

### The webcast will begin shortly...

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

May 6<sup>th</sup> , 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







### **Body Loads**

- Joint moments
- Muscle forces
- Joint reaction forces

AnyBody - License - Cl/Users/ki/Documents/ammi/Application/Examples/StandingPosturePrediction/WithLoad/StandingPosturePrediction.main.any									
File Edit View Operation Tools Window Help									
🗈 🕼 🛸 🔐 🥙 K 🗗 🗇 🗚 🔎 📅 🗸 🎼 Load j. Execute: 🔳 > M. RunApplication.									
1 🐨 🖓 💭 👷 🖓 Replay: 🔳 💽 💽	1								
Active Tools: Main.HumanModel: Configuration	on								
Model 🗸 🛪 🗙	StandingPorturePrediction main any 4 b x Model View 1	• • × = × =							
Model Operations Files	//This is a model which can neglict the norture as a consequence of annial loads in hands	uncti							
	//It does this by minimizing joint torques and apply blance drivers which account for external	Suc							
i HumanModel									
👜 📹 InputParameters	<pre>//The model is driven by a combination of the following drivers: // Drivers which sinking text by constinution of the following drivers: // Driver which tries to keep the GP inside the foot stance area. // Feet maintain contact with the ground, but the position can be controlled by widgets // Hands are linked to an object, of which positioning can be altered using widgets // The totake and the driver is the driver and the chickst address for a force matter //The totake of loads can be anothed within a force in the chickst address for a force matter is the driver of the driver address for a force matter is the driver address for address for address for address for address for address for a force matter is the driver address for address for a force matter is the driver address for add</pre>								
Model Kinematic Bre Study									
Study									
10-168 WidgetOperation									
RunApplication DesurSettinger	// mo type of lodus can be applied, either a fixed weight of the object and/or a force vector								
	//The current model has a force vector applied on the object being held between the hands with a zerc								
	// * Load the model								
	//* Try to drag (click and drag) one of the widgets in the ModelView (seen as small coordinate syste								
	// · when the wilder is release the model will run the analysis								
	#include "Libdef.any"								
	#include "jointlimit/Balance_template_foot_area.any"								
Information 🔫 🕸 🗙	#include "MinlorqueClass/MinlorqueClass.any"								
Main									
	//Switch to define if load is applied to both hands or a single hand.								
AnyMainFolder	//Three combinations LoadInlightHand,LoadInLeftHand,LoadInLeftHand								
	< >>								
Model Tree: Main	Main Ln 31 Col 29								
AnyScript Location:	Output	<del>~</del> ‡ ×							
StandingPosturePrediction.main.any (Line: 36)	0.0)Design variables have been updated.	^							
	0.1)Kinematic analysis completed. 02)Deenedariu vaiables are fully undated.								
	1.0) InverseDynamics (Operation: Main:Study.InverseDynamics):								
	1.0.0) initial conditions (Operation: Nain-Study,inverselynamics/recipitation); 1.0.0) initial conditions (Operation: Main-Study,initial conditions);								
	1.0.0.0Design variables have been updated.								
	Local Landrein winning the set of								
	1.0) Inverse dynamic analysis 1.0)Inverse dynamic analysis comoleted								
		~							
Ready									

MAY 6TH, 2021





Product optimization design

ANYBODY **Modeling System** 



ANY BODY

Sports



Orthopedics and rehab



# AnyBody Modelling System





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

Presented by PhD Candidate Periklis Tzanetis







## **UNIVERSITY OF TWENTE.**



Together with our customers, 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

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

#### Total knee arthroplasty



### About 33,000/year in the Netherlands

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

UNIVERSITY OF TWENTE. **stryker** 

#### Total knee arthroplasty



#### About 33,000/year in the Netherlands

Dutch Arthroplasty Register (LROI). Available online: www. Iroi.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 theNetherlands 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 <sup>1</sup> (%)							
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

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

© LROI 2020

### 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.

#### UNIVERSITY OF TWENTE. **stryker**

#### **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 <sup>1</sup>, 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 <sup>1</sup>, 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 <sup>1</sup>, David A Crawford <sup>1</sup>, Keith R Berend <sup>1</sup>, Joanne B Adams <sup>2</sup>, Adolph V Lombardi Jr <sup>3</sup> Affiliations + expand PMID: 29773277 DOI: 10.1016/j.arth.2018.04.026



Triathlon ® Knee System Surgical Protocol. Stryker Orthopaedics.

UNIVERSITY OF TWENTE. stryker

#### 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.

TLEM 2.0 model template <sup>1</sup>, Grand Challenge patient-specific dataset <sup>2</sup>

- Triathlon Cruciate Retaining (CR) total knee system
- Patella not resurfaced; dorsal facet 3-mm offset <sup>3</sup>

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

UNIVERSITY OF TWENTE. **stryker** 

#### 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.



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%





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

#### **Results and Discussion:** Tibiofemoral joint

• Consistent findings with earlier studies (9 mm,11 mm)<sup>5</sup>

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.

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



#### UNIVERSITY OF TWENTE. stryker

#### **Results and Discussion:** Patellofemoral joint

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





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



Accurate robotic-assisted surgical execution



#### **Future directions**

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



Simulating the intact and implanted musculoskeletal model configurations to assess the effect of morphological knee joint phenotype 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<sup>1</sup>, René Fluit<sup>1</sup>, Bart Koopman<sup>1</sup>, Nico Verdonschot<sup>1,2</sup>

<sup>1</sup> Department of Biomechanical Engineering, **University of Twente** 

<sup>2</sup> Orthopedic Research Laboratory, Radboud Institute for Health Sciences, **Radboud University Medical Centre** 

#### Stryker

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

## **UNIVERSITY OF TWENTE.**

Department of Biomechanical Engineering



Together with our customers, we are driven to make healthcare better.

## **Questions?**

Periklis Tzanetis, PhD Candidate

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

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

🔰 @TzanetisP

in periklistzanetis





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



## www.anybodytech.com

• Events, Dates, Publication list, ...

#### www.anyscript.org

• Wiki, Blog, Repositories, Forum

## **Events**

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

Meet us? Send email to <a href="mailto-sales@anybodytech.com">sales@anybodytech.com</a>







# Thank you for your attention - Time for auestions



MAY 6TH, 2021