Prediction of persisting pain and poor functional outcome after total knee arthroplasty using different machine learning algorithms

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INTRODUCTION:

Even though total knee arthroplasty (TKA) is an effective treatment for patients who suffer from end-stage osteoarthritis of the knee, ca. 10-20 % of the patients still remain unsatisfied with its outcome. Unsatisfied patients report symptoms such as pain, stiffness, and low functional outcome.

Recently, interest has shifted towards methods using machine learning and artificial intelligence to develop prediction models for different outcomes in medical research. Well-performing clinical prediction models can provide individualized risk estimates and stratification in terms of poor outcomes which means that unnecessary surgeries could be avoided and patients counseled preoperatively. Identification of potentially modifiable risk factors for poor outcomes would also be useful.

We aimed to develop prediction models using different machine learning algorithms for the prediction of 1) total Oxford Knee Score (OKS) 1 year postoperatively, 2) the change in OKS from preoperative level and 3) the presence of moderate or severe pain 1 year postoperatively.

METHODS:

In this retrospective cohort study, we included all the TKA patients from our institution operated between January 2008 and December 2021. Our data consists of 751 variables collected preoperatively for 11755 TKAs. Of these variables, 469 were different medications, 131 medical comorbidities and allergies, 30 different blood tests. The remaining variables were age, sex, ASA class, and BMI, information on previous knee injuries, smoking, operating surgeon (personal code for each surgeon, information on teaching surgery), wound closure technique, information on preoperative clinical examination of the knee joint (stability, range of movement, degree of malalignment, pulsation of dorsalis pedis and titbial posterior arteries, patellar status).

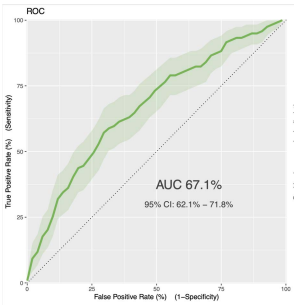
The multivariable models were formed based on the results from univariate analysis performed for each preoperative and outcome variable separately. Extreme Gradient Boosting (XGBoost) method was primarily used. Ridge regression and Elastic net methods were used as a reference. The discrimination capability of the models was measured with area under curves (AUC) and calibration graphs and the information of the most important variables were obtained for each model.

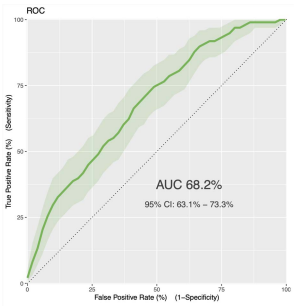
RESULTS:

Table 1 shows the demographics of this study. The highest AUC values were achieved with XGBoost method with all the models: 1) 0.67 (95% confidence interval (CI) 0.62 – 0.72), 2) 0.68 (CI 0.63-0.73), 3) 0.67 (CI 0.63 – 0.72) (figure 1a-c). The AUC values with Ridge and Elastic Net methods were just slightly smaller. The most important variables for model 1 were ASA class, preoperative malalignment measured with AP X-ray, age, hemoglobin, BMI. For model 2, the most important variables were preoperative malalignment, ASA, lower OKS preoperatively, use of neuropathic pain medicine. For model 3, the variables were lower OKS preoperatively, age, preoperative malalignment, use of neuropathic pain medicine, mild opioids, or thyroxine.

DISCUSSION AND CONCLUSION:

The prediction models achieved surprisingly poor AUCs and XGBoost managed best with all the outcomes. Prediction of pain and functional outcome after TKA is difficult and even with a large patient cohort, 751 patient-related variables and sophisticated machine-learning algorithms, the prediction capability of the developed models remained low. Our results confirm the clinical aspect that patient selection for TKA is complex and despite the multidimensional data and the modern analytical tools it is still hard to predict those patients who are likely to experience pain after primary TKA and not benefit from the procedure.





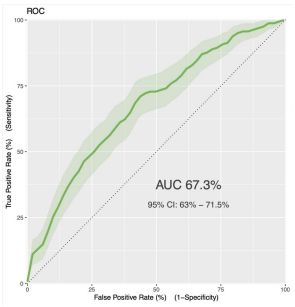


Table 1. The descriptives of the patient cohort

Variable		
Age (mean)	67 years	SD ±9.4
Gender	63 % of females	
BMI (mean)	30,50	SD ±5.5
ASA classification (n)		
1	675	
2	5183	
3	4962	
4	930	
5	0	
Total OKS 1 year (median)	43	IQR 38-46
Total OKS preoper (median)	21	IQR 16-24
Achievement in OKS (mean)	22	SD ±8.0