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ORIGINAL PAPER

Reasons and risk factors for ninety day re-admission following primary total knee arthroplasty in a high-volume centre

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Abstract
Purpose We aimed to assess the rates, reasons, and risk factors for 90-day re-admissions after total knee arthroplasty (TKA) in a European healthcare setting.
Methods We identified all primary elective TKA procedures performed in 2015 at a single high-volume centre. Patients with unplanned re-admissions within 90 days of primary discharge were compared to a 1:4 control cohort of patients having no relevant re-admission. We calculated re-admission rates, recorded the reasons for re-admission, and identified independent predictors of re-admission.
Results The 30-day and 90-day unplanned re-admission rates were 6.5% and 8.0%, respectively. The most common reason for re-admission within 90 days was infection (29.6%), followed by knee pain (14.1%), gastrointestinal complications (8.5%), and haematoma (8.5%). Multivariable logistic regression analysis revealed that the following factors were significant independent predictors of re-admission: asthma, psychiatric disease, pre-operative tibiofemoral valgus angle, and pre-operative knee flexion deficit.
Conclusions The re-admission rates in our health-care setting were slightly higher than those previously reported. Independent risk factors for re-admissions included pre-operative mechanical axis, range of motion, asthma, and psychiatric disease. Our present results will facilitate the targeting of new subgroups of TKA patients when developing new interventions to further reduce the total re-admission risk after TKA.

Keywords Total knee arthroplasty · Re-admissions · Health care economics · Total joint arthroplasty

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Introduction

Recent decades have seen substantial increased performance of total knee arthroplasty (TKA) procedures. The latest projections indicate that the number of total knee replacements performed in the United States will double from 2010 to 2020 [1]. Rising healthcare costs and increasing demand for TKA make it crucial to manage the expenses associated with this procedure. One promising means of reducing TKA-associated costs is to reduce the number of unplanned re-admissions. However, re-admission rates vary widely in the literature, and there is not yet a clear consensus regarding an acceptable baseline re-admission rate. The reported 30-day TKA re-admission rates range from 0.2 to 6.6% [2–9], and 90-day re-admission rates range from 5.6 to 9.7% [4, 6, 7, 9, 10]. Moreover, the exact definition of re-admission differs among studies.

Several factors reportedly increase the likelihood of early re-admission after total joint arthroplasty (TJA), including higher age; male gender; high American Society of Anesthesiologists (ASA) score; discharge to an inpatient institution; multiple co-existing comorbidities (e.g., diabetes mellitus and congestive heart failure); and hospital factors, such as surgeon volume and length of stay [5, 6, 8, 11]. However, the data supporting the influence of these risk factors are limited and somewhat conflicting, such that their true impact remains unclear. In fact, one recent study proposes that most unplanned re-admissions after total hip arthroplasty may not be preventable at all [12].

Surgical site infection, cellulitis, and periprosthetic fracture are the most common reasons for re-admission after TKA [2, 6]. However, some authors report completely different reasons for re-admission, such as ileus, arthrofibrosis, and cardiac issues [9, 13, 14]. Most of the published studies have been performed in the United States, where insurance status might be a confounding factor [15].

In our present study, we examined post-TKA re-admissions in a European healthcare setting. We specifically aimed to determine the 30- and 90-day re-admission rates after primary discharge, to report the main reasons for re-admission, and to identify any independent risk factors.

Materials and methods

We identified all primary elective TKA procedures performed at our institution during 2015 using procedure codes from the Finnish Hospital Discharge Register (FHDR), which is considered highly accurate for use in the present type of study [16]. Approximately 900 primary TKA and 100 revision TKA procedures are performed annually at our university hospital. TKA procedures are performed in a fast-track setting, with patients discharged at two to three days post-operatively. Patients have their wound staples removed at their primary care facility at two weeks post-TKA, and are scheduled for a clinical follow-up visit to our unit at two to three months post-operatively. A consultation phone service run by nurses specialised in total joint replacement is available every weekday, would any concerns arise prior to the clinical follow-up visit.

We also searched the FHDR to identify any re-admission to any hospital in the region occurring within 90 days of primary discharge. When defining re-admissions, we did not apply any criteria involving a time limit (e.g., 24 hours) or overnight hospital stay. After identifying all re-admitted patients, we performed a thorough chart review of the electronic medical records to identify the reasons for unplanned re-admissions. We excluded planned re-admissions or re-admissions that were clearly not attributable to the index procedure, e.g., planned contralateral joint replacements and cancer surgeries surgery. Re-admissions were categorised based on both the medical records and the ICD-10 diagnosis. In the absence of a clear ICD-10 diagnosis, the re-admission reason was classified mainly based on the symptoms present at re-admission. The re-admission rates were calculated by dividing the number of re-admissions by the total number of primary discharges.

All patients undergoing manipulation under anaesthesia (MUA) were coded as re-admitted in our hospital database. These re-admissions were considered as planned or unrelated, and were excluded from the analyses. Based on the time of follow-up, such MUA re-admissions were performed either within or slightly after 90 days, and thus including these MUA patients in the risk factor analysis could have skewed our results.

After excluding unrelated and planned re-admissions, we created a 1:4 control cohort by randomly selecting patients without a relevant re-admission during the study period. We obtained data on all patients in the study cohort by reviewing electronic medical records, surgery reports, laboratory results, pre-operative clinical exams, and pre-admission patient forms. The collected data included patient demographics (age, gender, ASA score, BMI, living conditions, and prior contralateral TKA surgery), laboratory results [pre-operative and post-operative haemoglobin, haematocrit, thrombocytes, creatinine, C-reactive protein (CRP), sodium, potassium, and international normalised ratio (INR)], Knee Society Score (KSS) and all individual factors included in the KSS rating [17], surgical variables (procedure time, surgeon experience, and anaesthesia type), discharge disposition, patient comorbidities, and medication.

These collected data were analysed by an independent biostatistician. Demographic characteristics were compared by analysing categorical variables with a chi-square test, and normally distributed variables with a two-sample *t*-test. We used the nonparametric Mann-Whitney U test to analyse non-normally distributed data, including CRP, INR, and length of hospital stay. We applied logistic regression analysis to investigate associations between re-admission and potential risk factors. Independent risk factors for admission were examined using a multivariable logistic regression model with a forward stepwise procedure (inclusion criteria, $P < 0.05$; exclusion criteria, $P \geq 0.05$). The stepwise model included 13 risk factors with P values of <0.10 in univariate analysis, and four risk factors were entered into the final multivariable model. Results are expressed using odds ratios (OR) and their 95% confidence intervals (CI). P values of <0.05 were considered statistically significant. Statistical analyses were performed using SAS System for Windows, version 9.4 (SAS Institute, Cary, NC).

Results

During the study period 894 elective primary TKA procedures were performed in 861 patients at our institution. Within 90 days after primary discharge, 99 of these patients were re-admitted a total of 116 times. Among these re-admissions, 45 were planned or clearly unrelated to the index procedure and were excluded from further analysis, leaving 60 patients included in our re-admission analyses. Table 1 presents the demographics of the study cohort. The 30- and 90-day all-cause re-admission rates were 6.9% (n = 61) and 13.1% (n = 116), respectively. After excluding the planned and clearly unrelated re-admissions, these re-admission rates were 6.5% (n = 58) and 8.0% (n = 71), respectively. Among the

Table 1 Characteristics of readmitted patients and control cohort of non-re-admitted patients

Variable	Re-admitted (n = 60)	Control cohort (n = 228)	P-value
Age, y	69.9 ± 9.9	67.1 ± 9.8	0.052[b]
Gender (% females)	60.0	64.5	0.52[a]
BMI (kg/m^2)	29.9 ± 4.9	29.6 ± 5.2	0.66[b]
Pre-operative ASA score			0.058[a]
1–2	25.0	38.2	
3–4	75.0	61.8	
Pre-operative KSS	85.2 ± 32.6	92.3 ± 31.3	0.12[b]
Primary hospital length of stay (days)	3.6 ± 2.0	3.1 ± 1.3	0.16[c]
Duration of surgery (min)	100.4 ± 32.8	96.2 ± 26.9	0.30[b]

Values are reported as mean ± standard deviation or percentage

BMI body mass index, *KSS* Knee Society Score, *ASA* American Society of Anesthesiologists

[a] Chi-square test

[b] Two-sample t-test

[c] Mann-Whitney U-test

unplanned re-admissions, 58 (82%) occurred during the first 30 days after discharge.

The most common reason for unplanned re-admission was infection, followed by knee pain, gastrointestinal reasons, and haematoma. Table 2 presents the ten most common reasons for 90-day unplanned re-admissions. Among these re-admissions, 67.6% were classified as surgical and 32.4% as medical. Infection, knee pain, and haematoma were the most common causes of surgical re-admissions, while GI-related complications, cellulitis, and cardiovascular events were the most common reasons for medical re-admissions.

Univariable logistic regression analysis revealed that re-admission was associated with the following risk factors ($P < 0.05$): higher number of drugs, asthma, pre-operative tibiofemoral angle of 11–15°, pre-operative knee flexion <110°, hypertension, psychiatric disease, epilepsy, use of walking aids, and longer length of hospital stay (Table 3). Age ($P = 0.053$), gender ($P = 0.52$), BMI ($P = 0.66$), Knee Society Score ($P = 0.12$), and ASA score ($P = 0.060$) were not associated with re-admission in the univariable logistic regression analysis. Multivariable logistic regression analysis revealed that the following four factors were significant independent predictors of re-admission: asthma (2.50 OR, 95% CI 1.20–5.21, $P = 0.015$), pre-operative tibiofemoral angle of 11–15° (2.67 OR, 95% CI 1.04–6.89, $P = 0.042$), psychiatric disease (3.20 OR, 95% CI 1.26–8.11, $P = 0.014$), and pre-operative knee flexion <110° (2.03 OR, 95% CI 1.08–3.81, $P = 0.027$).

Table 2 Ten most common reasons for unplanned 90-day re-admissions

Reason	Number of occurrences, n	Percent (%) of re-admissions
Infection	21	29.6%
Knee pain	10	14.1%
GI-related	6	8.5%
Haematoma	6	8.5%
Wound drainage	5	7.0%
Cellulitis	4	5.6%
Cardiovascular event	3	4.2%
Periprosthetic fracture	3	4.2%
Other fracture	3	4.2%
Pneumonia	2	2.8%
Total no. of re-admissions	71	100.0%

Discussion

The aim of our present study was to investigate the rates, reasons, and risk factors for re-admissions occurring within 30 and 90 days after discharge following TKA at our high-volume centre. We found 6.5% and 8.0% rates of unplanned re-admissions within 30 and 90 days, respectively. The most common reasons for re-admission were infection, knee pain, haematoma, and gastrointestinal complications. Independent predictors of re-admission included asthma, psychiatric disease, pre-operative knee flexion <110°, and pre-operative valgus knee deformity.

The presently reported readmission rates are somewhat higher than previously reported rates [4, 6, 7, 9, 10]. It is difficult to establish whether these higher rates are due to

Table 3 Univariate logistic regression analysis; risk factors associated with 90-day re-admission

Risk factor	Odds ratio (OR)	95% confidence interval (CI)		P-value
Number of drugs[b]	1.11	1.04	1.19	0.003
Asthma	2.60	1.30	5.21	0.007
Pre-operative TF[a]				
angle <0° vs 5°–10°	1.16	0.51	2.65	0.724
angle 0°–4° vs 5°–10°	1.18	0.46	3.04	0.726
angle 11°–15° vs 5°–10°	2.94	1.19	7.27	0.020
angle >15° vs 5°–10°	1.27	0.39	4.12	0.687
Hypertension	2.10	1.14	3.87	0.017
Psychiatric disease	2.97	1.30	6.81	0.010
Epilepsy	5.36	1.17	24.62	0.031
Pre-operative knee flexion ≤110°	1.86	1.03	3.36	0.040
Walking aid (cane vs no aids)	2.26	1.03	4.94	0.041
Hospital length of stay (days)[2]	1.19	1.00	1.40	0.046

[a] TF = Tibiofemoral

[b] Continuous variable; OR for one-unit increase

differences in the quality of care, or if they reflect differences in the healthcare and insurance settings. In Finland, everyone is insured by the government, regardless of age and socio-economic status. The higher re-admission rates could also be due to differences in study design. In our present study, we tracked patients' re-admissions to any hospital, while most previous single-institution studies have only identified re-admissions occurring to the hospital where the index procedure was performed [2, 3, 10].

Several comorbidities are well-established risk factors for re-admission after TKA, including hypertension, chronic obstructive pulmonary disease (COPD), diabetes mellitus, and congestive heart failure [8, 18]. Studies have also investigated the roles of certain psychiatric diseases, especially depression, which are linked to higher risks of complications and re-admissions after total joint replacement [19, 20]. In line with these previous findings, our present results indicated that psychiatric disease independently increased the risk for re-admission among TKA patients. This highlights the importance of providing special treatment for psychiatric patients undergoing TKA. These patients may benefit from additional scheduled follow-up visits or counselling both prior to and after surgery. The high re-admission risk for psychiatric patients could be addressed by more extensive multidisciplinary co-operation, for example, by having a psychiatric specialist and nurses specialised in working with psychiatric patients routinely involved in the care of TKA patients with psychiatric comorbidities.

Pulmonary diseases (e.g., COPD) also reportedly increase the risk of re-admission after primary TKA. To our knowledge, asthma has not previously been linked to increased re-admission risk after TKA. However, it is not surprising that asthma independently increased the re-admission risk in our present study. Compared to non-asthmatic patients, patients with asthma have a generally higher rate of chronic corticosteroid use, potentially explaining the higher re-admission risk since corticosteroid use is linked to a higher risk of re-admission [21]. Further research is needed to elucidate whether the higher re-admission risk in asthmatic patients is caused by asthma per se, or rather by asthma-related medication and/or comorbidities.

It is unclear how preoperative range of motion may influence re-admission risk assessment for TKA patients. We found that patients with a pre-operative knee flexion of less than 110° degrees had a higher re-admission risk than patients with a larger pre-operative range of motion. This difference may be related to the complexity of the required surgery, or to a poorer pre-operative or post-operative mobility level. Patients with a smaller pre-operative range of motion are more likely to require additional soft tissue releases, which may result in pain and swelling. Similarly, we found an increased re-admission risk among patients with a pre-operative valgus deformity compared to patients with a normal tibiofemoral angle. This may reflect the fact that total knee replacements in knees with a valgus deformity are often more technically challenging and require more soft tissue releases.

Our present study had some limitations. It was sometimes difficult to retrospectively categorise the main reason for re-admission, especially in cases with no clear ICD-10 diagnosis. Furthermore, there is a possibility of error when retrospectively determining the causality between a re-admission and the index procedure. To reduce the influence of these limitations, we took advantage of the retrospective design, performing careful longitudinal tracking of each patient across the medical records of different specialties, to more accurately determine whether a re-admission was related to the index procedure.

One strength of this study is that we collected detailed and first-hand data on every patient included in the analyses. Since these data were collected from the electronic medical records of individual patients rather than from a larger database or registry, we are confident in the accuracy of the laboratory values, comorbidities, and re-admission reasons. Another strength of this study is that we managed to track the patients' visits to all hospitals, ensuring that all major complications were in fact detected.

In conclusion, in our present study, we described the rates and reasons for early re-admissions after fast-track primary total knee arthroplasty, at a high-volume centre in a European healthcare system in which access to care is granted by government insurance. The re-admission rates were higher than those commonly reported after fast-track TKA, possibly due to differences in the healthcare system compared to previous studies. We also identified several independent predictors of re-admission within 90 days of primary discharge, including pre-operative mechanical axis and range of motion, which are not previously reported re-admission risk factors. This knowledge can be used to improve the risk stratification of TKA patients. Our present results will enable the targeting of new subgroups of TKA patients when developing new interventions to further reduce the total re-admission risk after TKA.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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