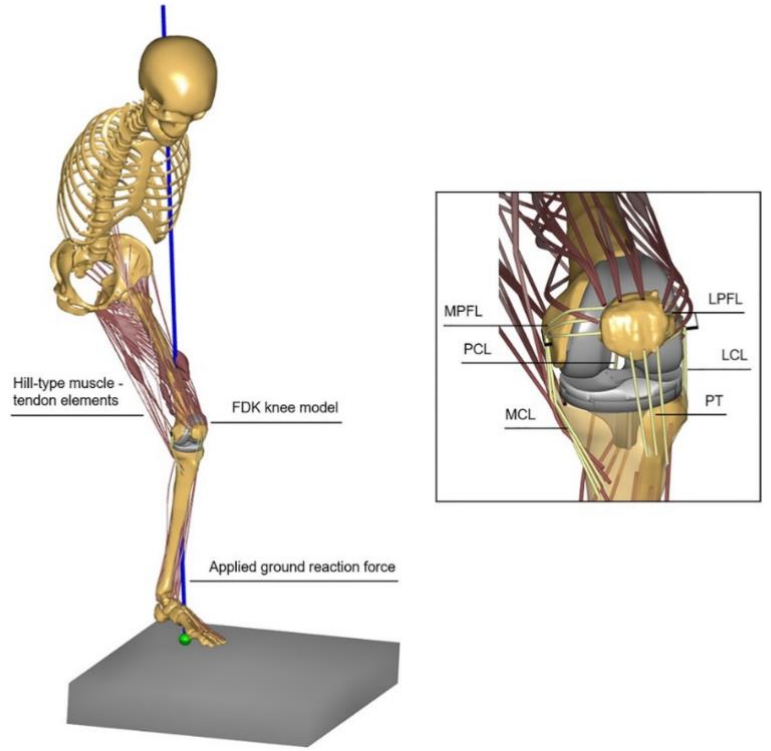
The webcast will begin shortly…

A model-based methodology to predict the biomechanical consequences of tibial insert thickness after total knee arthroplasty

May 6th , 2021



Outline

- General introduction to the AnyBody Modeling System
- Presentation by Periklis Tzanetis
  - *A model-based methodology to predict the biomechanical consequences of tibial insert thickness after total knee arthroplasty*
  - Question and answer session

Presenter:
Periklis Tzanetis, PhD candidate,

University of Twente,
Netherlands

Founder & Leader of the Biomedical Engineering group Twente

Host(s):
Morten Enemark Lund
Sr. R&D Engineer

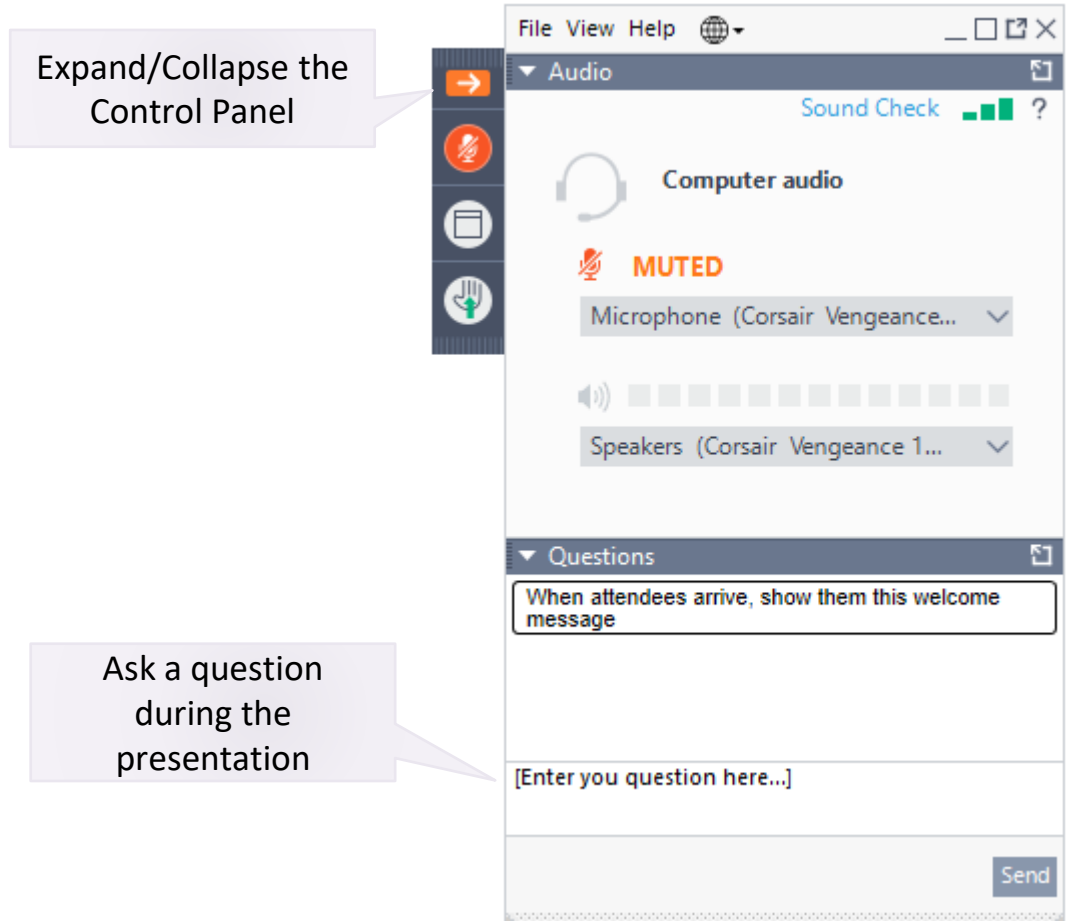
Kristoffer Iversen
Technical Sales Executive

Control Panel

The Control Panel appears on the right side of your screen.

Submit questions and comments via the Questions panel.

Questions will be addressed at the end of the presentation. If your question is not addressed, we will do so by email.



Musculoskeletal Simulation

Motion Data

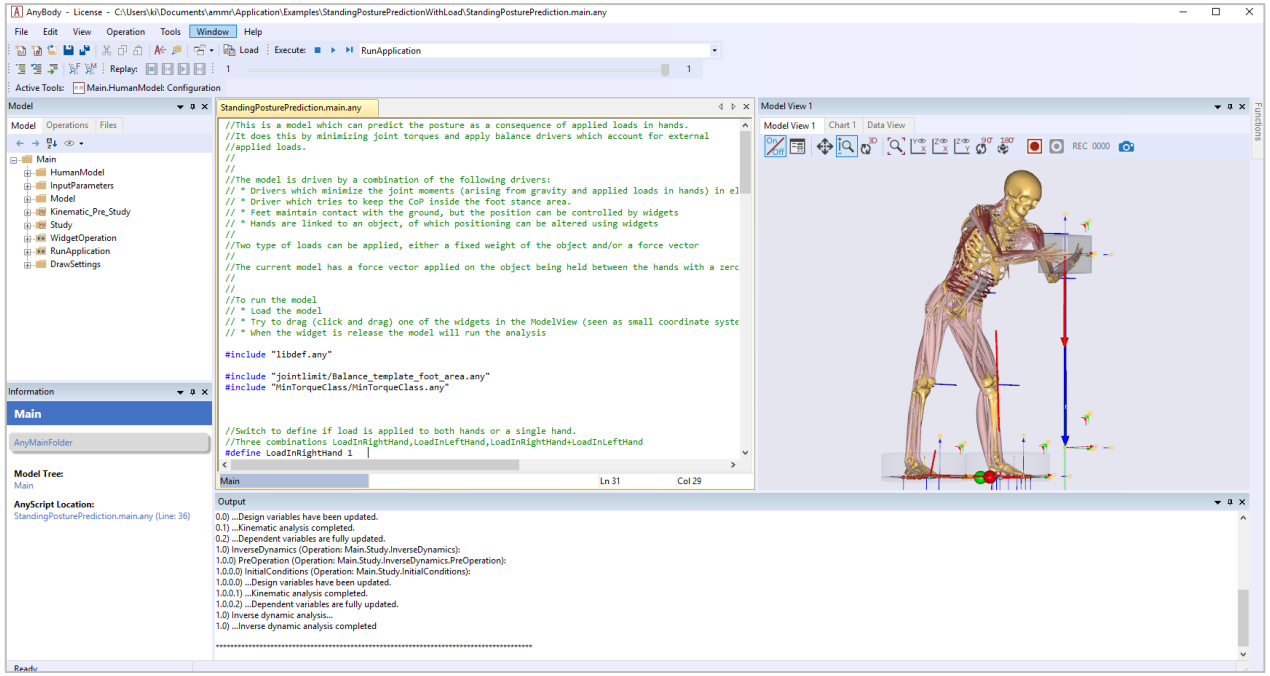
Kinematics and Forces

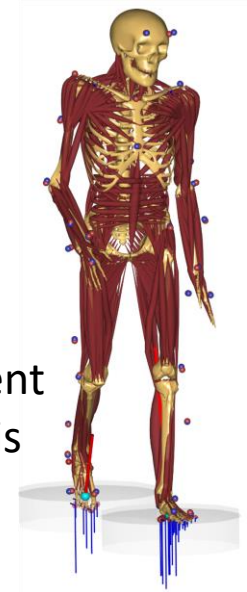
ANYBODY

Modeling System

Body Loads

- Joint moments
- Muscle forces
- Joint reaction forces

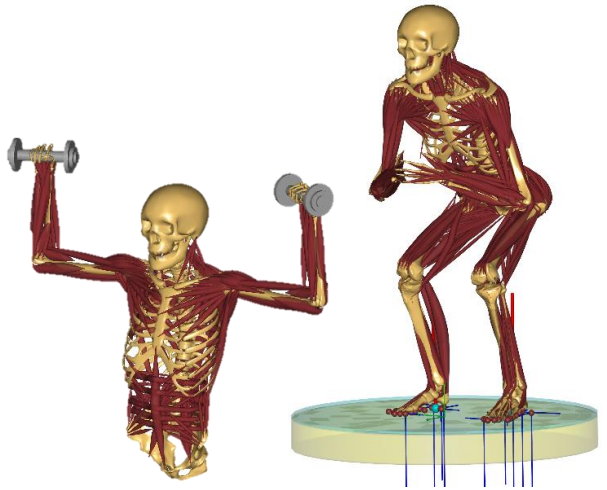




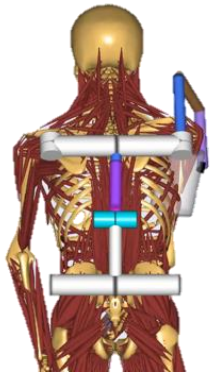
Movement Analysis

Product optimization design

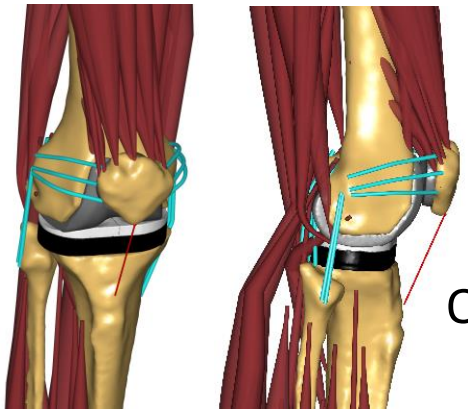
ANYBODY Modeling System



Sports



Assistive Devices



Orthopedics and rehab

AnyBody Modelling System

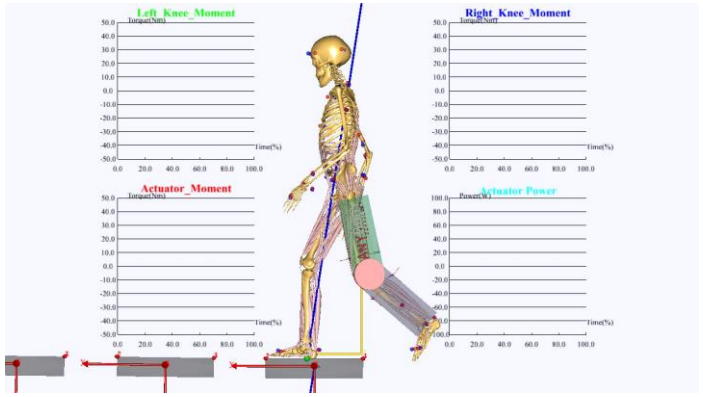
Motion and Forces

Body model

Environment model

Inverse dynamics
Muscle recruitment

Simulation



Internal body loads

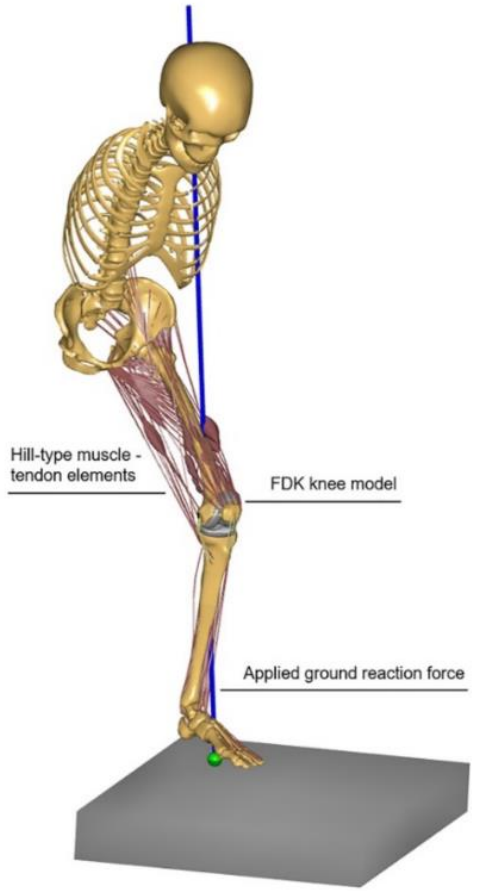
- Muscle forces
- Joint moments

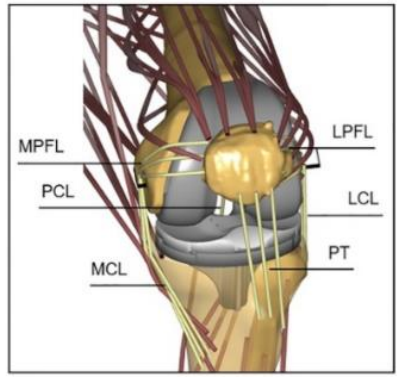
Design Optimization

Post Processing (e.g. Finite element tools)

A model-based methodology to predict the biomechanical consequences of tibial insert thickness after total knee arthroplasty

Presented by PhD Candidate Periklis Tzanetis





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we are driven
to make healthcare better.

University of Twente, Department of Biomechanical Engineering

A model-based methodology to predict the biomechanical consequences of tibial insert thickness after total knee arthroplasty

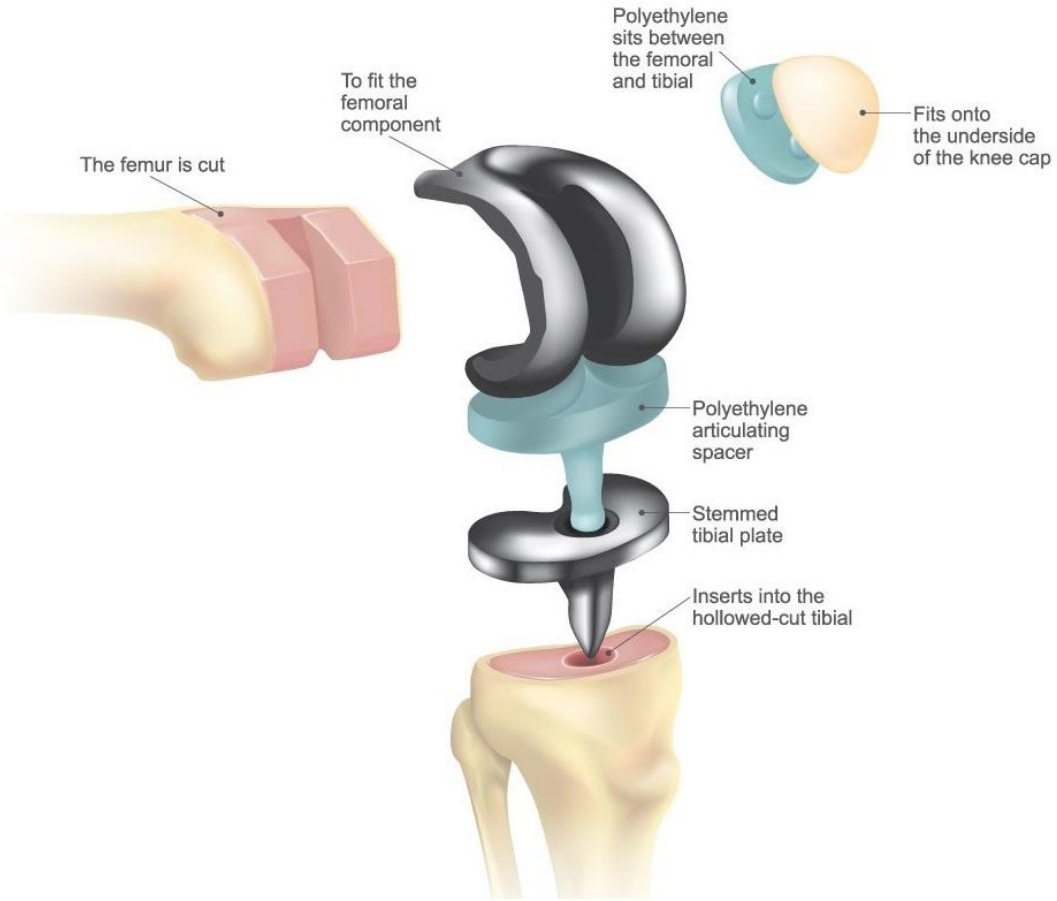
Periklis Tzanetis, PhD Candidate

Email of Presenting Author: p.tzanetis@utwente.nl

Open Access Article

Tzanetis, P.; Marra, M.A.; Fluit, R.; Koopman, B.; Verdonschot, N. Biomechanical Consequences of Tibial Insert Thickness after Total Knee Arthroplasty: A Musculoskeletal Simulation Study. *Appl. Sci.* **2021**, *11*, 2423. https://doi.org/10.3390/app11052423

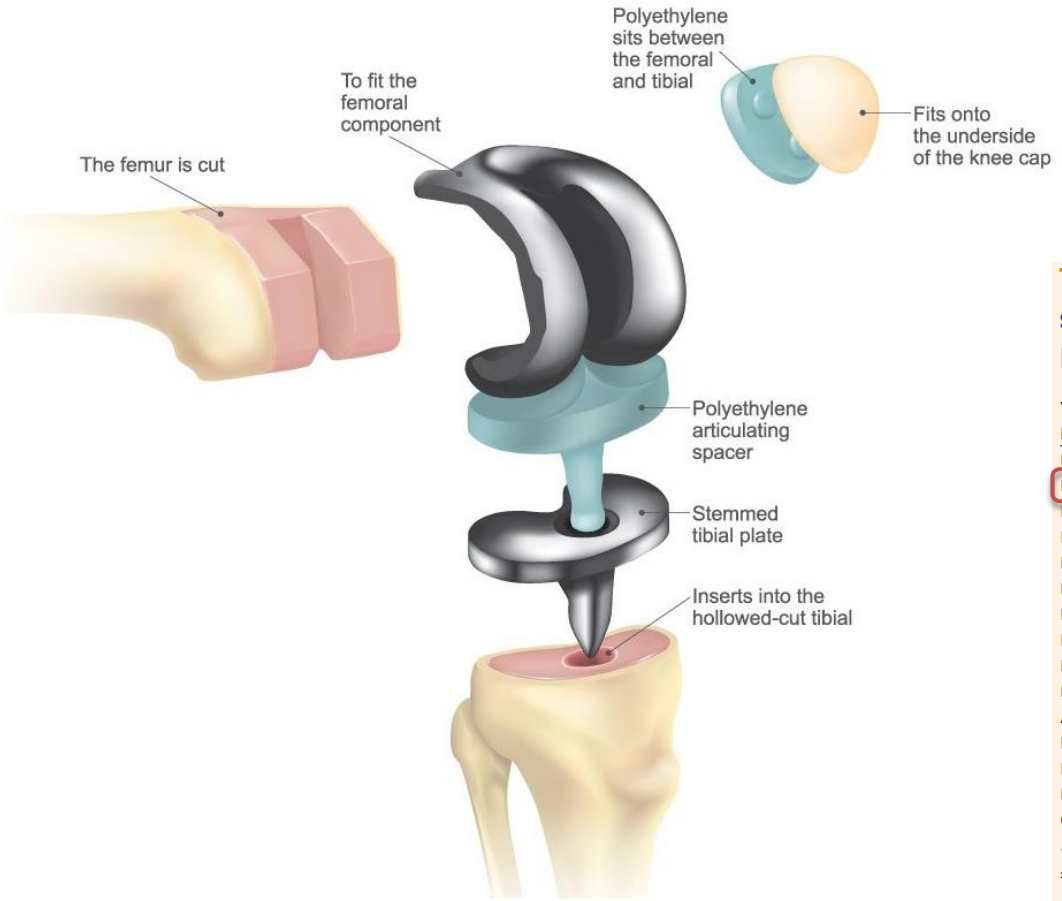
Total knee arthroplasty



About 33,000/year in the Netherlands

Dutch Arthroplasty Register (LROI). Available online: www. lroi.nl (accessed on 16 April 2021).

Total knee arthroplasty



About 33,000/year in the Netherlands

Dutch Arthroplasty Register (LROI). Available online: www. lroi.nl (accessed on 16 April 2021).

TABLE Trend (proportion [%] per year) in reasons for revision or re-surgery in patients who underwent a knee revision arthropalsty in the Netherlands in 2014-2019

Year	2014	2015	2016	2017	2018	2019	Total
Knee revision arthroplasty (n)	2,557	2,685	2,926	2,997	2,931	3,069	17,165
Reasons for revision; Proportion[1] (%)							
Instability	25.3	26.4	25.1	27.7	25.8	27.4	26.3
Patellar pain	22.9	23.0	21.5	19.7	18.9	20.2	21.0
Loosening of tibia component	22.3	20.6	21.9	20.9	19.5	20.9	21.0
Infection	14.7	16.5	19.6	20.3	20.8	19.9	18.8
Malalignment	15.7	14.7	13.9	11.3	10.7	10.2	12.6
Loosening of femur component	10.0	9.5	9.0	8.9	8.4	8.7	9.0
Progression of osteoarthritis	9.1	8.3	9.3	8.2	8.7	8.0	8.6
Insert wear	8.4	7.8	7.6	6.8	6.6	7.1	7.3
Revision after knee removal	6.9	5.7	6.3	5.6	4.9	4.2	5.6
Arthrofibrosis	4.7	5.1	4.3	4.9	4.6	5.3	4.8
Patellar dislocation	2.5	2.8	2.1	2.4	2.2	2.4	2.4
Periprosthetic fracture	2.2	2.3	1.7	1.8	1.5	1.9	1.9
Loosening of patella component	2.0	1.5	1.9	1.8	1.4	1.8	1.7
Other	8.1	8.6	8.3	7.4	7.8	7.9	8.0

[1] One patient may have more than one reason for revision or re-surgery. As such, the total proportion is over 100%.

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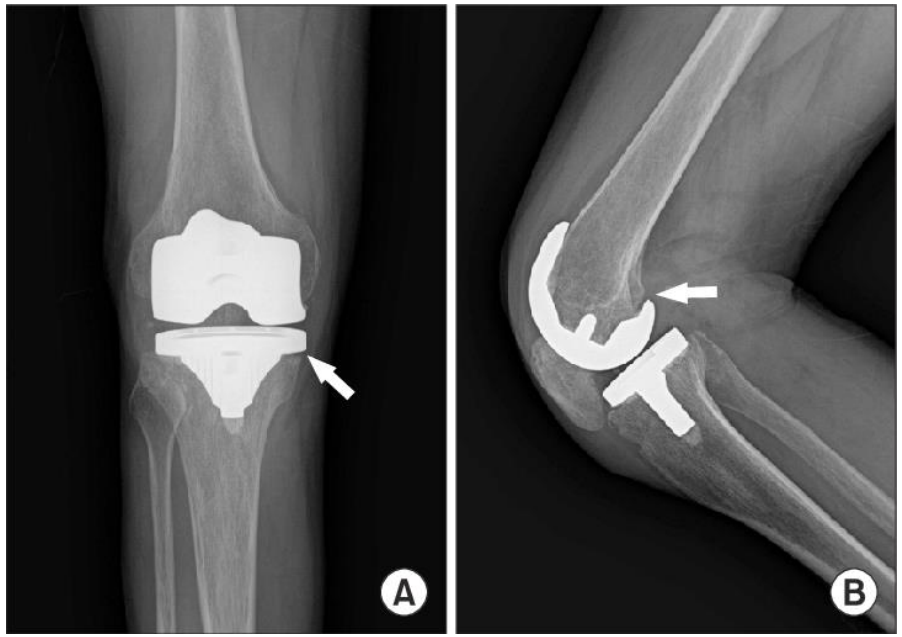
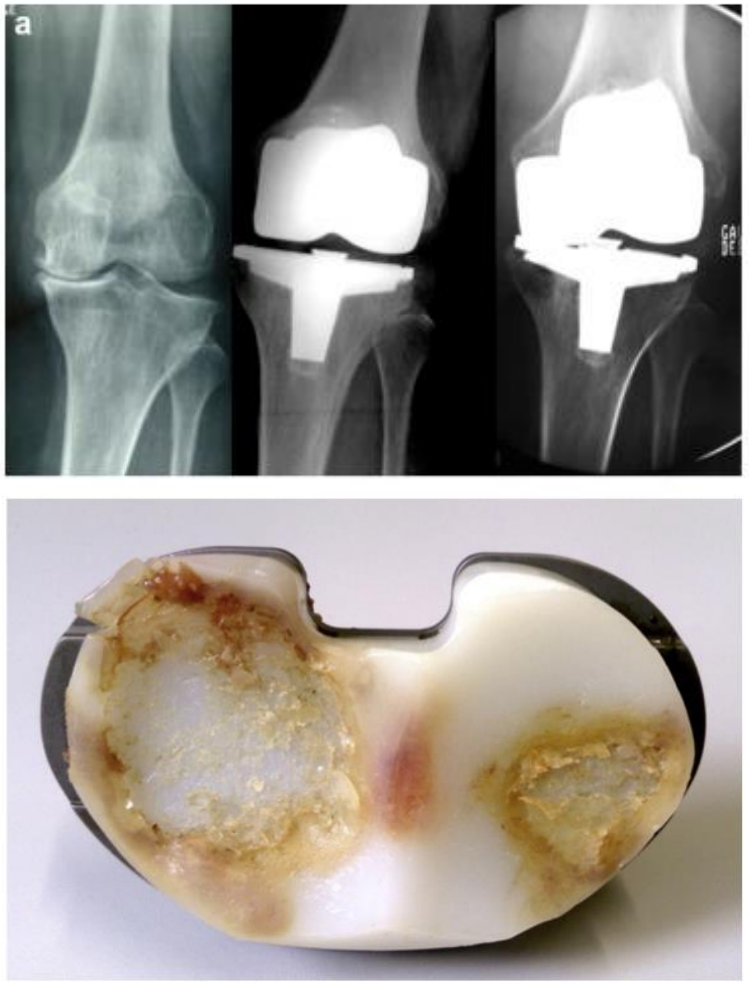
Early surgical failure



Lee et al., J Korean Orthop Assoc, 49(5):385-388, 2014.

- Inadequate tibial PE insert thickness.
- Important to select an optimum insert thickness



Massin et al., Orthop Traumatol Surg Res, 103(1S):S21-S27, 2017.

Optimum PE insert thickness

J Bone Joint Surg Br. 1992 Jan;74(1):9-17. doi: 10.1302/0301-620X.74B1.1732274.

Polyethylene wear of metal-backed tibial components in total and unicompartmental knee prostheses

G A Engh [1], K A Dwyer, C K Hanes

Affiliations + expand

PMID: 1732274 DOI: 10.1302/0301-620X.74B1.1732274

J Arthroplasty. 2010 Sep;25(6 Suppl):17-20. doi: 10.1016/j.arth.2010.04.031.

"Thicker" polyethylene bearings are associated with higher failure rates in primary total knee arthroplasty

Michael E Berend [1], Peter J Davis, Merrill A Ritter, E Michael Keating, Philip M Faris, John B Meding, Robert A Malinzak

Affiliations + expand

PMID: 20732620 DOI: 10.1016/j.arth.2010.04.031

J Arthroplasty. 2018 Sep;33(9):2810-2814. doi: 10.1016/j.arth.2018.04.026. Epub 2018 Apr 23.

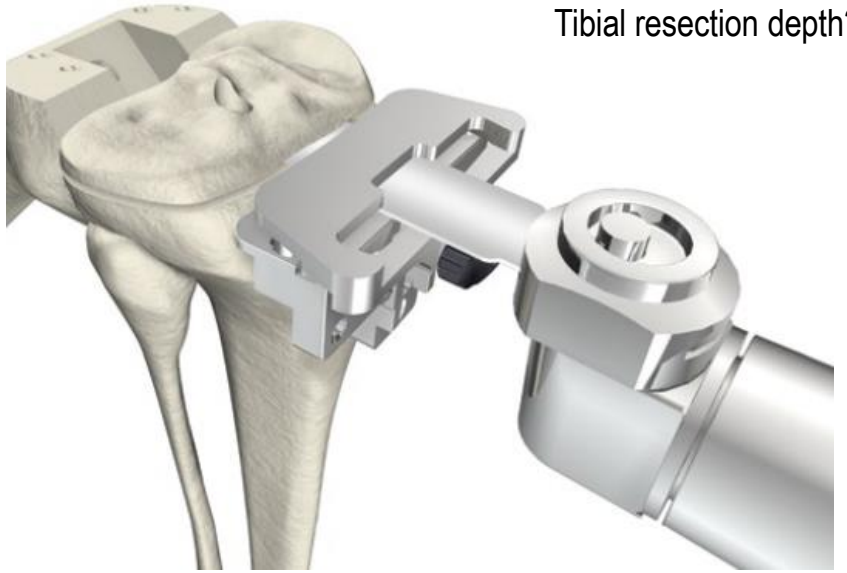
"Thicker" Polyethylene Bearings Are Not Associated With Higher Failure Rates in Primary Total Knee Arthroplasty

Nicholas J Greco [1], David A Crawford [1], Keith R Berend [1], Joanne B Adams [2], Adolph V Lombardi Jr [3]

Affiliations + expand

PMID: 29773277 DOI: 10.1016/j.arth.2018.04.026

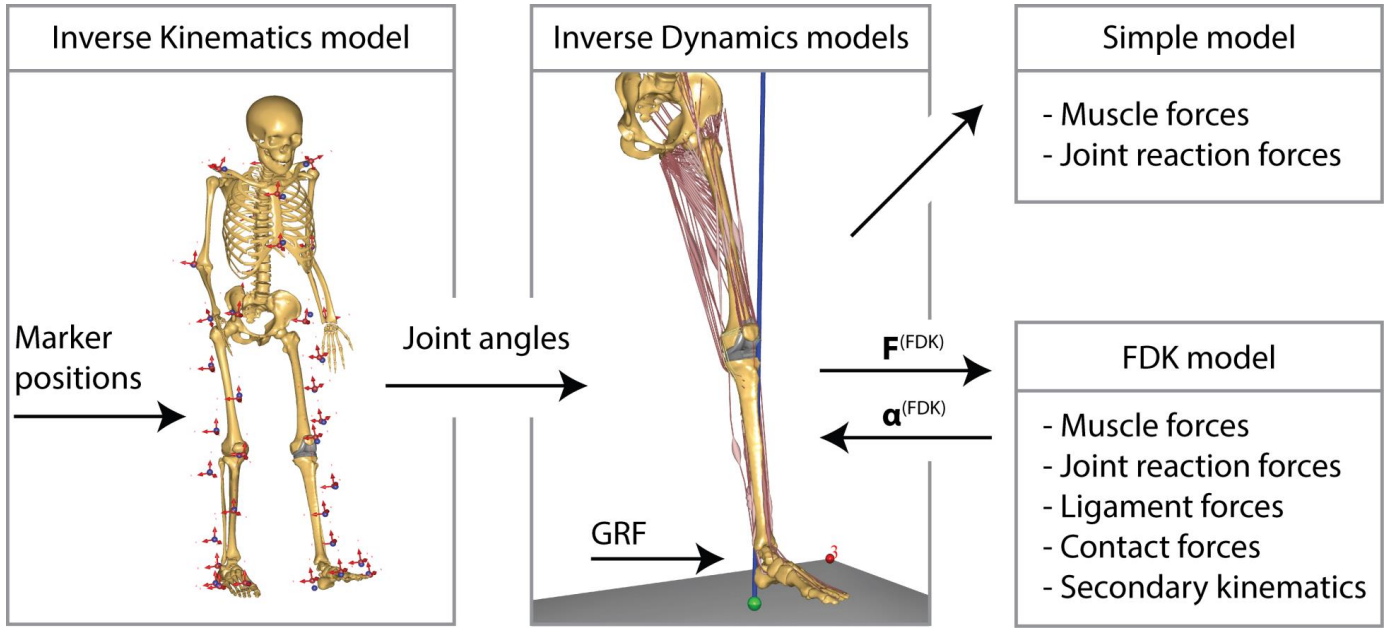
Tibial resection depth?

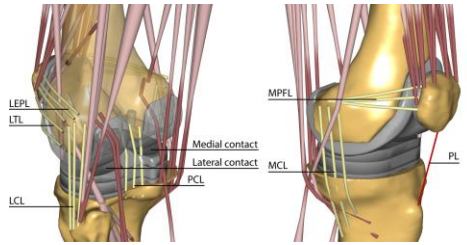


Triathlon ® Knee System Surgical Protocol. Stryker Orthopaedics.

Musculoskeletal models

- Valuable tool in the intraoperative decision-making procedure
- In vivo and non-invasive estimation of *muscle, ligament forces, joint loads*, and *kinematics*



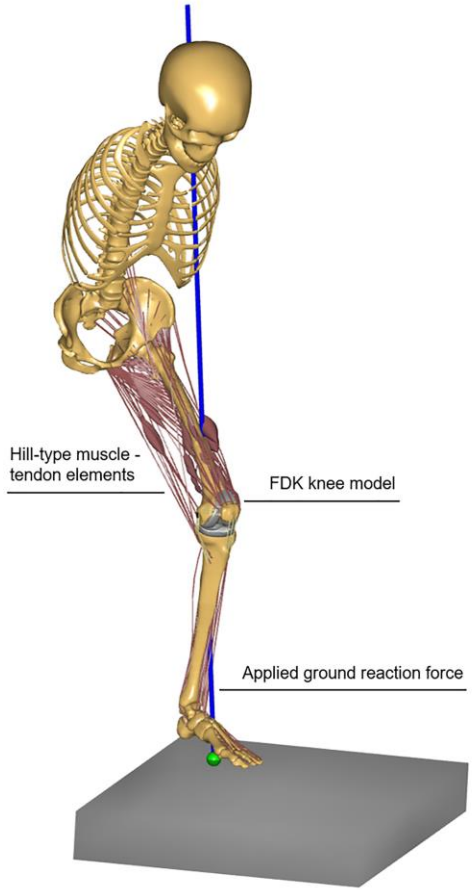


Andersen et al., J Biomech Eng, 139(9):091001, 2017.
Marra et al., J Biomech Eng, 137(2): 020904, 2015.

Study objectives

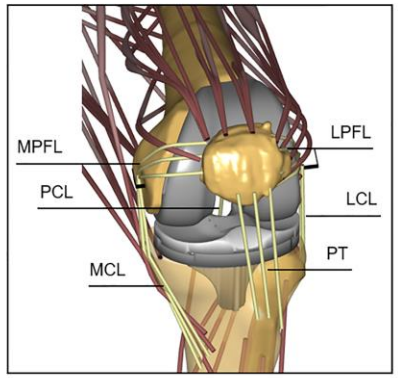
Investigate the influence of tibial insert thickness, in isolation, on the tibiofemoral (TF) joint, in terms of ligament and compressive forces, and assess to what extent thickness variation affects the biomechanical parameters in the patellofemoral (PF) joint.

Methods: Musculoskeletal knee model



Tzanetis et al., Appl Sci, 11(5):2423, 2021.

ANYBODY TECHNOLOGY



TLEM 2.0 model template [1], Grand Challenge patient-specific dataset [2]

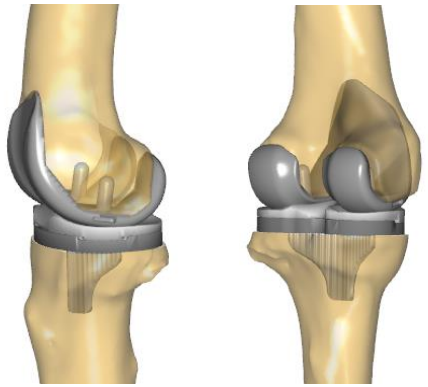
- Triathlon Cruciate Retaining (CR) total knee system
- Patella not resurfaced; dorsal facet 3-mm offset [3]

1. Carbone et al., J Biomech, 48(5):734-41, 2015.
2. Fregly et al., J Orthop Res, 30(4):503-513, 2012.
3. Cohen et al., Osteoarthritis Cartilage, 7(1):95-109, 1999.

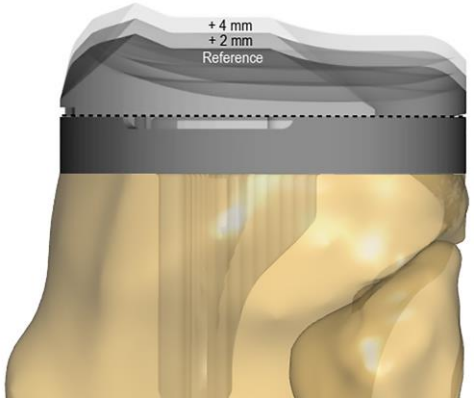
Methods: Varying tibial insert thickness

- Reference tibial insert thickness (9 mm)
- Varying thickness with 2 mm increments or decrements

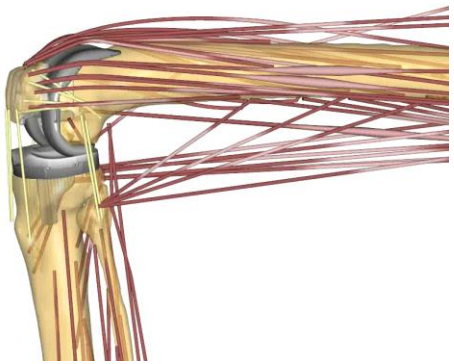
CR Triathlon implantation
Mechanical alignment of the femoral and tibial prosthetic components.



Tibial insert thickness variation
PE Inserts of 5 mm, 7 mm, 9 mm (reference), 11 mm, and 13 mm thickness.



Simulating a chair-rising activity
Motion capture data available as part of the open-access grand challenge competition dataset.

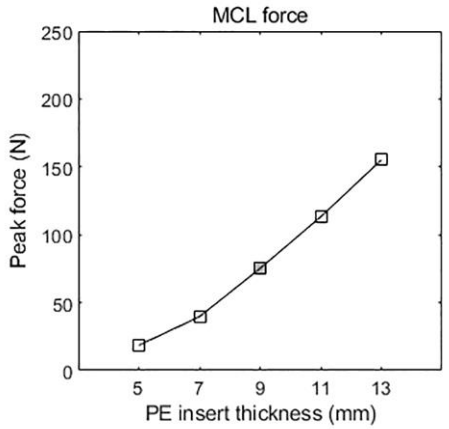


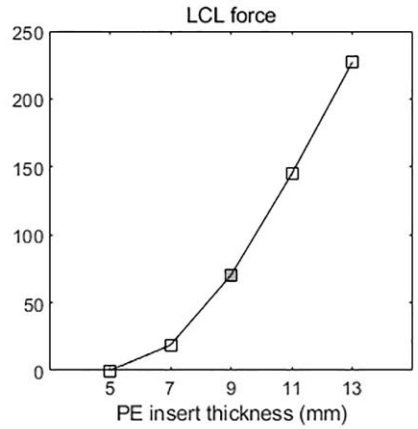
Results and Discussion: Tibiofemoral joint

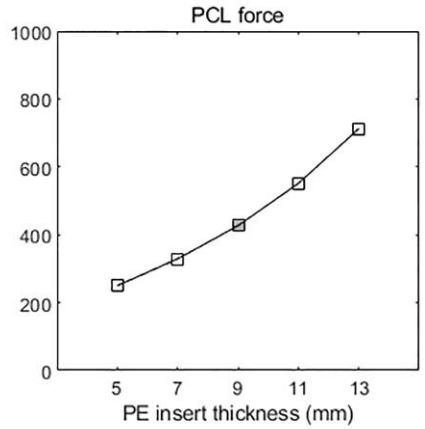
- Medial and lateral collateral ligaments (MCL, LCL) strain 0-6%
- Slack MCL and LCL in flexion; knee instability
- Posterior cruciate ligament (PCL) strain ~ 10%

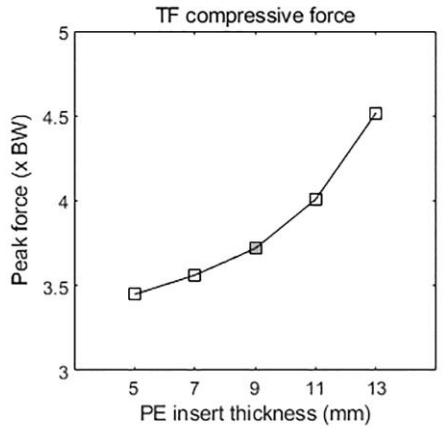
Overstretched ligament?

~ 14% yield strain [4]









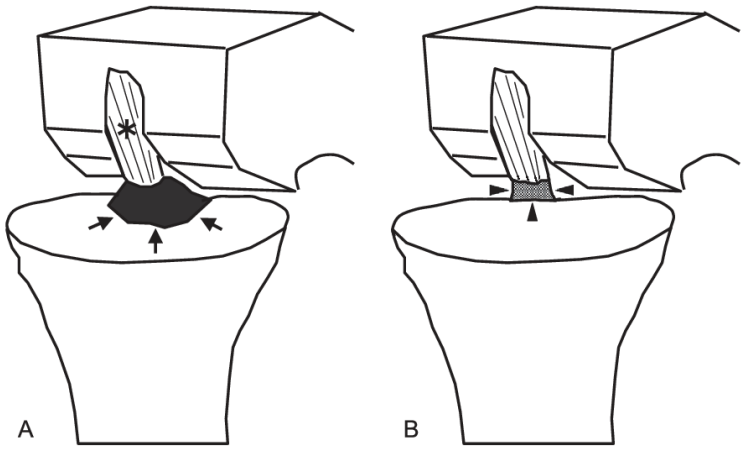
4. Butler et al., J Biomech, 19(6):425-432, 1986.

Results and Discussion: Tibiofemoral joint

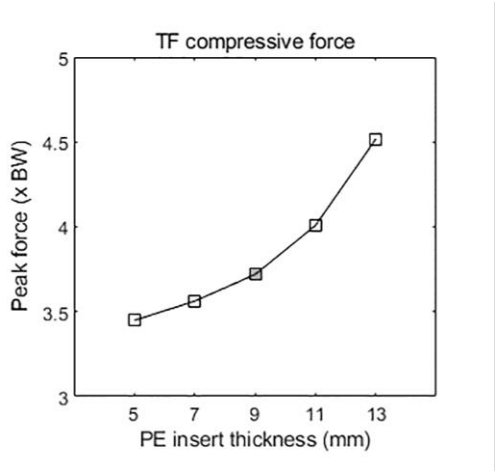
Too thin or too thick insert gives a sub-optimal solution

- Consistent findings with earlier studies (9 mm,11 mm) [5]

Thicker inserts (13 mm or more) could elevate joint loads; destructive wear



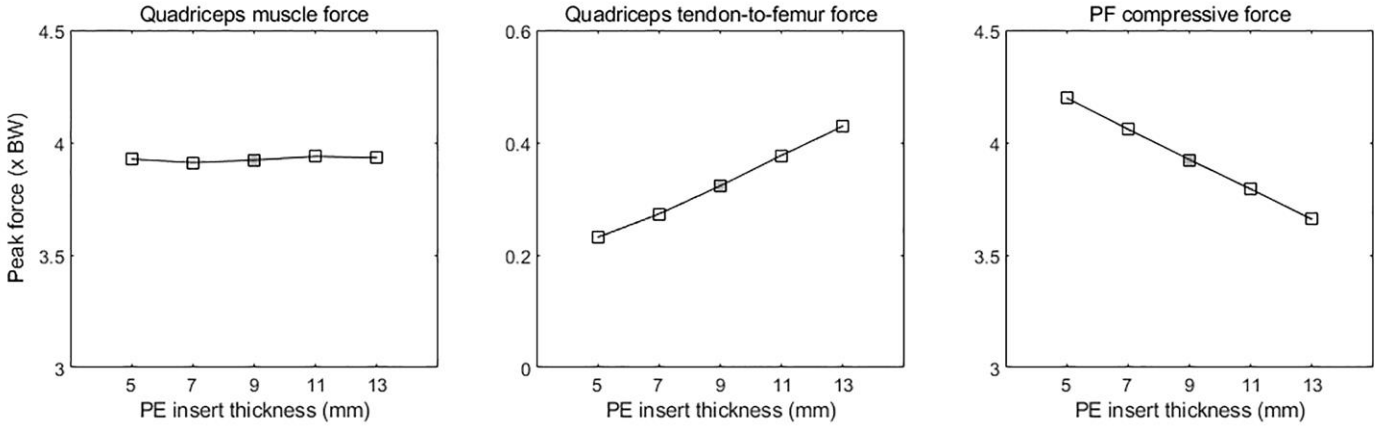
Onishi et al., The influence of tibial resection on the PCL in PCL retaining total knee arthroplasty: A clinical and cadaveric study. *J Orthop. Sci, 21(6)*: 798–803, 2016.



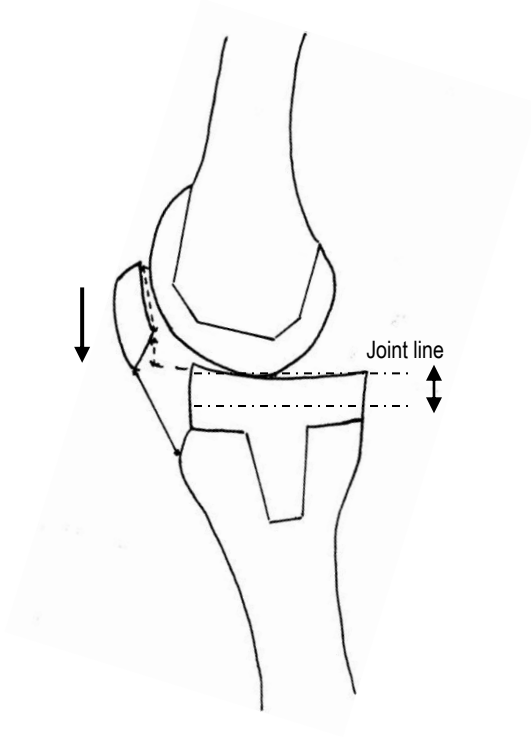
5. Ellis et al., J Biomed Eng, 6(2):113-120, 1984.

Results and Discussion: Patellofemoral joint

- Quadriceps-femur load sharing
- Distal shift of the patella in the groove; joint line elevation



Patella baja?



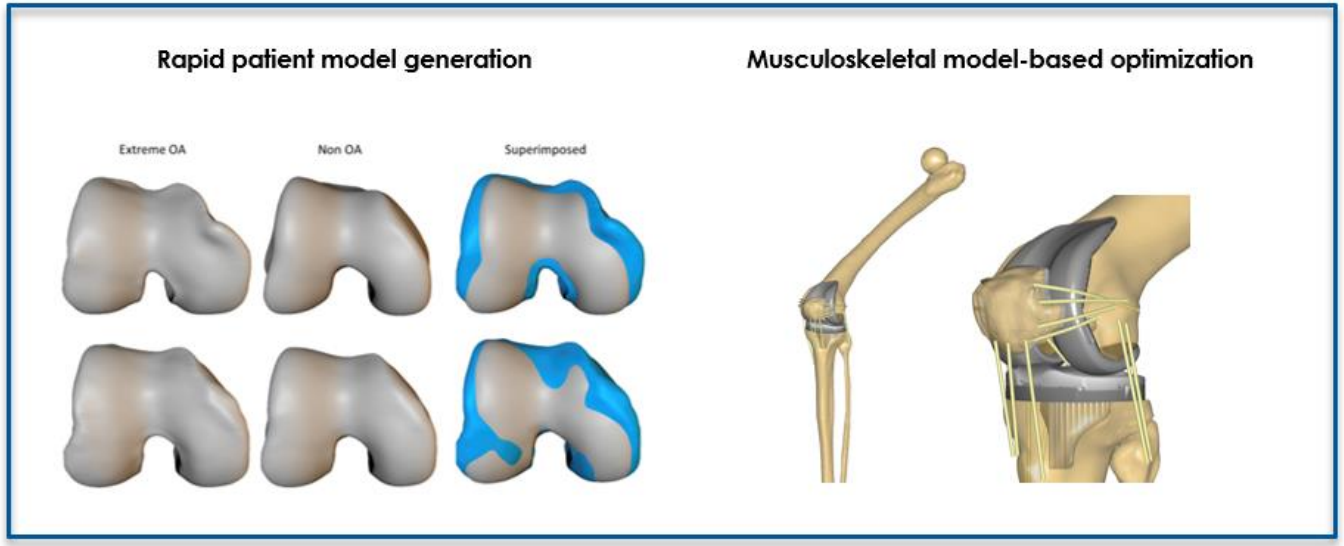
Grelsamer, Patella Baja After Knee Arthroplasty Surgery. Is It Really Patella Baja? J Arthroplasty, 17(1):66-9, 2002

Limitations

- Ligamentous mechanical properties
- Representing a mechanically aligned CR prosthesis
- Simulation of one patient, while there is anatomical variability

Future directions

- Optimized function through customized total knee arthroplasty
- **Effect of morphological knee joint phenotypes on total knee arthroplasty outcomes**



Future directions

- Optimized function through customized total knee arthroplasty
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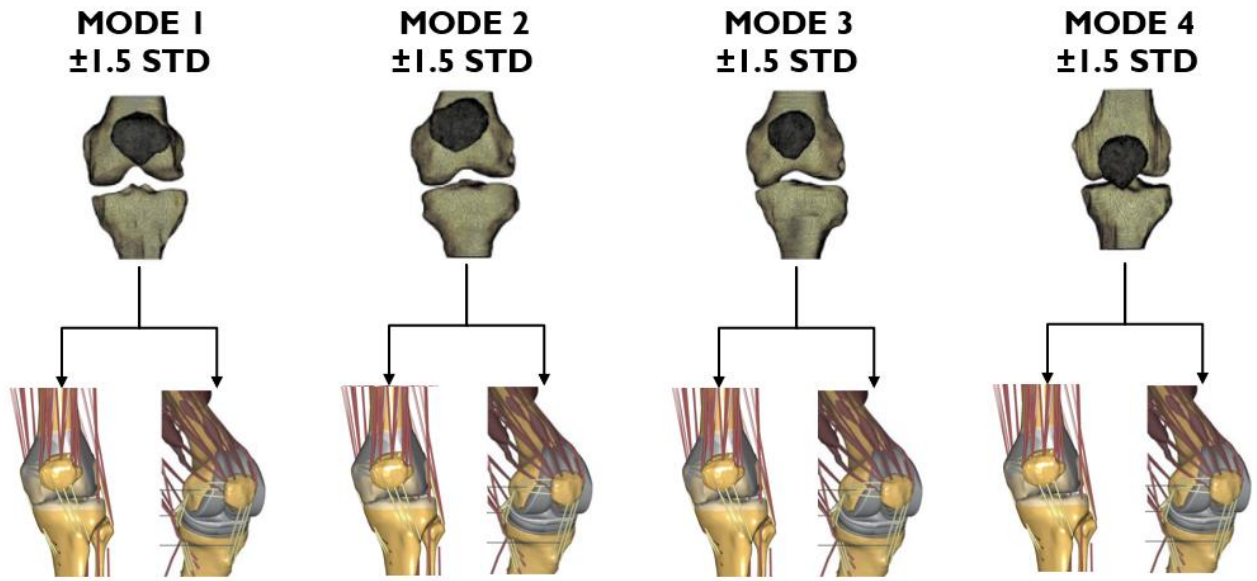

Simulating the intact and implanted musculoskeletal model configurations to assess the effect of morphological knee joint phenotypes on muscle and joint contact forces, as well as patellar tracking and contact trajectories after total knee replacement surgery.

Acknowledgements

- This research has been funded by TKI Top Sector HTSM and Stryker European Operations.

Marco. A. Marra [1], René Fluit [1], Bart Koopman [1], Nico Verdonschot [1,2]

[1] Department of Biomechanical Engineering, **University of Twente**

[2] Orthopedic Research Laboratory, Radboud Institute for Health Sciences, **Radboud University Medical Centre**

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Eric Garling, Arman Motesharei, José-Luis Moctezuma, Daniele De Massari

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Department of Biomechanical Engineering

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Questions?

Periklis Tzanetis, PhD Candidate

Founder and Leader at Biomedical Engineering Group Twente | bioengtwente.nl

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@TzanetisP periklistzanetis

Open Access Article

Tzanetis, P.; Marra, M.A.; Fluit, R.; Koopman, B.; Verdonschot, N. Biomechanical Consequences of Tibial Insert Thickness after Total Knee Arthroplasty: A Musculoskeletal Simulation Study. *Appl. Sci.* **2021**, *11*, 2423. https://doi.org/10.3390/app11052423

AnyBody Webcast, 6th May 2021 | 09:00, 17:00 (CEST)

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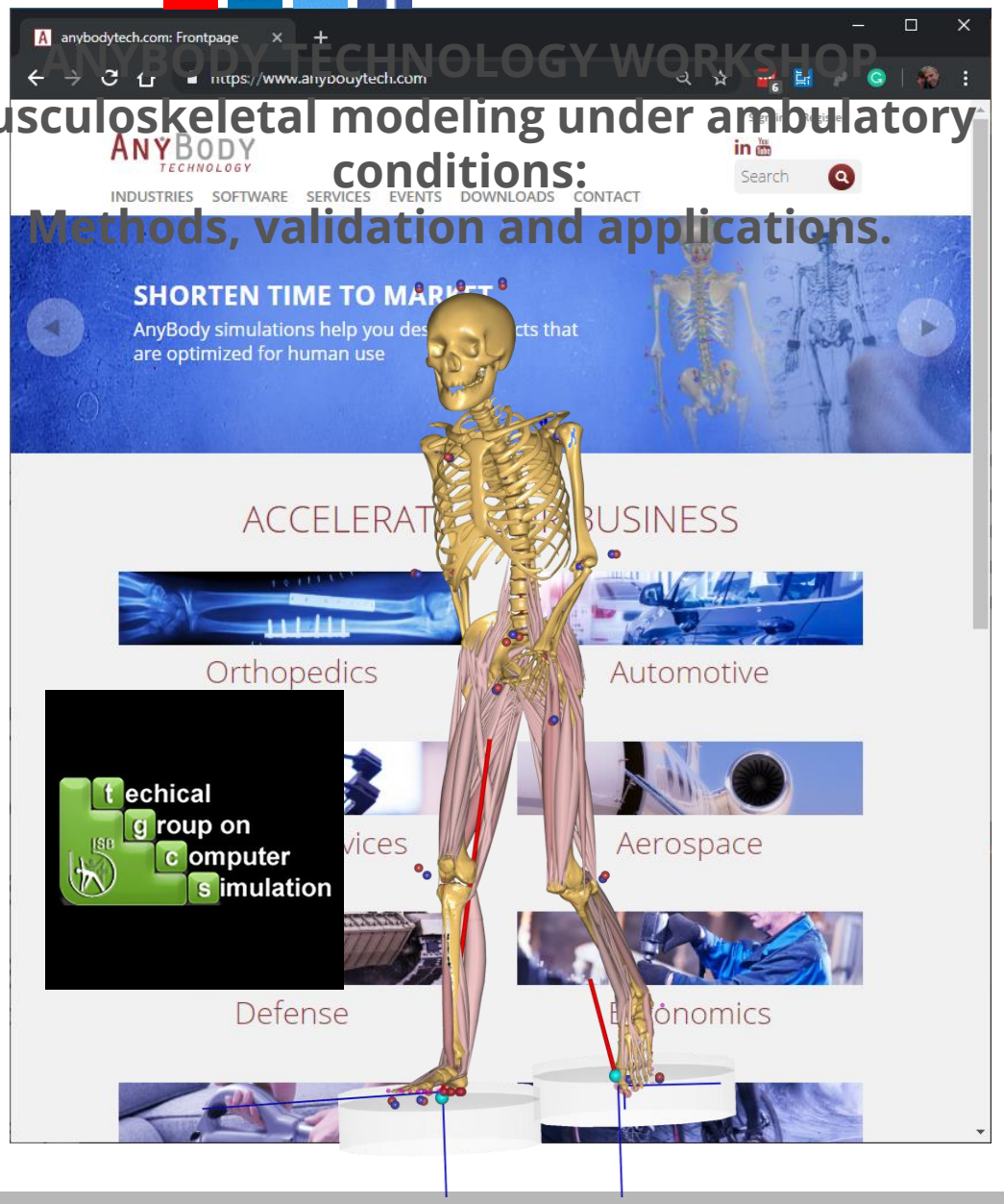
Events

- **June 3rd Webcast**: From motion capturing with Xsens to simulation and analysis with the AnyBody Modeling System (hosted by Xsens)
- **July 21st Workshop**: Musculoskeletal modeling under ambulatory conditions: Methods, validation and applications. @TGCS 2021



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Thank you for your attention - Time for questions