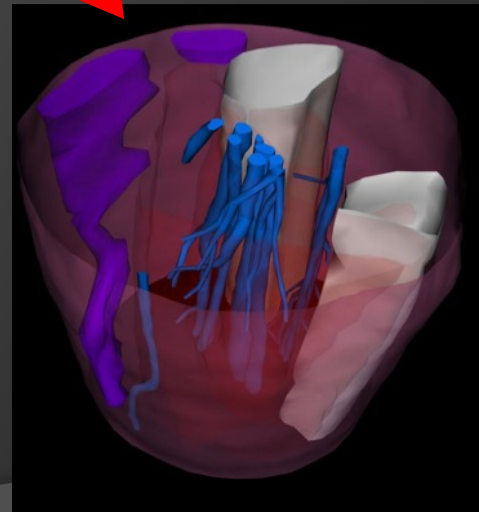
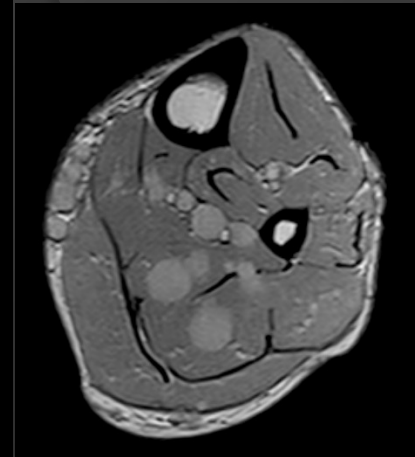
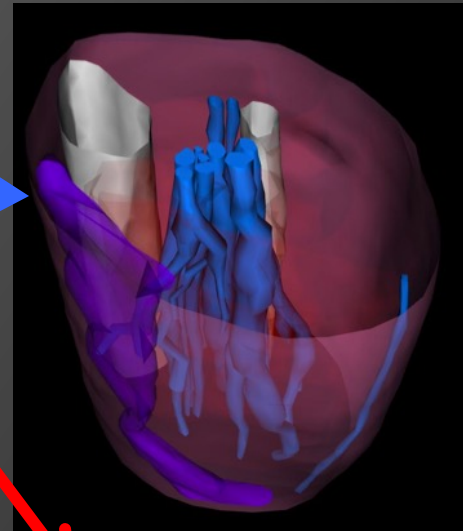
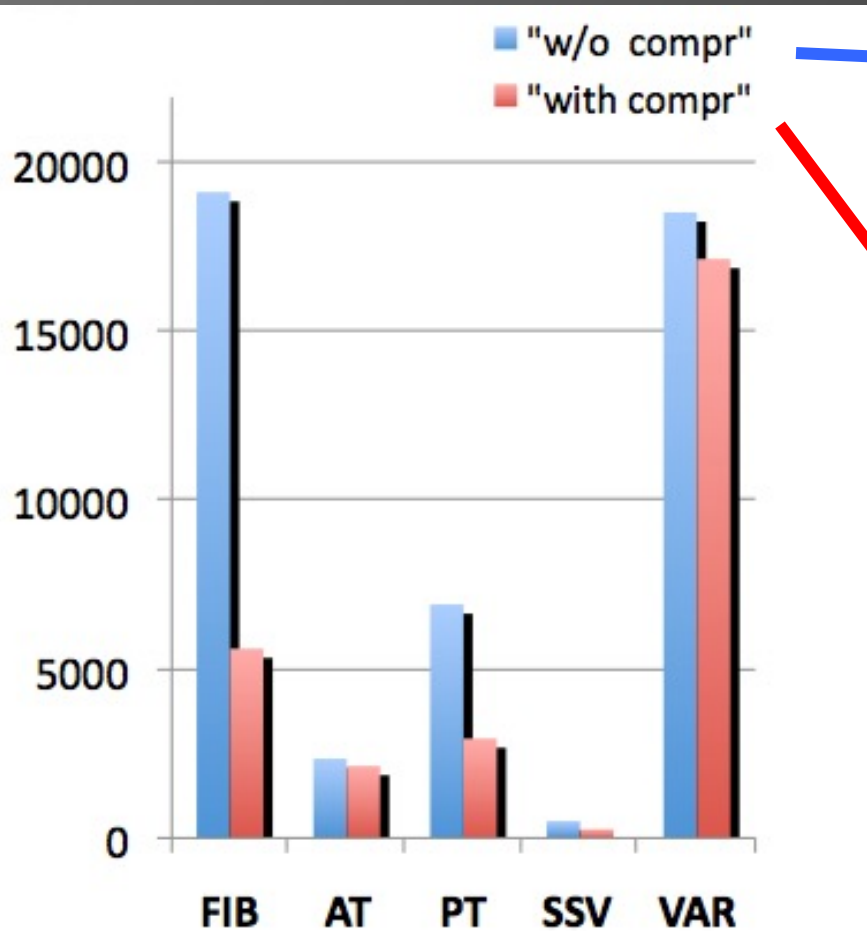


Without compression



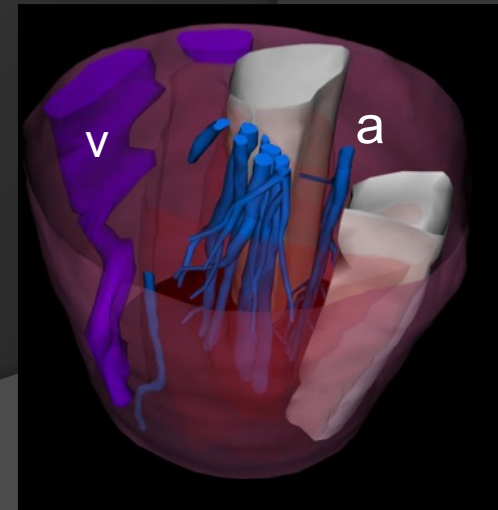
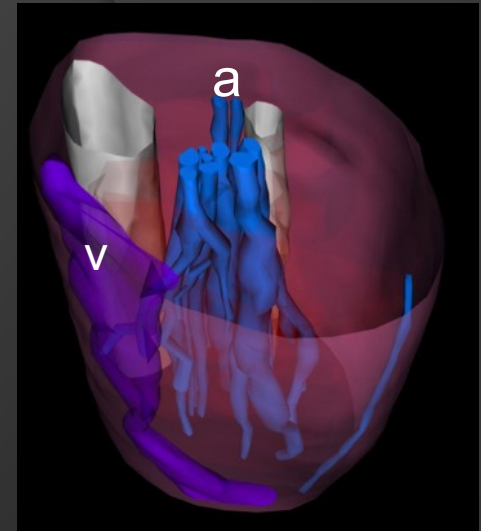
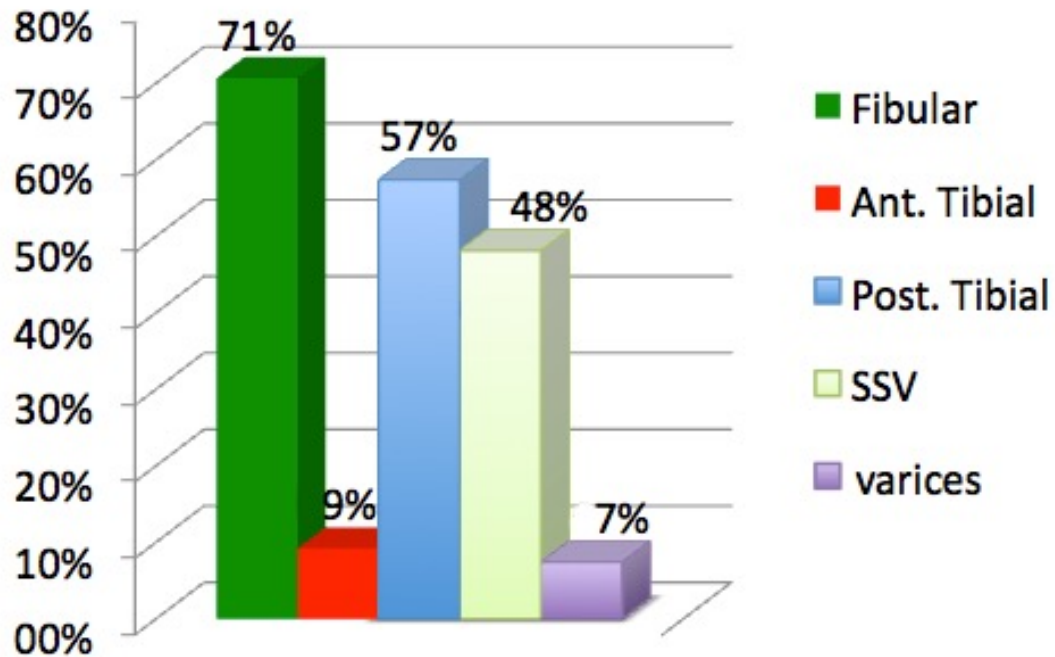
QUANTIFICATION OF VENOUS VOLUMES

MRI standing



QUANTIFICATION OF VENOUS VOLUMES (2)

Reduction of vein volume (%) due to compression



CONCLUSION

The explanation of this paradox is unclear.

Probably the deep aponeurosis and the systolic intramuscular pressure play a crucial role

CONCLUSION (2)

3D modeling of the leg and venous system has a major impact on research and clinical practice in CVD and compression