I. Introduction

Outcomes of Total Knee Arthroplasty (TKA) are dependent on surgical technique, patient variability, and implant design.

- Poor designs result in undesirable contact mechanics, including instability and reduced range of motion.
- Patient satisfaction rates have been reported to range from 75% to 92%, with only 22% of patients rating the surgical results as ‘excellent’ (Youn-Il An 2016, Knee Surg Relat Res 1-15).

II. Objective

Our objective was the development of a statistical shape-function model of a posterior stabilized implant knee to predict output mechanics in a timely and resource efficient manner. Which could be useful to design teams in a number of ways.

- Allow technicians to produce and screen outputs before engineers
- Generate design parameters from supplied outputs
- High quality prediction throughout the sample space for:
  - Kinematic translocations
  - Kinematic Rotations
  - Mid flexion joint contact forces
  - Ligament displacements

More tuning of the model is required for the prediction of:

- Early and late flexion contact forces
- Joint contact moments
- Contact area and pressure
- Ligament forces

III. Methods

Using a previously validated tibial-femoral (TF) implant joint model performing a squat cycle (Fitzpatrick 2012, J Orthop 2015-2024), design of experiments (DOE) techniques were used to model joint behavior.

- Implant geometry parameterized using 9 predictor variables.
- Ranges of design parameters were determined from measurements of current TKA components.

DOE sampling can cause odd combinations of parameters, which can lead to FEA simulations failing to finish. To combat this a subspace was sampled initially, with further iterations introducing wider sample spaces.

1. Initial samples formed an inscribed central composite design (100% successful)
2. An expanded full factorial cube was performed (99% successful)
3. A full-factorial sampling of the entire space was added (52% successful)

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IV. Results

High quality prediction throughout the sample space for:

- Kinematic translations
- Kinematic Rotations
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V. Next Steps

1. Run a similar DOE with surgical parameters.
   - Anterior insert slope
   - Femoral I-E alignment

2. Combine the most sensitive parameters from each study for a final DOE.

3. Insert shape-function models into design optimization pipeline.