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Factors predicting repeat revision and outcome after aseptic revision total knee arthroplasty: results from the New Zealand Joint Registry

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Abstract

Purpose The number of Revision TKAs performed continues to increase; however there is limited data on risk factors for failure. Additionally, clinical decisions regarding when and how to revise a failed TKA may be as important as the technical aspects of the procedure. The purpose of this study was to analyze factors predicting repeat revision following aseptic revision TKA.

Methods Of 85,769 primary TKAs recorded on the New Zealand National Joint Registry, 1720 patients undergoing subsequent revision for aseptic indications between January 1999 and December 2015 were identified. Re-revision was recorded in 208 patients (12.1%). The analysis included demographic characteristics, surgeon revision case volume, surgical time, surgical ownership of index TKA as independent variables using logistic and linear regression. The primary outcome measure was incidence of subsequent re-revision and Oxford Knee Scores of revised TKAs (OKS). The secondary outcome measure was the influence of component exchange in major revisions on re-revision rate.

Results Younger patients undergoing a revision (HR 0.974) and male gender (HR 0.666) were predictors of re-revision. Elapsed time since index surgery (unstandardized coefficient 0.060) and lower ASA score (UC − 2.749) were significant predictors of OKS. Femoral component revision was a predictor of re-revision (HR 1.696) and had the lowest OKS, compared to tibial and all component revision ($p = 0.003$).

Conclusions Repeat revision TKA is a rare and complex procedure influenced by a number of confounding factors. Using raw registry data, younger and male patients were found to be at a higher risk of re-revision after aseptic revision TKA. A longer time between primary TKA and revision was associated with better clinical outcomes. Isolated femoral component exchange led to worse outcomes both in terms of survivorship and functional scores.

Level of evidence III.

Keywords Revision knee arthroplasty · Outcomes · Repeat revision · Total knee replacement · Aseptic

Introduction

The demand for primary total knee arthroplasty (TKA) continues to increase, and with it the number of subsequent revision surgeries [15]. In the UK the recorded number of knee revisions increased by 313% in 12 years [14]. As this 'revision burden' increases, it is important to identify the various factors affecting outcomes and how such factors influence decision making around complex revision procedures [5]. Studies are difficult to compare due to the heterogeneity of patient and surgeon groups, and variability of how outcomes have been recorded.

Some risk factors for poor outcome and failure of revision knee arthroplasty have been reported. Hardeman et al. [8] concluded that younger patients and those who

The research has been performed at the North Shore Hospital and the New Zealand Joint Registry.

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were revised within 2 years of primary surgery had the worst outcome. Van Kempen et al. found that revision for aseptic loosening had better outcomes than for instability, malposition or septic loosening [10]. Kasmire et al. found that a higher BMI was predictive of a lower post-operative Oxford Knee Score [9]. The impact of surgeon experience on outcome following revision TKA has also been investigated, with evidence of lower morbidity and mortality in specialized centers [6] and better outcomes if the revision was performed by more specialized surgeons [4]. The definition of terms such as experienced, high volume or more specialized is study dependent and varies, with greater emphasis placed on centers rather than surgeons [4]. Philips et al. validly discuss that surgeons performing revision TKA should be suitably experienced to deal with issues of these procedures [17].

Due to the low number of revisions and varied reasons for revision, available data arise from studies with small patient cohorts. Furthermore, the outcomes from revising one's own primary TKA has been uninvestigated.

The purpose of this study was to analyze surgical, demographic and surgeon-related factors predicting repeat revision and clinical outcomes after aseptic revision total knee arthroplasty using registry data. We hypothesized that younger patients, revisions performed by the same surgeon who performed the index procedure, revision performed by less experienced surgeons and single component revisions would be at a higher risk of repeat revision.

Methods

Definition of revision surgery

Revision is defined by the registry as a new operation in a previously replaced knee joint, during which one or more of the components is exchanged, removed, manipulated or added. It includes arthrodesis or amputation. A two or more staged procedure is registered as one revision. Excluded were any cases that had been revised for fracture and infection. A 'major' revision was defined as exchange of the femoral component and/or the tibial component with subgroups of tibial, femoral and all component exchange. A 'minor' revision was change of polyethylene liner and/or an addition or revision of the patella component. Surgical duration was defined as the time between the first skin incision and final skin closure. Each surgeon in the registry has a unique ID number. Times between primary and revision as well as re-revision have been recorded. Early and late revisions were defined as before and after 24 months, respectively [18]. The New Zealand Joint registry has an ongoing ethical approval.

Patients

All primary TKAs recorded in the New Zealand Joint Registry between 1999 and 2015 were queried for revision. Included were all TKAs that subsequently underwent a revision procedure. Excluded were revision TKAs performed due to infection, leaving 1720 aseptic revision cases for the analysis (Fig. 1). There were 743 minor and 977 major revisions recorded. Demographic data collected was gender, age at primary and revision surgery, body mass index (BMI) and American Society of Anesthesiologists (ASA) score. From the initial cohort of 1720 revisions, 208 cases underwent a second revision (12.1%). Using a cutoff of 2 years since primary TKA, there were 614 'early' (< 2 years) and 1106 'late' revisions (> 2 years).

Outcome measures

The primary outcome measures were incidence of re-revision and the OKS after the revision. The secondary outcome measure was the influence of component exchange in major revisions on the re-revision rate. The influence of surgical experience and surgical ownership of the index TKA on the outcome measures was assessed using the registry dating back to 1999. The annual revision case volume of the surgeon was grouped into three categories, with minimal volume signifying overall less than a total of five revision cases, low volume signifying ≤ 5 revision cases per year and higher volume ≥ 5 revision cases per year. The annual volume was the total number of revision cases divided by the number of years the surgeon has been

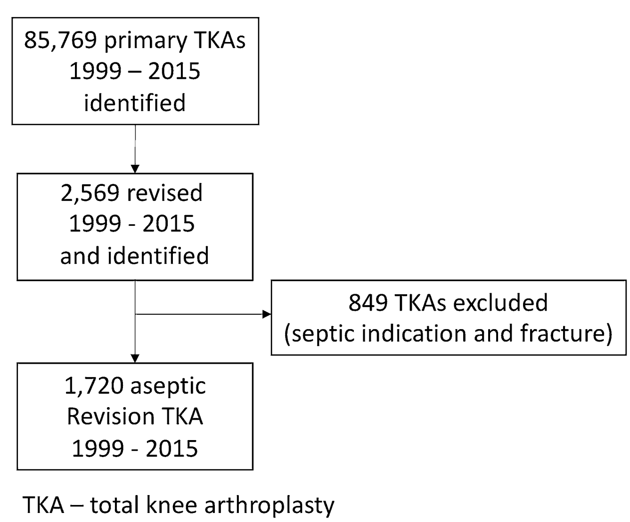

Fig. 1 Patient inclusion flowchart

active in the registry. Ownership of the index case refers to whether the surgeon who performed the revision TKA also performed the primary TKA (same surgeon) or not (different surgeon).

Statistical analysis

Normality of distribution was analyzed using the Shapiro–Wilk test. Distribution of indications as well as the stratification by experience and time was performed using the Chi-square test. The threshold of five cases/year was calculated using k-means cluster analysis. The third group, minimal, was then created by subtracting the surgeons registering less than five cases overall in the registry. Analysis of associations between the collected data and re-revision as dependent variable was performed with a two-step Cox regression. At the first step, univariate analysis was performed for each of the independent variables. At the second step, a multivariate analysis was performed to control for co-variates where an association was identified. OKS at 6 months after revision was available in 55.7% of cases. The target OKS for New Zealand Registry is 25%. Predictive variables for OKS were analyzed using linear regression. Group comparison was performed using the Mann–Whitney *U* test and analysis of variance, where appropriate. The statistical significance level was set at 5%. SPSS 24 (IBM, Armonk, USA) was used for the statistical analysis.

Results

Reasons for aseptic revision and repeat revision

The reasons for aseptic revision TKA in the NZ registry are reported in Table 1. Table 2 reports the reasons for repeat revision after aseptic revision TKA. The repeat revision rate is 12.0%. The infection rate needing revision surgery after the first TKA revision was 2.55%.

Table 2 Reasons for repeat revision

Indication for repeat revision	Number (%)
Loosening	63 (30.3%)
Pain/other	52 (25.0%)
Infection	44 (21.2%)
Instability	22 (10.6%)
Stiffness	9 (4.3%)
Patellofemoral	9 (4.3%)
Malalignment	6 (2.9%)
Extensor deficiency	2 (0.9%)
Fracture	1 (0.4%)
Total	208

Primary outcome measure

On univariate regression analysis, younger age at the time of revision, male gender, fewer months since primary TKA to revision, same surgeon that performed the index procedure performing the revision and longer surgical duration of revision were associated with subsequent re-revision surgery (Table 3). On multivariate regression analysis, younger age at the time of revision and male gender were significant predictors of re-revision (Table 4). Males had a 40% higher risk of re-revision, and the difference in risk for re-revision was 26% for every 10 years of decreasing age. A shorter time since primary TKA and the same surgeon performing the revision were not significant. Surgical experience in revision surgery was not a predictive variable for repeat revision (n.s.).

When using 6-month OKS as the outcome, on linear regression analysis, major revisions, fewer months since primary, longer surgical time and lower ASA score at revision were associated with higher OKS scores (Table 5). When controlling for co-variates on multivariate analysis, months since primary and lower ASA score were associated with improved OKS scores (Table 6). Surgical experience in

Table 1 Indications for first aseptic revision, by timeline and type

	All revisions	Early revision	Late revision	Minor revision	Major revision
Number of cases	1720	614	1106	743	977
Aseptic loosening	583 (34%)	105 (17%)	478 (43%)	33 (4%)	550 (56%)
Pain/other	612 (36%)	278 (45%)	334 (30%)	433 (58%)	179 (18%)
Stiffness/arthrofibrosis	123 (7%)	65 (11%)	58 (5%)	56 (8%)	67 (7%)
Instability	205 (12%)	85 (14%)	120 (11%)	113 (15%)	92 (9%)
Malalignment	68 (4%)	41 (7%)	27 (2%)	17 (2%)	51 (5%)
Avascular necrosis	6 (1%)	4 (1%)	2 (< 1%)	1 (< 1%)	5 (< 1%)
Poly failure	68 (4%)	11 (18%)	57 (5%)	42 (6%)	26 (3%)
Patellofemoral arthrosis	50 (3%)	24 (4%)	26 (2%)	47 (6%)	3 (< 1%)
Extensor mechanism deficiency	5 (1%)	1 (< 1%)	4 (< 1%)	1 (< 1%)	4 (< 1%)

Table 3 Univariate regression for re-revision as the dependent variable

Independent variable		*p* value	Hazard ratio	95% confidence interval
Mean age at time of revision	66.3 (±9.6)	<0.001	0.977	0.965–0.990
% Female gender	839 (48.8%)	0.009	0.696	0.529–0.915
% Major revision	977 (56.8%)	n.s	1.071	0.813–1.411
Mean months since primary	49.7 (3.0 – 192.2)	0.021	0.995	0.991–0.999
'Same surgeon' ownership of revision	1032 (60%)	0.023	1.416	1.049–1.912
Revision surgeon case volume (revisions)	Minimal (2.3%) Low (57.5%) Higher (40.2%)	n.s	1.071	0.822–1.395
Surgical duration (revision procedure)	109 (25–653)	0.009	0.997	0.994–0.999
Mean BMI	31.8 (±6.1)	n.s	0.995	0.934–1.059
ASA at revision	I (8.4%)	n.s	2.028	0.281–14.631
	II (48.8%)	n.s	1.813	0.243–13.543
	III (26.3%)	n.s	1.288	0.179–9.253
	IV (0.6%)	n.s	1.295	0.178–9.428

BMI body mass index

Table 4 Multivariate regression for re-revision as the dependent variable

Independent variable	Mean	*p* value	Hazard ratio	95% confidence interval
Age at time of revision	66.3 (±9.6)	<0.001	0.974	0.960–0.988
Female gender (*n*, %)	839 (48.8%)	0.005	0.6	0.500–0.886
Months since primary TKA	49.7 (3.0–192.2)	n.s	0.995	0.991–0.999
'Same Surgeon' ownership of revision (*n*, %)	1032 (60%)	n.s	1.30	0.944–1.784
Mean Surgical duration (revision TKA, min)	109 (25–653)	n.s	0.997	0.992–1.002

Table 5 Univariate linear regression for Oxford Knee Score as the dependent variable

Independent variable	Value	*p* value	Unstandardized coefficient	95% confidence interval
Age at time of revision	66.3 (±9.6)	n.s	0.057	− 0.017 to 0.130
Female gender	839 (48.8%)	n.s	0.044	− 1.229 to 1.316
Major revision	977 (56.8%)	0.009	1.715	0.424 to 3.006
Months since primary	49.7 (3.0–192.2)	<0.001	0.060	0.045 to 0.074
Surgeon ownership of revision	1032 (60%)	n.s	− 0.848	− 2.150 to 0.453
Surgeon case volume at revision	Minimal (2.3%) Low (57.5%) Higher (40.2%)	n.s	0.597	− 0.604 to 1.798
Surgical time of revision	109 (25–653)	0.004	0.016	0.005 to 0.027
BMI	31.8 (±6.1)	n.s	− 0.083	− 0.437 to 0.271
ASA at revision		<0.001	− 3.162	− 4.672 to (− 1.651)

BMI body mass index

revisions was not a predictive variable for OKS after revision surgery (n.s.).

Secondary outcome measure

When analyzing major revisions, only isolated femoral component exchange was a predictor of re-revision, compared to individual tibial exchange or all component exchange (Table 7). Overall survivorship was highest for all

Table 6 Multivariate linear regression for Oxford Knee Score as the dependent variable

Independent variable	Value	*p* value	Unstandardized coefficient	95% confidence interval
Major revision	977 (56.8%)	n.s	− 1.683	− 4.036 to (− 1.220)
Months since primary	49.7 (3.0–192.2)	< 0.001	0.060	0.045 to 0.074
Surgical time of revision	109 (25–653)	n.s	0.011	− 0.009 to 0.031
ASA at revision		< 0.001	− 2.749	− 4.279 to (− 1.220)

BMI body mass index

Table 7 Uni- and multivariate regression for re-revision as the dependent variable, by revision type

Independent variable	Number (% re-revised)	*p* value	Hazard ratio	95% confidence interval
Univariate regression				
Tibial component revision	225 (14.7%)	n.s	1.092	0.731–1.632
Femoral component revision	113 (23.9%)	0.001	2.046	1.331–3.145
All component revision	640 (9.3%)	0.008	0.617	0.431–0.884
Multivariate regression				
Femoral component revision	113 (23.9%)	0.042	1.696	1.019–2.823
All component revision	640 (9.3%)	n.s	0.757	0.495–1.158

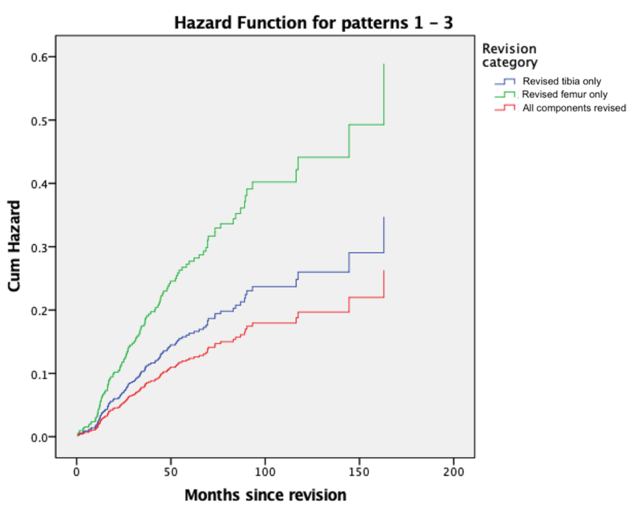

Fig. 2 Cumulative revision hazard for femoral, tibial and all component revision

component exchange (Fig. 2). OKS at 6 months was 33.5 for tibia exchange, 29.3 for femur exchange and 33.6 for all component exchange ($p = 0.003$).

Discussion

The most important findings of this study are that younger and male patients were found to be at a higher risk of re-revision, confirming one of the main hypotheses and being consistent with current literature reports. Better outcomes were observed when all components were exchanged, confirming another hypothesis and also consistent with the literature. Patients with a lower ASA score and a longer elapsed time since primary TKA achieved higher 6-month Oxford Knee Scores. Revision of only the femoral component was associated with a higher risk of subsequent re-revision, contrary to previous reports. The hypothesis that surgical experience decreased risk of repeat revision was not confirmed by this study. The final hypothesis that revisions performed by the surgeon who performed the index procedure have a higher risk of repeat revision was not entirely rebutted.

Loosening, unexplained pain, stiffness and instability remain the main reported problem, even in the repeat revision scenario. Infection occurring after an aseptic TKA revision, needing surgery, had an incidence of 2.55%, which is half of what was previously reported in comparable literature [12].

The finding of a lower re-revision rate in females reflects trends seen in primary TKA in the NZJR and other registries. NZJR reports a revision rate of 0.45 per 100 component years in females compared to 0.54 for males following primary TKA [16]. In the UK, females have a 12% cumulative revision risk at 10 years following primary TKA, compared to males having 12.4% [14]. This trend is observed in Australia, where females have 5% cumulative revision rate at 10 years, compared to 5.8% for men [15]. This is the first study that identifies this difference following revision TKA [13]. Similarly, the finding that younger patients have higher re-revision rates follows the same pattern seen in younger patients undergoing a primary TKA [2, 14–16].

Higher re-revision rate in patients with a shorter time between primary and first revision was observed on univariate analysis, not seen in previous studies [11, 18]. In the multivariate model, however, it lost statistical significance.

This may be due to the differing reasons for revision between early and late revisions, with the most common reasons for revision in late (> 2 years) revisions being aseptic loosening (43%), but for early revisions being unexplained pain (23%). In addition, patients who chose revision surgery early to treat a problem following primary TKA may be more likely to make the same choice if they have an unsatisfactory outcome following revision TKA.

For major revisions, all component exchange provided better clinical outcomes than single component exchange supporting the findings of a previous study [7]. This study also demonstrates the highest survivorship for all component revision. Exchanging only one component may lead to difficulty balancing flexion and extension gaps with still one component in situ [7]. A further problem in partial revision is changing the level of constraint, which is not always possible if a partial revision is performed. Removal of the tibial component without the femoral component is another challenge that could lead to damage of the femoral component or the surrounding soft tissue. Different systems used in revisions have different survivorships, which also affects the revision rate. Similar to a recent single center studies [3], the numbers are small, and in a multivariate analysis such as in this study, with every substratification, the study gets less powered. Repeat revisions are significantly less frequent than first revisions, and the multifactorial nature of their results need to be kept in mind when interpreting results.

Phillips et al. published an editorial asking the question:" Am I the right surgeon, in the right hospital, with the right equipment and staff to do this operation?" specifically discussing the issue of revision TKA [17]. Even though not all revisions require a specialist center [17] and there are experienced revision surgeons outside of high volume centres [1], the results of this study imply that the same surgeon who performed the index case should potentially not be performing the revision. This remained significant only at univariate regression analysis, but nevertheless demonstrated significance as an independent variable.

There are a number of limitations to this study. As a registry study, radiological, laboratory or clinical data could not be accessed. Therefore, we are unable to audit the reasons for revision using standardized criteria or the rationale by the surgeon making the indication, rather the revision indication was recorded on the registry form by the treating surgeon. Registry data allow for analysis of a larger number of revisions than has been analyzed in previous case series, and as the NZJR has a nationwide accuracy of over > 95% [16] a subsequent re-revision for any reason will be captured, justifying the use of registry data for these rare events. Secondly, a change in surgical experience or caseload was not controlled for. The number of these surgeons would be minimal and would not impact the results significantly. Finally, the registry only records 'revision' procedures where a component is manipulated, exchanged, or removed, and isolated soft tissue procedures are not recorded. Additionally, many patients with an unsatisfactory outcome may be unwilling or unable to undergo revision surgery, due to its burden. The threshold for revision surgery is furthermore influenced by surgeon's experience in revision, which was not significant in this study. The cases that a higher volume surgeon would have revised remain uncaptured by the registry. The influence of type of constraint used in the revision was not analyzed, as a further substratification would have underpowered the study for this outcome measure and would not influence the main demographic findings. As the number of hinges is small compared to condylar constraint implants in first revision, the differences between isolated and all component exchange would have remained the same. Isolated soft tissue procedures are uncommon, and minor procedures such as manipulation under anesthesia may have limited effect on outcome [14, 15]. This study benefited from the use of Oxford Knee Scores in the NZJR, allowing an alternate form of outcome assessment than simply revision rate as is typical in registry-based studies.

Conclusions

Repeat revision TKA is a rare and complex procedure influenced by a number of confounding factors. Using raw registry data, younger and male patients were found to be at a higher risk of re-revision after aseptic revision TKA. A longer time between primary TKA and revision was associated with better clinical outcomes. Isolated femoral component exchange led to worse outcomes both in terms of survivorship and functional scores. Surgeons need to be aware of these risk factors and inform the patients of them when planning any aseptic TKA revision.

Author contributions SWY devised the study. AK and CF analyzed the data. AK, PM and MZ drafted the manuscript. SWY revised it. All authors have given approval for the final version of the manuscript. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Compliance with ethical standards

Conflict of interest SWY has received research support and is a consultant for Stryker. Other authors have no conflicts to declare.

Ethical approval The New Zealand Joint Registry is funded from contributions from surgeons, Accident Compensation Corporation (ACC), the New Zealand government, and Southern Cross Hospital. It has an ongoing ethical approval obtained from Canterbury District Health Board in 1998.

Informed consent All patients provide written consent to the registry for data collection.

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