

# Generic 3D Geometrical and Mechanical Modeling of the Skin/Subcutaneous Complex by a Procedural Hybrid Method



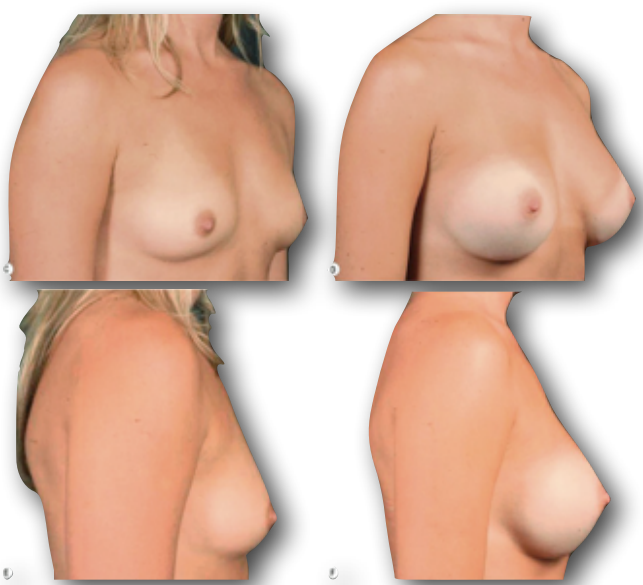
**C. HERLIN<sup>1</sup>, B. GILLES<sup>2</sup>, G. SUBSOL<sup>2</sup>, G. CAPTIER<sup>1</sup>**

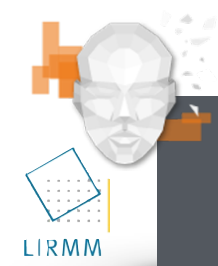
1. Plastic and Craniofacial Surgery - CHRU//University of Montpellier 1, France

2. ICAR Research Team, LIRMM, CNRS/University of Montpellier 2, France

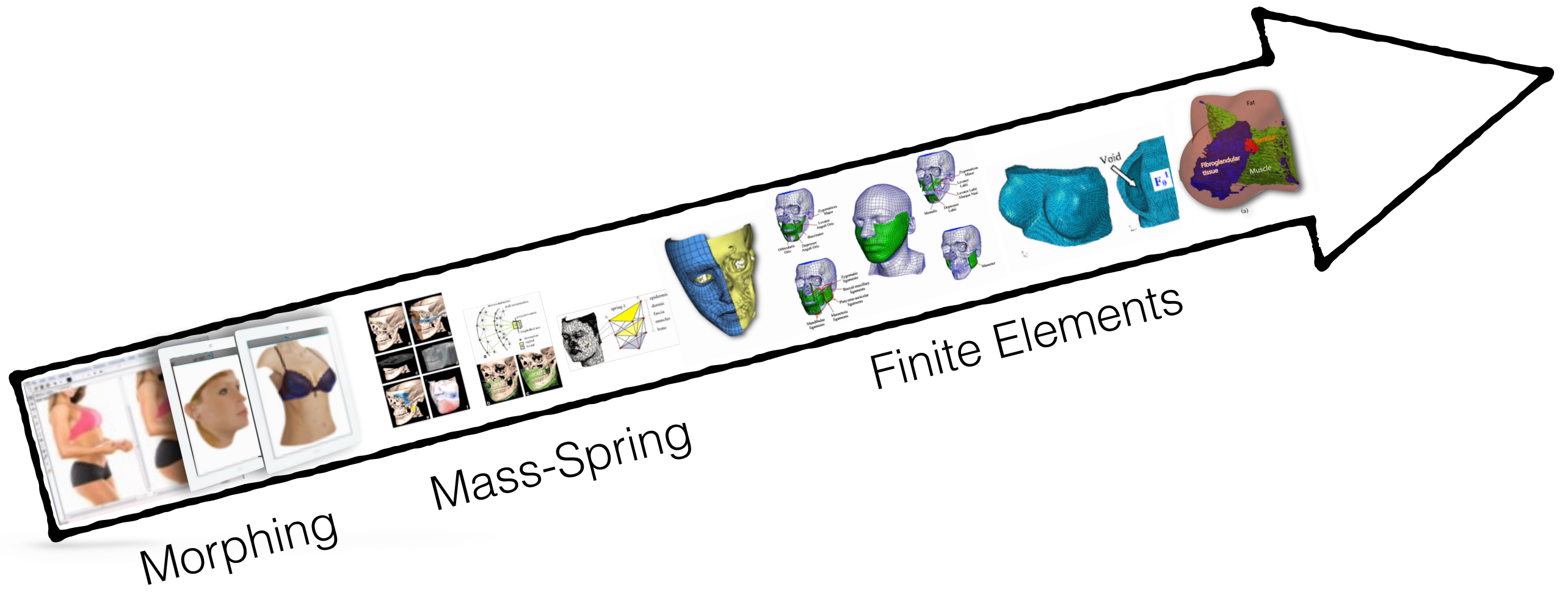


# Why planification is important in soft tissue augmentation?



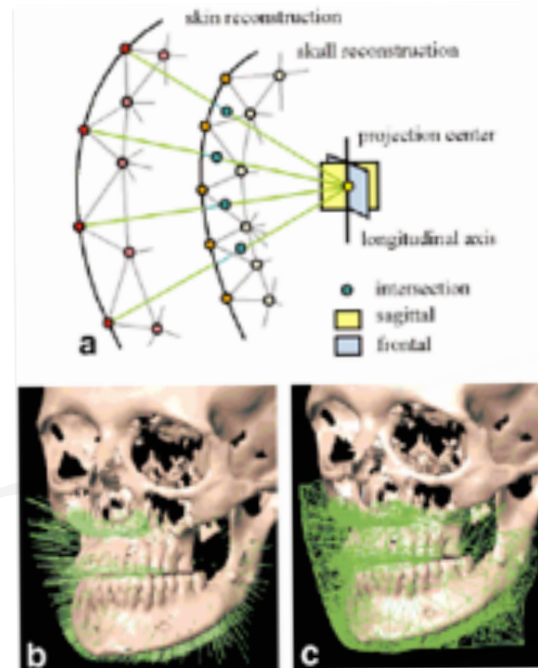
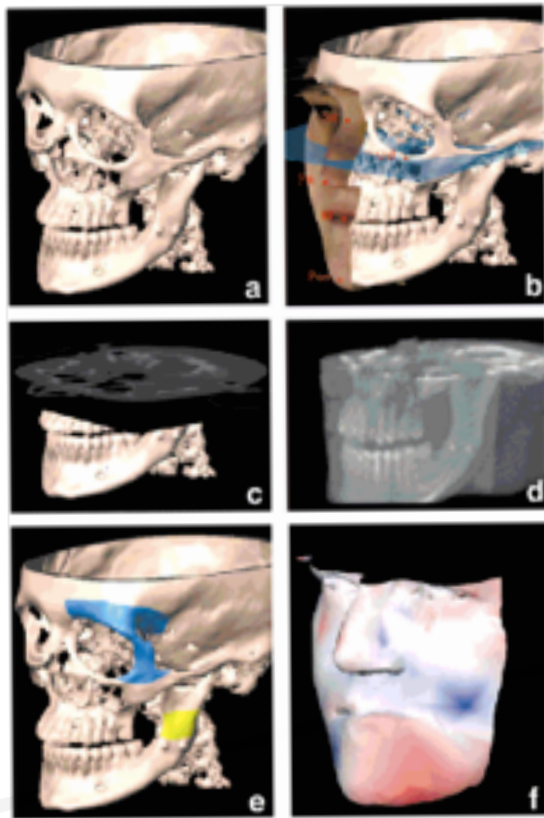


# Current state of simulation in plastic surgery

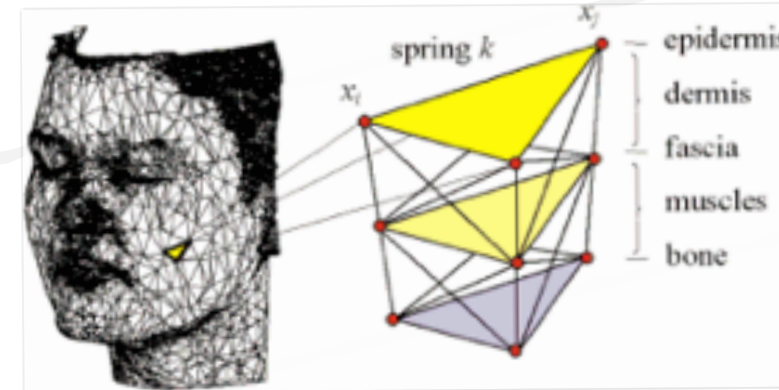




# Current state of simulation in plastic surgery

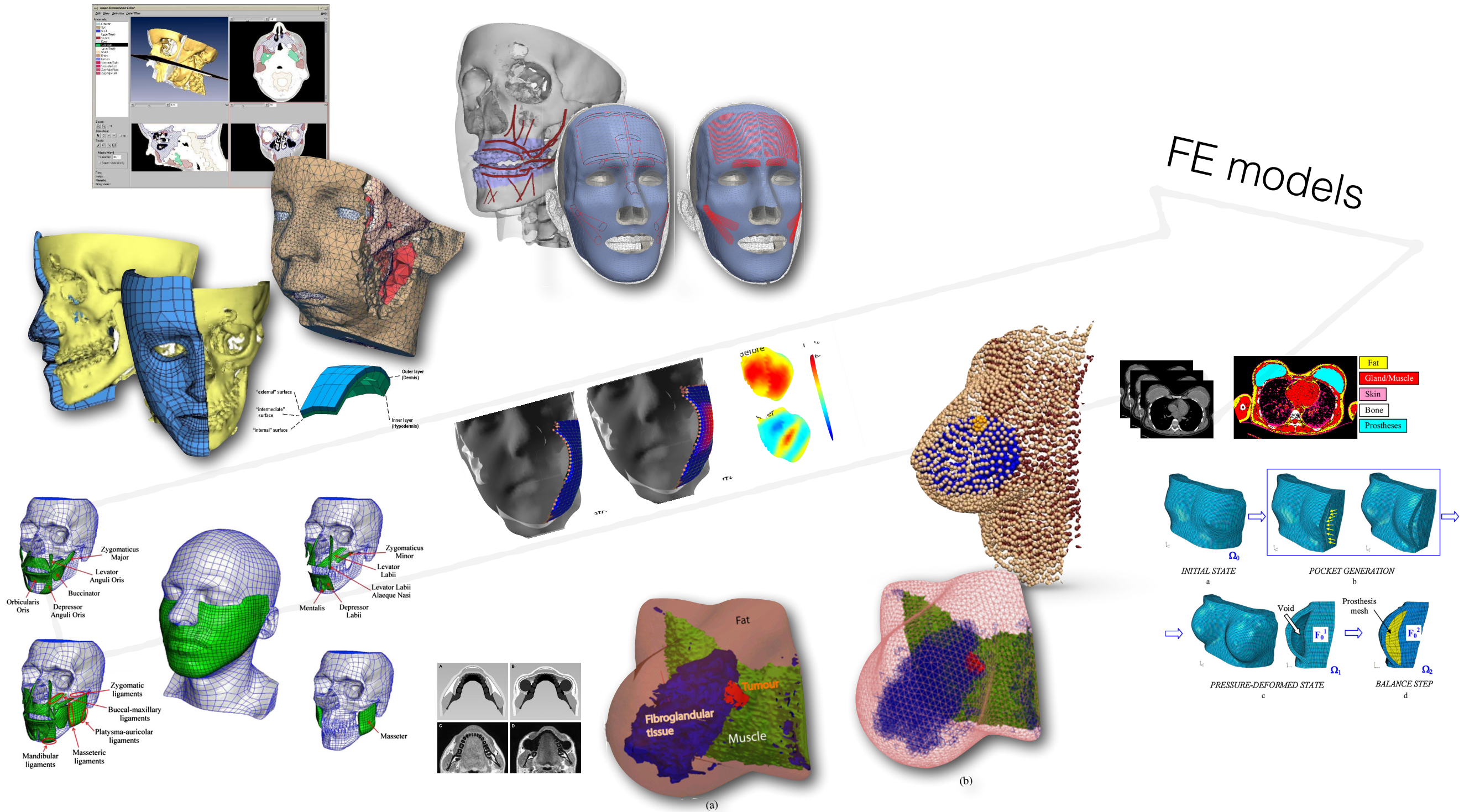


Mass Spring models





# Current state of simulation in plastic surgery



Westermarck A et al. J Craniofac Surg. 2005. 16. 100-104

Mazza E et al. Facial Plast Surg Clin North Am. 2011. 19:623-637

Chabanas M et al. Med Image Anal. 2003. 7:131-151

Nazari MA et al. Comput Methods Biomech Biomed Engin. 2010. 13:469-482

Majorczyk, V. Cotin, S., Duriez, C., Allard, J. MICCAI 2013. 299-306.

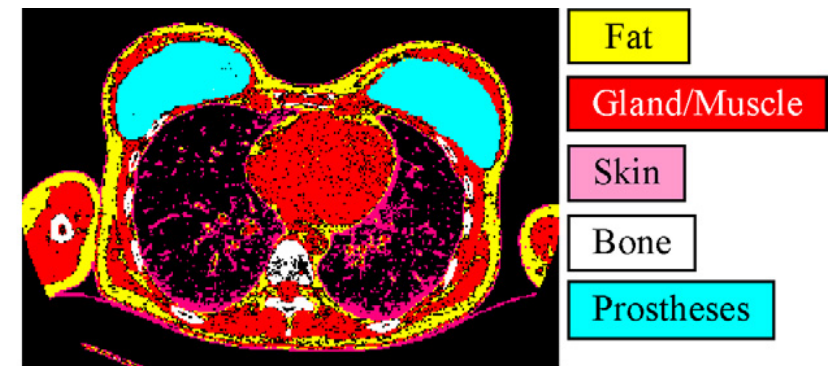
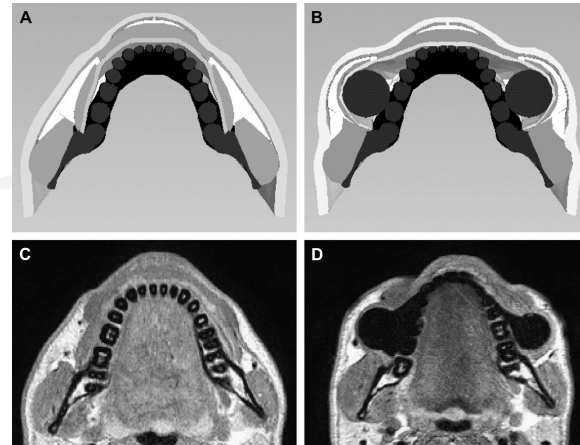
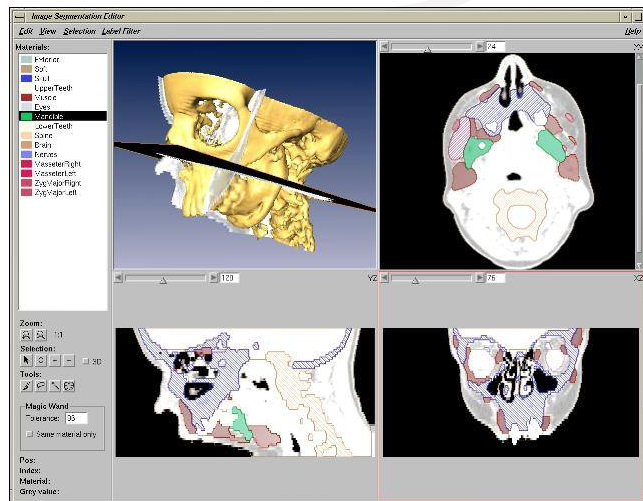
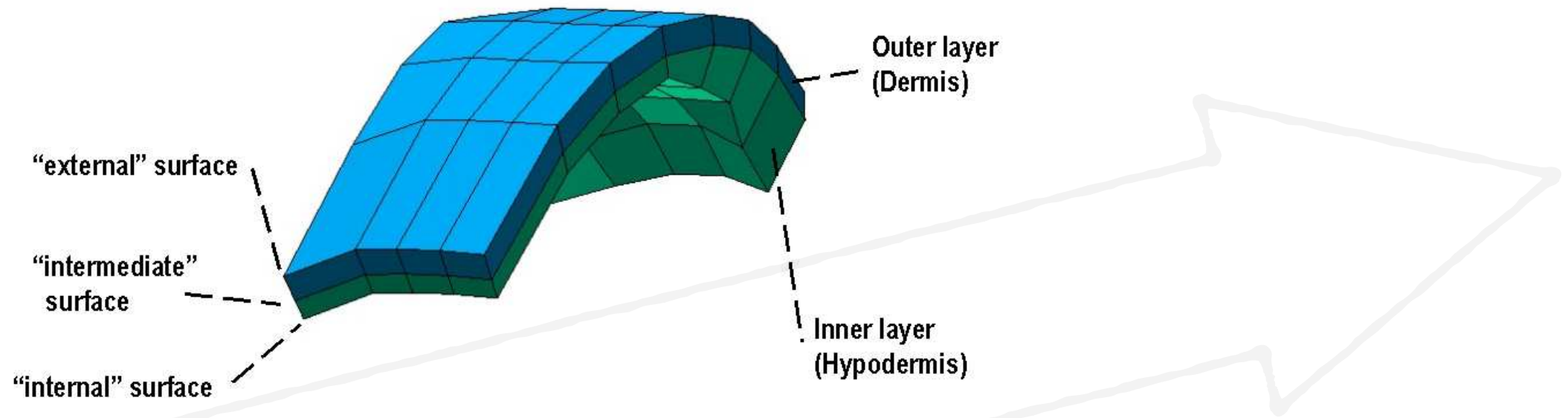
Rajagopal V et al. Acad Radiol. 2008. 15. 1425-1436

Han L et al. Phys Med Biol. 2011.15 455-472

Lapuebla-Ferri et al. Med Eng Phys. 2011. 21:1-9



# Current state of simulation in plastic surgery



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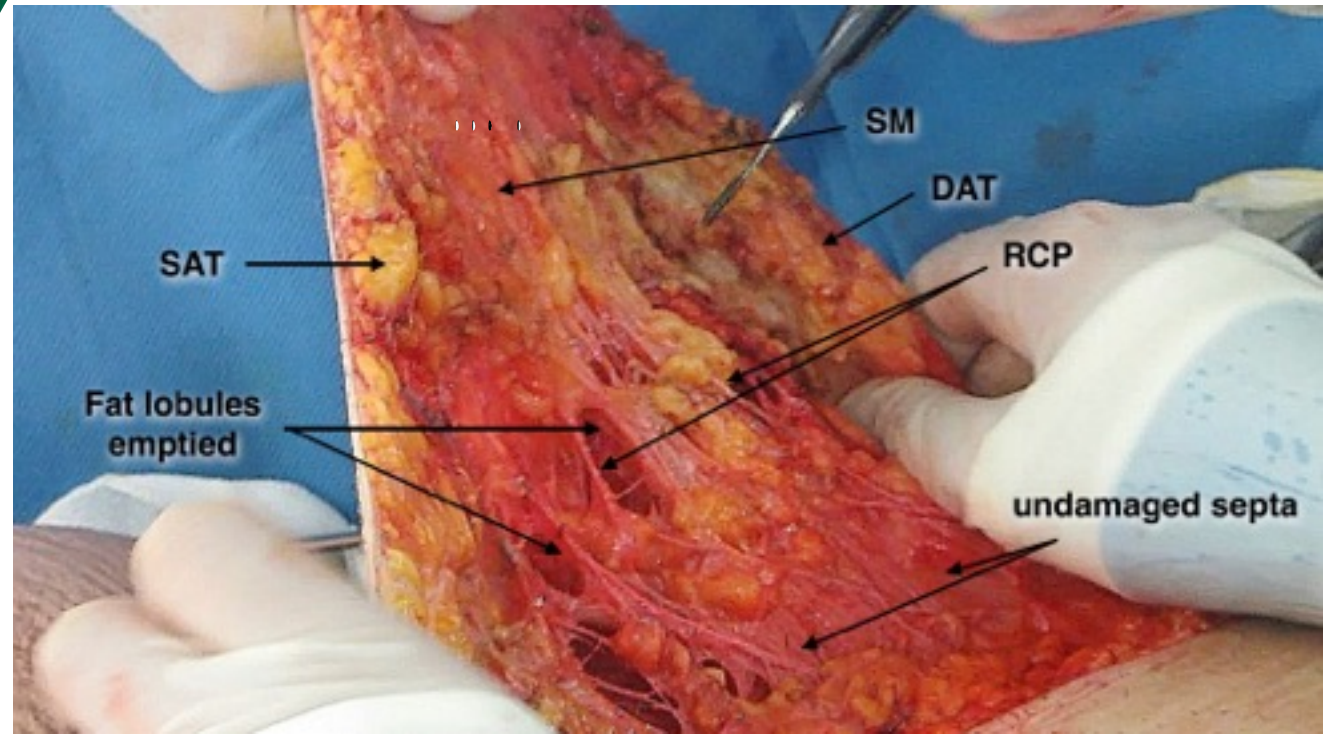
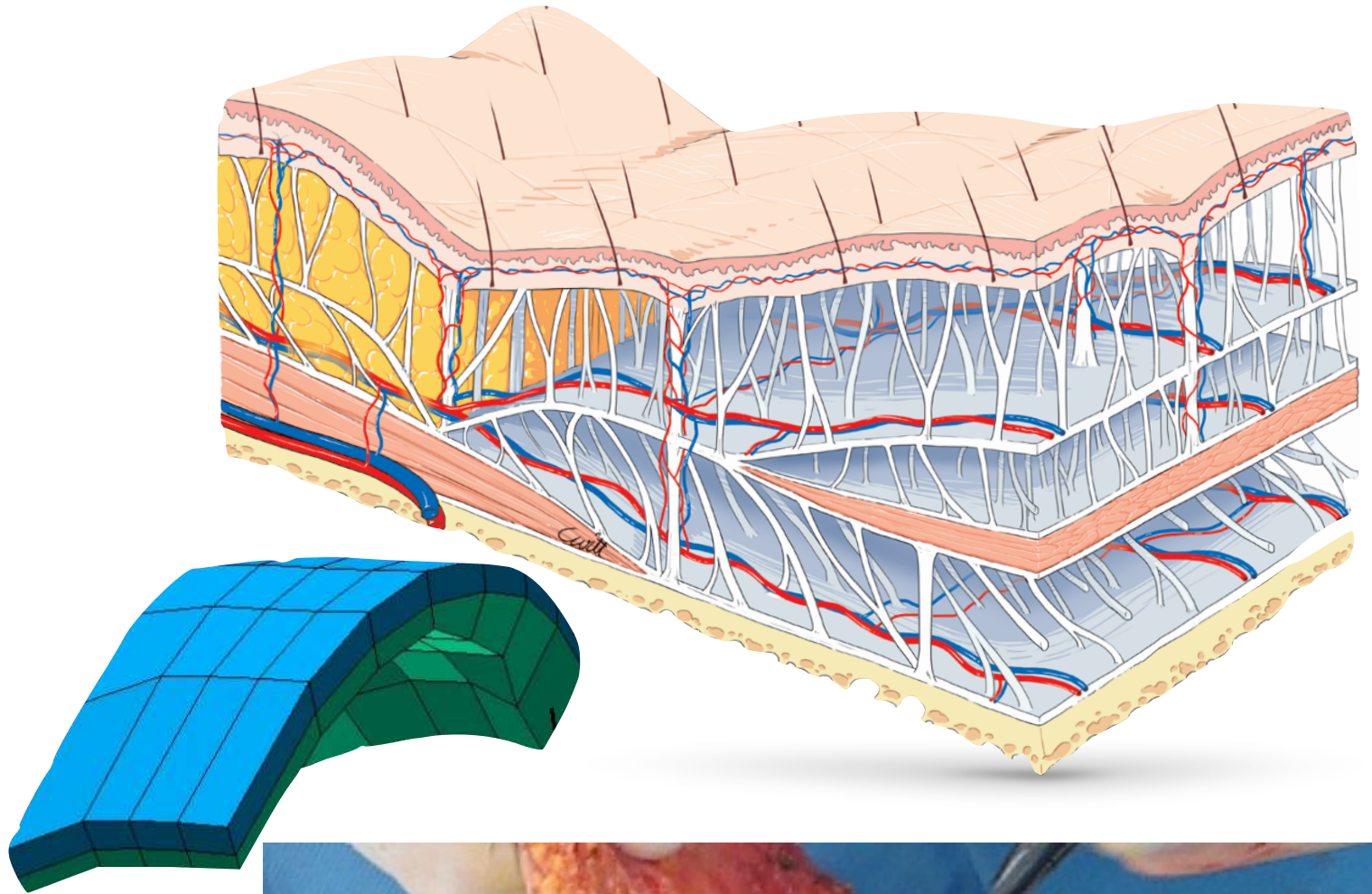
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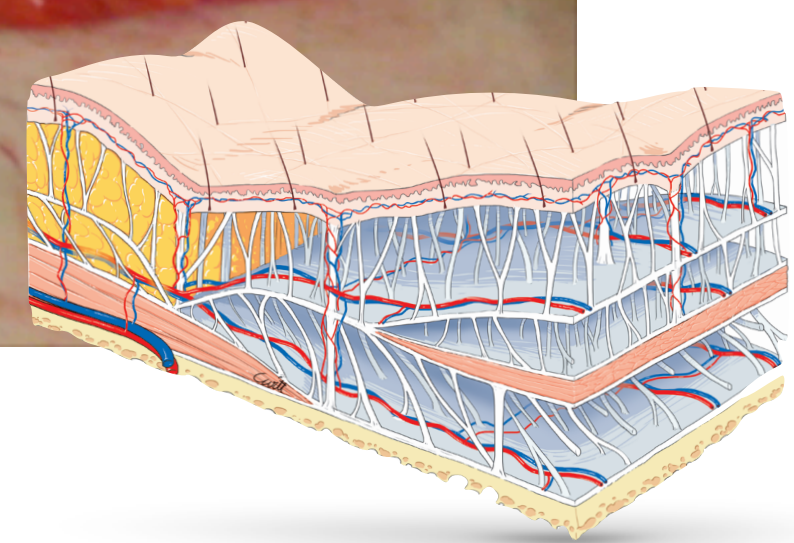
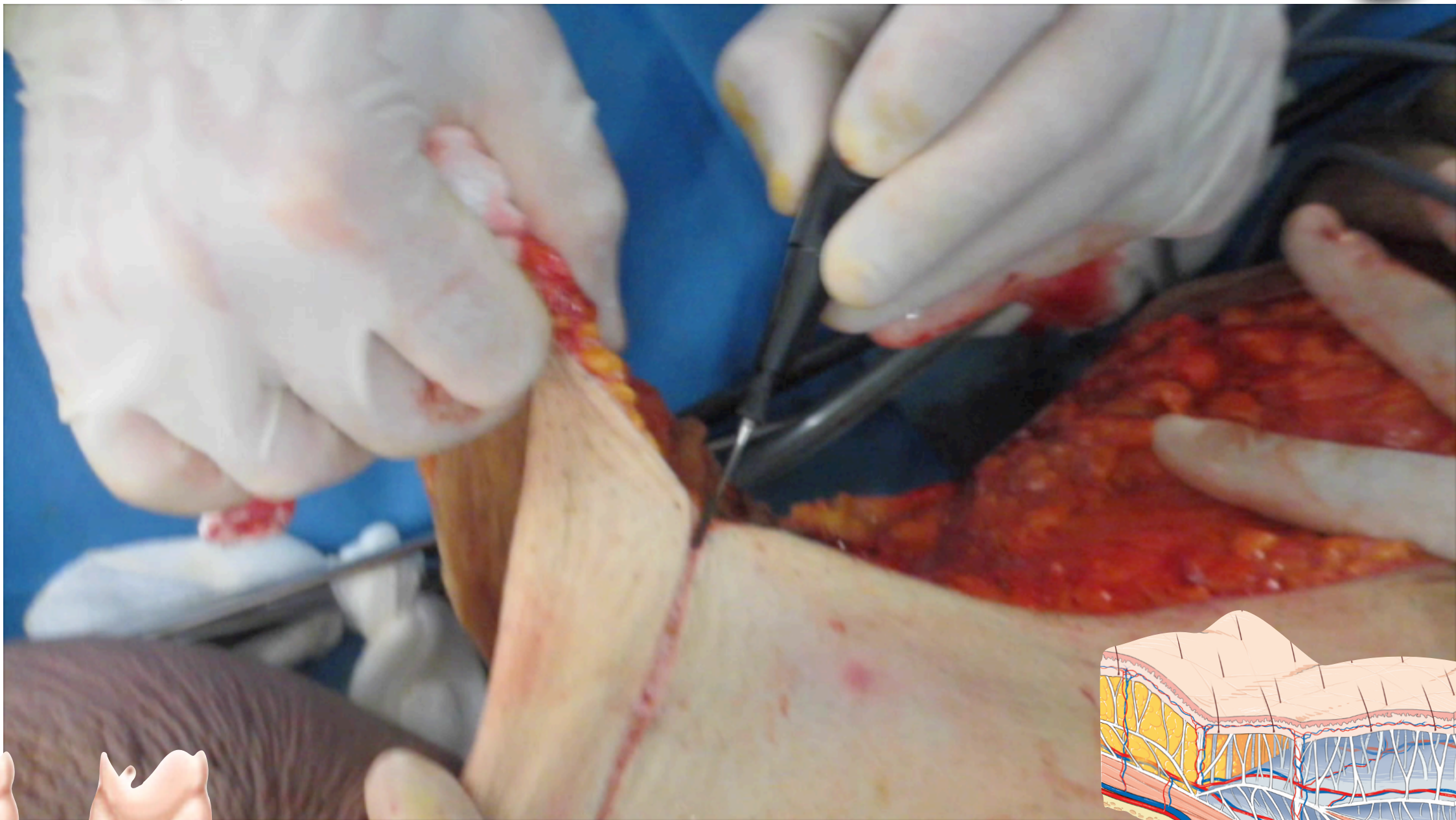
# but Lamellar models are not enough...







# Operative observation





# Our contributions

#1

Procedural Geometrical Model of the SSC

#2

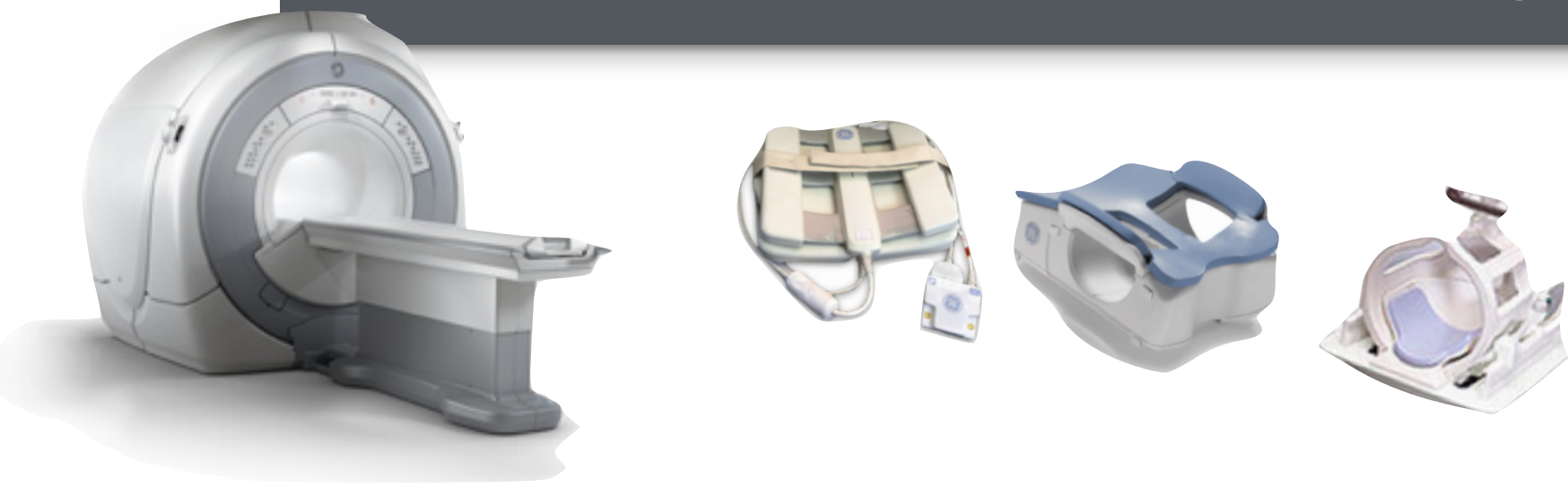
Hybrid Mechanical Model

#3

Simulation of Surgical Procedures

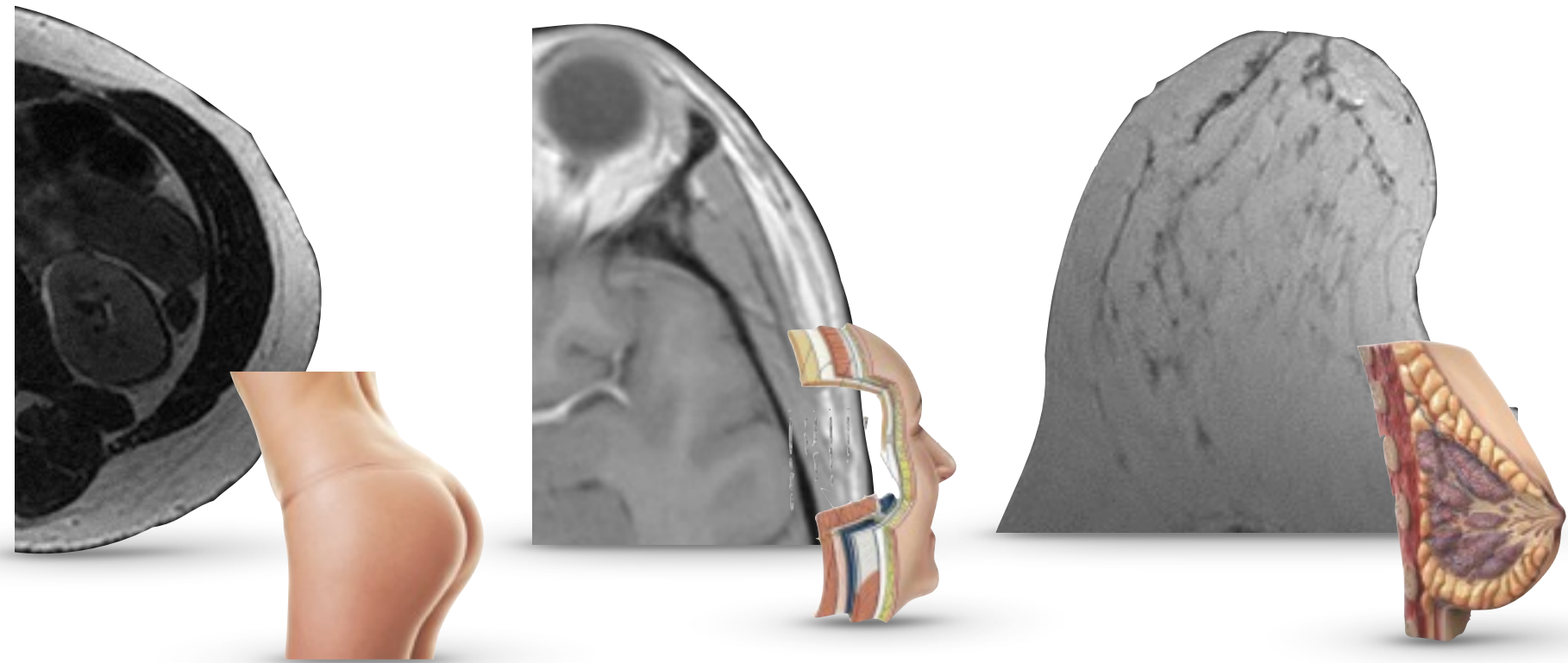


# RadioAnatomical Study

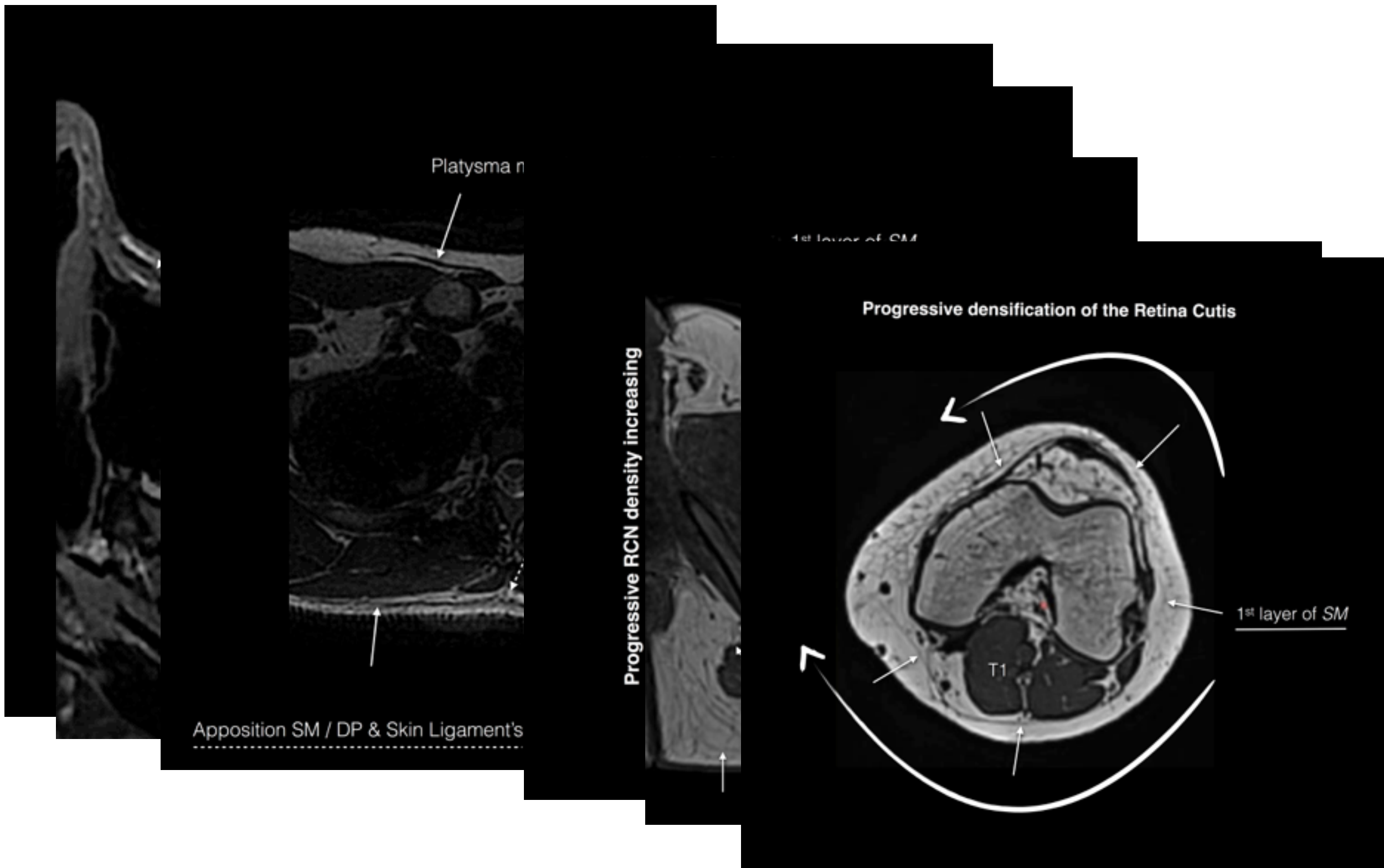


8 acquisitions 3T-MRI  
on 6 subjects

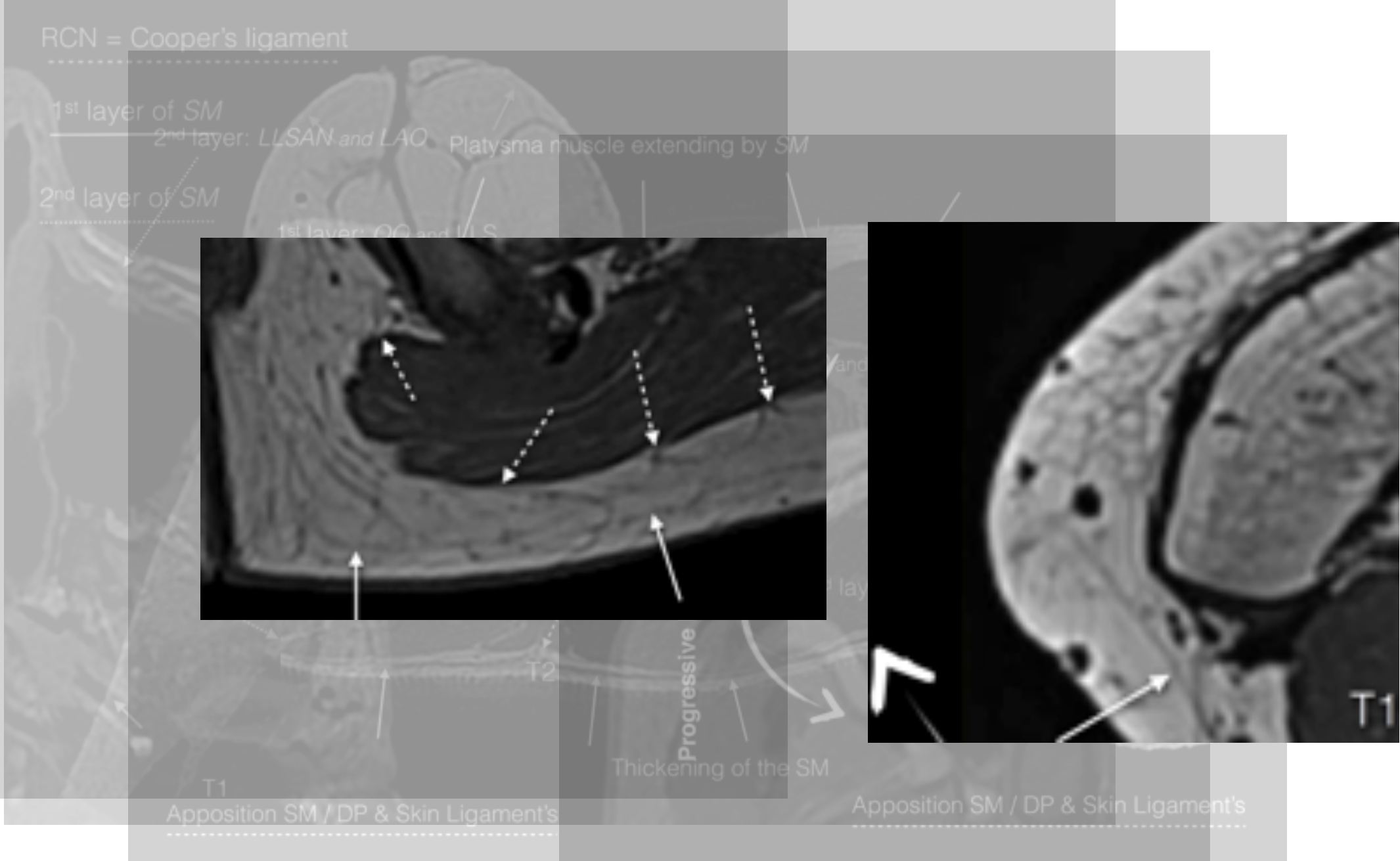
Face, Breast, Thorax, Abdomen, Upper & Lower Limbs



# MRI 3T acquisitions



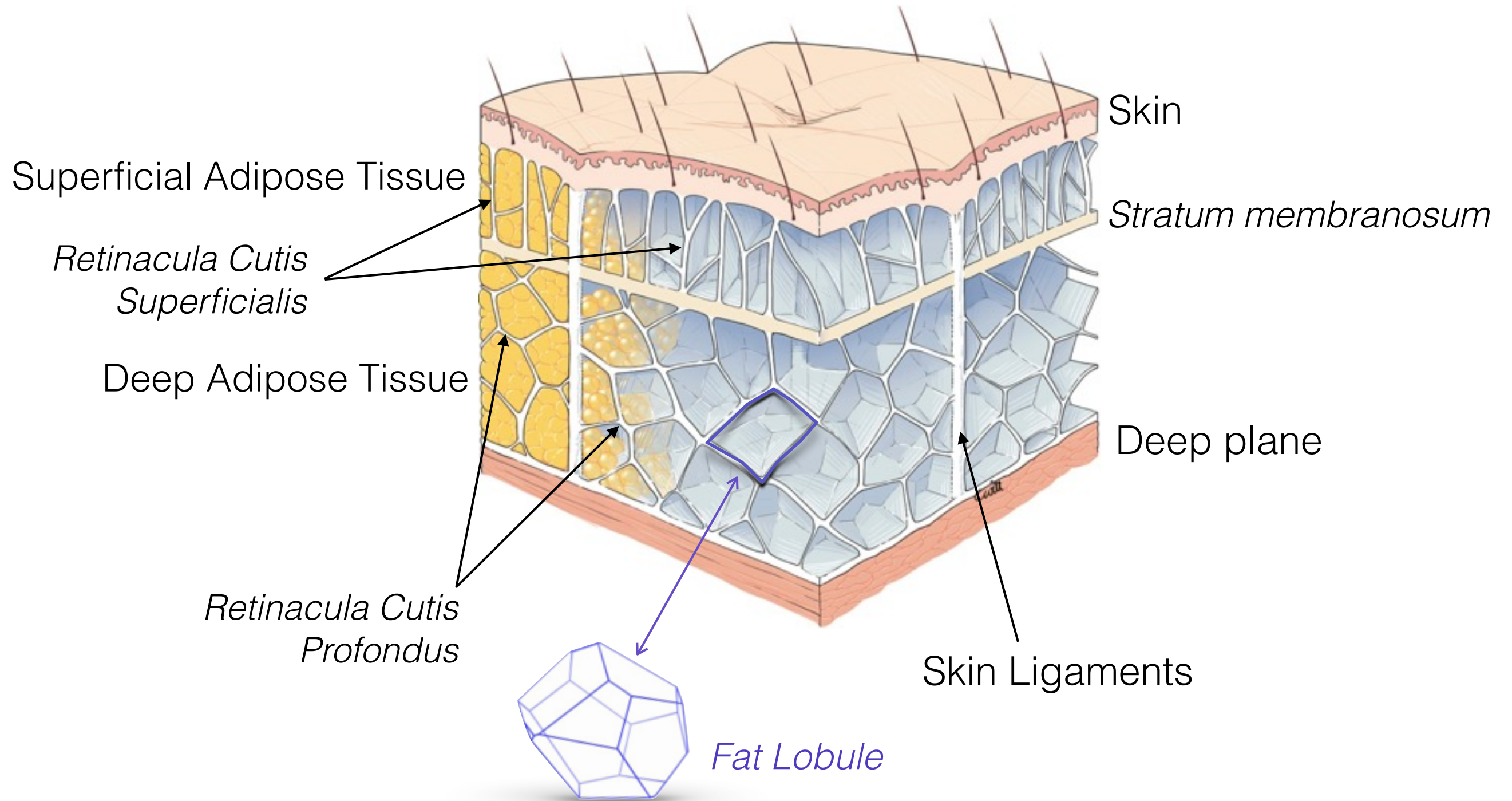
# MRI 3T acquisitions



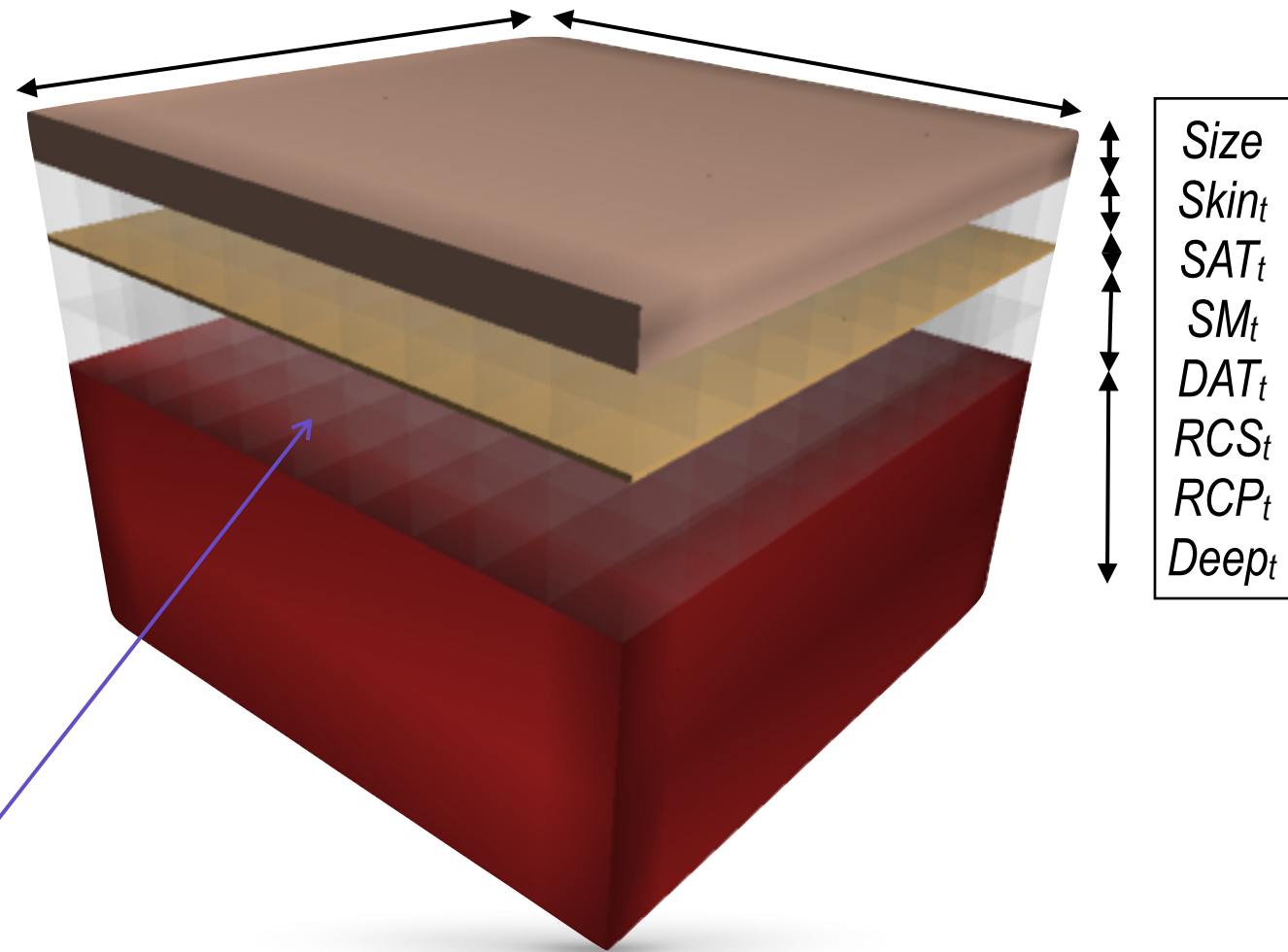
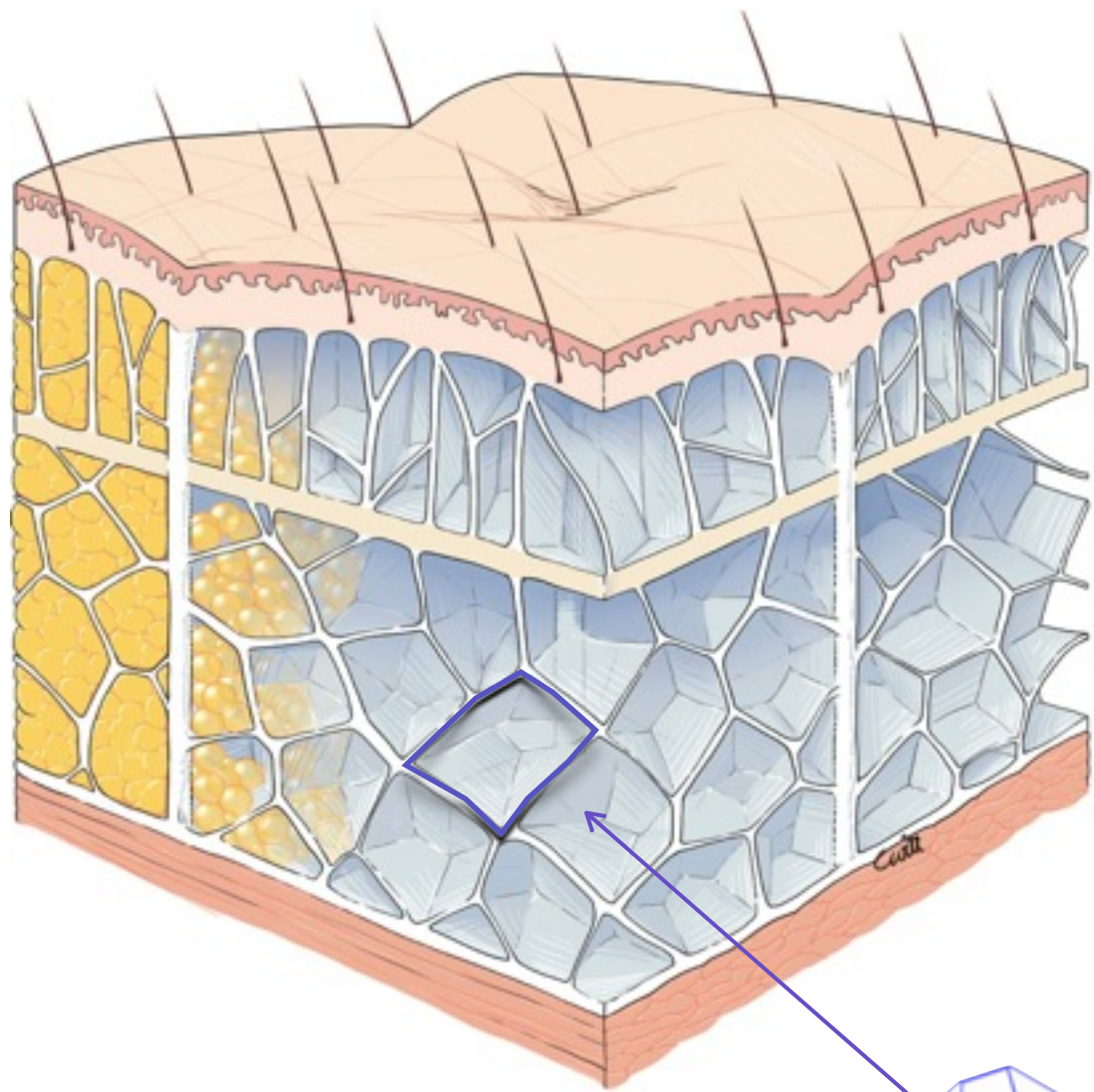




# from Generic architectural model...

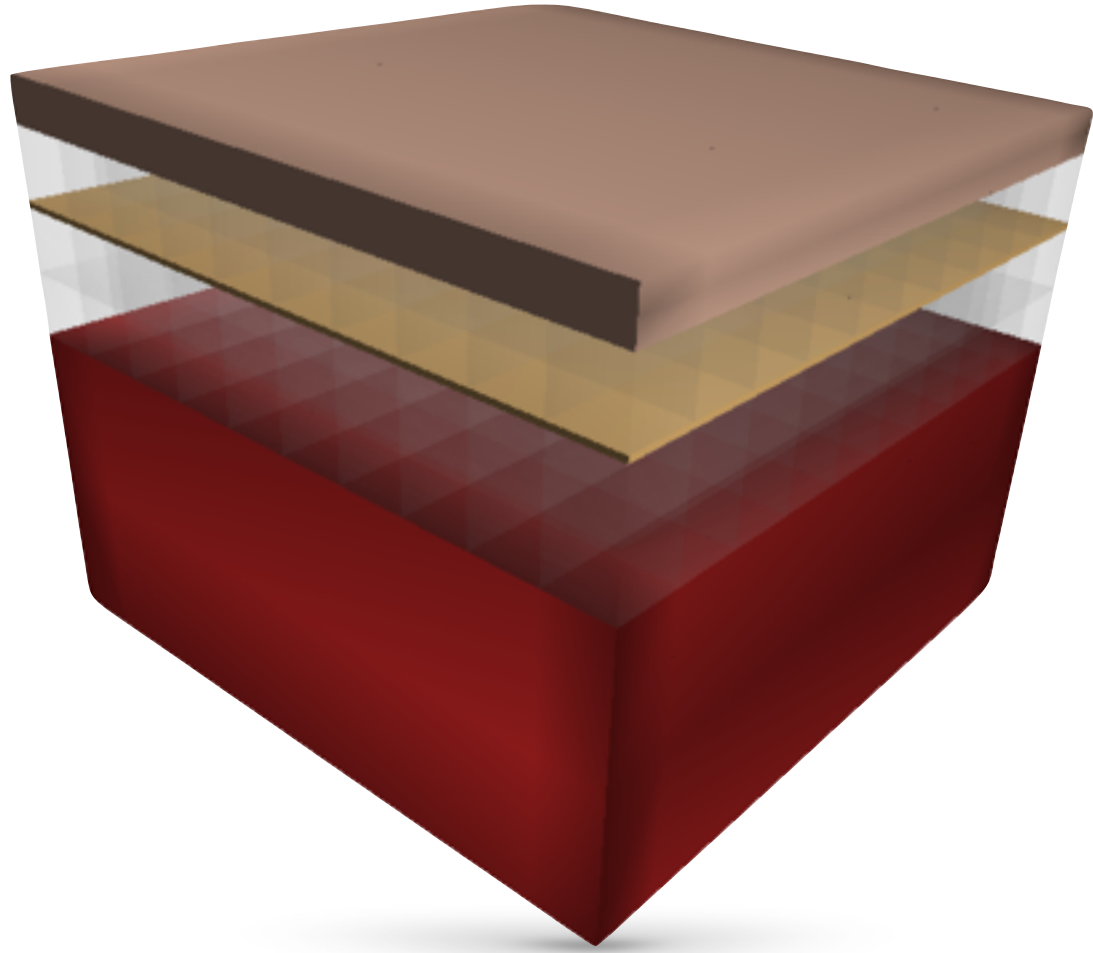


# to a Parametrical geometrical model and...





# from Parametrical geometrical model to...

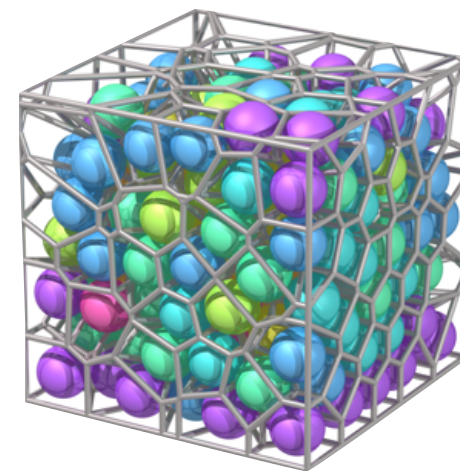
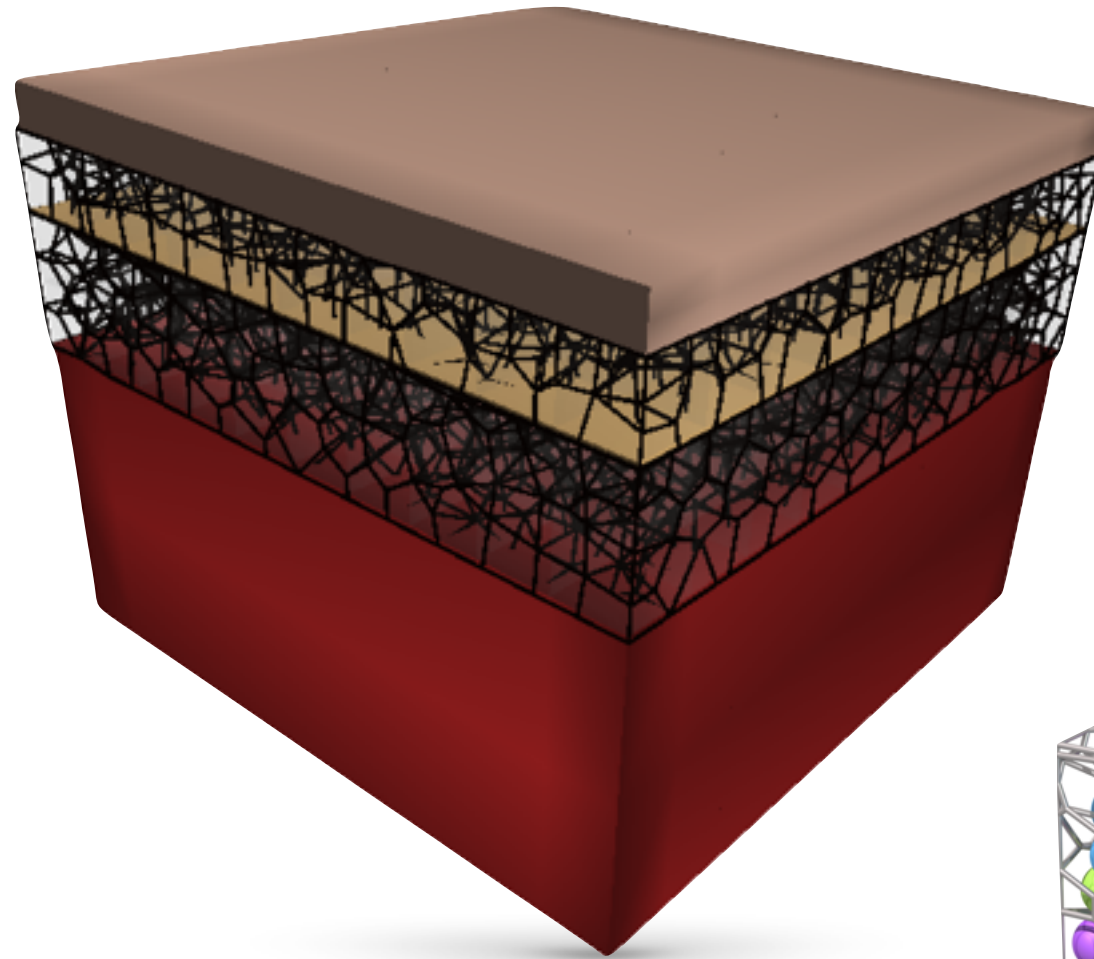
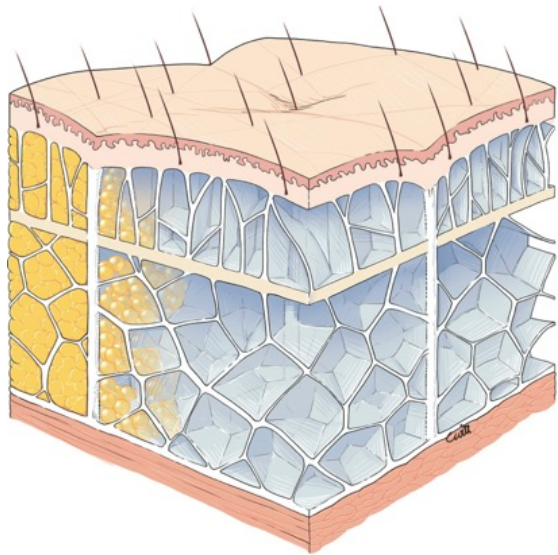


- Size*
- Skin<sub>t</sub>*
- SAT<sub>t</sub>*
- SM<sub>t</sub>*
- DAT<sub>t</sub>*
- RCS<sub>t</sub>*
- RCP<sub>t</sub>*
- Deep<sub>t</sub>*





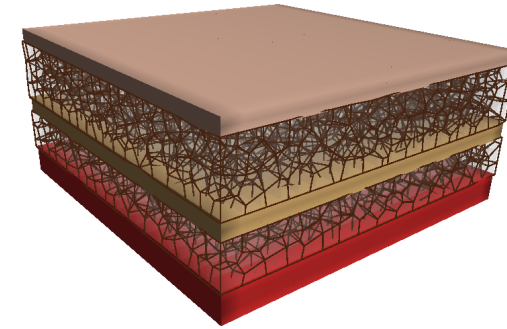
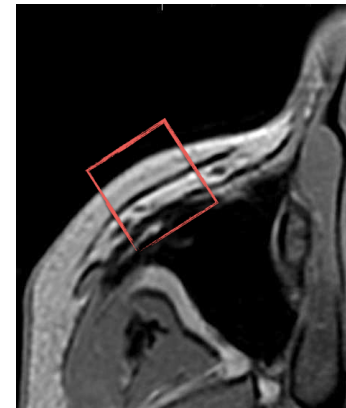
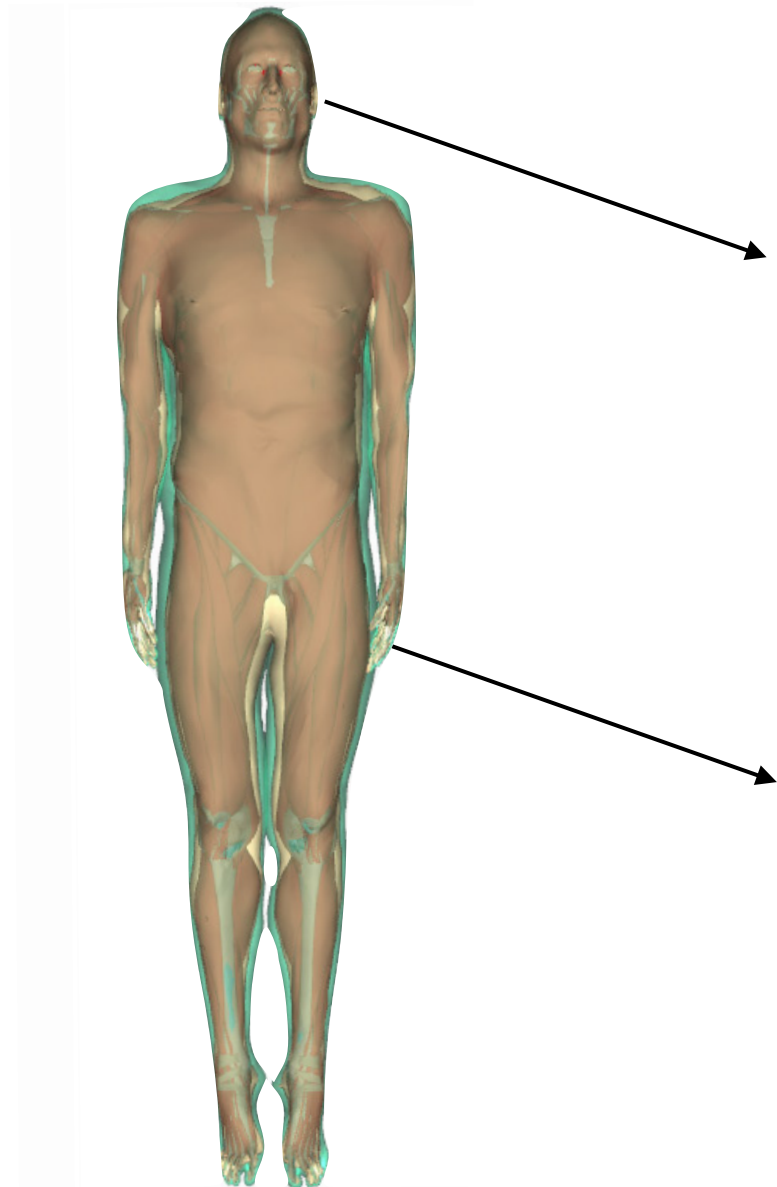
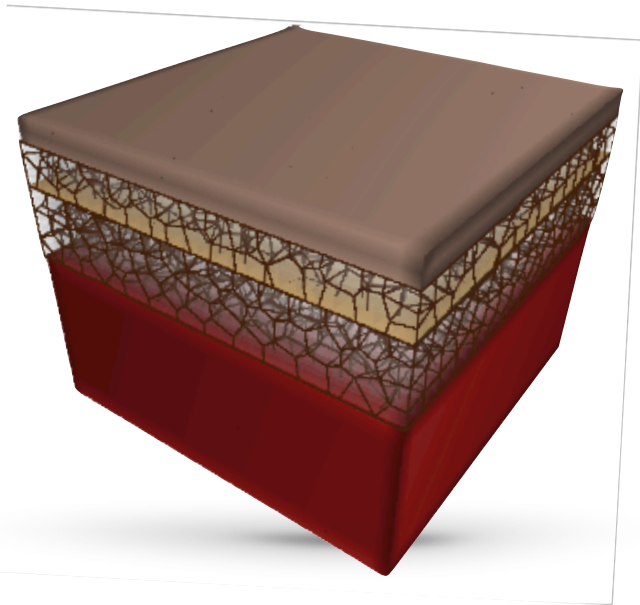
# a Procedural lobular geometrical model



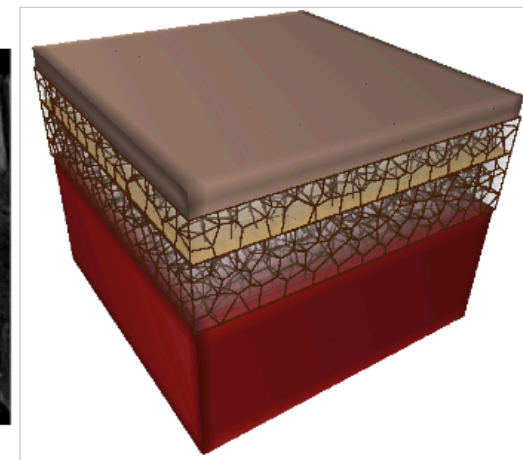
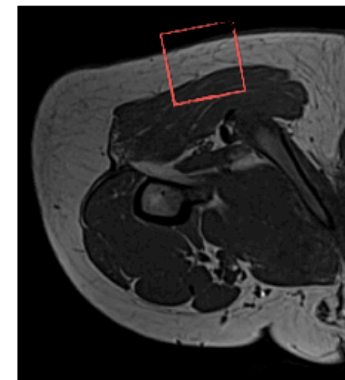
- Size
- Skin<sub>t</sub>
- SAT<sub>t</sub>
- SM<sub>t</sub>
- DAT<sub>t</sub>
- RCS<sub>t</sub>
- RCP<sub>t</sub>
- Deep<sub>t</sub>

Uniform 3D sampling of fat layers by Lloyd relaxation  
Voronoi tessellation used to model fat lobules as polyhedra

# Specialization



size=3×3 cm  
 $skin_t=1.2$  mm  
 $SAT_t=5.0$  mm  
 $SM_t=1.2$  mm  
 $DAT_t=3.4$  mm  
 $lobule_d=1.5$  mm  
 $RCS_t=0.2$  mm  
 $RCP_t=0.1$  mm  
 $deep_t=2.5$  mm



size=7×7 cm  
 $skin_t=4.5$  mm  
 $SAT_t=7.0$  mm  
 $SM_t=0.6$  mm  
 $DAT_t=12.5$  mm  
 $lobule_d=4$  mm  
 $RCS_t=0.4$  mm  
 $RCP_t=0.4$  mm  
 $deep_t=30$  mm

# Our contributions

#1

Procedural Geometrical Model of the SSC

#2

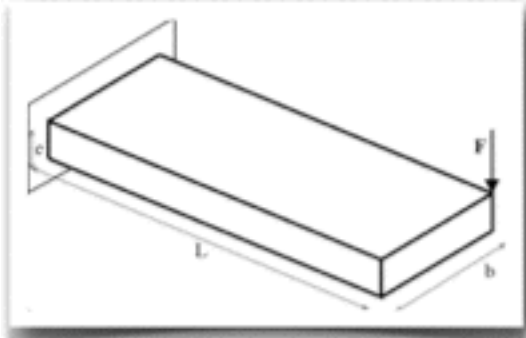
Hybrid Mechanical Model

#3

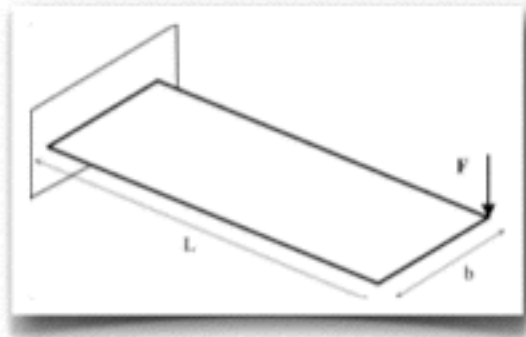
Simulations of Surgical Procedures



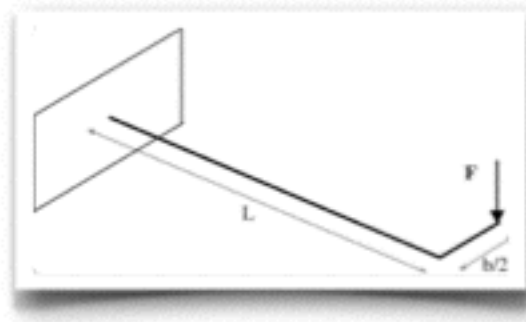
# Hybrid Mechanical model



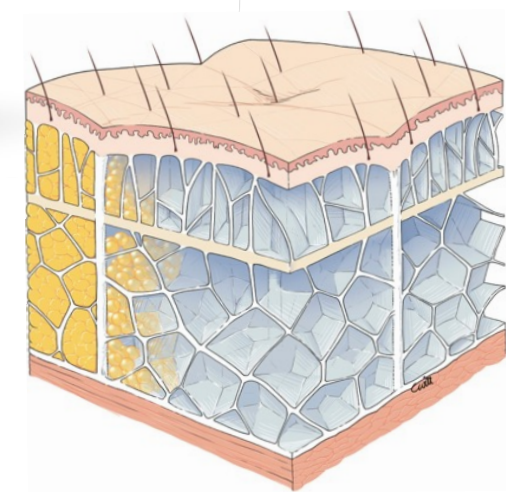
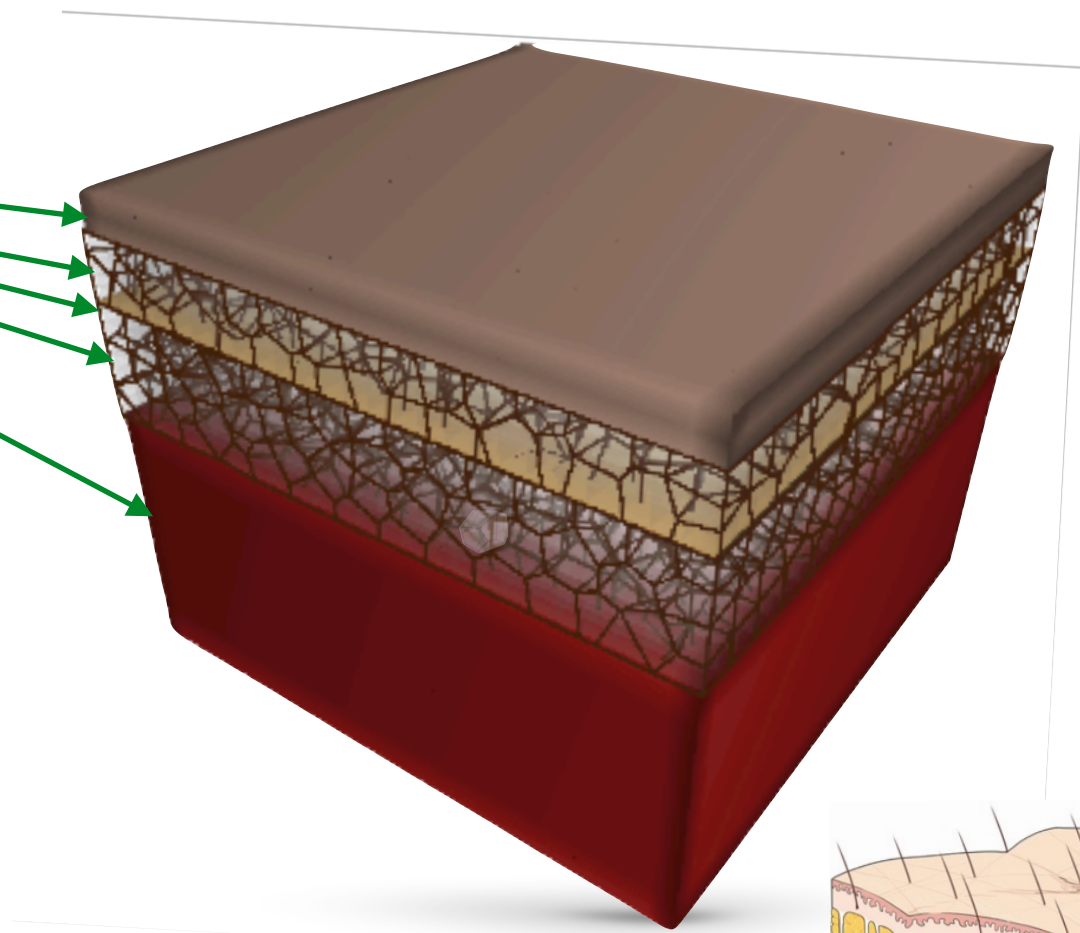
**Volume**  
(Fine Hexahedra)



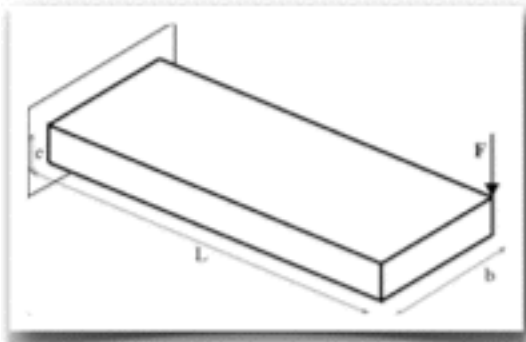
**Surface**  
(Triangle)



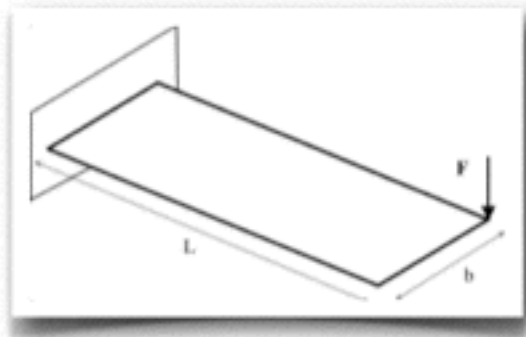
**Line**  
(Edge)



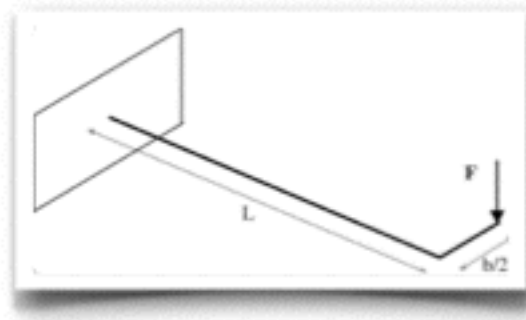
# Hybrid Mechanical model



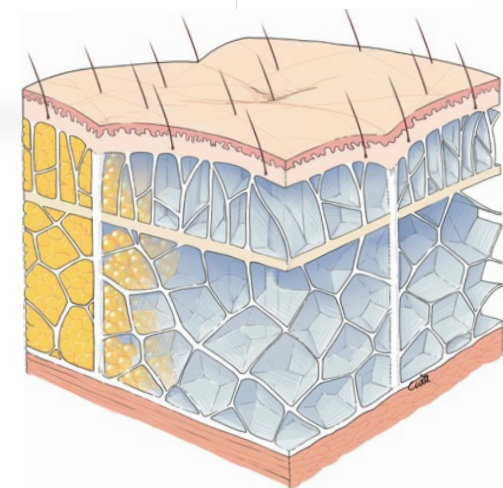
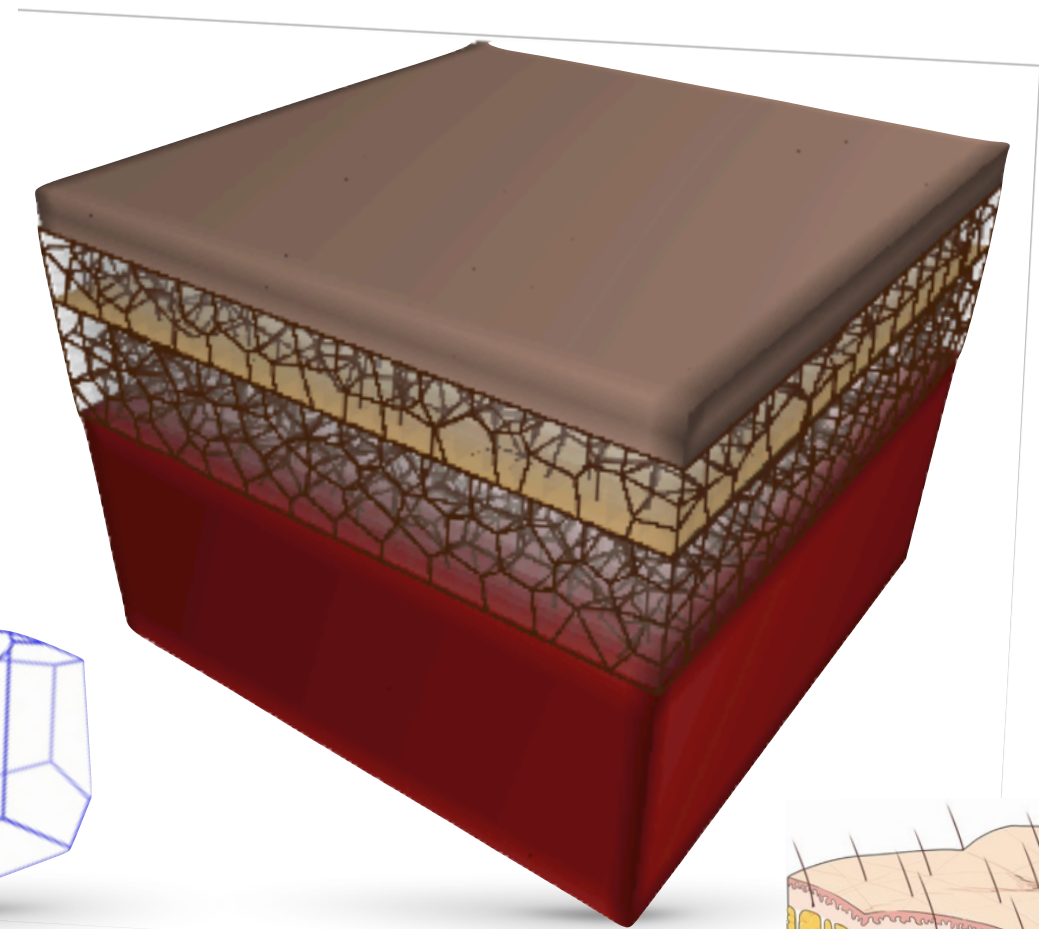
**Volume**  
(Fine Hexahedra)



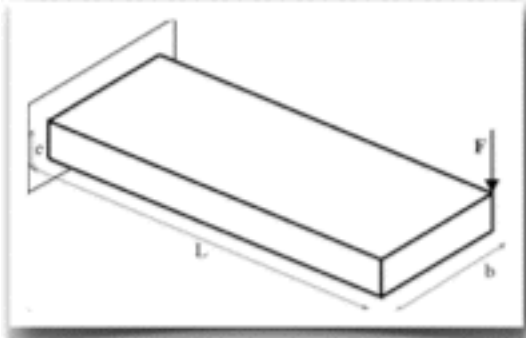
**Surface**  
(Triangle)



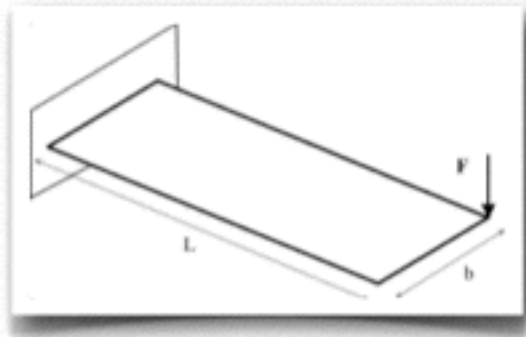
**Line**  
(Edge)



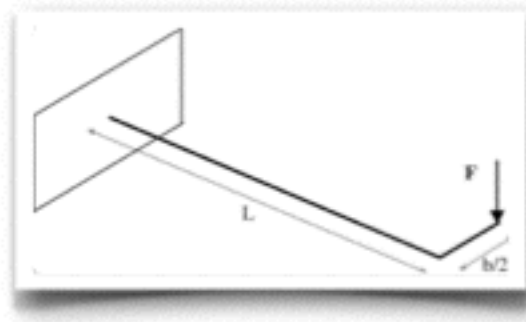
# Hybrid Mechanical model



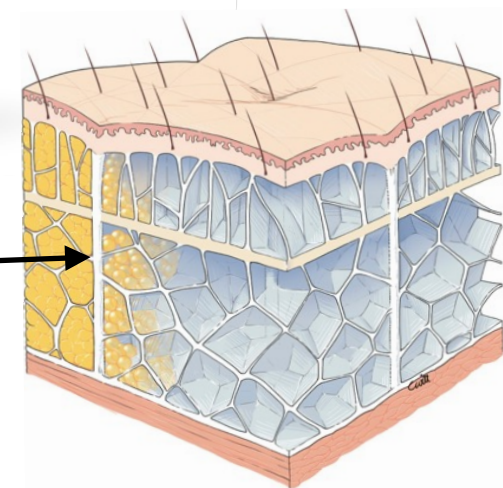
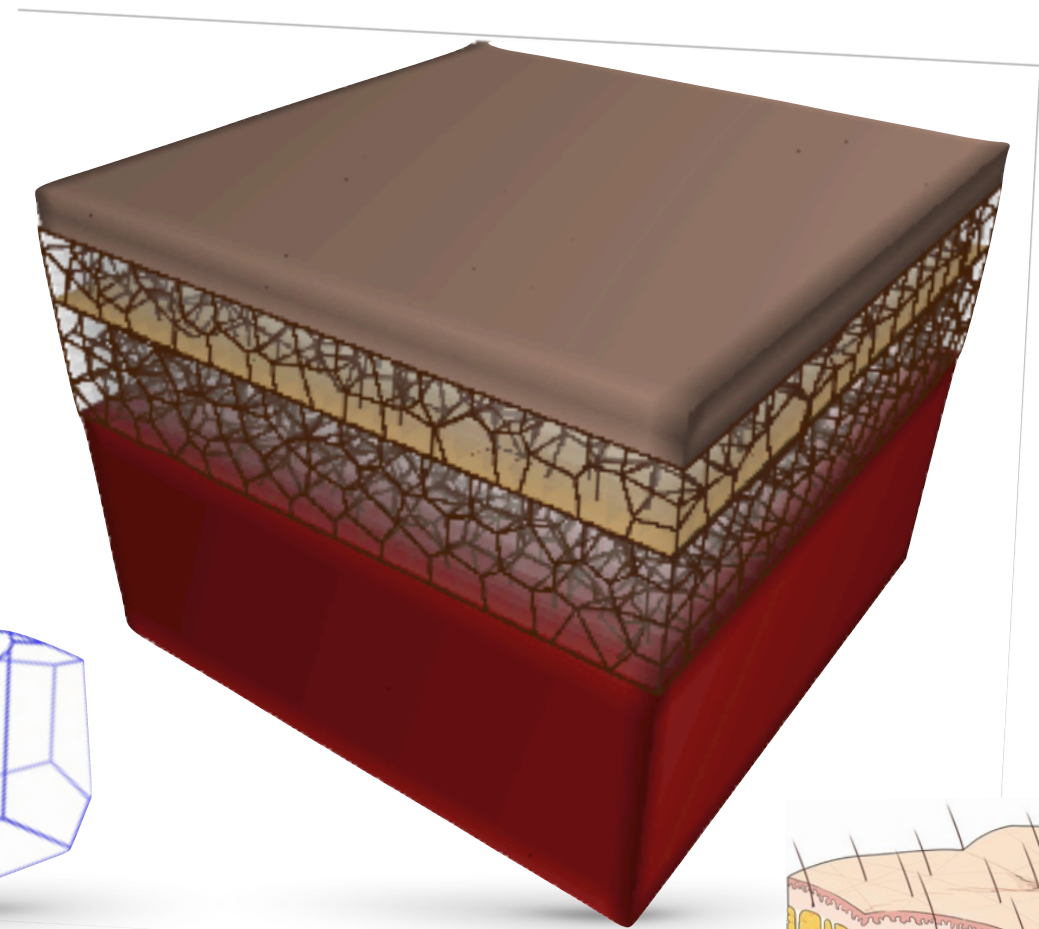
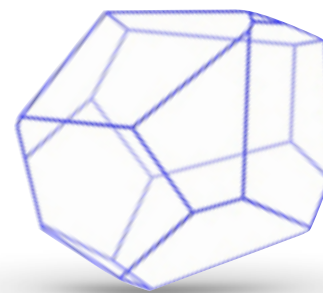
**Volume**  
(Fine Hexahedra)



**Surface**  
(Triangle)

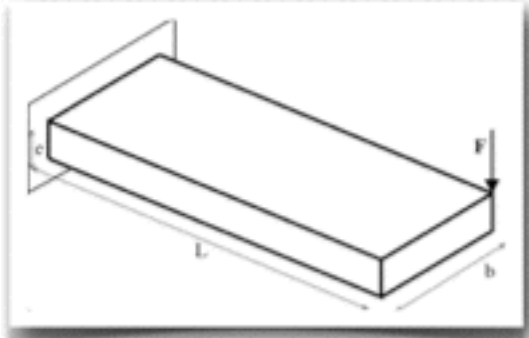


**Line**  
(Edge)

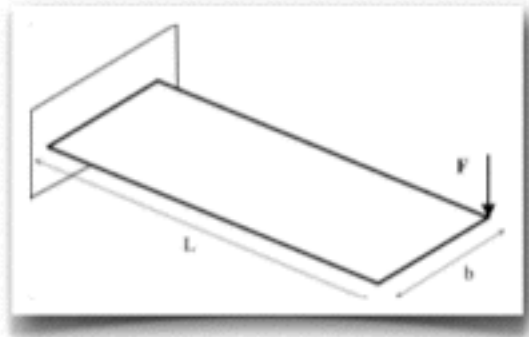




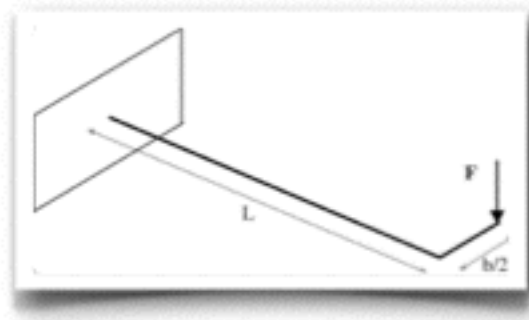
# Hybrid Mechanical model



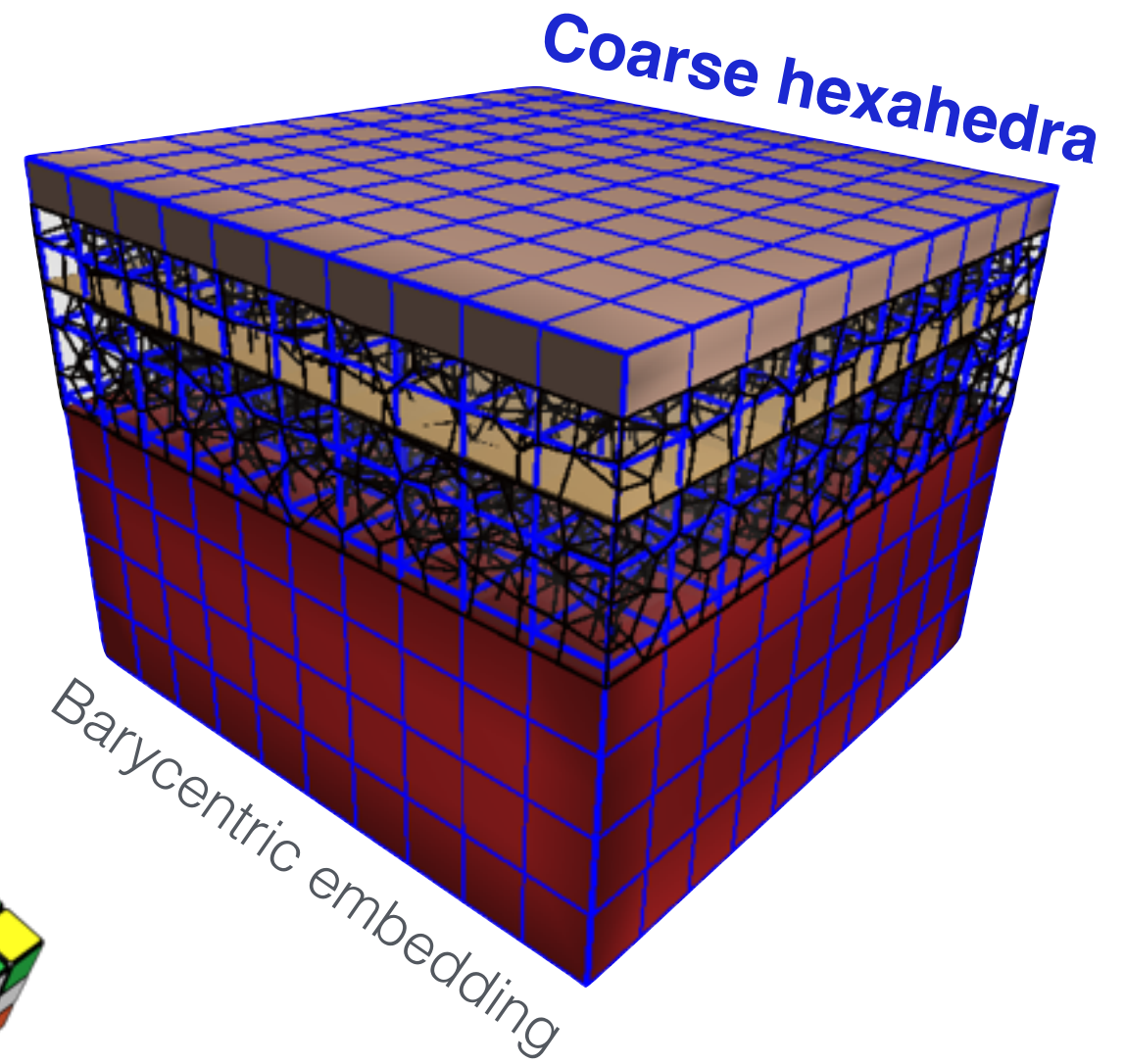
**Volume**  
(Fine Hexahedra)



**Surface**  
(Triangle)

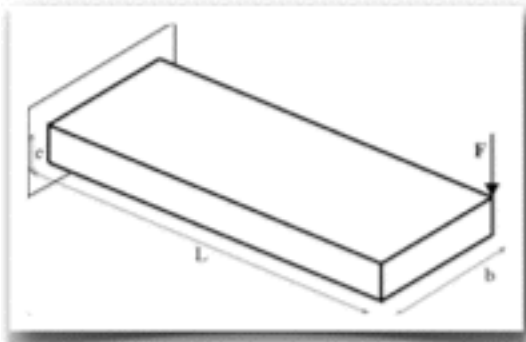


**Line**  
(Edge)

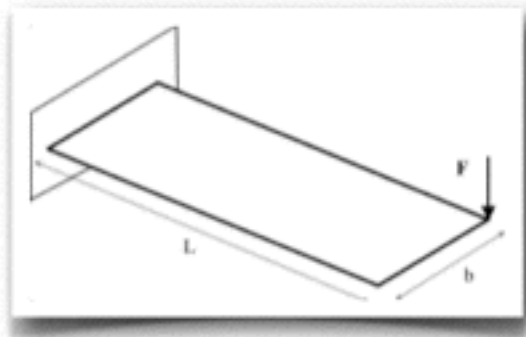


**Implicit Euler Solver**

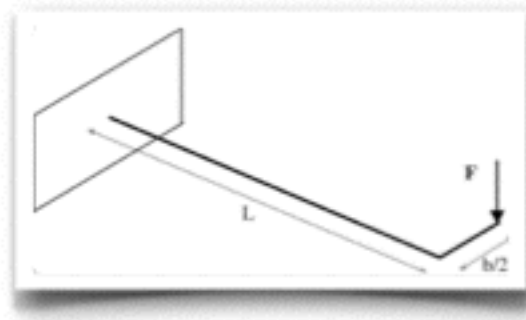
# Hybrid Mechanical model



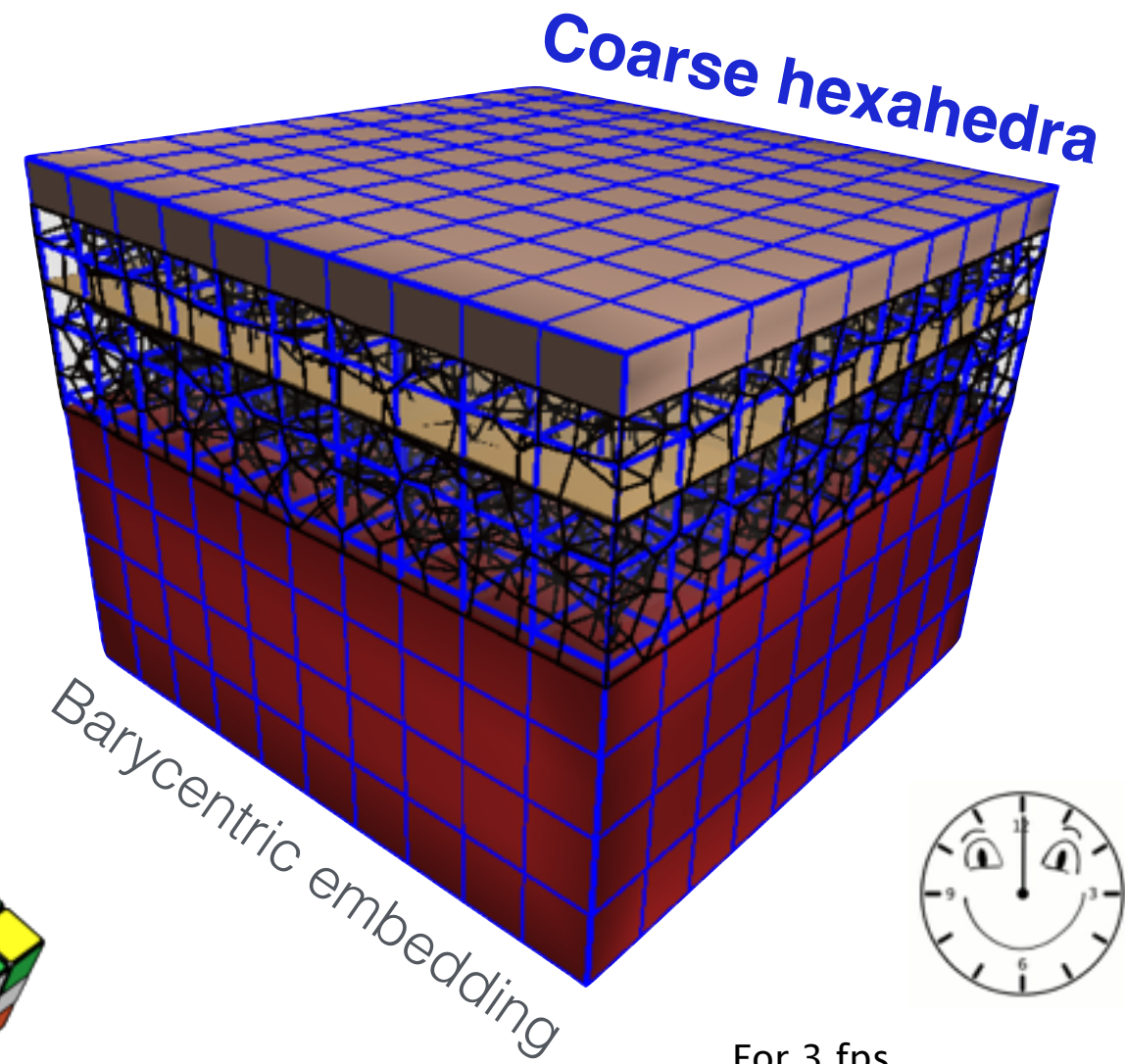
**Volume**  
(Fine Hexahedra)



**Surface**  
(Triangle)



**Line**  
(Edge)



**Implicit Euler Solver**



For 3 fps  
700 hexahedra  
23000 triangles // DAT  
13000 // SAT



# Our contributions

#1

Procedural Geometrical Model of the SSC

#2

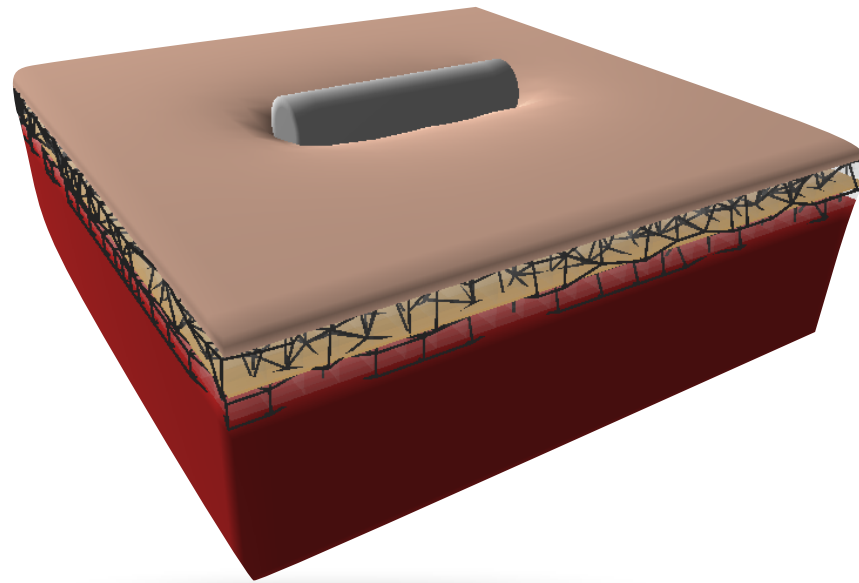
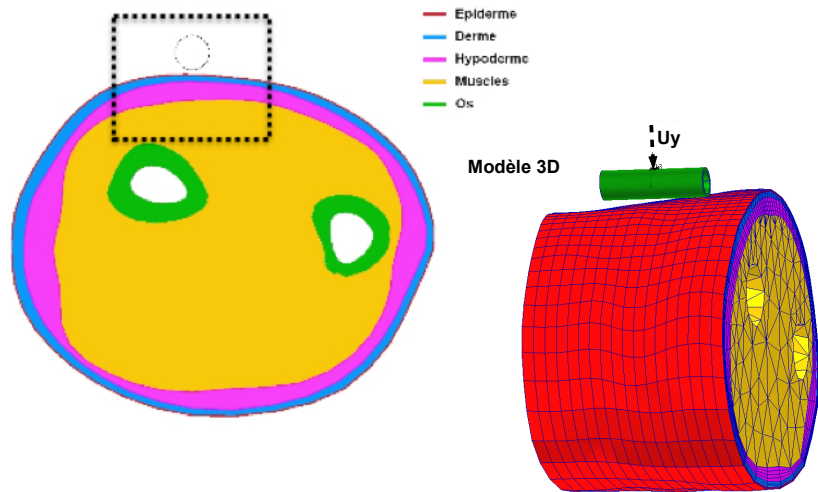
Hybrid Mechanical Model

#3

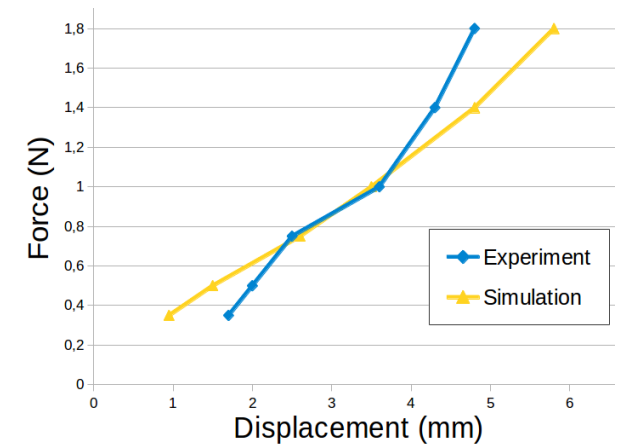
Simulations of Surgical Procedures



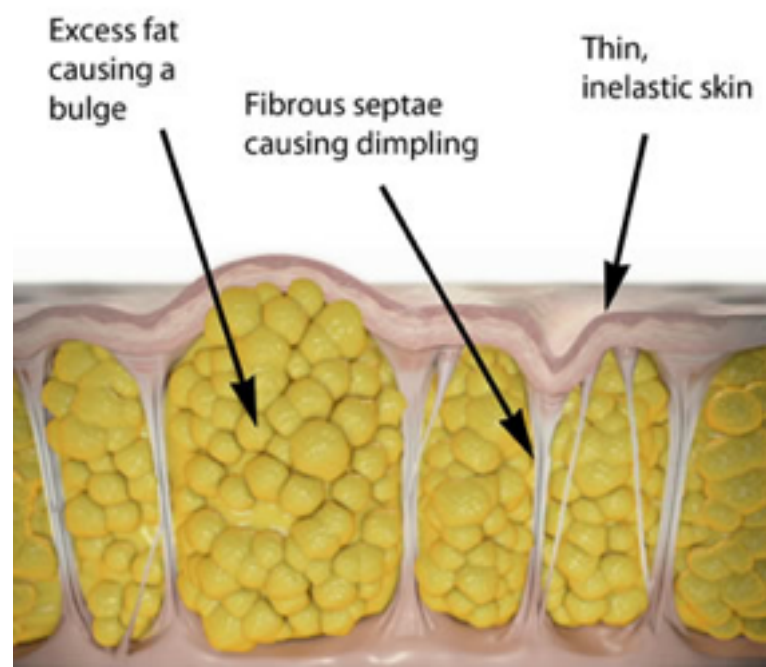
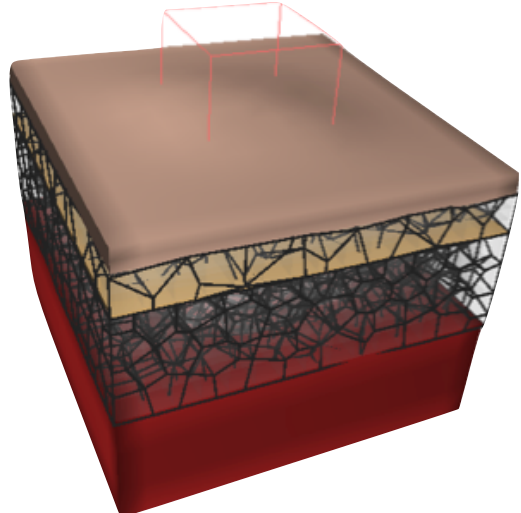
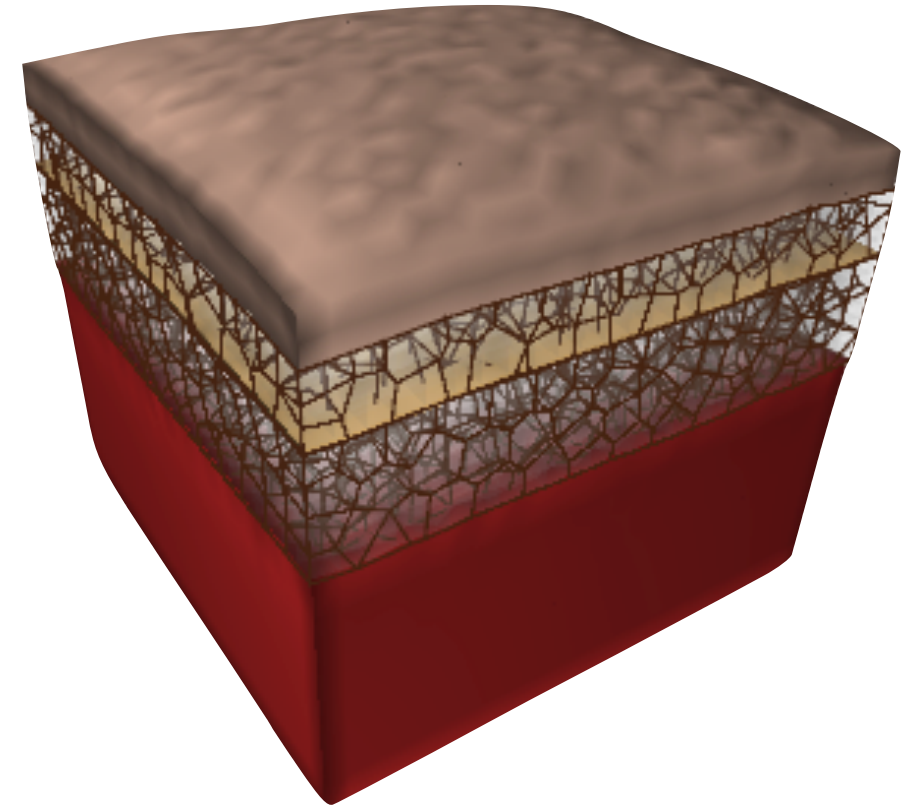
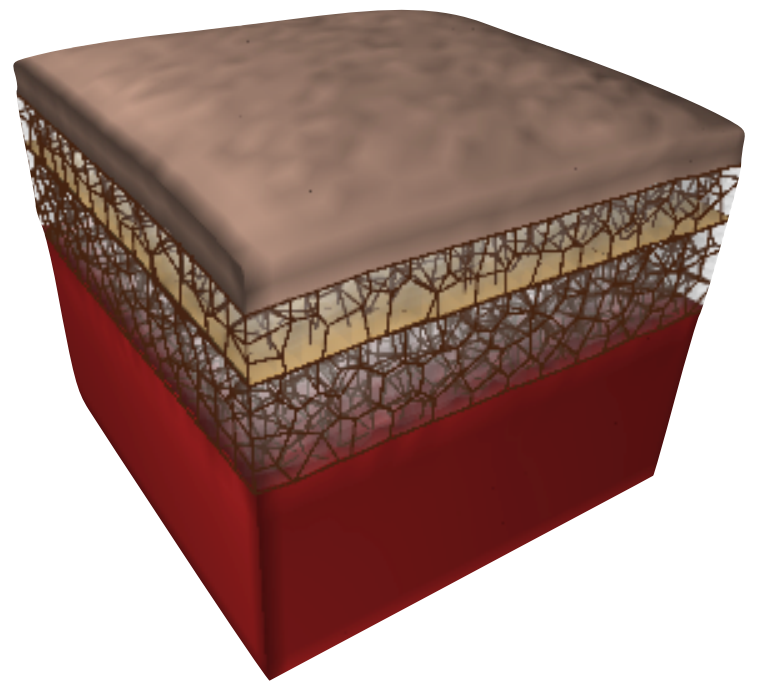
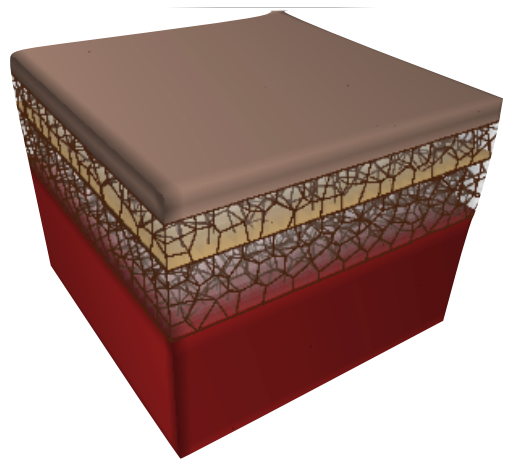
# Simulation of Indentation



size=5×5 cm  
 $skin_t=1.48$  mm  
 $SAT_t=1.6$  mm  
 $SM_t=0.2$  mm  
 $DAT_t=0.68$  mm  
 $lobule_d=1.8$  mm  
 $RCS_t=0.1$  mm  
 $RCP_t=0.1$  mm  
 $deep_t=12$  mm

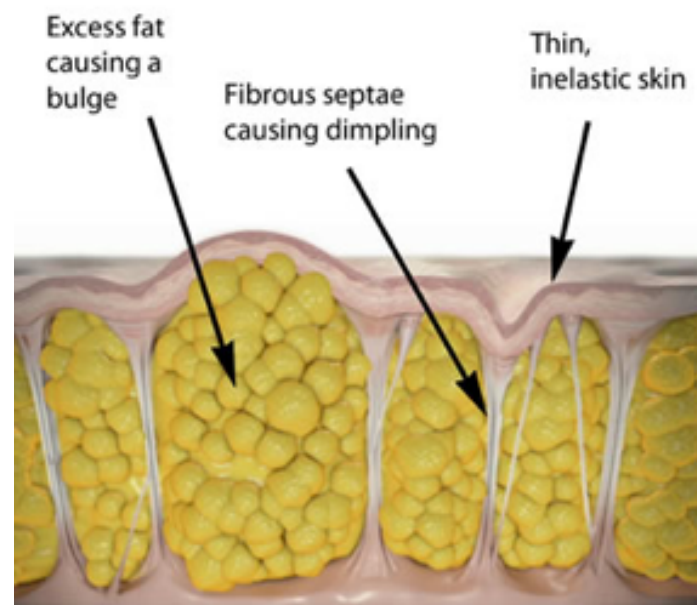
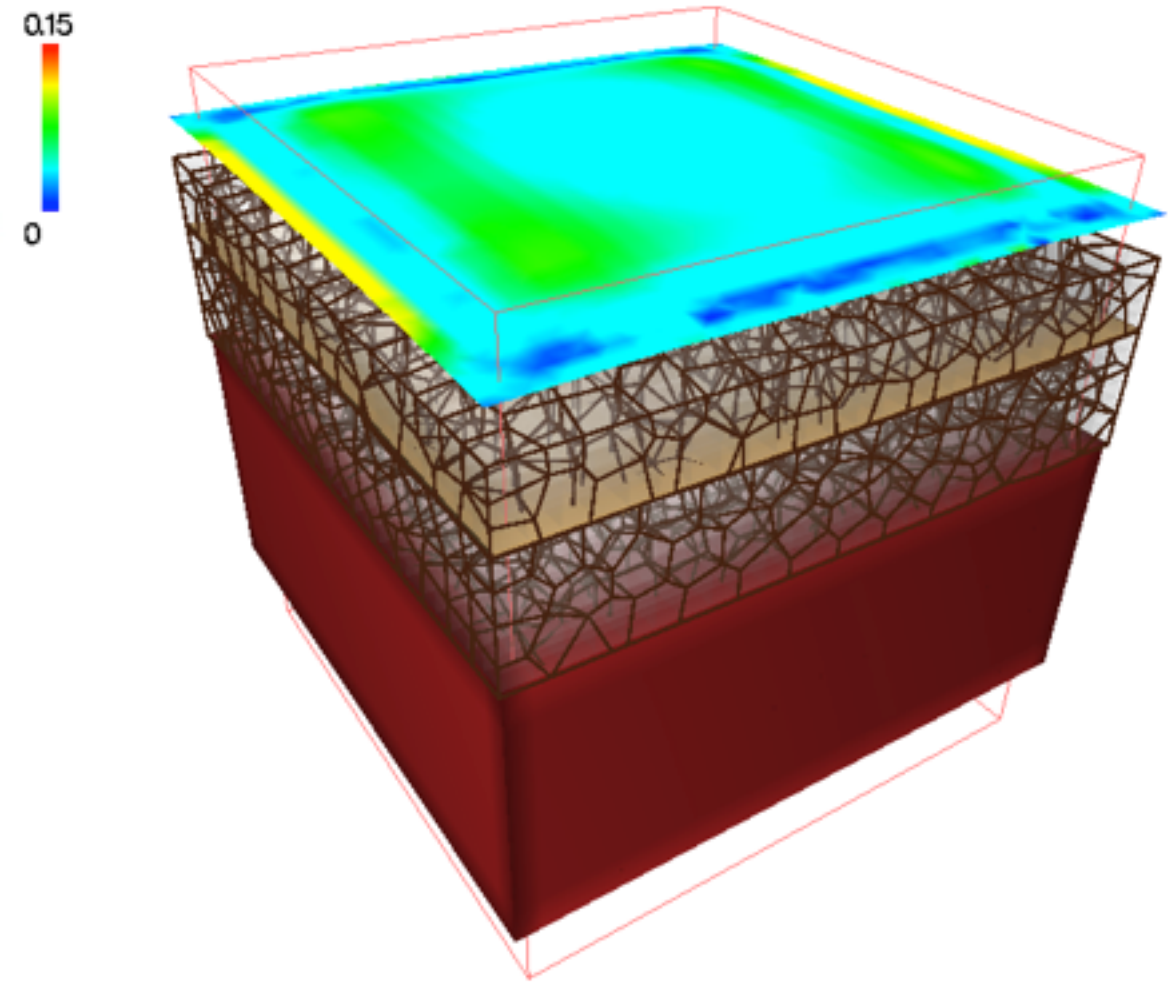
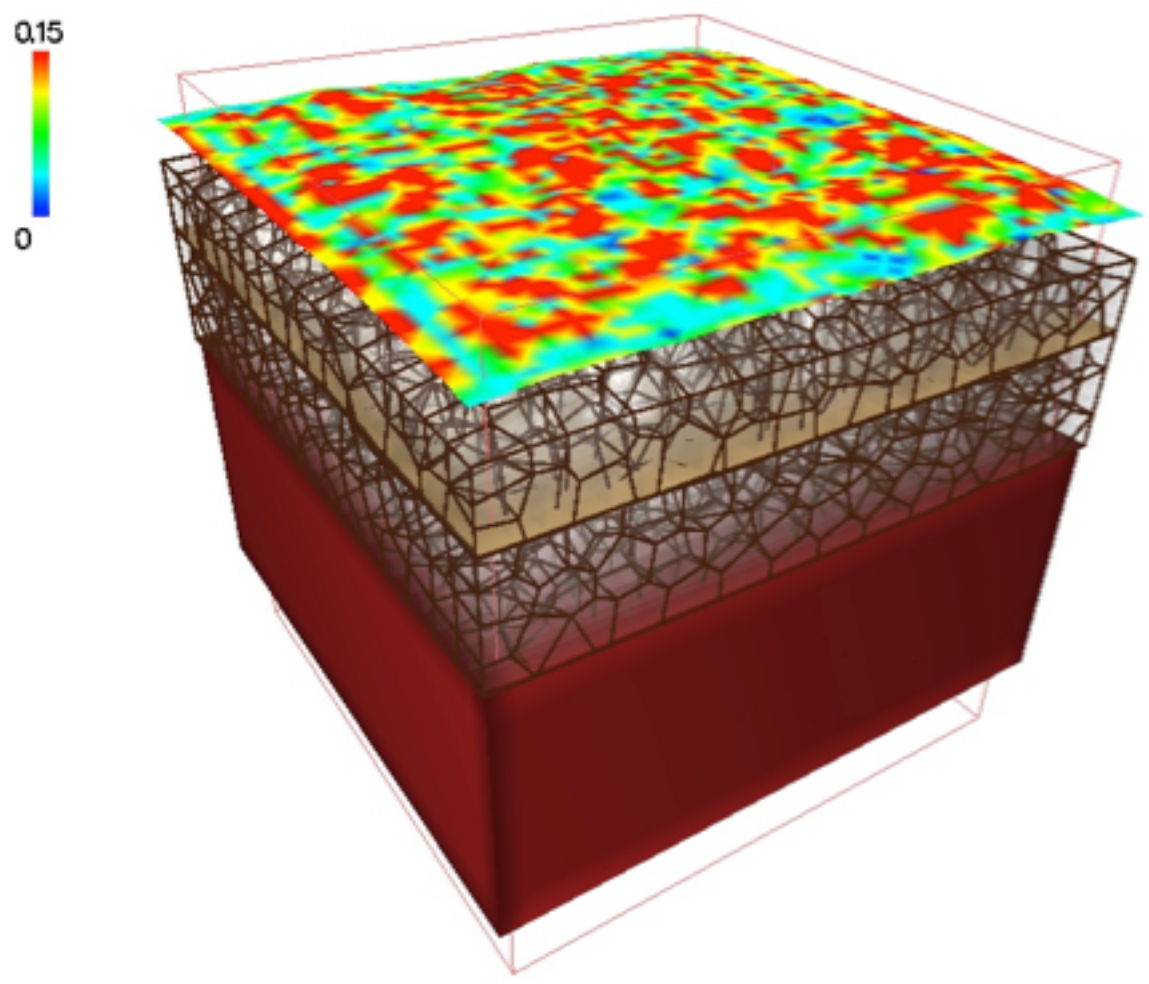


# Simulation of Cellulite

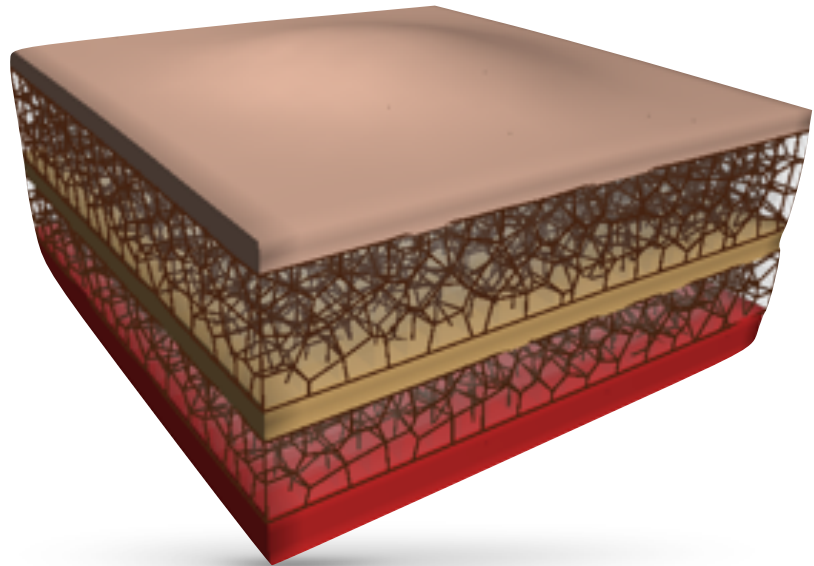
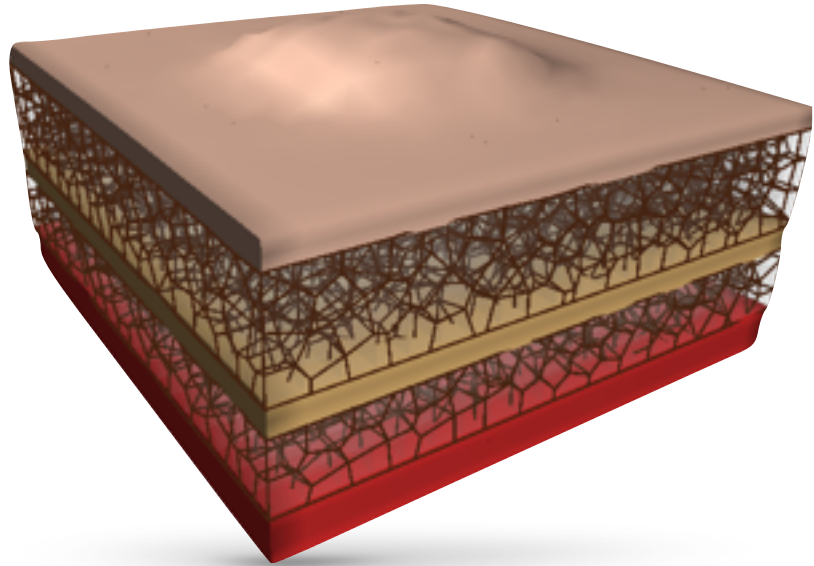
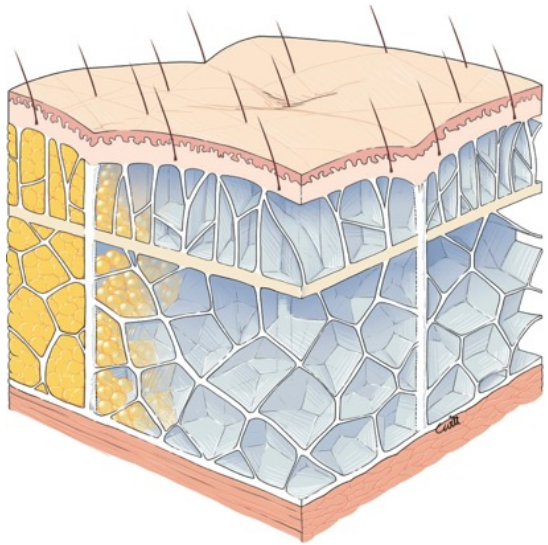




# Simulation of Cellulite

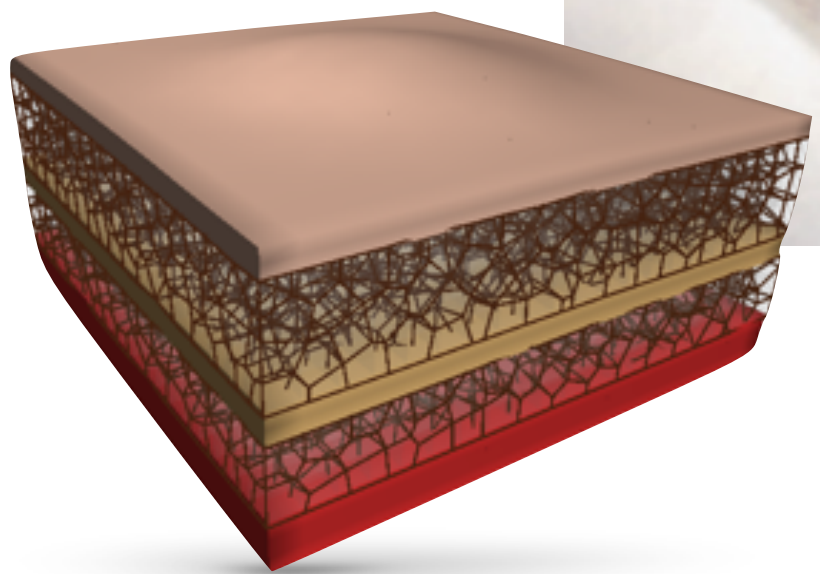
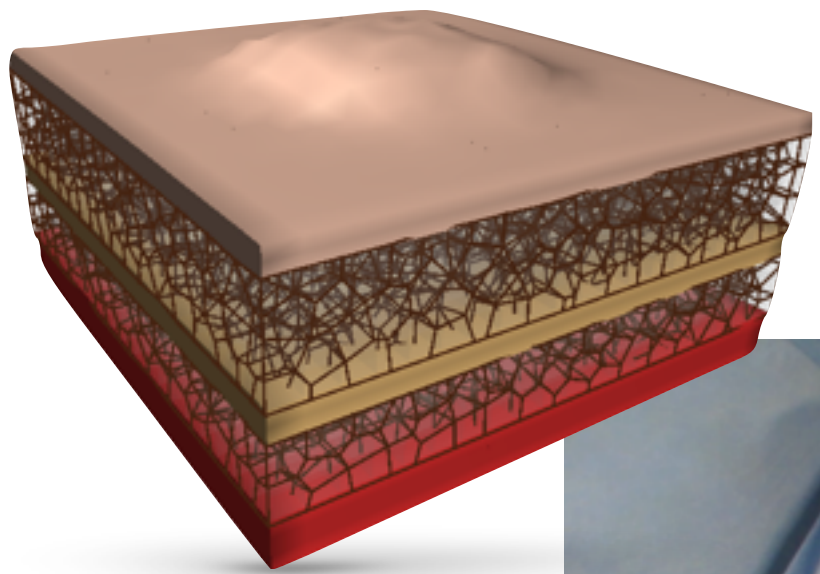
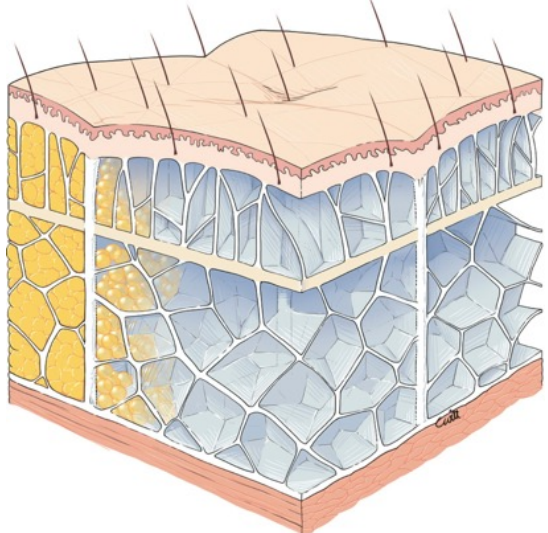


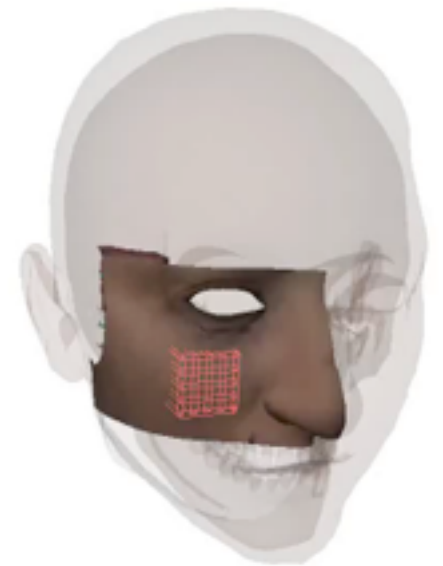
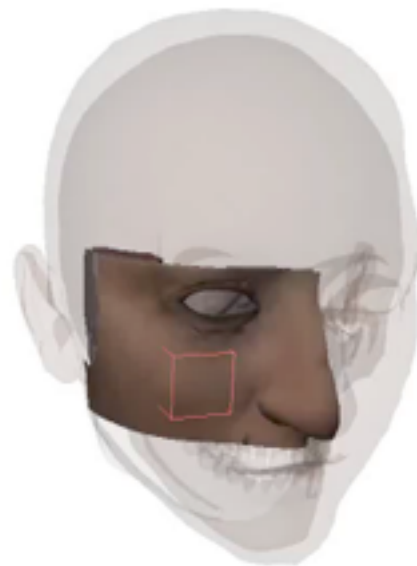
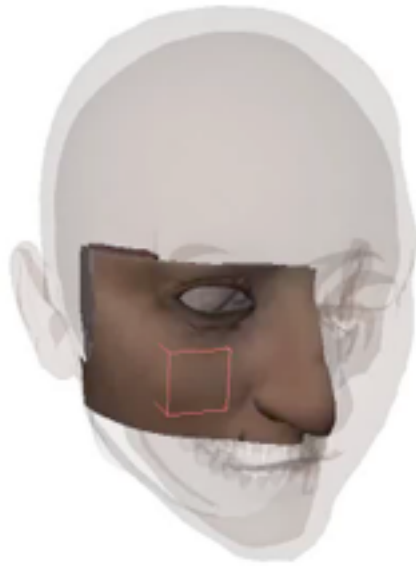
# Simulation of Fat Injection Level





# Simulation of Fat Injection Level

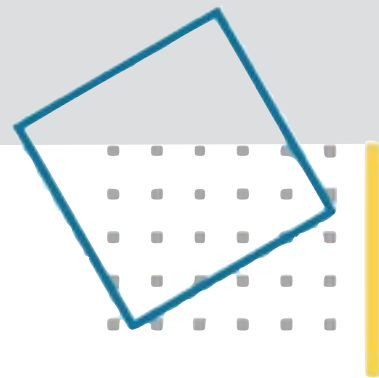




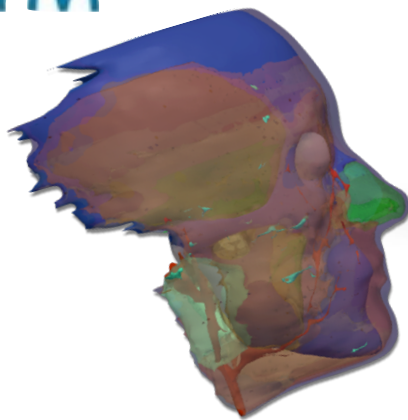
# Generic 3D Geometrical and Mechanical Modeling of the Skin/Subcutaneous Complex by a Procedural Hybrid Method



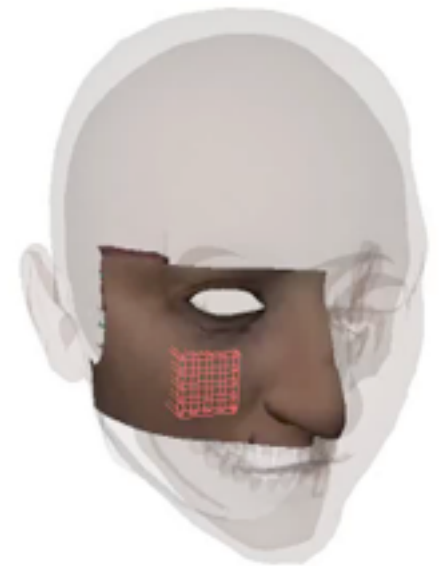
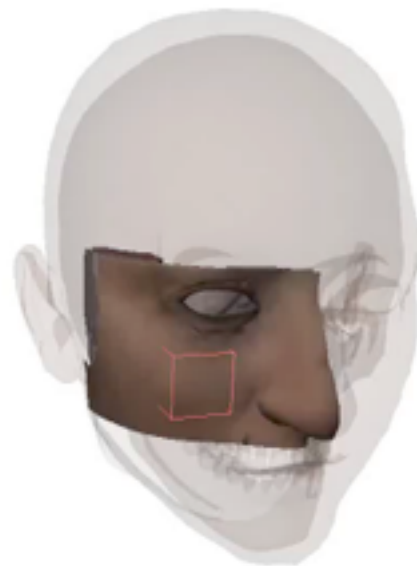
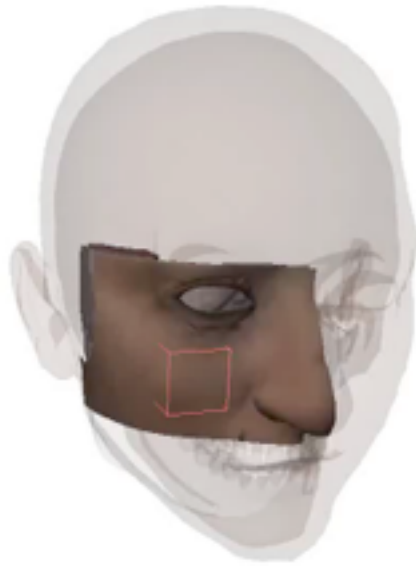
C. HERLIN, B. GILLES, G. SUBSOL, G. CAPTIER



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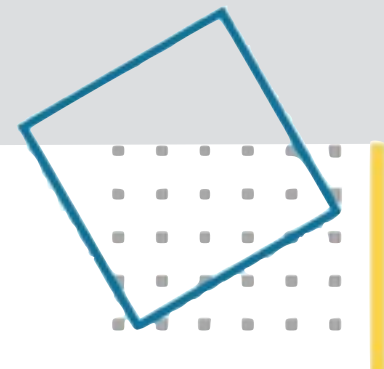




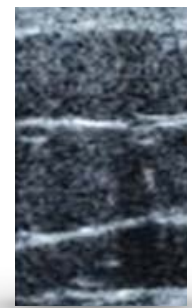
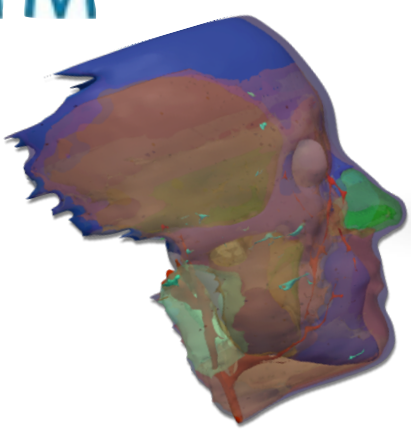


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# What is Fat Grafting ???

