Algorithm for Intraoperative Detection of Component Malalignment during Total Knee Arthroplasty

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Total knee arthroplasty (TKA) is the most common treatment for severe osteoarthritis of the knee. Up to 20% of patients are not satisfied after TKA.

Component alignment is a modifiable surgical factor associated with satisfaction and function after TKA.
Component malalignment leads to altered knee biomechanics associated with sub-optimal outcomes

- Increased Contact Forces
- Altered Kinematics
- Decreased Laxities
Contact forces, kinematics, and laxities can be measured intraoperatively using advanced surgical technologies.

- **Force Sensors**
- **Computer Navigation**
- **Loading Fixture**

Contact Forces → Kinematics → Laxities

Gustke, Bone Joint J, 2014; Jones, J Arthroplasty, 2018; Siston, J Biomech Eng, 2012
Objective: Develop an algorithm to leverage advanced technologies to intraoperatively identify component malalignment during TKA.
Virtually Performed TKA on Multibody Model of the Knee

• 6 degree-of-freedom patellofemoral and tibiofemoral joints
• Elastic foundation contact model
• Non-linear springs to represent ligaments

Validated against:
• Dynamic MRI
• In vitro tibial contact forces
Determined tibial forces, kinematics, and laxities during passive flexion in 1000 virtual TKA patients
Combinations of tibial forces, kinematics, and laxities from half of virtual TKAs used to train regression model to predict component malalignment

V-V, I-E, A-P, C-D, and M-L kinematics:
- 0°, 45°, and 90°
- 45°-0°, 90°-45°, 90°-0°

V-V laxities:
- 0°, 45°, and 90°
- 45°-0°, 90°-45°, 90°-0°

Medial, lateral, and medial-lateral forces:
- 0°, 45°, and 90°
- 45°-0°, 90°-45°, 90°-0°
Low errors in predicted malalignments in second half of virtual TKA patients using trained regression models

(99%, 95%) Tolerance Interval
99% of population lies within interval with 95% confidence
Take home: Training linear regression models is a promising approach to identifying component malalignment during TKA.
Thank you!

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Acknowledgements

NIH National Institutes of Health
5 T32 AG 213-26

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