A Novel Machine Learning-Based Re-Operation Risk Score for Patients Undergoing Intertrochanteric Femur Fracture Fixation

James L Cross, Arielle Richey Levine, Shawn Wahi, Trevan Kyle Klug, Michael Patrick Leslie, Matthew Riedel

INTRODUCTION: Intertrochanteric hip fracture burden is increasing globally with the aging population; however, the reported rates of re-operation vary widely. While most previous studies investigate specific risk factors or vulnerable populations, a comprehensive risk model for reoperation of patients that have undergone intertrochanteric hip fracture fixation remains unexplored. The purpose of this study is 1) to develop and validate an interpretable machine learning-based re-operation risk score for patients undergoing intertrochanteric femur fracture fixation, and 2) to integrate our algorithm into a publicly accessible online calculator.

METHODS: We retrospectively reviewed 2063 intertrochanteric hip fracture patients between 2014 and 2023 at a large academic center. Variables included demographics, comorbidities, medications, fracture characteristics, operative variables, and radiographic and clinical outcomes. Re-operation was defined as any additional surgical treatment or revision of the affected hip after index surgery date. The data were split into 80% training, 10% test, and 10% holdout validation. An extreme gradient boosting (XGB) model was fit on the training set using 4-fold cross-validation with hyperparameter tuning. Performance was evaluated using accuracy and area under the receiver operating characteristic curve (AUC). The top 15 predictive features based on Shapley Additive Explanation (SHAP) values were identified and incorporated into the final multivariate logistic regression risk model, which was subsequently validated on the holdout validation set.

RESULTS: The observed re-operation rate in our cohort was 5.3% (N=110). The XGB model achieved 92.8% accuracy and 0.69 AUC on the test set **(Figure 1B)**. Top predictive features based on mean SHAP value included age, sex, BMI, ASA status, ambulatory status, kidney dysfunction, dyslipidemia, hypertension, surgery duration, estimated blood loss, lag screw length, adequate reduction of sagittal plane (lateral), restoration of Shenton's line, tip-apex distance (TAD), and neck shaft angle (NSA) **(Figure 1A, 1D)**. The final re-operation risk score based on these features achieved 97.1% accuracy and 0.71 AUC on the holdout validation data **(Figure 1C)**. Our user-friendly risk score calculator interface is shown in **Figure 2.**

DISCUSSION AND CONCLUSION: We introduce a novel, interpretable, and readily deployable risk-prediction tool that translates routinely collected peri-operative data into individualized re-operation risk predictions for intertrochanteric fracture fixation patients. By highlighting high-impact, actionable factors such as reduction quality, sagittal alignment, operative duration, and blood loss, our algorithm informs tailored peri-operative management, balancing of surgical and pre-operative priorities, and targeted surveillance of high-risk patients. Prospective multi-institutional studies are warranted to confirm generalizability and measure impact on clinical decision-making and outcomes.