Development and validation of patient-level prediction models for adverse outcomes following total knee arthroplasty

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Introduction

Elective total knee replacement (TKR) is a safe and cost-effective treatment for severe knee osteoarthritis (OA). Although complications following surgery are rare, prediction tools could help identify at risk subjects to target with preventative interventions.

Several guidelines provide stratification guidance based on a personalised risk profile. As such, a well validated clinical prediction model could have immediate impact on patient outcomes.

Materials and Methods

We conducted a multinational, multi-database cohort analysis using electronic health records and claims data from the US and the UK. In total we used 7 data sources mapped to the Observational Medical Outcomes Partnership common data model (OMOP-CDM) and processed using the same analytical platform developed by the Observational Health Data Sciences and Informatics (OHDSI) initiative. All subjects undergoing a first TKR, aged 40 years or older and registered in any of the contributing data sources for at least 1 year before surgery were included. Key adverse outcomes included post-operative (90-day) mortality, venous thrombo-embolism, infection, readmission; and long-term (5-year) revision surgery. Lasso logistic regression models were fit independently in 5 data sources and were then evaluated using discrimination and calibration. Those considered to have the potential for clinical use were then externally validated in other available datasets.

Results

A total of 503,923 participants were included, with size per data source ranging from 158,549 to 15,292. Overall, 90-day mortality, VTE, infection and readmission were seen in a range 0.20%-0.32%, 1.7%-3.0%, 7.1%-9.0%, 2.2%-4.8% respectively. Five-year revision surgery was observed in 1.5%-3.1% of participants. None of the models for VTE or infection had good performance.

We trained models for 90-day mortality, VTE, infection, readmission, and 5-year revision. Only 90-day mortality yielded AUROC > 0.70, other outcomes were not predictive. 90-day mortality had AUC of 0.78 and 0.68 in internal validation on Optum and THIN respectively, and the Optum model got 0.69, 0.86, 0.76, 0.72 AUC in external validation on THIN, Columbia, Stanford and MDCD.

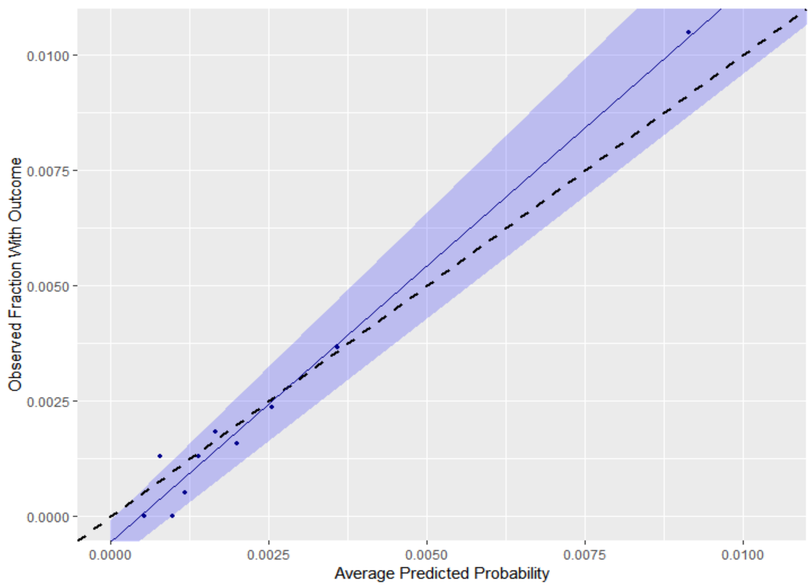

Figure 1. showing the calibration of the 90-day mortality Optum model

Development database	Validation database	AUROC	Test population	Outcome count in test population (% incidence)
OPTUM	OPTUM	0.78	38,166	88 (0.23)
OPTUM	THIN	0.69	40,950	81 (0.20)
OPTUM	CUMC	0.86	1853	6 (0.32)
OPTUM	STRIDE	0.76	2306	7 (0.30)
OPTUM	MDCD	0.72	15292	44 (0.29)
THIN	THIN	0.68	10,237	20 (0.20)
THIN	OPTUM	0.68	152,665	353 (0.23)
THIN	CUMC	0.84	1853	6 (0.32)
THIN	STRIDE	0.70	2306	7 (0.30)

Table 1. showing the internal and external AUROC of the two 90-day mortality models

Conclusion

We developed and externally validated prediction tools for the identification of subjects at high risk of short-term mortality as well as developing models for readmission, venous thromboembolism and long-term revision. The primary finding of the research is high predictability of short-term mortality and the unpredictability of the other investigated outcomes. This suggests that decisions can be stratified based on personalised risk of short-term mortality, however we were unable to produce adequate models for the other adverse outcomes.

Acknowledgements

Special thanks go to all attendees of the OHDSI_EHDEN Study-athon hosted by Ndorms in Oxford, UK who contributed

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This project has received funding from the Innovative Medicines Initiative 2 Joint Undertaking (JU) under grant agreement No 806968. The JU receives support from the European Union's Horizon 2020 research and innovation programme and EFPIA.