Building Surgeon-specific Predictive Models of Tibial Insert Thickness using Knee Joint Laxity Signature

Wen Fan[1], Laurent Angibaud[1], Amaury Jung[2], James Huddleston[3]
[1]Exactech, Gainesville, FL, USA, [2]Blue-Ortho, Meylan, FR, [3]Stanford University Medical Center, Stanford, CA, USA
Laurent.angibaud@exac.com

Disclosures: Wen Fan (3B-Exactech), Laurent Angibaud (3A-Exactech), Amaury Jung (3A-Blue Ortho), James Huddleston (3B-Exactech)

INTRODUCTION: Soft tissue balancing plays an important role in total knee arthroplasty (TKA) which affects both short and long term post-operative clinical outcomes. One of the factors contributes to a successful soft tissue assessment relates to the thickness of the tibial insert, an intraoperative surgical decision that varies based on surgeon experience and preference. However, only few studies have evaluated factors that were potentially predictive of tibial insert thickness. Given the situation that there is a paucity of information when determining the proper tibial insert thickness intraoperatively, the aim of this study was to 1) test the correlation between laxity curves and tibial insert thickness; 2) build surgeon-specific models to predict tibial insert thickness.

METHODS: The study cohorts included 203 cases using an instrumented CAOS system (ExactechGPS, Blue-Ortho) with a tibia first technique performed by 6 different surgeons without any exclusions. During trial reduction, a trial femoral component was impacted onto the prepared distal femur and a novel intra-articular tibial distractor was introduced into the joint space which applied a quasi-constant distraction force once released regardless of the joint gap. Then, the limb was manually taken through a full arc of motion and the corresponding joint laxities were recorded by the CAOS system. Medial and lateral (ML) gaps were measured at 0° to 120° of flexion with 5° or 10° increments. Correlation coefficient between tibial insert thickness and gaps was calculated at each available flexion on a surgeon basis. For each surgeon, the flexion that was associated with the highest correlation between either medial or lateral gap and tibial insert thickness was selected to train the predictive model. Two statistical models used in this study were random forest and ordinal logistic regression model. Random forest model can adaptively avoid overfitting and have better prediction performance as it is less subjected to model assumption requirements according to some studies [3]; in the other hand, logistic regression model is more favorable in situations with small sample sizes. For each surgeon, data was divided into training and testing datasets with the ratio 2:1. Predictors of the model were defined as medial and lateral gaps. Accuracy of models was evaluated by calculating proportions of exact predictions, predictions within 1mm, and predictions within 2mm using testing datasets.

RESULTS SECTION: Among 203 cases, 4 surgeons with more than 30 cases of tibial insert thickness data (176 in total) were selected in the correlation analysis. When considering all four surgeons together, the correlation coefficients between ML gaps and tibial insert thickness across degrees of flexion were all less than 0.35. Two out of four surgeons had their highest correlation coefficients less than 0.4 at 5° and 45° of flexion respectively and were not selected for the model training process. The rest of the two surgeons that were selected for model training showed relatively high correlation between ML gaps and tibial insert thickness with correlation coefficients of 0.45/0.48 and 0.71/0.56 (Figure 1) at 15° of flexion. For surgeon A, the random forest model had higher exact prediction accuracy of tibial insert thickness than the ordinal logistic regression model (39% vs 31%) while for surgeon B, the ordinal logistic regression model was 9% more accurate than random forest (Table 1). Both models had high accuracy in predicting tibial insert thickness within 1mm and 2mm difference.

DISCUSSION: This study first investigated correlation between the knee joint laxity and tibial insert thickness in TKA with tibial-first technique, and the findings demonstrated that the relationship tended to be surgeon specific. Predictive models built with both random forest and ordinal logistic regression methods were shown to be accurate based on surgeons with high correlation between joint gaps and tibial insert thickness. These models can guide surgeons select the proper thickness of the tibial insert during the surgery, which not only provides a more efficient way in terms of making surgical decisions, but also ensures joint stability postoperatively. Sample size is one of the limitations of this study which can impact the model training process and testing results. Further investigations of other potential predictors of tibial insert thickness will be performed to improve performance of predictive models.

SIGNIFICANCE/CLINICAL RELEVANCE: Better and more accurate prediction of tibial insert thickness during surgeries will reduce surgical time while ensure joint stability.

IMAGES AND TABLES:
Figure 1: correlation between tibial insert thickness and ML gaps of Surgeon 1 & Surgeon 2

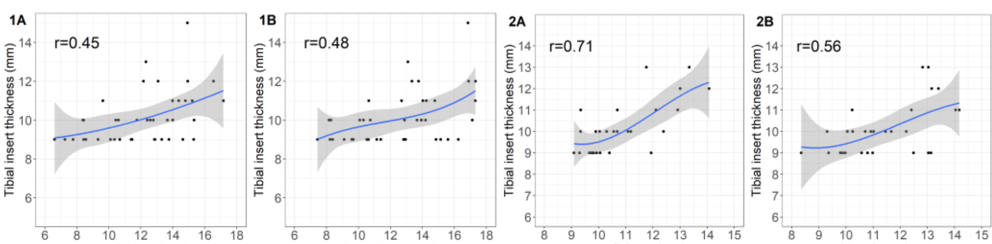

Table 1: Predictive models accuracy summary for Surgeon 1 & Surgeon 2 on testing datasets

	Random Forest (%)	**Ordinal Logistic Regression (%)**
Surgeon 1: N=13		
Exact prediction	39%	31%
|Predicted - Actual thickness| ≤ 1mm	85%	77%
|Predicted - Actual thickness| ≤ 2mm	100%	92%
Surgeon 2: N=11		
Exact prediction	45%	54%
|Predicted - Actual thickness| ≤ 1mm	82%	82%
|Predicted - Actual thickness| ≤ 2mm	100%	100%