

# materialise

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## Future of Computational Modeling for Patient Care

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Product Manager Academia  
Materialise N.V

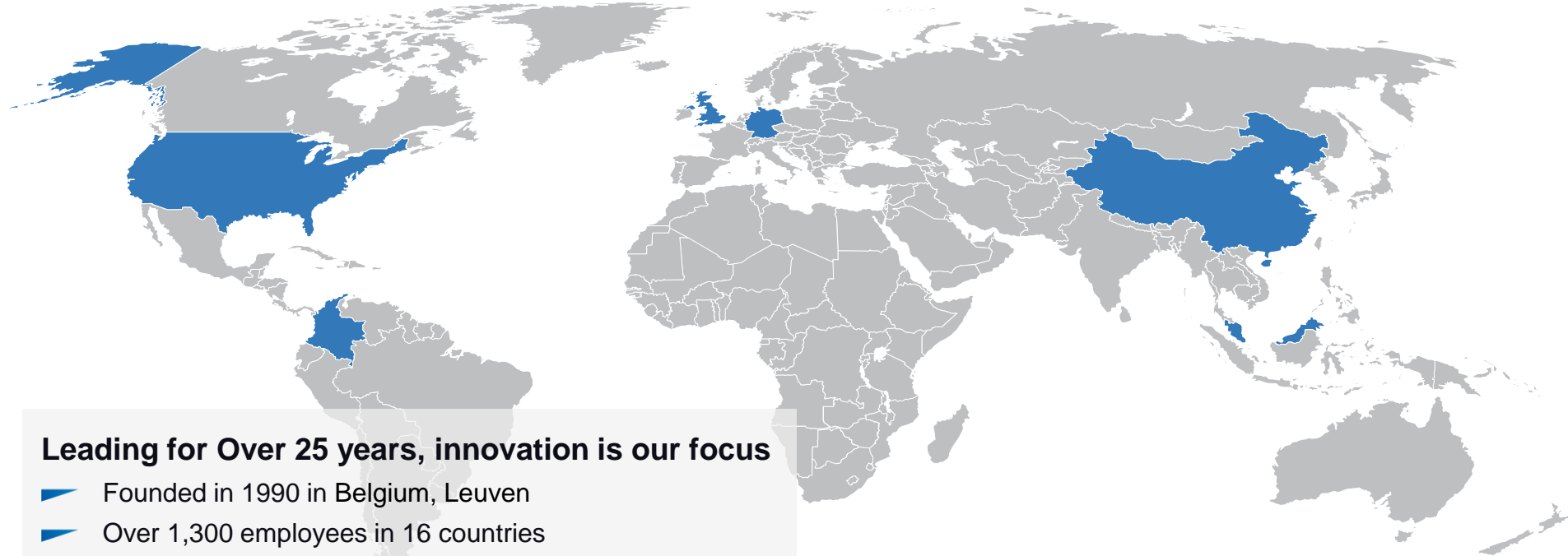




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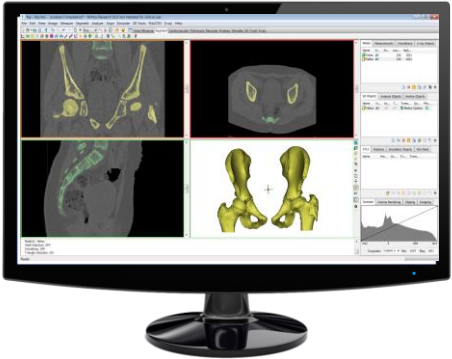
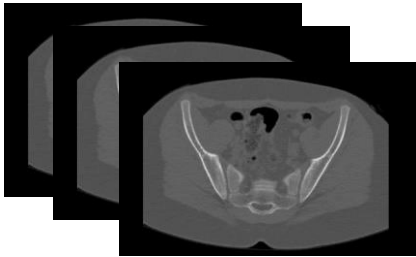
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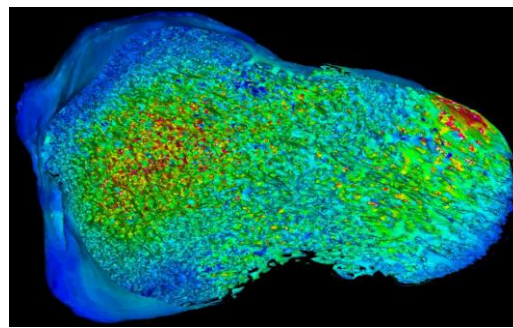


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Medical**

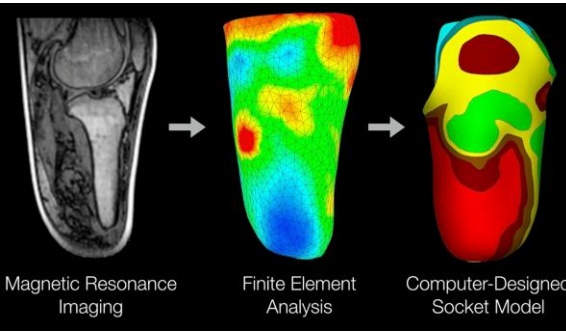
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# Mimics Innovation Suite

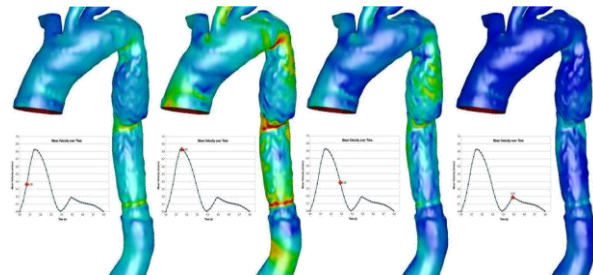




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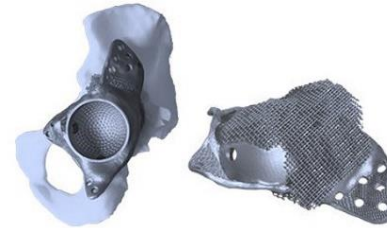
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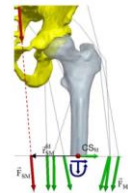
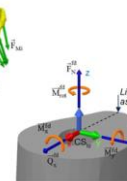
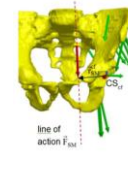
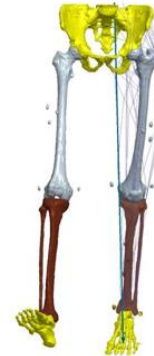
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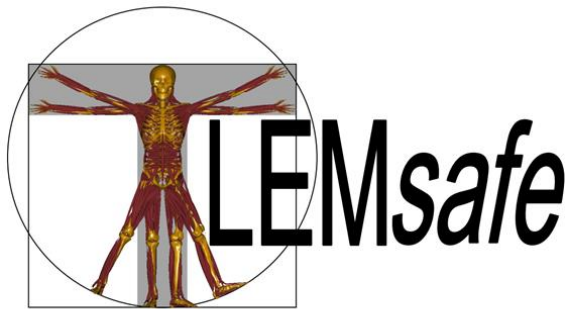
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European Funded Project



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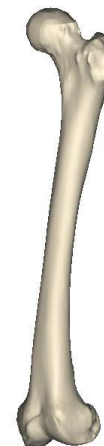
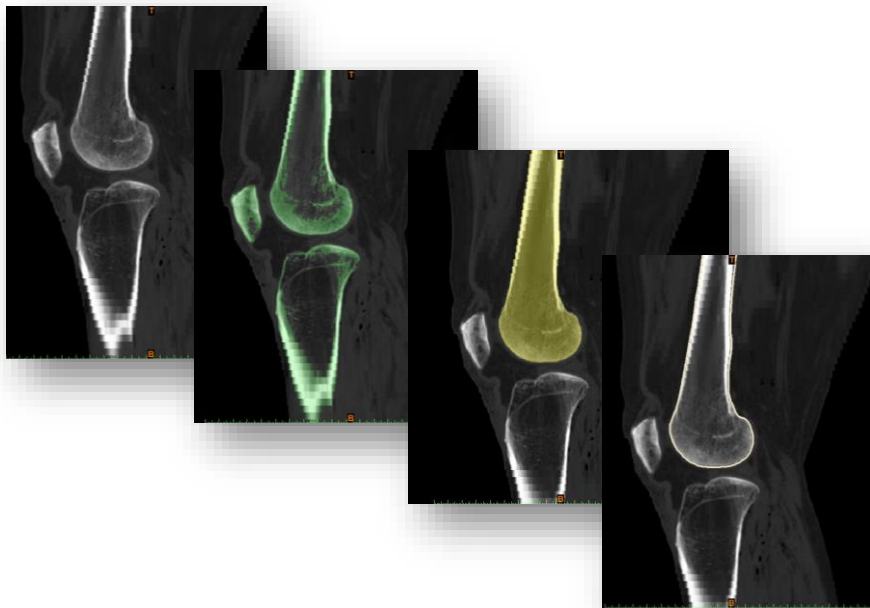
## Mimics MSM Workflow

Goal: Construct detailed subject-specific anatomical models of healthy subjects based on MRI scans and validate their muscle activity predictions with metabolic information from PET

1. Segmentation of bones
2. Obtaining attachment points
3. Segmentation of muscles
4. Combining anatomical and metabolic imaging data
5. Validating the subject-specific models

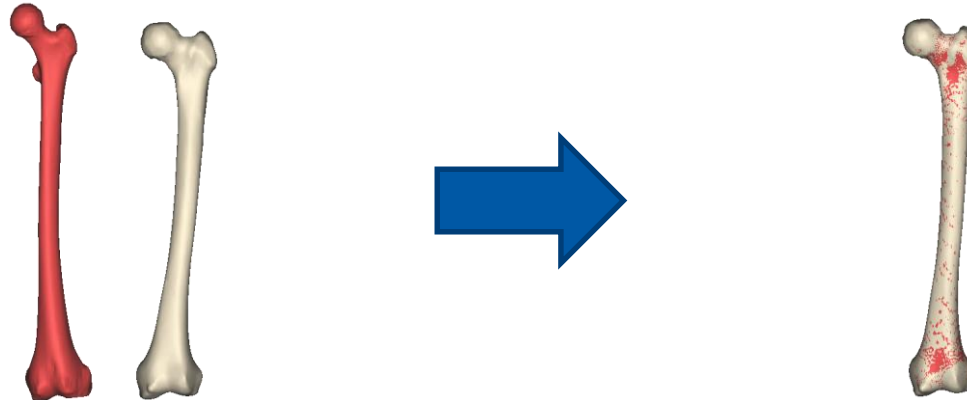


# Bone Segmentation



## Personalized models include Personalized muscle attachment points

- Use **3D mapping** tool to morph bone models
- Move muscle attachment points with bone
- Use points as input for MS modeling



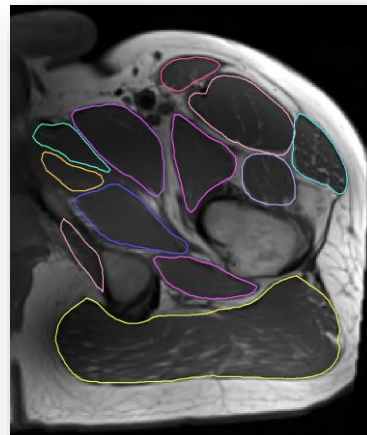
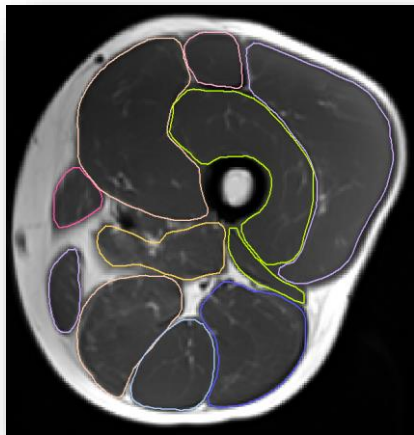
# Personalized models include Personalized muscle volumes

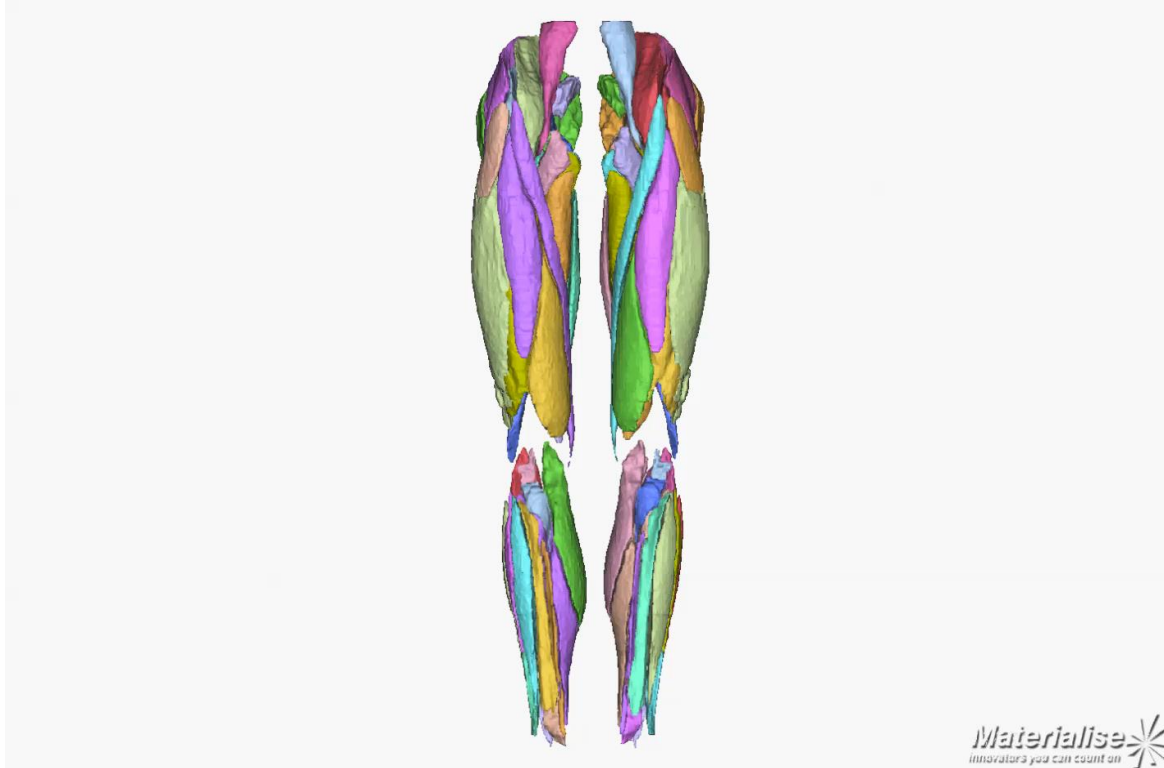
Create image-based subject-specific musculo-skeletal models

Image modality: Full leg MRI scans

Methodology:

Atlas based, therefore it becomes sequentially easier to segment scans as more atlases are created

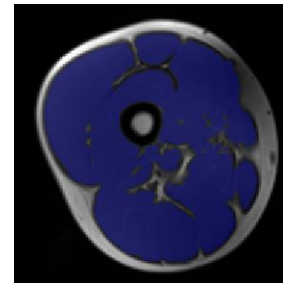
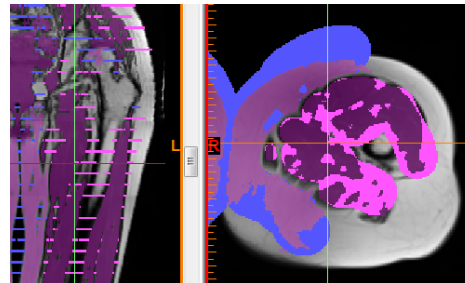
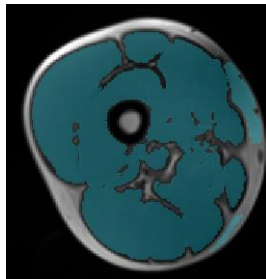
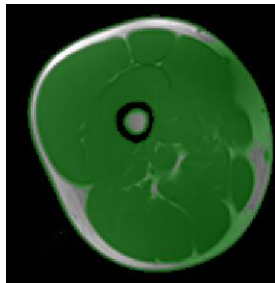
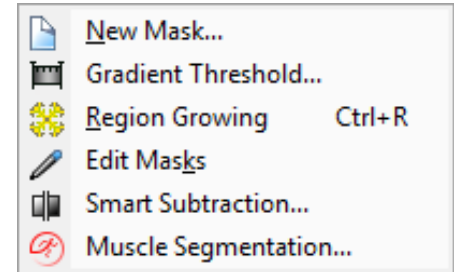




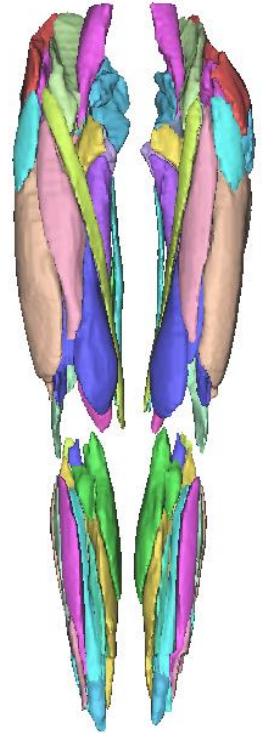


## How does it work

- (1) Thresholding
- (2) Removing strong gradients
- (3) Region Growing
- (4) Smart Subtraction
- (5) Muscle Segmentation



Results: 78 segmented muscles



## Methods – Subjects

10 healthy subjects

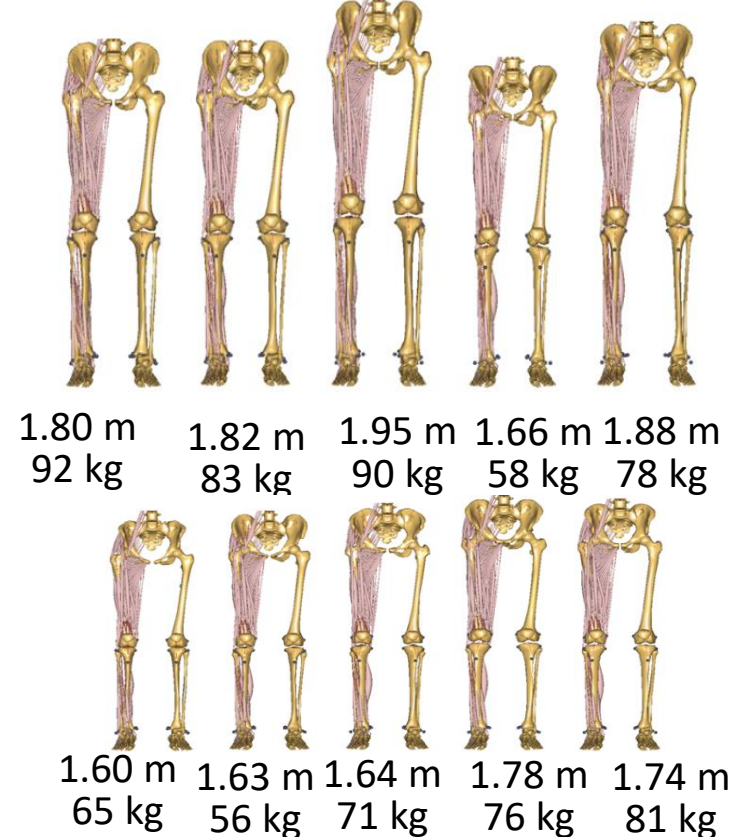
18-60 years

Body Mass Index < 30

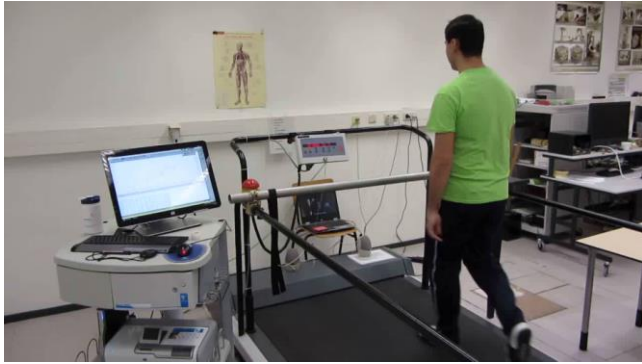
5 male, 5 female

fasted at least 6 hours

no exercise past 2 days



## Methods – Protocol



Walk 60 min

FDG  
injection

Walk 30  
min

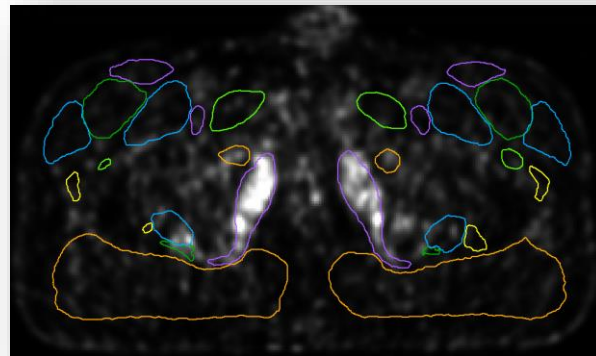
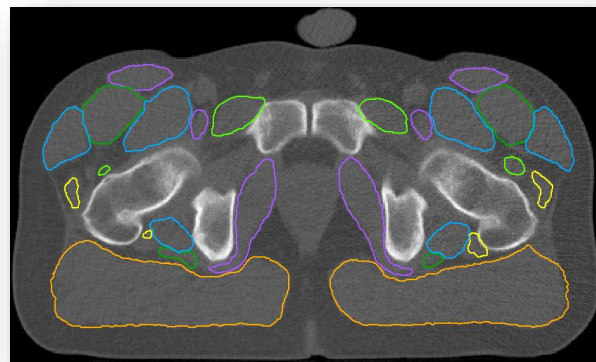
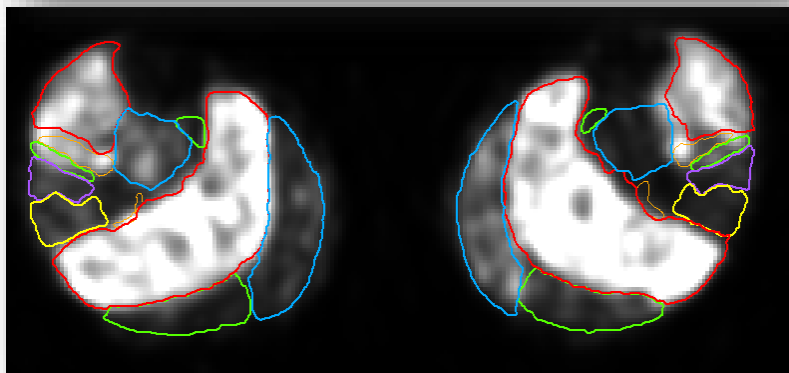
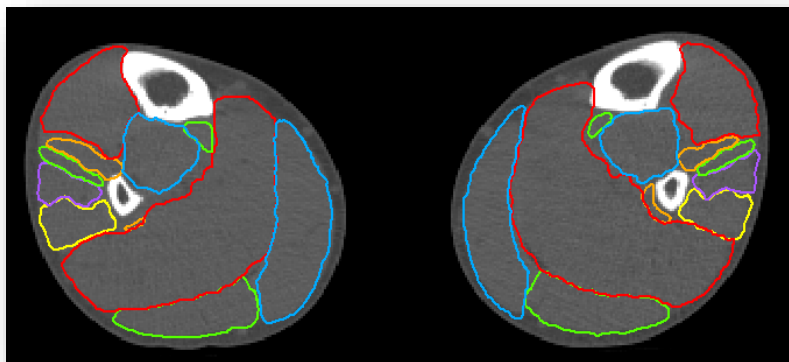
PET/CT  
Scan

+ MRI scan made prior to FDG-PET experiment

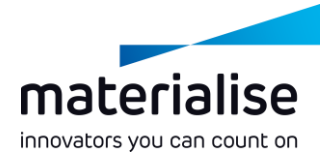


# Multi-modality: Combining muscle anatomy and metabolism

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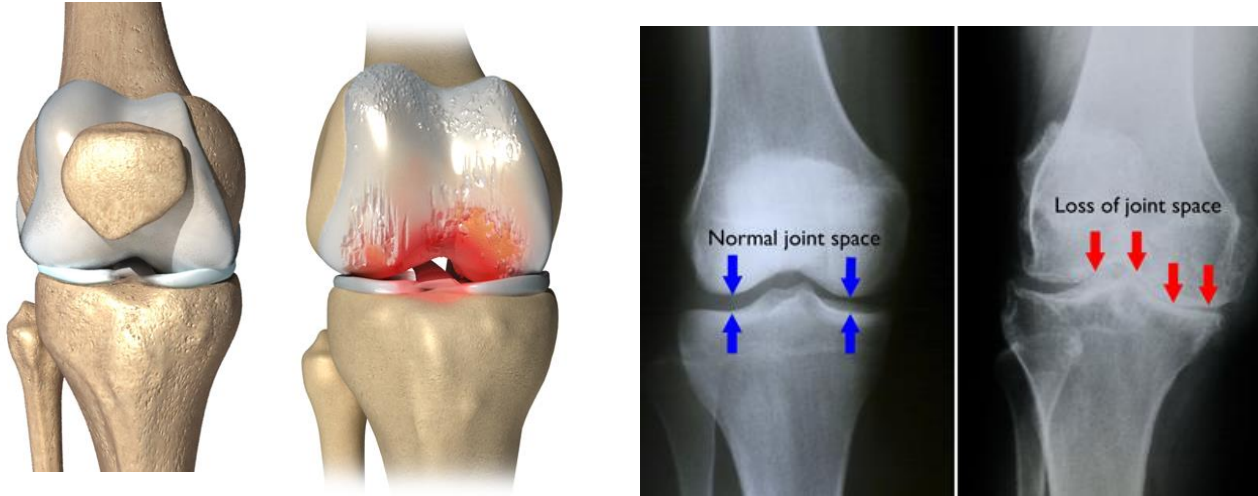


Collaborative Project KUL & Materialise  
Belgian National Grant



# Application of subject-specific models for **surgical planning of knee implants**

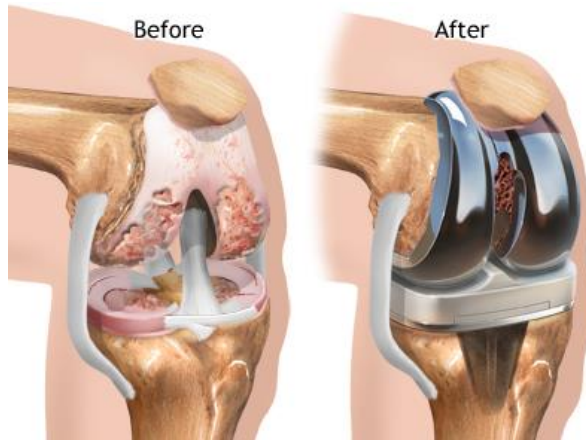
# Osteoarthritis is characterised by the loss of articular cartilage



13% of women and 10% of men have symptomatic knee OA ( $\geq 60$  years)<sup>1</sup>

<sup>1</sup>Zhang, Y., and Jordan, J. M. Epidemiology of osteoarthritis. Clinics in geriatric medicine 26, 3 (2010), 355–369.

# Total knee arthroplasty (TKA) is the standard of care treatment for severe OA



Total Knee Arthroplasty (TKA)

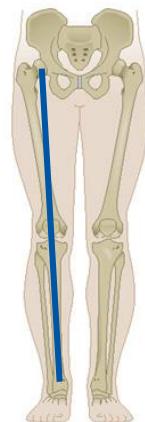
In 2010: 730 000 TKA in USA<sup>1</sup>  
In 2030: 3.4 million TKA in USA<sup>1</sup>



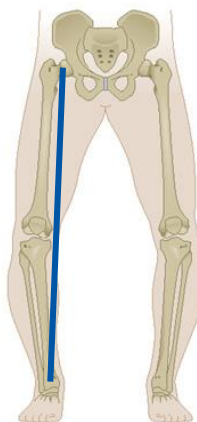
<sup>1</sup>Kurtz, S., Ong, K., Lau, E., Mowat, F., and Halpern, M. Projections of primary and revision hip and knee arthroplasty in the united states from 2005 to 2030. The Journal of Bone & Joint Surgery 89, 4 (2007), 780–785.



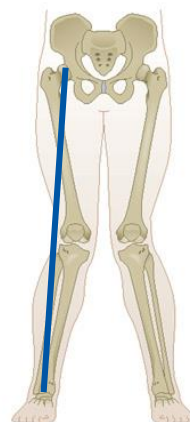
Current TKA procedure aims to restore an overall neutral leg alignment



neutral



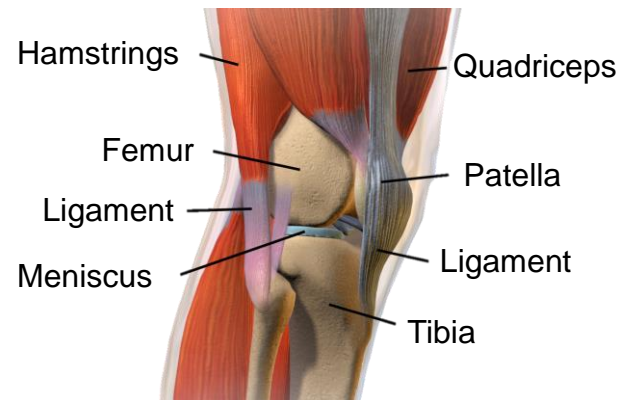
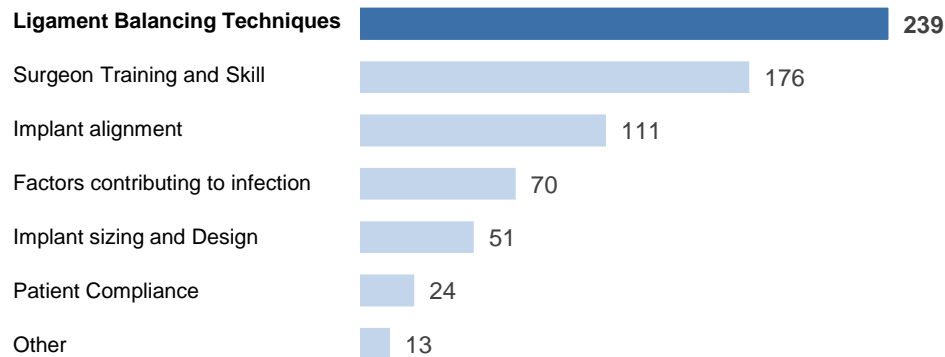
varus



valgus

# Current TKA procedure does not always result in the expected functional outcome

Independent surgeon poll: **What areas need to be addressed most urgently to improve TKA outcomes?**<sup>1</sup>



<sup>1</sup>Bolognesi, M. (2013). Why are total knees failing today? Retrieved <https://www.vumedi.com/discussion/why-are-total-knees-failing-today-etiology-of-total-knee-revision-in-2010-and-2011/>

# Preoperative surgical planning allows to plan the surgical approach before going into the operating room

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Imaging

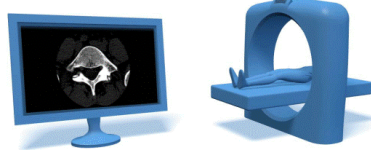
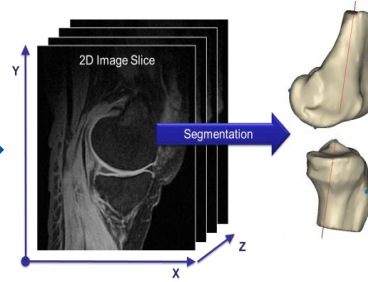
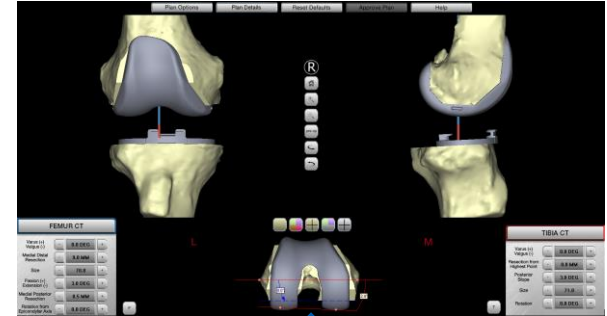


Image processing



Preoperative planning



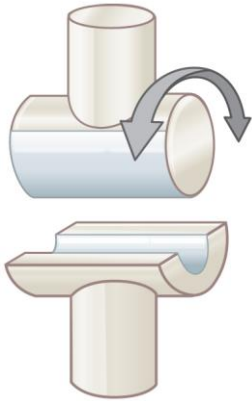
...but what about soft tissues?



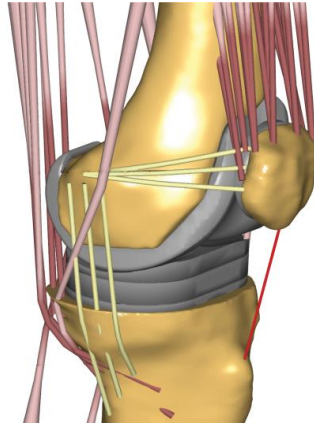
# Application of **subject-specific models** for surgical planning of knee implants



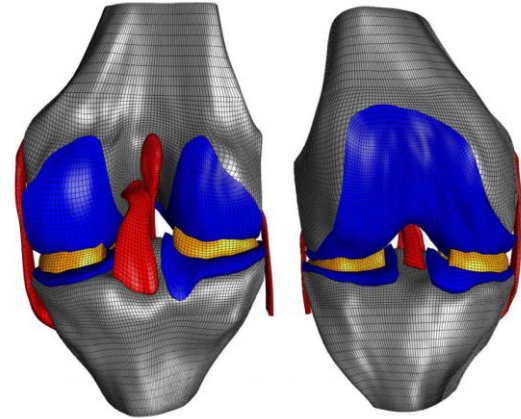
# Computational knee models with different degrees of complexity can be used



Phenomenological models

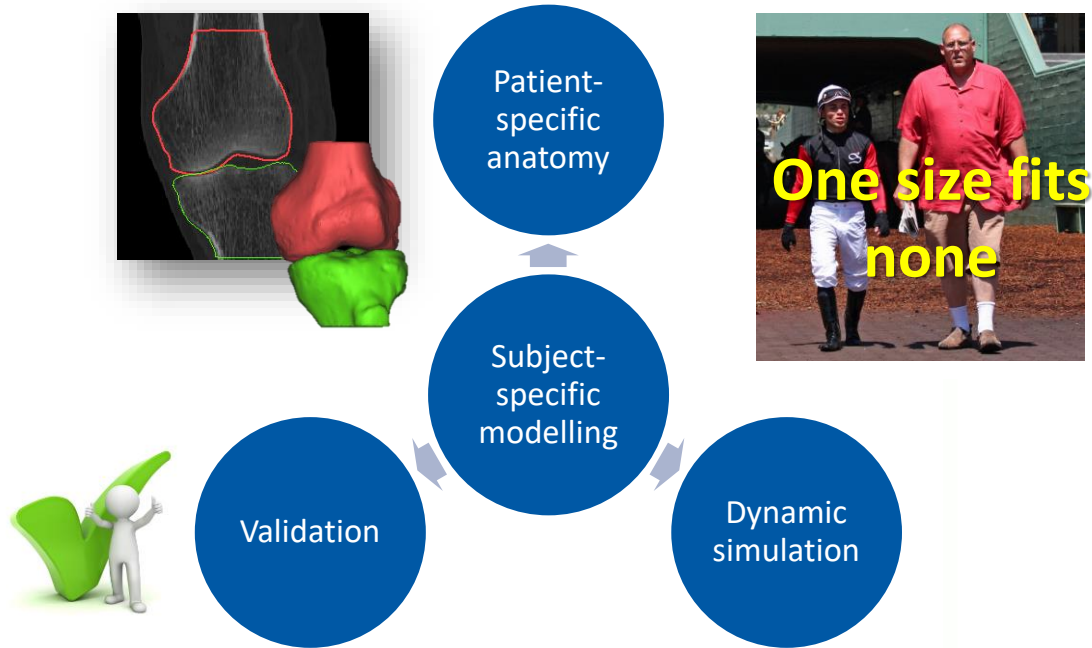


Musculoskeletal models (MSM)



Finite element models (FE)

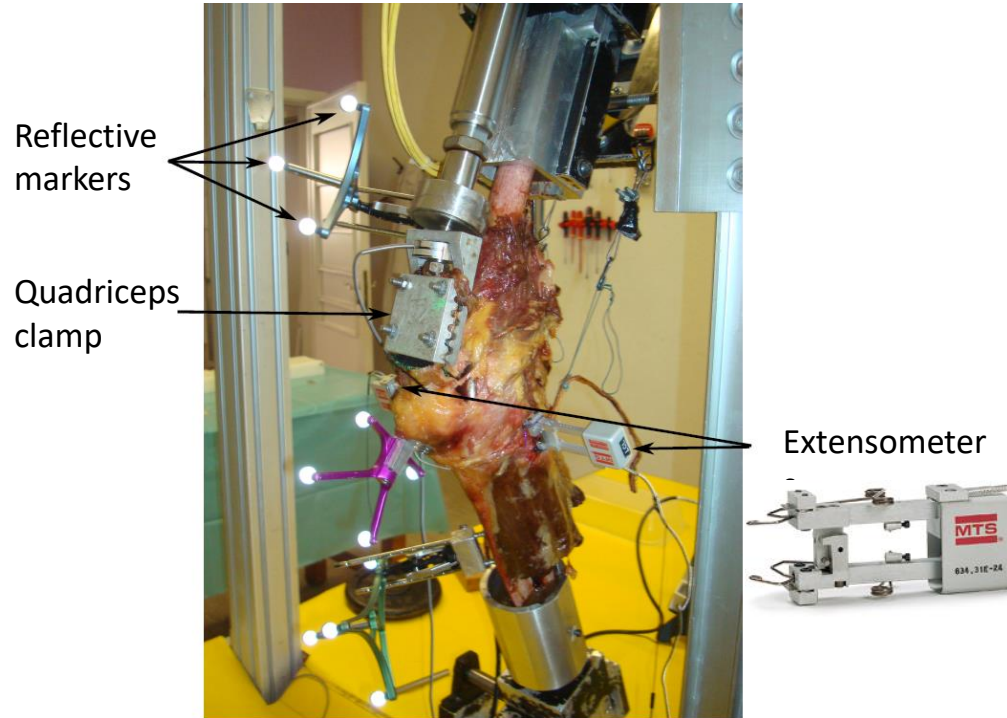
# Personalisation and validation are crucial



Validation is essential to transfer numerical models into clinical practice

# *In vitro* validation using cadavers to validate model

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Model

Data

Native

TKA

Optimisation

5



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