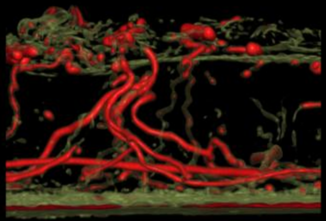

The Use of Micro Computed Tomography in Plastic Surgery: Towards a Better Understanding of Flaps Microvascular Architecture

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Disclosures

- No Disclosures

Background

- 2008: Use of 3D and 4D CT Angiography for flap perfusion investigation[1]
  - 2009: Definition of the Perforasome theory[2], with direct linking vessels and indirect linking vessels (subdermal plexus, also called "choke vessels" by Taylor[3], Palmer and Morris)
  - Poor resolution of classic CT Scanner for the assessment of the subdermal plexus and flap microvascular architecture

→ USE OF MICRO CT SCANNER

[1] Saint-Cyr M, Wong C, Schaverien M, Mojallal A, Rohrich RJ. Three- and four-dimensional computed tomographic angiography and venography for the investigation of the vascular anatomy and perfusion of perforator flaps. Plast Reconstr Surg. 2008 Mar;121(3):772-80

[2] Saint-Cyr M, Wong C, Schaverien M, Mojallal A, Rohrich RJ. The perforasome theory: Vascular anatomy and clinical im- plications. Plast Reconstr Surg. 2009;124:1529–1544

[3] Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: Experimental study and clinical applications. Br J Plast Surg. 1987;40:113–141

Methodology – Harvest of the Flap

- Fresh cadavers acquired through the Anatomy Department at Mayo Clinic, Rochester MN after IRB approval

- First step: Study of the vascularization of a whole region (thigh and abdomen) with AngioCT and Micro AngioCT

- Second step: Study of the vascularization of perforator flap harvested from the thigh (ALT flap) and the abdomen (DIEP flap) with AngioCT and Micro AngioCT

- Analysis of the results

Methodology – Flap Harvest (First Step)

Canulation of the Deep Inferior Epigastric Artery at its origin

Canulation of Lateral Circumflex Femoral Artery at its origin

Injection of Microfil (Flow Tech Inc., Carver, MA) under pressure monitoring, at physiologic pressure of 120-130 mmHg

Polymerization of the Microfils during 48 h

Harvest of the whole abdominal fasciocutaneous flap

Harvest of the whole anterolateral thigh region

Methodology – Flap Harvest (Second Step)

Dissection of a hemi-DIEP flap

Dissection of a hemi-DIEP flap

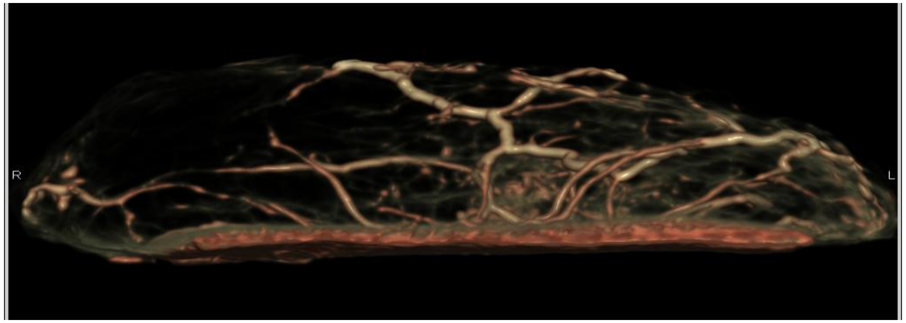
Cannulation of the largest dominant perforator

Injection of Microfil (Flow Tech Inc., Carver, MA) under pressure monitoring, at physiologic pressure of 120-130 mmHg, directly in the cannulated perforator

Polymerization of the Microfils during 48 h

Methodology – CT Scanner

- AngioCT Scanner of the specimen (Definition, Siemens Healthcare, Forchheim, Germany)
- Analysis of the images
- Incorporation of radio-opaque marks on the specimen, in order to define the specimen to be sent for Micro-CTScanner processing



Example of a 3D rendering of a classic CT Scanner image (GULF Flap)

Methodology – MicroCT Scanner

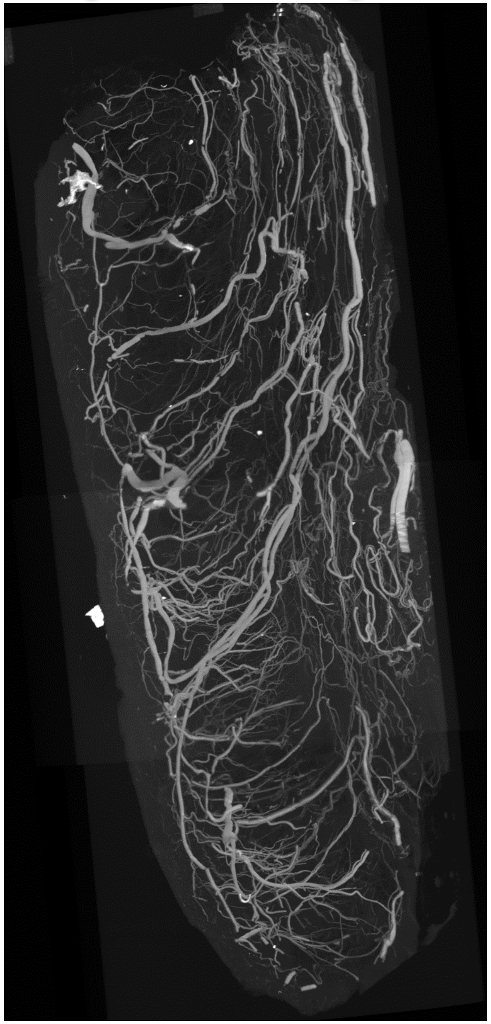
- Microcomputed tomography (micro-CT) scanner
  - generates three-dimensional (3-D) images consisting of up to a billion cubic voxels, each 5–25 µm on a side
  - isotropic spatial resolution
- The duration of each scan depends on the magnification desired (normally 20 µm cubic voxel but also 10 and 5 µm cubic voxels)

Jorgensen SM, Demirkaya O, Ritman EL. Three-dimensional imaging of vasculature and parenchyma in intact rodent organs with X-ray micro-CT. Am J Physiol: Heart, Circ Physiol. 1998;275(3):H1103-H1114

Results - Abdomen

* Injected perforator

SKIN ↔ FAT



Whole abdomen (DIEA injected)

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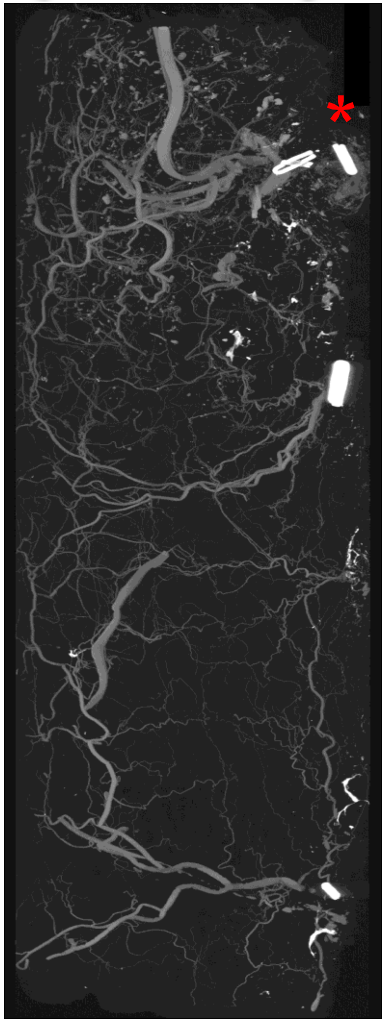

DIEP Flap (largest perforator injected)

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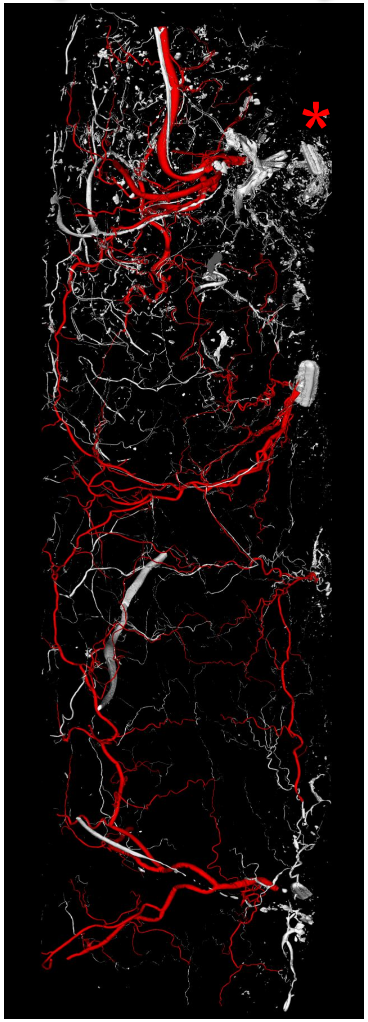
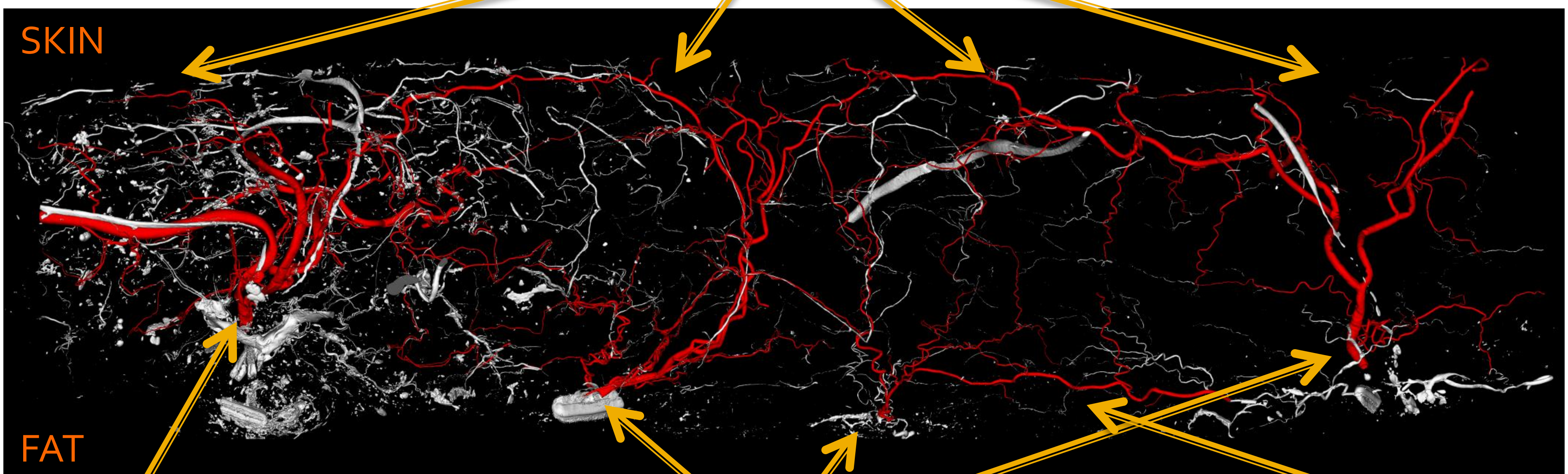


DIEP Flap with vessel tracking

Results - Abdomen

Clear visualization of the subdermal plexus
(indirect linking vessels)



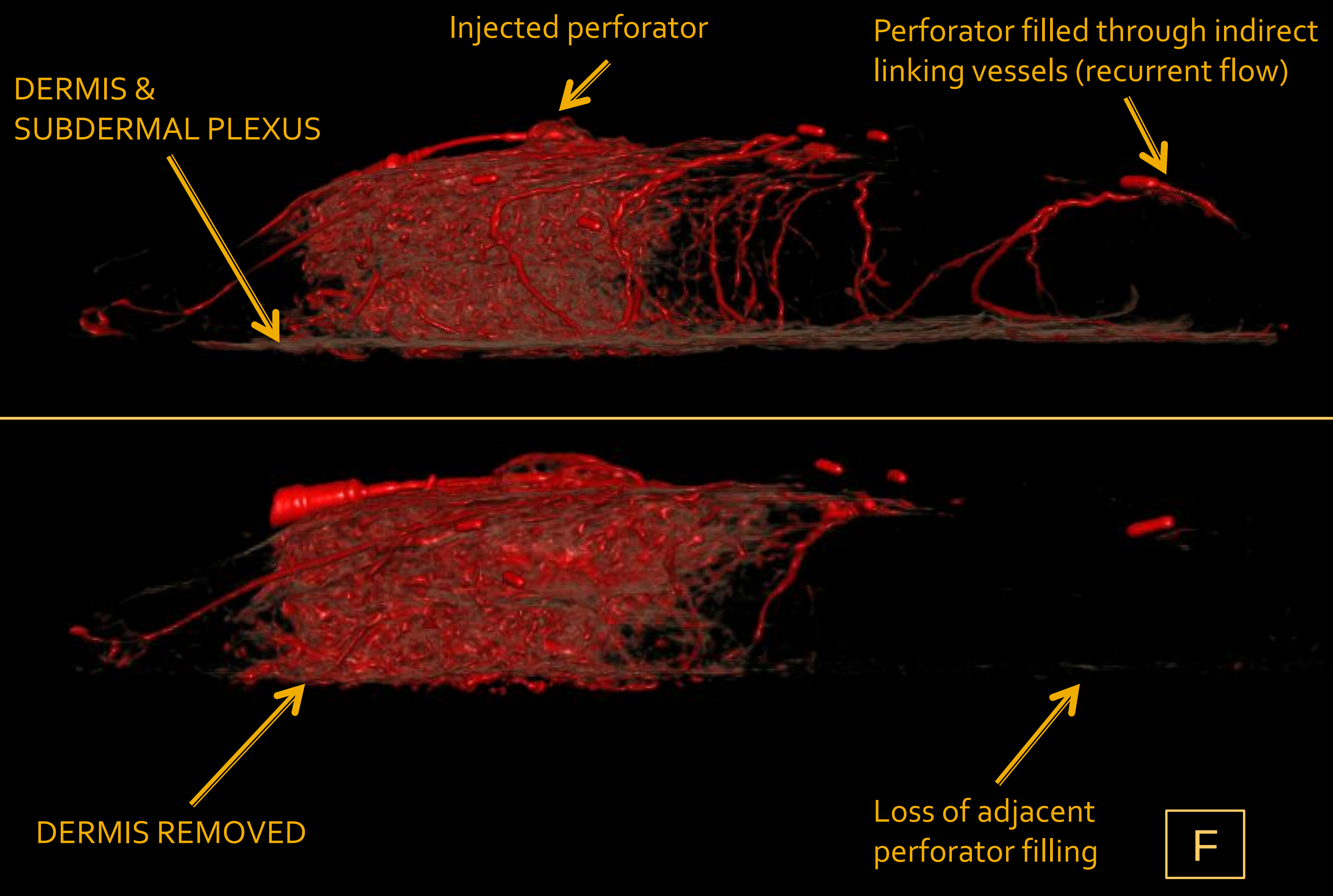
Injected
Perforator

Visualization of 3 adjacent perforators filled by direct flow through the direct linking vessels and recurrent flow through indirect linking vessels

Direct linking vessel

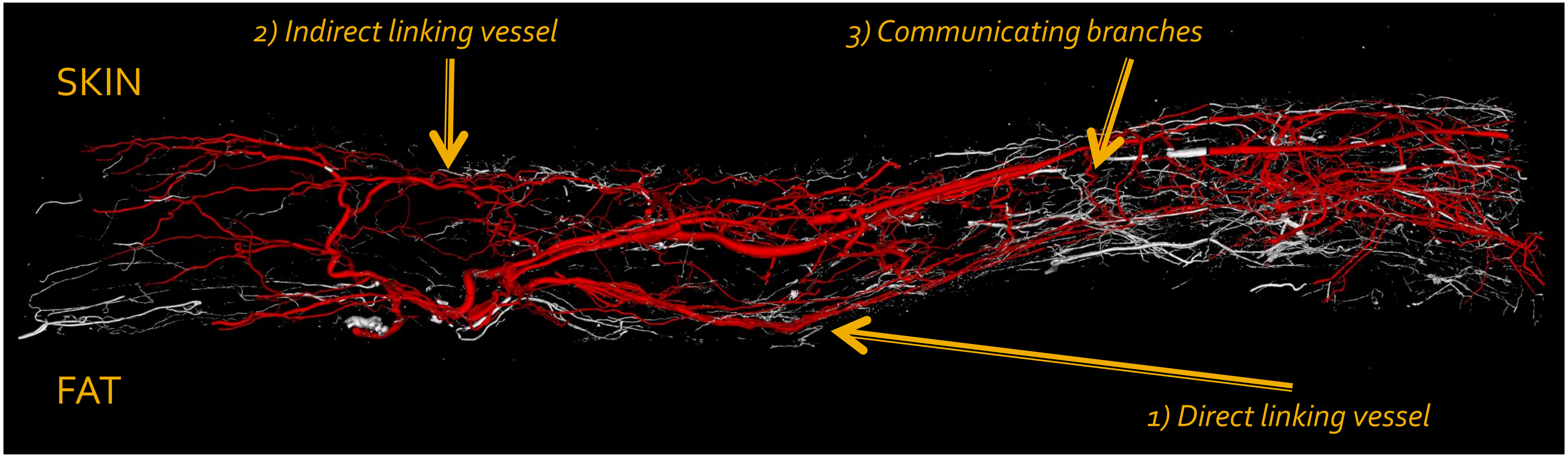
Results – Abdomen
Contribution of the dermis in DIEP Flap Perfusion

- Application of the technology for a study with direct clinical impact
- AIM = To study the impact of dermis removal on a DIEP flap before inset of the flap in breast reconstruction (instead of meticulous de-epithelialization)
  - 12 Hemi-DIEP flaps harvested
  - Scanned after contrast injection in the largest cannulated perforator
  - Contrast flushed out and dermis removed with cautery
  - Flap reinjected and rescanned
  - RESULTS: Mean difference in flap perfused percentage = 26%



DIEP FLAP WITH AND WITHOUT DERMIS

Results – Full Thigh

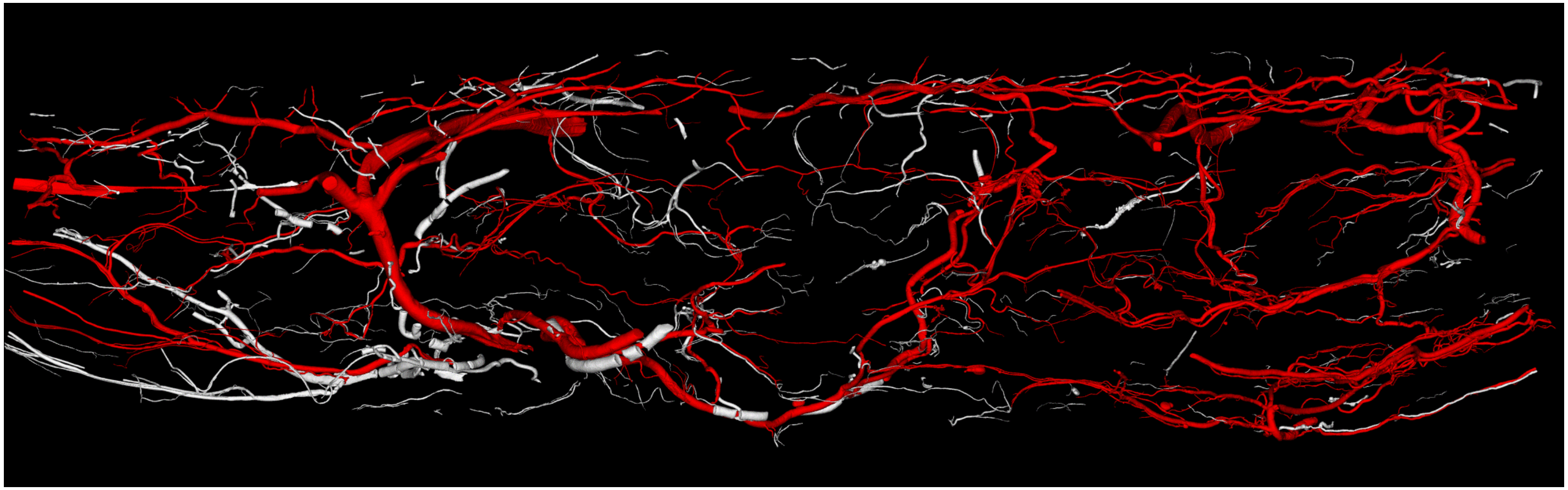


Full thigh

Vascular architecture is organized in 3 main components:

1) Deep at the level of the subcutaneous fat: direct linking vessels
2) Superficial at the level of the skin : subdermal plexus (indirect linking vessels)
3) Communicating branches between direct and indirect linking vessels

Results – Thigh (ALT Flap)



ALT Flap

Conclusion – Micro-CTScanner

- Advantage:
  - High Voxel definition
  - Visualization of microvascular structures (cf. subdermal plexuses in flaps)
- Inconvenient :
  - Small specimen (max size 2cm x 2cm x 2cm per scanner)
  - Expensive: $350/scanner
  - Requires a trained team (engineers, analysts)
- New tool in flap perfusion research, with clinical impact (cf. DIEP flap perfusion and dermis removal)