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Review article

Factors associated with hospital stay length, discharge destination, and 30-day readmission rate after primary hip or knee arthroplasty: Retrospective Cohort Study

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ABSTRACT

Background: In France and in the US, predictions for 2030 include an increased number of total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures together with an overall trend towards shorter hospital stays. Predictors of hospital length of stay (LOS) include the day of surgery, discharge destination, and patient comorbidities. Available data are conflicting, however, and to our knowledge predictors of LOS after THA or TKA have not been evaluated in France. Improved knowledge of these predictors would be expected to increase patient care efficiency. The objectives of this study were: (1) to determine whether the above-listed factors predict LOS after THA or TKA, (2) to identify predictors of discharge to a rehabilitation unit and of readmission within 30 days after surgery.
Hypothesis: Both patient-related factors unamenable to modification and modifiable organisational factors are associated with LOS after THA or TKA.
Material and methods: This large single-centre retrospective cohort study included all adults who underwent primary THA or TKA at our university hospital between 1 January 2015 and 31 December 2016. Non-inclusion criteria were revision arthroplasty, THA with femoral or acetabular reconstruction, TKA using a constrained hinged implant, and fracture as the reason for arthroplasty. Preoperative parameters, type of arthroplasty, and postoperative care were recorded.
Results: We included 938 patients with THA and 725 patients with TKA. By multivariate analysis, the likelihood of being discharged by day 5 decreased with older age (HR, 0.986; 95%CI: 0.98–0.99) and was lower by 13% in females (HR, 0,871; 95%CI: 0.77–0.986), by 39% in patients with diabetes (HR, 0.606; 95%CI: 0.5–0.73), by 68% in patients discharged to rehabilitation units (HR, 0.322; 95%CI: 0.267–0.389), and by 27% in patients who had arthroplasty on a Friday (HR, 0.733; 95%CI: 0.631–0.852). Factors predicting discharge to rehabilitation unit were older age, female gender, chronic obstructive pulmonary disease, anxiety-depressive disorder, and a history of stroke. Risk factors for 30-day readmission were male gender, obesity, and discharge to rehabilitation unit.
Discussion: In this study, predictors of LOS were identified using a survival model that considered age as a continuous variable, separate comorbidities, and the discharge destination. Our findings are consistent with earlier reports and confirm the strong associations linking LOS to diabetes, day of surgery, and discharge destination in France. We also identified predictors of discharge to rehabilitation and of readmission within 30 days.
Level of evidence: IV, retrospective observational cohort study.

1. Introduction

Over 200 000 total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures were performed in France in 2017 according to the French hospitalisation data collection agency, and

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the overall demand is rising steadily. Primary THA and TKA volumes are predicted to increase between 2014 and 2030 by 71% and 85%, respectively, in the US [1]. Estimates for France predict an about 135% increase in THAs and a greater than 200% increase in TKAs between 2012 and 2030 [2]. Hospital length of stay (LOS) after THA or TKA has decreased overall in France [3,4] and in other countries [5,6]. Known predictors of LOS are day of surgery [5,7,8], discharge to a rehabilitation unit [9,10], and patient comorbidities [5–9,11–14]. Available data are conflicting however, and we are not aware of any published studies conducted in France to identify predictors of LOS, discharge destination, and unscheduled readmission. Improved knowledge of such predictors would be expected to benefit patient care efficiency [10].

The objectives of this study were:(1) to determine whether the above-listed factors predict LOS after THA or TKA, (2) to identify predictors of discharge to a rehabilitation unit and of readmission within 30 days after surgery. To achieve these objectives we performed a single-centre retrospective observational study in a large cohort. The working hypothesis was that both patient-related factors unamenable to modification and modifiable organisational factors are associated with LOS after THA or TKA.

2. Material and methods

A single-centre retrospective observational cohort study was performed. No ethics committee approval is required in France for this study design. The database was registered with the French data protection authority (*Commission Nationale de l'Informatique et des Libertés*, CNIL).

2.1. Patients

Adults who underwent primary THA or TKA at our university hospital between 1 January 2015 and 31 December 2016 were identified by searching the hospital database. Non-inclusion criteria were revision arthroplasty, THA with femoral or acetabular reconstruction, TKA using a hinged implant, and admission via the emergency department for a fracture requiring arthroplasty.

2.2. Data collection

The following data were collected for each patient: age, sex, body mass index (BMI), comorbidities, day of surgery, type of arthroplasty, date and destination of discharge, and whether readmission was required within 30 days. The classification for medical procedures applied in French hospitals was used to record comorbidities, as follows: obesity (BMI $\geq 30\,kg/m^2$), hypertension, heart failure (left or right sided), coronary artery disease, diabetes, obstructive sleep apnoea syndrome, chronic obstructive pulmonary disease, chronic respiratory failure, asthma, smoking, history of stroke, and anxiety-depressive disorder (Supplementary data, Appendix 1). Table 1 reports the main features of the study patients according to the type of surgery performed.

2.3. Management

All patients were admitted on the day before surgery. After surgery, a nursing assistant was available on weekdays and on Saturday mornings to ensure early ambulation of arthroplasty patients.

2.4. Assessment methods

The primary outcome measure was the probability of being discharged by day 5 after surgery. Hospital LOS was defined as the number of days from admission (on the day before surgery) to discharge from the orthopaedic surgery department.

The secondary outcome measures were the associations linking the study factors to discharge to a rehabilitation unit and to readmission within 30 days. Readmission was defined as any hospital admission within 30 days after the arthroplasty procedure; emergency department visits were not classified as readmissions.

Table 1
Main features in the groups with primary total hip arthroplasty and primary total knee arthroplasty.

	THA $n=938$	TKA $n=725$
Age, years, mean ± SD (range)	66 ± 12 (19–95)	69 ± 9 (28–92)
LOS, days, median (range)	5 (1–28)	5 (1–22)
Sex, *n* (%)		
Male	420 (44.8)	259 (35.7)
Female	518 (55.2)	466 (64.3)
Day of surgery, *n* (%)		
Monday to Thursday	747 (79.6)	178 (24.6)
Friday	191 (20.4)	547 (75.4)
Discharge destination, *n* (%)		
Rehabilitation unit	193 (20.6)	206 (28.4)
Home	745 (79.4)	519 (71.6)
Comorbidities, *n* (%)		
Obesity (BMI ≥ 30 [kg/m^2])	249 (26.6)	285 (39.3)
Hypertension	483 (51.5)	444 (61.2)
Heart failure	3 (0.3)	3 (0.4)
Coronary artery disease	54 (5.8)	40 (5.5)
Diabetes	131 (14)	108 (14.9)
Obstructive sleep apnoea syndrome	29 (3.1)	27 (3.7)
COPD	67 (7.1)	35 (4.8)
Chronic respiratory failure	2 (0.2)	0 (0)
Asthma	35 (3.7)	35 (4.8)
Smoking	117 (12.5)	49 (6.8)
Anxiety-depressive disorder	78 (8.3)	67 (9.2)
Stroke	28 (3)	32 (4.4)
Readmission within 30 days, *n* (%)	40 (4.3)	11 (1.5)

THA: total hip arthroplasty; TKA: total knee arthroplasty; LOS: length of stay; BMI: body mass index; COPD: chronic obstructive pulmonary disease.

2.5. Statistical analysis

2.5.1. Primary outcome measure

LOS distribution was discrete and markedly skewed. Even after transformation of LOS values, linear regression modelling failed to meet the residual normality assumption. We therefore analysed LOS using a survival model with discharge as the endpoint. Associations linking each study factor to the instantaneous hazard ratio for discharge were assessed by building Cox proportional risk models with censuring of all patients discharged after day 5, which was the median LOS in our population. Sensitivity analyses were performed by censuring patients discharged after 4, 7, or 10 days.

Secondary outcome measures

Univariate logistic regression analyses were performed to identify predictors of discharge destination and of readmission within 30 days.

For the primary outcome measure and each of the secondary outcome measures, a multivariate model was built using the factors associated with p values < 0.10 by univariate analysis. At each step of the statistical analysis, adjustment on the type of surgery (THA or TKA) was performed. The hazard ratios (HRs) and odds ratios (ORs) were computed with their 95% confidence intervals (95%CIs). Values of $p < 0.05$ were taken to indicate significant associations by multivariate analysis.

Descriptive statistics were computed for the characteristics of the study population, LOS, and potential risk factors studied. Quantitative variables were described using the mean ± SD and the

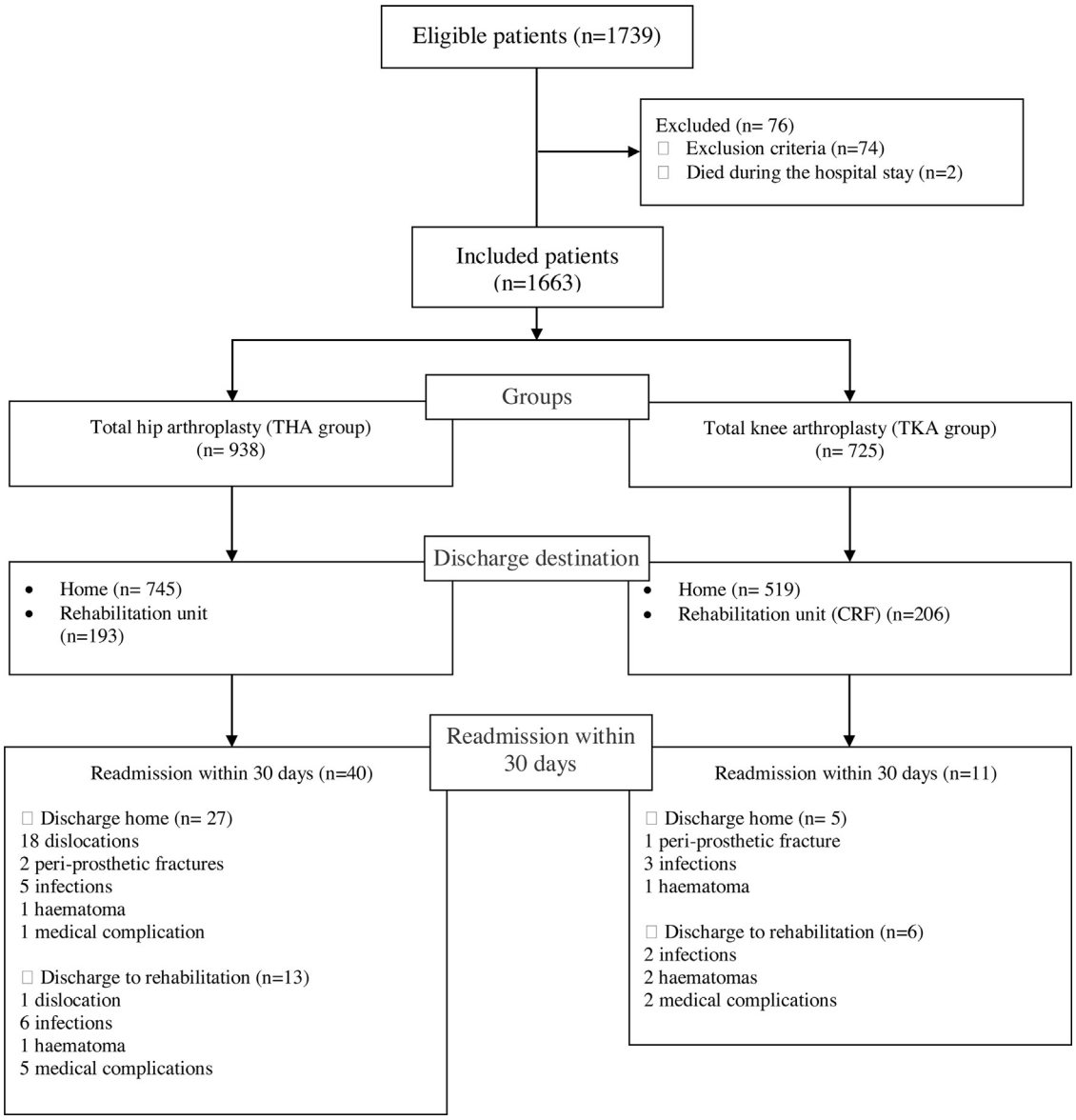

Fig. 1. Patient flow chart.

median (range) and qualitative variables using *n* (%). All statistical analyses were run on SAS version 9.4 software (SAS Institute, Cary, NC, USA).

3. Results

Our hospital database search identified 1739 potentially eligible patients, of whom 76 were found to have exclusion criteria, leaving 1663 patients for the study, 938 in the THA group and 725 in the TKA group (Fig. 1). Readmission within 30 days occurred in 40 (4.3%) THA patients and 11 (1.5%) TKA patients (Table 1).

The univariate analyses of the primary outcome measure showed no associations with obesity, obstructive sleep apnoea syndrome, chronic obstructive pulmonary disease, asthma, or anxiety-depressive disorder (Table 2). By multivariate analysis, the likelihood of being discharged by day 5 decreased with older age (HR, 0.986; 95%CI: 0.98–0.99) and was lower by 13% in females (HR, 0.871; 95%CI: 0.77–0.986), by 39% in patients with diabetes (HR, 0.606; 95%CI: 0.5–0.73), by 68% in patients discharged to rehabilitation units (HR, 0.322; 95%CI: 0.267–0.389), and by 27% in patients who underwent arthroplasty on a Friday (HR, 0.733; 95%CI: 0.631–0.852) (Table 2).

The multivariate analyses of the secondary outcome measures showed that discharge to a rehabilitation unit was significantly associated with older age (OR, 1.081; 95%CI: 1.07–1.1); female sex (OR, 2.119; 95%CI: 1.61–2.78); and a history of chronic obstructive pulmonary disease (OR, 1.643; 95%CI: 1.03–2.62), anxiety–depressive disorder (OR, 1.533; 95%CI: 1.02–2.3), or stroke (OR, 2.364; 95%CI: 1.33–4.2) (Table 3). Factors significantly associated with readmission within 30 days were obesity (OR, 2.576; 95%CI: 1.455–4.561) and discharge to a rehabilitation unit (OR, 2.531; 95%CI: 1.379; 4.646). Females were significantly less likely to be readmitted within 30 days (OR, 0.535; 95%CI: 0.294–0.973) (Table 4). In the THA group, discharge to a rehabilitation unit was associated with higher rates of medical complications ($p = 0.0017$) and further surgery ($p = 0.0201$), notably due to infection ($p = 0.0129$) (Table 5).

Table 2
Predictors of discharge by day 5 (primary outcome measure).

	Univariate analysis	*p* value	Multivariate analysis	*p* value
	Hazard Ratio [95%CI]		Hazard Ratio [95%CI]	
Age (per additional year)	0.977 [0.97; 0.98]	< 0.0001 *	0.986 [0.98; 0.99]	< 0.0001 *
Sex				
Female vs. male	0.787 [0.699; 0.887]	< 0.0001 *	0.871 [0.77; 0.986]	0.0294 *
Day of surgery				
Friday vs. Monday-Thursday	0.772 [0.667; 0.895]	< 0.0001 *	0.733 [0.631; 0.852]	< 0.0001 *
Discharge destination				
Rehabilitation vs. Home	0.322 [0.267; 0. 389]	< 0.0001 *	0.337 [0.277; 0. 409]	< 0.0001 *
Comorbidities				
Obesity (IMC≥30 kg/m^2)	1.066 [0.94; 1.21]	0.3273	–	–
Hypertension	0.807 [0.72; 0.91]	0.0004 *	0.93 [0.82; 1.05]	0.254
Heart failure	–	–	–	–
Coronary artery disease	0.76 [0.58; 0.996]	0.0468 *	0.812 [0.62; 1.07]	0.1415
Diabetes	0.633 [0.53; 0.76]	< 0.0001 *	0.606 [0.5; 0.73]	< 0.0001 *
Obstructive sleep apnoea syndrome	0.928 [0.66; 1.3]	0.6616	–	
COPD	0.927 [0.73; 1.19]	0.5438	–	
Chronic respiratory failure	–	–	–	–
Asthma	1.108 [0.84; 1.47]	0.4754	–	
Smoking	1.261 [1.05; 1.52]	0.0142 *	0.967 [0.79; 1.18]	0.7407
Anxiety-depressive disorder	0.829 [0.66; 1.04]	0.0997	0.866 [0.69; 1.09]	0.2119
Stroke	0.697 [0.49; 0.997]	0.0481 *	0.863 [0.6; 1.24]	0.4257

95%CI: 95% confidence interval; BMI: body mass index; COPD: chronic obstructive pulmonary disease.
* $p < 0.05$.

Table 3
Predictors of discharge to rehabilitation (secondary outcome measure).

	Univariate analysis	*p* value	Multivariate analysis	*p* value
	Odds Ratio [95%CI]		Odds Ratio [95%CI]	
Age (per additional year)	1.085 [1.07; 1.1]	< 0.0001 *	1.081 [1.07; 1.1]	< 0.0001 *
Sex				
Female vs. male	2.155 [1.67; 2.78]	< 0.0001 *	2.119 [1.61; 2.78]	< 0.0001 *
Comorbidities				
Obesity (BMI≥30 [kg/m^2])	0.866 [0.68; 1.11]	0.2537	–	–
Hypertension	1.422 [1.13; 1.8]	0.003 *	1.001 [0.78; 1.29]	0.9956
Heart failure	–	–	–	–
Coronary artery disease	1.622 [1.04; 2.54]	0.0344 *	1.536 [0.93; 2.53]	0.0923
Diabetes	0.88 [0.63; 1.22]	0.4465	–	–
Obstructive sleep apnoea syndrome	0.936 [0.5; 1.76]	0.839	–	–
COPD	1.806 [1.18; 2.77]	0.0068 *	1.643 [1.03; 2.62]	0.0361 *
Chronic respiratory failure	–	–	–	–
Asthma	1.442 [0.86; 2.43]	0.1678	–	–
Smoking	0.428 [0.26; 0.7]	0.0006 *	0.981 [0.58; 1.67]	0.9429
Anxiety-depressive disorder	1.521 [1.05; 2.21]	0.0268 *	1.533 [1.02; 2.3]	0.0387 *
Stroke	2.438 [1.44; 4.13]	0.0009 *	2.364 [1.33; 4.2]	0.0033 *

95%CI: 95% confidence interval; BMI: body mass index; COPD: chronic obstructive pulmonary disease.
* $p < 0.05$.

4. Discussion

Our results for the primary outcome measure confirm our working hypothesis that both patient-related and organisational factors are associated with LOS after primary THA or TKA. Patient-related factors included older age, female gender and a history of diabetes, whereas organisational factors were arthroplasty on a Friday and discharge to a rehabilitation unit.

Factors associated with LOS after arthroplasty have been investigated previously [5–7,9,11–14]. However, a single study considered the discharge destination [9]. To our knowledge, ours is the only study in which the factors associated with LOS were evaluated using a survival model with age as a continuous variable, a number of separate comorbidities, and discharge destination. This analysis plan preserved statistical power and avoided information and interpretation biases [15–17].

In keeping with earlier work, our multivariate analysis identified female gender [7,12,13,18] and older age [5,7–9,11–14,18] as factors independently associated with LOS. The effect of gender on LOS was substantial, whereas the effect of age was barely noticeable, although highly statistically significant. Neither of these two factors is amenable to modification. A history of diabetes was strongly associated with LOS. The prevalence of diabetes in our patients was 1.5 times that reported in the general population in France [19] but similar to those in the British joint replacement registry [20] and in studies of arthroplasty patients by El Bitar et al. [9] and O'Malley et al. [11]. The available data suggest that diabetes may promote the development of osteoarthritis [21] and that optimal diabetes control may play a major role in the total hospital LOS. In our study, LOS was not significantly associated with heart disease, respiratory disease, smoking, anxiety-depressive disorder [13], or a history of stroke. We are not aware of other studies investigating a potential association between a history of stroke and LOS. Associations of LOS with heart and lung diseases have varied across studies [6,12,13]. Our sample size was too small to produce definitive conclusions regarding possible associations of LOS with heart failure and/or chronic respiratory failure. A study of a nationwide cohort might be able to settle this issue.

Table 4
Predictors of readmission within 30 days (secondary outcome measure).

	Univariate analysis	*p* value	Multivariate analysis	*p* value
	Odds Ratio [95%CI]		Odds Ratio [95%CI]	
Age (per additional year)	1.018 [0.99; 1.05]	0.1735	–	–
Genre				
Female vs. male	0.554 [0.315; 0.976]	0.0409 *	0.535 [0.294; 0.973]	0.0404 *
Discharge destination				
Rehabilitation vs. home	2.154 [1.2; 3.867]	0.0101 *	2.531 [1.379; 4.646]	0.0027 *
Comorbidities				
Obesity (BMI≥30 [kg/m^2])	2.652 [1.51; 4.67]	0.0007 *	2.576 [1.455; 4.561]	0.0012 *
Hypertension	1.057 [0.6; 1.86]	0.8483	–	–
Heart failure	–	–	–	–
Coronary artery disease	2.787 [1.21; 6.4]	0.0157	–	–
Diabetes	0.506 [0.18; 1.42]	0.1955	–	–
Obstructive sleep apnoea syndrome	1.234 [0.29; 5.24]	0.7757	–	–
COPD	1.939 [0.8; 4.68]	0.1408	–	–
Chronic respiratory failure	–	–	–	–
Asthma	0.475 [0.07; 3.5]	0.4652	–	–
Smoking	0.662 [0.23; 1.87]	0.4352	–	–
Anxiety-depressive disorder	0.911 [0.32; 2.58]	0.861	–	–
Stroke	1.893 [0.57; 6.31]	0.2991	–	–

95%CI: 95% confidence interval; BMI: body mass index; COPD: chronic obstructive pulmonary disease.
* $p < 0.05$.

Table 5
Reasons for readmission within 30 days after arthroplasty according to type of arthroplasty and discharge destination.

Group	THA				TKA			
Discharge destination	All discharges *n* = 938	Home *n* = 745	Rehab *n* = 193	Home vs. Rehab *p* value	All discharges *n* = 725	Home *n* = 519	Rehab *n* = 206	Home vs. Rehab *p* value
Readmission, *n* (%)	40 (4.3)	27 (3.6)	13 (6.7)		11 (1.5)	5 (1.0)	6 (2.9)	–
Dislocation, *n* (%)	19 (2)	18 (2.4)	1 (0.5)	0.1472	0 (0)	–	–	NA
Medical complication, *n* (%)	6 (0.6)	1 (0.1)	5 (2.6)	0.0017 *	2 (0.3)	–	2 (1.0)	NA
Further surgery, *n* (%)	15 (1.6)	8 (1.1)	7 (3.6)	0.0201 *	9 (1.2)	5 (1.0)	4 (1.9)	0.2822
Peri-prosthetic fracture, *n* (%)	2 (0.2)	2 (0.3)	–	NA	1 (0.1)	1 (0.2)	–	NA
Infection, *n* (%)	11 (1.2)	5 (0.7)	6 (3.1)	0.0129 *	5 (0.7)	3 (0.6)	2 (1.0)	0.6261
Haematoma, *n* (%)	2 (0.2)	1 (0.1)	1 (0.5)	NA	3 (0.4)	1 (0.2)	2 (1.0)	0.196

THA: total hip arthroplasty; TKA: total knee arthroplasty; Rehab: rehabilitation unit; NA: not applicable. Comparisons were with the chi^2 test or Fisher's exact test depending on sample size.
* $p < 0.005$.

LOS was longer in patients who had arthroplasty on a Friday in our study. Similarly, in previous work, surgery on a Thursday or Friday was associated with longer LOS durations [5,7,8]. In a prospective study of 2302 THA patients, Dall et al. [6] observed that surgery on a Friday was associated with a shorter LOS but found no explanation to this unexpected result. Early mobilisation is known to be associated with shorter LOS durations [22]. In our patients, however, contrary to common practice in other centres, early ambulation was guided by assistant nurses instead of by physical therapists. Nonetheless, rather than the category of staff responsible for ensuring early ambulation, the smaller number of staff members present during the first 48 h after surgery, notably on Saturday afternoons, may explain the longer LOS durations in patients who had surgery on a Friday [6].

Discharge to a rehabilitation unit was associated with a longer LOS in our population. Similarly, a vast database study by El Bitar et al. [9] of over 1.9 million patients who underwent THA between 2009 and 2011 also showed longer LOS durations in patients discharged to rehabilitation units. Sharareh et al. obtained comparable findings in a retrospective study of 100 patients [23]. We agree with El Bitar et al. [9] that the most likely explanation to this result is that patients cannot be discharged to rehabilitation units on weekends. These data complement those on arthroplasty costs reported by Lernout et al. [10].

Among secondary outcome measures, in keeping with earlier studies, older age [18,24,25] and female gender [25] were associated with discharge to a rehabilitation unit. However, neither of these factors is amenable to modification. In contrast to Sharareh et al. [23], we found an association of discharge to a rehabilitation centre with anxiety-depressive disorder. However, their retrospective study [23] was small and may therefore have lacked statistical power to detect an association with anxiety and depression. A history of stroke was associated with discharge to rehabilitation, and its prevalence of 3.6% was similar to that in two earlier studies from France and Europe, respectively [26,27]. Keswani et al. [28] reported a nearly significant association ($p = 0.06$) despite a low prevalence of stroke in their population of only 0.6%.

Our data on predictors of 30-day readmission are consistent with a report by Otero et al. [29] that obesity and male gender were significant risk factors in a population of over 108 000 patients. However, smoking, chronic obstructive pulmonary disease, and coronary artery disease were associated with 30-day readmission in their study but not in ours. Diabetes and discharge to rehabilitation were also significantly associated with 30-day readmission in our population. When we looked at reasons for readmission, we found that discharge to rehabilitation was associated with higher rates of complications and of further surgery, notably due to infection, and with a lower rate of dislocation. We suggest that these findings may reflect the closer medical monitoring of patients in rehabilitation units, as well as differences in age, comorbidities, and self-sufficiency compared to patients who are discharged home. Nevertheless, further studies would be needed to obtain definitive conclusions about these uncommon events.

The main limitations of our study are the retrospective design and the assessment of known risk factors. Other factors that might have influenced the outcome measures were probably not examined. We arbitrarily chose 5 days, i.e., the median LOS in our population, to define the primary outcome measure. However, the sensitivity analyses performed using 4, 7, or 10 days produced similar results. Given the single-centre patient recruitment, our findings may not apply to all populations, although our large sample size produced robust estimates of the outcome measures chosen for the study. The hospital database used to identify the study patients may have contained errors. Any such errors were probably minimal, as the prevalences in our population were consistent with those found in French epidemiological studies [30–34] and in studies of arthroplasty patients [20,35]. Furthermore, the consistency of our data with the results of the international literature, as cited above, support the external validity of our findings. Finally, the use of our hospital database ensured that no patient was lost to follow-up.

5. Conclusion

Our study identified predictors of LOS, discharge destination, and 30-day readmission in THA and TKA patients in France. Future studies should consider discharge destination as a major predictor of LOS. Also, improved patient selection for discharge to rehabilitation and optimal management of patients with diabetes and/or obesity should benefit the efficiency of care after primary arthroplasty. Additional work is needed to further improve our knowledge in these areas.

Disclosure of interest

P. Mertl acts occasionally as a consultant for Adler, De Puy, Stryker, Zimmer, and X-nov.

The authors declare that they have no competing interest.

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Contributions of each author

A.L., C.R., E.H., and P.M. conceived and designed the study, acquired the data, and analysed and interpreted the data.

C.R., E.D., E.H., M.D., PM., and Y.B. drafted the manuscript and revised it critically for important intellectual content.

A.L., C.R., E.D., E.H., M.D., P.M., and Y.B. gave final approval of the version to be submitted.

A.L., C.R., Y.B. performed the statistical analyses.

E.H., P.M. performed the surgical procedures.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.04.012.

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