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ORIGINAL ARTICLE

When can I go home after my knee replacement? Factors affecting the duration of in-hospital stay after knee replacement

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Abstract

Background Despite a sevenfold decline in the number of postoperative nights (21–3) after a total knee arthroplasty (TKA) over the last four decades, predictors of length of stay (LOS) are not fully understood. We attempted to ascertain these factors by analyzing a large cohort of patients.

Methods Prospectively collected data between January 2016 and March 2017 were retrospectively analyzed at our institute. Charts of 1663 consecutive, simple primary unilateral and bilateral TKAs were reviewed for the LOS excluding staggered bilateral, complex primary and revision knees. Statistical analysis: Preoperative variables [demographics, cash/credit status, historical, clinical, laboratory findings, Knee Society Function Scores and Oxford Knee Scores (OKSs)] were scrutinized by multivariate regression to identify significant factors affecting LOS and formulate model equations for patients and health caregivers. Results were incorporated into an iOS application, which was tested for accuracy.

Results Among 1524 unilateral and 139 bilateral TKAs, mean LOS was 4.4 and 5.2 days, respectively. Five factors, namely insurance, flexion/hyperextension deformity, preoperative OKS and a rheumatoid etiology, were significantly associated with prolonged LOS in unilateral knees. The impact of these independent variables on LOS could be calculated by:

$$\mathrm{LOS} = 5.6 - (0.39 \times \mathrm{CI}) + (0.04 \times \mathrm{FFD}) - (0.03 \times \mathrm{PREOPOKS}) + (0.06 \times \mathrm{HE}) - (0.71 \times \mathrm{ET})$$

For bilateral cases, the only significant variable extending LOS was a low preoperative OKS and the equation is given as follows:

$$\mathrm{LOS} = 7.71 - (0.15 \times \mathrm{PREOPKS})$$

The iOS-app-predicted LOS and actual LOS were similar ($p > 0.05$) for 115 prospectively operated knees.

Conclusion Poor preoperative OKS, rheumatoid etiology, flexion and hyperextension deformity and delays in insurance affected unilateral TKR LOS, while poor preoperative OKS alone affected LOS in bilateral cases.

Keywords Length of stay · Discharge delays · Equations predicting stay · Primary total knee arthroplasty · Insurance delays · Severe deformities

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Introduction

Among close to 300 conditions, knee osteoarthritis (OA) ranks as the 11th most disabling condition worldwide [1]. Evolving surgical and technological refinements have provided patients debilitated with knee OA, an improved quality of life demonstrable by high satisfaction scores following total knee arthroplasty (TKA). Additionally, the emergence of excellent long-term implant survival (99%) after TKA has made it a game changer for clinicians in managing patients with tricompartmental OA [2–4].

Current global trends advocate three broad approaches to the timing of surgery in patients planned for TKA: unilateral (U/L, one knee at a time), staggered bilateral (both knees within the same hospital admission with a gap of a few days) and simultaneous bilateral (B/L, as a one-time surgery for both knees). The risks and benefits of each of these have been debated at length, and a clear winner is yet to be declared [5, 6].

Nonetheless, with an overall mortality rate of less than 0.5%, the numbers of patients undergoing and accepting either version of TKA as a safe and definitive treatment modality are much likely to increase in the future [7]. This will most definitely bring about an increased percentage of postoperative patients occupying surgical intensive care units and postoperative wards. Although the average number of nights patients spend following surgery at a hospital has drastically reduced from 21 in 1974 to 3 in recent times, there are no clear guidelines informing patients and clinicians on the length of stay (LOS) at a hospital after TKA [8–10]. One of the most frequently encountered queries, the LOS has been also shown to possess an inverse relationship with patient satisfaction [9, 11]. An increased LOS after hip and knee arthroplasty is more frequently encountered in low-volume centers [12, 13].

In the past, studies have looked at variables influencing the LOS in patients after a lower limb arthroplasty. However, they had several inherent shortcomings such as retrospective designs, the inclusion of patients undergoing both hip and knee arthroplasty, different operating surgeons and implant types, lack of consideration of variables such as the type of disease and insurance policies and varying rehabilitation protocols. Also, none of them have exclusively focused on the preoperative factors [9, 10, 14–17]. To the best of our knowledge, no previous study attempted to derive a predictive formula to estimate the LOS after a unilateral or bilateral TKA.

To obviate the uncertainties surrounding the factors responsible for prolonging the in-hospital stay after TKA, we attempted to ascertain the crucial ones through a retrospective analysis of a large cohort of patients. The aim of this research was to establish criteria that would help estimate the length of in-hospital stay for patients undergoing primary unilateral and bilateral TKA. The primary outcome was to identify factors that significantly influenced the LOS. As a secondary outcome, the factors responsible for prolonging LOS were to be incorporated into a patient-friendly smartphone application. This was then tested prospectively for accuracy and utility in reliably predicting the LOS after a simple primary unilateral or bilateral TKA.

Materials and methods

This retrospective analysis of prospectively collected material was conducted at a tertiary care center with one of the largest number of primary and revision joint replacement surgeries in the Asia–Pacific region. The trial was cleared by the institutional ethics committee (vide no. SS/2017/IEC162) and was prospectively registered with the National Clinical Trials Registry (vide no. CTRI/2017/06/008873).

Patient selection and data collection

Charts of patients undergoing consecutive, simple primary TKAs were reviewed between January 2016 and March 2017. The LOS was defined as the number of days from surgery till discharge. All patients above 40 years of age who had undergone a U/L and simultaneous B/L TKA were included in the study. Staggered B/L knees (to avoid bias from the date of second knee surgery), complex primary and revision TKAs and infected cases were excluded from the study. Also excluded were patients with cardiac, vascular and neurological conditions (e.g., Parkinson's disease, Alzheimer's disease) and patients living alone at home without a family.

Our records from a total of 2450 primary knees (in 1987 patients) operated over the 15-month period included 1524 unilateral knees (1524 patients), 648 (324 patients) staggered bilateral knees and 278 (139 patients) single-stage bilateral knees. After excluding the 648 (324 patients) staggered knees, the records of the 1802 eligible knees (1663 patients) were analyzed for several preoperative variables that might have been significantly associated with an increased inpatient stay after a primary TKA. Our knee replacement database registers details of each patient including age, gender, address (including the city), height, weight, body mass index (BMI), mode of remittance (cash or insurance), etiology [(OA or rheumatoid arthritis (RA)], duration of symptoms, comorbidities, spectrum of deformities (varus, valgus, flexion and hyperextension), range of motion (ROM), American Society of Anesthesiologists (ASA) grade, preoperative hemoglobin (Hb), preoperative Knee Society Function Score (KFS) and the Oxford Knee Score (OKS).

Preoperative workup, surgical routine and postoperative protocol

All patients were admitted on the day of surgery. The preoperative orthopedic and anesthetic evaluation was aided by a methodical appraisal of clinical and laboratory measures along with physician, pulmonologist and cardiologist consultations. Special instructions for patients, if any, were meticulously recorded and communicated among fellows and consultants. Implant selection was performed from a wide armamentarium of knee systems based on the patients' clinical profile, affordability and surgeon preference.

A single surgeon performed all cases. Spinal anesthesia was administered routinely for all patients, and preoperative measures followed included a third-generation cephalosporin prophylaxis, intravenous (i.v.) tranexamic acid administration and strict aseptic preparatory methods including chlorhexidine scrub and paint, impervious, sterile draping and povidone–iodine Ioban (3M, Maplewood, MN). For bilateral knees, the more symptomatic knee was operated first after preparing both knees.

All surgeries were performed under tourniquet control using a midline incision and medial parapatellar approach. Posterior stabilized implants were used in all cases, and patella was not resurfaced. All patients were administered multimodal periarticular infiltration after bone cuts, and a combination of ropivacaine, ketorolac and morphine was used. The tourniquet was deflated after cementing, hemostasis secured and wound closure was done. Drains were not used.

All patients received an ultrasound-guided adductor canal block 3 h after surgery. Two additional postoperative doses of i.v. antibiotics were administered. Other postoperative measures, including 1 g i.v. paracetamol twice daily and 5 mg buprenorphine patches for pain relief and thromboprophylaxis with enoxaparin 40 mg twice daily for 3 days followed by aspirin 150 mg for 6 weeks, were administered. Patients were monitored overnight in surgical intensive care unit (SICU). After being mobilized with a walker on the first postoperative morning, room transfers were carried out. Thereafter, our team of orthopedicians, physicians, physiotherapists and dieticians attended to the patients and a discharge decision was made on a case-to-case basis in accord with the medicine team advice. Patients were encouraged to bear full weight while ambulating, and the walker was weaned off in 2 weeks through an intensive home physiotherapy program. Staples were removed and patients reviewed 2 weeks from surgery followed by 3, 6 and 12 months postoperatively and yearly thereafter.

Statistical analysis

We utilized the Statistical Package for the Social Sciences version 21.0 (SPSS Inc., IBM Corp., New York, USA). Continuous data (e.g., age, BMI, Hb levels) were analyzed using the Spearman's rank correlation test, while discrete data were investigated by the Mann–Whitney and Kruskal–Wallis tests (based on two or more possible outcomes, respectively). Multivariate regression analysis was performed using the ANOVA test to identify significant factors affecting the LOS. The tests were two-tailed and significance set at a p value of < 0.05. This analysis would also help us in formulating a model equation for patients and health caregivers. Keeping the LOS as the dependent variable and using the significant factors associated with a delay in discharge, this equation would enable the LOS calculation by simply entering values.

The iOS LOS app

The equations, thus derived, were incorporated into the convenient and portable smartphone using an iOS smartphone app. This app was prospectively tested over a 1-month period on 100 unilateral and 15 bilateral simple TKAs, and the LOS predicted using the app before surgery was compared with the actual duration of days the patient has spent at the hospital at the time of discharge. Statistical significance was set at $p < 0.05$ using an unpaired t-test.

Results

Among the 1663 patients, 1524 unilateral patients had a mean LOS of 4.4 days (range 2–15, SD 1.47) and mean age of 63.3 years (range 30–93, SD 8.49). The respective values for the 139 simultaneous bilateral patients were 5.2 days (range 3–11, SD 1.19) and 57.2 years (range 40–68, SD 5.58). Other demographic details are given in Tables 1 and 2.

Unilateral knees analysis using the Spearman rank correlation (SRC), Mann–Whitney (MW) and Kruskal–Wallis (KW) tests revealed that only male gender and insurance as a method of remittance were associated with longer hospital stays among other factors (Table 3).

On performing a multivariate regression analysis using the ANOVA test, however, we observed that five factors, namely insurance, FFD/hyperextension, preoperative OKS and a rheumatoid etiology, were significantly associated with a prolonged hospital stay. The impact of these independent variables on the dependent variable (LOS) could be calculated by our model equation:

$$\begin{aligned}\mathrm{LOS} = 5.6 - (0.39 \times \mathrm{CI}) + (0.04 \times \mathrm{FFD}) \\ -(0.03 \times \mathrm{PREOPOKS}) + (0.06 \times \mathrm{HE}) - (0.71 \times \mathrm{ET})\end{aligned}$$

CI: mode of remittance; cash (1)/insurance (0),
FFD: degree of fixed flexion deformity,
PREOPOKS: preoperative OKS,
HE: degree of hyperextension deformity,
ET: etiology: osteoarthritis (1)/rheumatoid arthritis (0).

The numbers used in the equation represent unstandardized coefficients derived from the regression analysis, which represent the magnitude of change in a dependent

Table 1 Descriptive data for unilateral knees

Descriptive statistics			
	Mean	Std. deviation	*N*
LOS (days)	4.36	1.47	1524
Age (years)	63.42	8.49	1524
Sex (M/F)	0.33	0.54	1524
City (1 = same city as hospital, 0 = different city)	0.74	0.44	1524
Height (cm)	157.96	9.99	1524
Weight (kg)	72.20	11.41	1524
BMI (kg/m^2)	29.37	11.46	1524
Etiology (osteoarthritis: 1, rheumatoid arthritis: 0)	0.99	0.11	1524
Comorbidities (N = 0, 1, 2, 3, 4…)	1.23	0.93	1524
PREOP valgus (°)	0.16	1.43	1524
PREOP varus (°)	7.53	3.72	1524
FFD (°)	1.80	3.92	1524
PREOP ROM (°)	103.64	10.07	1524
Duration of symptoms (years)	4.70	2.80	1524
Hyperextension (°)	0.06	1.23	1524
Cash/insurance: mode of remittance; cash (1)/insurance (0)	0.34	0.48	1524
ASAGRADE	1.99	0.19	1524
PREOPHB (g/dL)	12.50	5.38	1524
PREOPKFS (score)	82.22	28.37	1524
PREOPOKS (score)	17.32	5.12	1524

Std. standard, *N* number, *BMI* body mass index, *ASAGRADE* American Society of Anesthesiologists grade, *PREOPHB* preoperative hemoglobin, *PREOPKFS* preoperative Knee Function Score, *PREOPOKS* preoperative Oxford Knee Score

variable attributable to a change in an independent one. The coefficient of determination (COD) R^2 for this model was low at 0.05. This implied that the 5% of the change in the LOS could be explained by the above-mentioned factors. The significance of the remaining 18 factors was negligible.

Among data for *bilateral cases*, the only significant variable suggestive of a prolonged LOS was a low preoperative OKS (Table 4). The strength of association of this variable (OKS), however, was good as the COD for OKS in B/L knees (R^2) was 0.339. This implied that 33.9% of the variation in the dependent variable (LOS) could be explained by a change in the pre-op OKS. The regression equation for B/L cases was observed to be:

$$\text{LOS} = 7.71-(0.15 \times \text{PREOPKS})$$

The iOS LOS app: We then designed an app for the smartphone (iPhone-based) incorporating our equations into it. As a *second part* of our study, we prospectively trialed the app on the subsequent 115 patients admitted for TKA (100 unilateral and 15 bilateral) over a month to check for the accuracy of our research (Figs. 1, 2, 3, 4, 5). On comparing the app-predicted LOS with the actual LOS using the unpaired *t*-test, we observed that there were no significant differences between the two for unilateral and bilateral cases (Tables 5, 6).

Discussion

With a surge in TKA numbers, the accompanying expenses are bound to exponentially rise. A significant chunk of these figures comes from hospital stay. Being, at least partially, a surgeon-controlled variable, a short hospital stay can result in lower costs for patients and the healthcare system [16]. Modern fast-track surgical protocols have empowered hospitals with the ability to send patients home within 2 days of surgery [18].

Although several authors have introspected into the factors affecting the LOS after orthopedic surgery, non-standardized methodology, heterogeneous study populations and staggered surgical details have made the application of these identified conjectures difficult and impractical in the clinical scenario (Table 7) [9, 10, 14–16]. The paucity of established, preoperative predictors for LOS after U/L and B/L TKA had impelled us to dissect and analyze our own large pool of data for elements causing delayed discharges after TKA.

Studies comparing the LOS in U/L and B/L knees have had varying results. Our population had mean LOS of 4.4

Table 2 Descriptive data for bilateral knees

Descriptive statistics	Mean	Std. deviation	*N*
LOS (days)	5.24	1.20	139
Age (years)	57.22	5.58	139
Sex (M/F)	0.19	0.39	139
City (1 = same city as hospital, 0 = different city)	0.62	0.49	139
Height (cm)	156.67	8.41	139
Weight (kg)	73.19	10.74	139
BMI (kg/m^2)	29.92	4.63	139
Etiology (osteoarthritis: 1, rheumatoid arthritis: 0)	0.97	0.17	139
Comorbidities (*N* = 0, 1, 2, 3, 4…)	0.97	0.85	139
PREOP valgus (°)	0.14	1.03	139
PREOP varus (°)	7.71	3.91	139
PREOP ROM (°)	101.69	10.61	139
FFD	2.01	4.92	139
Duration of symptoms (years)	4.92	2.54	139
Hyperextension (°)	0.14	1.70	139
Cash/insurance: mode of remittance; cash (1)/insurance (0)	0.62	0.47	139
ASA grade	2.01	0.33	139
PREOPHB (g/dL)	12.56	1.51	139
PREOPKFS (score)	82.33	31.90	139
PREOPOKS (score)	16.73	4.71	139

Std. standard, *N* number, *BMI* body mass index, *ASAGRADE* American Society of Anesthesiologists grade, *PREOPHB* preoperative hemoglobin, *PREOPKFS* preoperative Knee Function Score, *PREOPOKS* preoperative Oxford Knee Score

Table 3 Statistical analysis for unilateral knees

Variable	Test	*p* value
Age	SRC	0.629
Gender	MW	0.023
Add (near/far from Hyderabad)	MW	0.657
Height	SRC	0.115
Weight	SRC	0.207
BMI	SRC	0.054
Mode of remittance (C/I)	MW	0.001
Etiology (OA, RA)	MW	0.071
Duration of symptoms	SRC	0.463
Comorbidities	KW	0.428
Varus	SRC	0.803
Valgus	SRC	0.810
FFD	SRC	0.372
H/E	SRC	0.075
ROM	SRC	0.229
Hb	SRC	0.055
ASA grade	KW	0.799
KFS	SRC	0.884
OKS	SRC	0.001

Add address, *BMI* body mass index, *FFD* fixed flexion deformity, *H/E* hyperextension, *ROM* range of movement, *ASA grade* American Society of Anesthesiologists grade, *KFS* Knee Function Score, *OKS* Oxford Knee Score

Table 4 Statistical analysis for bilateral knees

Variable	Test	*p* value
Age	SRC	0.305
Gender	MW	0.862
Add (near/far from Hyderabad)	MW	0.435
Height	SRC	0.874
Weight	SRC	0.175
BMI	SRC	0.443
Mode of remittance (C/I)	MW	0.652
Etiology (OA, RA)	MW	0.509
Duration of symptoms	SRC	0.366
Comorbidities	KW	0.798
Varus	SRC	0.213
Valgus	SRC	0.846
FFD	SRC	0.833
H/E	SRC	0.222
ROM	SRC	0.897
Hb	SRC	0.781
ASA grade	KW	0.996
KFS	SRC	0.249
OKS	SRC	0.001

Add address, *BMI* Body Mass Index, *FFD* fixed flexion deformity, *H/E* hyperextension, *ROM* range of movement, *ASA grade* American Society of Anesthesiologists grade, *KFS* Knee Function Score, *OKS* Oxford Knee Score

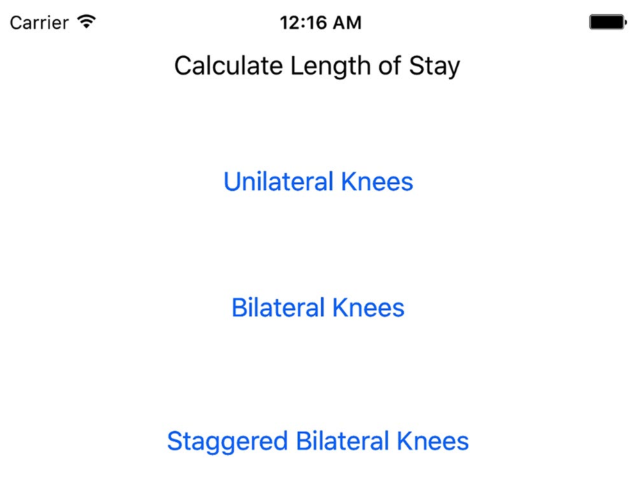

Fig. 1 Welcome screen

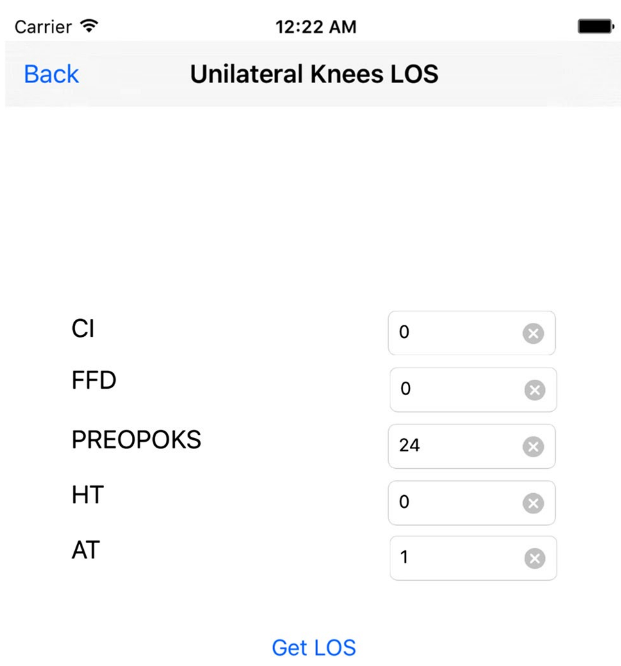

Fig. 2 Data for unilateral knees

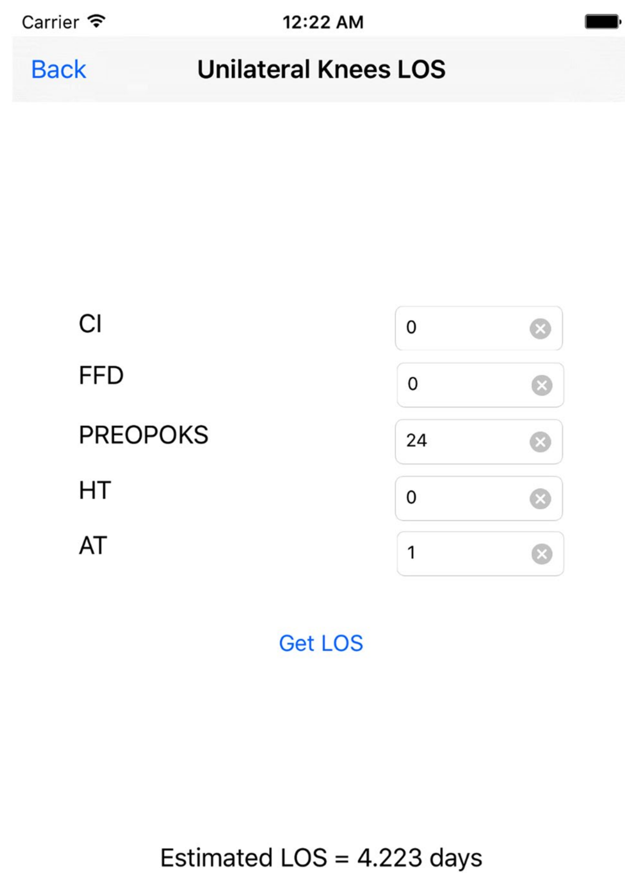

Fig. 3 LOS for unilateral knees

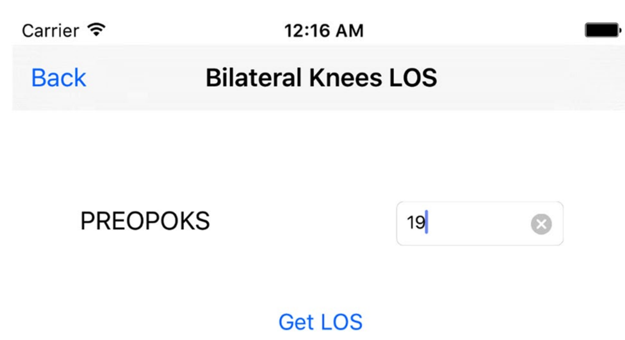

Fig. 4 Data for bilateral knees

and 5.2 days in both groups, respectively. This understandably longer stay in U/L cases is in concordance with the published literature [19]. In a recent retrospective analysis of over 238,000 patients, Bohm et al. [20] from Canada reported significantly higher (8 vs 6) median LOS in B/L cases. Although Lane et al. from the Rothman Institute, Philadelphia, USA, had published similar LOS in both groups (6.4 vs 6 days) in 1997, a majority of their B/L cases (89) required a sojourn in rehab facilities when compared to U/L knees (45%). Moreover, the practices and discharge protocols have led to sharp falls in the LOS over the last two decades as has been reflected, on comparison, in our findings [21].

Our observations led us to formulate two equations, one each for U/L and B/L TKA. The number of factors in both groups tends to decrease as we move from U/L to B/L knees. Sagittal plane deformities, poor OKSs, rheumatoid disease and insurance all seem to increase the number of days a U/L patient spends at the hospital. Bilateral knees, on the other hand, are only affected by the OKS, which appears to be the common factor for both groups.

A flexion or a hyperextension deformity is known to complicate a TKA. Although it may be wiser to err on the side

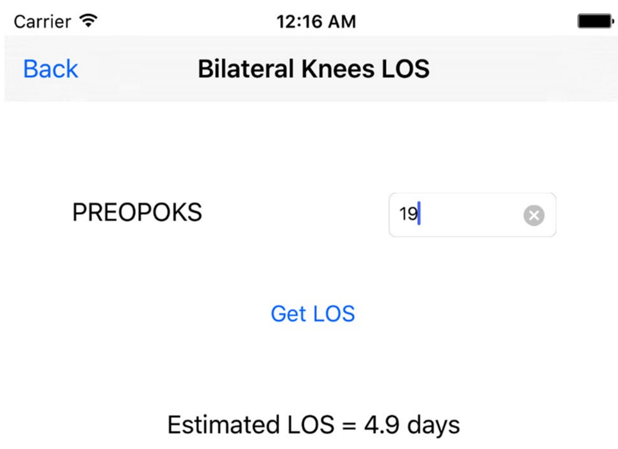

Fig. 5 LOS for bilateral knees

Table 5 Comparison of LOS with app-predicted LOS (APP-LOS) for unilateral knees ($n = 100$)

	LOS	APP-LOS	Two-tailed p value (unpaired t-test)
Mean LOS (days)	4.04	4.08	0.3648 (> 0.05)
SD	0.3458	0.2727	

Table 6 Comparison of LOS with app-predicted LOS (APP-LOS) for bilateral knees ($n = 15$)

	LOS	APP-LOS	Two-tailed p value (unpaired t-test)
Mean LOS (days)	4.73	4.87	0.5915 (> 0.05)
SD	0.7	0.64	

of flexion if a neutral alignment is difficult to establish in a recurvatum knee, the surgery can be a challenging one with increased postoperative pain and prolonged rehabilitation course. In one of the first studies to compare outcomes of sagittal plane deformities after TKA, Koo and colleagues observed that despite better knee flexion in recurvatum cases, 2-year function was significantly superior in patients with preoperative flexion deformities. The authors postulated that quadriceps exercises could be credited for bring knees toward neutral extension in patients with preoperative fixed flexion deformities [22]. Literature has, however, been sparse and varied on the effect of coronal plane and sagittal plane deformities on LOS. While Sodhi et al. observed no significant differences in LOS among hinged (for more complex deformities) and primary non-hinged knee implants (for less severe deformities), Zhang et al. have reported longer stays of patients presenting with valgus deformities [23, 24]. Overall, increasingly complex deformities may prolong intra- and postoperative courses and consequent LOS. It may also be a reason behind the identification of preoperative flexion and extension deformities as important factors determining the LOS from the present study.

Compared to OA knees and hips, those with a rheumatoid disease have been shown to demand greater resources; however, the LOS has not been shown to vary much. Liao et al. [25] compared 146 RA knees with 6574 OA knees and found that the LOS for both groups was between 7.4 and 8.4 days. In contrast, we observed that our U/L patients with RA were discharged later than their OA counterparts. Reasons for a prolonged stay after TKA in patients with RA have been identified in a multivariate regression model by Escalante and Beardmore [26] as a Steinbrocker functional class 3 or 4, positive rheumatoid factor, bone cement use and increased surgery time. This could also stem from the pathology and more severe systemic involvement with RA.

Having the distinction of being one of the most reliable knee scores, the OKS is one of the most accurate predictors of knee function of after TKA [27]. This study re-iterated its strong correlative ability, as it was the most consistent variable independently and inversely related to the LOS, especially in B/L knees.

A delay in discharge/facility transfer with insurance pre-certification has been documented to occur even in the most developed parts of the world [28]. In a large cross-sectional study published in 2015, Mehta et al. evaluated the determinants of discharge times in local settings in a developing Asian country. The authors reported that mean discharge times for insured patients were significantly higher ($p < 0.0001$) than those of uninsured patients (paying by self/self-paid) [29]. Even developed countries have been facing similar obstacles when it comes to discharging insured patients on time. In a recent American study analyzing the National Trauma Data Bank, Englum et al. evaluated the relationship between insurance status and LOS in 884,493 patients admitted between 2007 and 2010. LOS was then compared among privately insured, publically insured and uninsured patients. The authors observed that uninsured patients (self-paid) had significantly shorter hospital stays (0.3 days) with respect to patients with private insurance. Also, they observed that those publicly insured had longer risk-adjusted LOS (0.9 days), thereby concluding that the patient's ability to pay could, in fact, have a significant bearing on the LOS [30]. The findings of the present study are in agreement with those of published literature in view of the significant delays patients have to face when it comes to settling insurance bills. Swifter and efficient protocols based on sound principles of modern hospital administration could help ease this leash for hospital staff striving hard to send patients home on time and save patients the trouble of having to overstay despite being medically fit to go home.

Table 7 Evidence table

Authors	Year	Study design	*N* (knees)	Mean age (years)	Mean LOS (days)	Risk factors (prolonging LOS)
Husted et al. [27]	2004	Retrospective	48		8 (4.4–12.8)	
Husted et al. [9]	2003–2004	Prospective	342	69	3.9	Age, gender (women), living alone, walking aids, day of surgery, ASA grade, Hb
Smith et al. [16]	1994–2007 (13 years)	Prospective	2106		9.4	Year of admission, consultant details, stair score, walking aid score, age
Raut et al. [15]	2008–2009	Retrospective	387	80.7 (all > 75)	6.25	Age, pre-op mobility, walking aids, BMI, mobilization, day of walking 10 m/90° flexion, Hb
Halawi et al. [10]	2012	Retrospective	267	63.9	3	Comorbidities, lack of assistance, B/L TKA
Ong et al. [17]	2009–2011	Retrospective	1609			Age, comorbidities, ROM, depression, support needed, TKA [vs UKA), B/L TKA, no carer, low-volume surgeon
Forrest et al. [14]	1995	Retrospective	62	63.4 (THA + TKA)	6.4 (THA + TKA)	Age
Present study	2016–2017 (15 m)	Retrospective analysis of prospective data	1663	61	5.8; 4.4 (U/L), 5.2 (B/L)	U/L; insurance, FFD/H/E, PREOPOKS, RA B/L: pre-op OKS

N number, *ASA grade* American Society of Anesthesiologists grade, *UKA* Unicompartmental Knee Arthroplasty, *THA* total hip arthroplasty, *U/L* unilateral, *B/L* staggered bilateral, *FFD* fixed flexion deformity, *H/E* hyperextension, *PREOPOKS* preoperative Oxford Knee Score, *RA* rheumatoid arthritis

While others have identified factors such as the age, gender, ASA score and Hb levels as being predictive of prolonged hospital stay, our analysis did not these as being significant [9, 14–17, 31]. One of the reasons for this could be an improvement in contemporary medical and surgical practice that has allowed surgeons to plan and execute elective procedures with comfort and confidence. We did not consider the day of admission as our hospital offered round-the-clock services, 7 days a week that did not allow the discharge process to halt on the weekends.

Our wide range of population and large sample size allowed us to arrive conclusively at factors delaying discharge. In a recent article by Raut et al., the authors identified several causes of prolonged LOS at the hospital after TKA. Their study, however, focused exclusively on patients over 75 years of age. As a result, patients from their study had higher mean LOS (6.25 days) when compared to previously published data (3 days for patients with a mean age of 64) [10, 15]. This could have made a generalization of numbers difficult for patients planned for TKA.

Smith et al. on a younger population prospectively analyzed the LOS of 2106 patients undergoing a unilateral primary TKA. They found the year of admission, consultant details, stair and walking aid score along with patient age significant preoperative factors associated with increased LOS. The inclusion of a large study period of 14 years could have affected their findings, as with improving surgical techniques, discharges would have naturally been done sooner over the years. Also, the effect of having 11 operating surgeons in the study could have left a bias as each surgeon had a different timing of discharge. Further, excluding bilateral cases made identification of predictive factors impossible for these cases [16].

Based on a retrospective analysis of 1609 patients, Ong and Pua from the Singapore General Hospital developed a prediction model for LOS after total and unicompartmental knee arthroplasty. Although powerful statistical analyses by the authors provided a first-of-its-kind nomogram and calibration plot, the practical applicability of their findings was not established on patients prospectively as a part of their study [17]. As a measure to reduce the burden on our health resources, the identification of factors making an impact on the LOS will help in simplifying matters for the hospitals and patients.

Literature has only a few selective reports pertaining to anticipating LOS before admission. In a recent study from Canada, Cunic et al. employed a novel Blaylock Risk Assessment Screening Score (BRASS) to identify patients requiring discharge planning. Among a heterogeneous cohort of 241 hip and knee arthroplasty cases, a raised BRASS was significantly predictive of prolonged LOS and was seen in patients with greater ages and ASA scores. They, however, did not prospectively explore the utility of the score or test for its accuracy that would probably have made the model more applicable. Further, numerically predicting the LOS could not be achieved with their results [32]. In an excellent work of research, Carter and Potts from Oxford, UK, identified an equation to predict the LOS after a TKA. Although a thorough design and large study population did make it a powerful tool, a lack of separate consideration for bilateral knees along with the need to prospectively analyze patient data for the usefulness of the equation did bring out a few shortcomings in their study. Also, a handy tool, such as a smartphone app, could have further augmented the acceptability of the equation and allowed widespread convenient usage for the healthcare workers and patients alike [33]. The present study has been able to successfully synthesize distinct equations from statistical analysis and incorporate them into software, which has proven accurate and valuable in predicting the LOS for a TKA in the modern context.

We are aware of our shortcomings including those of a retrospective analysis. Also, we at our institute offer our patients with a diverse spectrum of implants (including various designs from different companies). Although this could have had an impact on the patient outcomes, its effect on the LOS is yet to be documented. Moreover, a single operating surgeon for all cases would have potentially removed any bias arising from the different surgical and postoperative routines of multiple surgeons. Bilateral cases were younger than of the two groups, which could have had an impact on the LOS. To avoid this bias, we have separately analyzed both categories of patients. To elude confusion arising from variability of the date of surgery of the second side, we excluded staggered bilateral cases from our study population.

We were also able to come up with predictive equations for both groups of patients that could forecast the LOS among patients prior to admission for the convenience of patients and hospitals. Knowledge of the possible date of discharge could have manifold implications, allowing mental preparedness, lowering stress and planning of stay and travel arrangements, especially for outstation patients. This could also considerably ease the planning of operating lists and filling of insurance forms for the hospital authorities and insurance desks.

Conclusion

Our study has enlisted the statistically significant preoperative predictors of discharge following unilateral and simultaneous bilateral TKA. We realize the insurance clearances can impact the hospital stay and hope that with our audit, the practices will be modified to enable a smoother functioning by incorporating our equations.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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