Risk Calculators for Failure of Knee and Hip Replacement in a Large Health Maintenance Organization

Christopher F. Ake, PhD • Elizabeth W. Paxton, MA • Maria C.S. Inacio, MS • Monti Khatod, MD • Eric Yue, MD • Robert S. Namba, MD • Tad T. Funahashi, MD

Introduction

- Each year in the United States over 750,000 total joint replacement (TJR) surgeries are performed[1].
- While TJR implants can last 10-20 years, replacements more often fail and require revision surgery[2-3].
- The increased risk and cost associated with revision procedures emphasize the need for prevention. Identification of risk factors associated with TJR failures and revisions is one method for potentially reducing TJR revision rates.
- Patient characteristics are important indicators of the outcome of TJR procedures. Patients' age, race, body mass index (BMI), activity level, co-morbid conditions (such as diabetes, obesity, cardiovascular disease), and gender have all been found to be associated with higher complication rates and utilization rates post TJR in Medicare populations and/or smaller population based studies[5-7].
- Total hip replacement (THR) and total knee replacement (TKR) risk calculators can be used by both patients and surgeons in clinical decision making to reduce failures and revision total hip and knee replacement.
- Risk calculators have a long history of use in medicine[8-9] and have shown to be useful in pre-operative care of patients. These tools provide a probability of outcomes and when given the right context (setting, patient population), assumptions (diagnosis of the population, distribution of events), time period clarifications, and uncertainty around the probability they can be a useful prognostic tool for surgeons pre-operatively.
- The purpose of this study was to identify patient-level risk factors associated with total hip and total knee replacement revision for development of risk calculators for clinical treatment decisions with the ultimate goal of reduction in total hip and knee replacement revision rates.

Methods

- This is a cross-sectional analysis of prospectively collected data. All cases registered in a Total Joint Replacement Registry (TJRR) between 04/2001 and 04/2009 were used in the analysis.
- Prediction models were developed using 100% data sample from the corresponding registry. Cases with a missing value for any candidate predictor were excluded from the modeling.
- Risk of revision was modeled by logistic regression. Candidate predictors were selected from pre-operative patient characteristics on the basis of clinical knowledge with a criterion of being readily available from Kaiser Permanente's routinely collected data (outpatient electronic health record, etc.) or easily determinable at time of consult.
- Models were assessed by the Hosmer-Lemeshow goodness of fit criterion. To assess the effect of varying lengths of observation time, logistic regression models were compared to Cox regression and Poisson regression with time offset models. For risk models selected, parameter estimates were highly congruent across such models. Cross-validation for model checking was done using 90-95% subsamples.

Results

- Registry data included 39288 hip primaries, of which 667 (1.70%) were revised and 26541 knee primaries, with 511 (1.93%) revisions. After exclusions for missing data, 27270 primary cases were used for knee (69.4%) and 20897 cases for hip modeling (79.1%).

Knee Risk Calculator:

- Predictors included were age, gender, BMI, diabetes (Y/N), osteoarthritis (Y/N), inflammatory arthritis (Y/N), post-traumatic arthritis (Y/N), rheumatoid arthritis (Y/N), and osteonecrosis (Y/N). The 4th power of BMI is used and all other terms are linear.
- BMI, age, post-traumatic arthritis and osteonecrosis were predictors of revision. *See Table 1 for detail.*

Table 1. Knee Risk Calculator Odds-Ratios

	OR	OR 95% LL	OR 95% UL	P-value
	0.98	0.97	0.99	<0.0001
Gender	0.79	0.65	0.96	0.015
Diabetes	1.28	1.03	1.58	0.023
Osteoarthritis age	1.34	0.69	2.59	0.388
Inflammatory arthritis	2.26	0.78	6.57	0.135
Post-traumatic arthritis	3.40	1.78	6.50	<0.001
Rheumatoid arthritis	1.24	0.53	2.90	0.615
Osteonecrosis	4.10	1.66	10.15	0.002
BMI to 4th power[1]	1+1.3E-7	1+6.2E-8	1+1.7E-7	<0.0001

- The knee model predicted well in the highest decile of risk: 92.6 revisions versus an observed 91, and lowest: 22.6 versus an observed 21, and did least well in the mid-range. Patients in the highest-decile of risk were 4.3 times more likely to have a revision than those in the lowest decile of risk. The riskiest 10% of knee patients suffered 20.9% of all revisions.

Hip Risk Calculator:

- Predictors selected were gender, BMI, diabetes (Y/N) and inflammatory arthritis (Y/N). The 4th power of BMI is used and all other terms are linear.
- BMI was a highly significant predictor of revision. *See Table 2 for detail.*

Table 2. Hip Risk Calculator Odds-Ratios

	OR	OR 95%LL	OR 95% UL	P-value
Gender	1.28	1.03	1.59	0.026
Diabetes	1.23	0.93	1.64	0.146
Inflammatory Arthritis	2.27	0.78	6.61	0.131
Bmi to 4th Power[1]	1+1.3E-7	1+6E-8	1+2.1E-7	0.0007

Application Development:

- Model parameters were entered into Excel algorithms to allow creation of limited use websites at which Kaiser Permanente orthopedic surgeons can now enter patient data to obtain a predicted revision risk. *See Figure 1 for detail.*

[1]*The odds ratios shown for BMI in each model are not simple to interpret, since they represent the increase in odds of revision for a one-unit increase in the fourth power of BMI. Thus an increase of BMI from 25 to 26 would involve a 264-254=456976-390625=66351 unit increase in BMI to the fourth power. Since (1.000000116)66351=1.007714, this increase in BMI represents about a 1% increase in the odds of having a total knee replacement revision. For further comparison, a BMI of 40 represents an increase in odds of a knee revision of about 22% compared with a BMI of 30.*

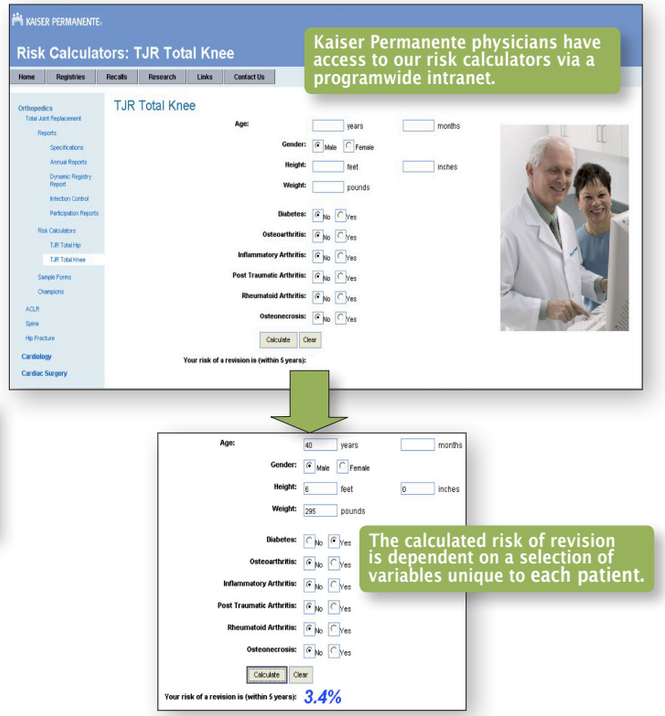
Discussion

- The total joint revision rates in this study were similar to those published previously [10-13]. Similar to other studies that have examined revision risk factors, our study identified gender, age, BMI, diagnosis, and diabetes as risk factors of revision [14-17].
- These risk factors were included in a prognostic risk calculator to enhance patient and surgeon clinical decision making.

Strengths:

- Large number of TJR cases used, with revision cases adjudicated by chart review of all cases.
- Development of pragmatic prognostic risk calculators that can be applied in a clinical decision making setting.

Figure 1: Risk Calculator Application



Limitations:

- Potential bias due to the proportion of cases with missing values which were not used in model development.
- These risk predictors have yet to be validated in other populations and outside our healthcare setting and may not predict as well in these situations.

Future versions of these risk calculators can benefit from surgeon feedback concerning additional candidate predictors to examine, such as prior knee surgery, steroid use, and Hemoglobin A1c levels, as well as ways to improve calculator website interface design, and greatly reduced levels of BMI missingness.

Conclusion:

Total joint revision risks calculators may assist surgeons and patients in clinical decision making at the point of care. Identification of risk factors to influence treatment decisions may reduce revision total joint replacement and enhance quality of care.

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