Abstract

Joint replacement is a highly successful and frequent surgical intervention. It can improve function and reduce pain in patients with end-stage arthritis of the joints. However, there is a wide variation in the outcome of prostheses/devices used in primary total hip replacements (THRs) and primary total knee replacements (TKRs). Joint replacement registries have significant roles in assessing the comparative performance of devices. The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) has established a standardised multi-stage approach for identifying prostheses with a higher than anticipated revision rate, also referred to as *'outliers'*. The AOANJRR standard compares the revision rate of prostheses to the average revision rate of all other prostheses that belong to the same broad device class—comparator. However, as changes are made in the design and performance of devices over time, the hip and knee comparator classes need to be re-evaluated. This study first aimed to explore how the rate of revision estimated in the comparator groups differs according to specific prosthesis design constructs. The cumulative percent revision (CPR) was calculated for 413,417 primary THR and 640,045 TKR undertaken for osteoarthritis from 1st January 2003 to 31st December 2019. The final hip comparator, which only includes satisfactory-performed prostheses of contemporary design and use, had a 10-year CPR of 4.30% (4.2, 4.41) which is lower than the current THR comparator used by the AOANJRR of 4.93% (4.84, 5.02). Using a comparator that only includes contemporary devices with modern bearings and excludes special devices used in more complex primary procedures has the potential to improve the early assessment of modern primary total hip prostheses sensitively. The AOANJRR standard detected 13 additional total conventional hip components utilizing the modified comparator. The final comparator group for conventional TKRs, which only includes the Cruciate Retaining and Posterior Stabilised designs, indicated a 10-year CPR of 5.2% (5.1, 5.3). Moreover, a comparator group of complex knee devices with 10.3% (8.6, 12.0) 10-year CPR was explored to reflect devices used only for specific purposes in primary TKR. The use of modified knee comparator groups led to identifying additional conventional knee prostheses but fewer complex knee designs as being at risk. The AOANJRR currently recommends the modern comparator groups for the early assessment of primary total hip and knee prostheses. Ideally, early identification of outliers uses a time-to-event

outcome while reducing the confounding effects of other components in the device and patient characteristics. Machine learning (ML), which contains self-learning algorithms, is one approach to consider many variables simultaneously to reduce the impact of confounding. Another principal objective of this study was to compare the effectiveness of using either Random Survival Forest (RSF) or regularized/unregularized Cox regression to account for patient and associated device confounding factors to current standard techniques. The effectiveness of the ML approaches was assessed based on the ability to detect the outliers identified by the AOANJRR standardised approach, where the standard identified ten individual THR prostheses and five TKR prosthesis combinations. The ML approaches identified some but not all the outliers detected by the AOANJRR in the study cohort. Both the methods identified three of the same THR prostheses, and the RSF identified the other five of the detected THR components. In primary TKR, both feature selection techniques identified two of the same total knee prostheses, and Cox detected one additional prosthesis as at higher risk of revision. In addition, both the RSF and Cox techniques detected a number of additional device components that were not previously identified by the standard approach. The results showed ML might be able to offer a supplementary approach to enhance the early identification of outlier devices. RSF was a more comparable feature selection technique to the AOANJRR standard. Further studies are required to better understand the potential of ML to improve the early identification of outliers.