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Predictors of Facility Discharge, Range of Motion, and Patient-Reported Physical Function Improvement Following Primary Total Knee Arthroplasty: A Prospective CohortAnalysis

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Abstract

Patients are discharged to home or inpatient settings following primary unilateral total knee arthroplasty (TKA). We identified predictors of inpatient discharge and 3-month postoperative range of motion (ROM) and patient-reported physical function improvement (VR12 PCS) between these discharge settings. We studied prospectively collected cohortdata for 738 TKAs between April 2011 and April 2013. Significant adjusted predictors of inpatient discharge included older age, female gender, surgeon, comorbidity, lower PCS, and BMI >40. Only lower preoperative ROM predicted postoperative ROM. Inpatient discharge and higher preoperative PCS predicted lower PCS improvement. Home-based rehabilitation was associated with greater 3-month PCS improvement and showed no difference with 3-month ROM. TKA inpatient discharge should be based on patient care requirements rather than perceived benefit of improved ROM and physical function.

Keywords

total knee arthroplasty; patient-reported measures; patient-reported outcomes; physical function; range of motion; discharge disposition

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Introduction

Total knee arthroplasty (TKA) is an effective measure in improving pain and returning function to individuals afflicted with knee osteoarthritis[1-4]. Nationwide, the annual number of TKAs performed is approaching 700,000 procedures with an aggregated cost of over $11 billion dollars[5-7]. TKAs are expected to approach 3.5 million procedures per year by 2030[8]. Historical evidence suggests that this will likely place a large burden on inpatient rehabilitation facilities[3,9,10]. Appropriate and judicious use of limited healthcare resources will require an evaluation of the available discharge settings in terms of patient outcomes and value[3].

Currently, most patients are discharged either to home or to an inpatient setting such as a skilled nursing or acute rehabilitation facility. The decision to discharge a patient to an inpatient setting following TKA depends on many factors. Patient characteristics and preferences, baseline living situation, regional practice patterns, and clinician preferencesare considered in planning discharge disposition [9,11,12]. Receipt of rehabilitative care in an inpatient setting is estimated to cost between two and tentimes as much as an episode of care in a home-based model[4,13,14]. Little research has been done to investigate variations in patient outcomes between these two rehabilitation models for primary TKA patients specifically[2,10]. A few previous studies suggest that discharge disposition has little influence on patient outcomes or postoperative complications [1,3,12,13]. However, aninvestigation completed in 2010 has identified higher 90-day readmission rates and complication ratesfor patients sent to skilled nursing facilities [15].

More information regarding patient outcomes and discharge setting may inform the decisions made by patients and clinicians following TKA. We sought to identify preoperative patient characteristics that predict discharge to inpatient rehabilitation and, by extension, greater resource utilization, in an observational prospective cohort undergoing primary TKA. An additional goal of this investigation was to identify any differences in patient-reported or functional outcomes between those who were discharged to home-based or inpatient rehabilitation settings. We hypothesized that no clinically relevant differences in patient-reported or functional outcomes would be observed between patients discharged directly home and those discharged to an inpatient setting following unilateral primary TKA. Additionally, we hypothesized that there would be no differences in the complication rates between these two populations after risk-adjustment.

Material and Methods

This study reports a retrospective analysis of prospectively collected cohortdata for primary unilateral total knee arthroplasties performed between April 1, 2011 and April 30, 2013 at a rural tertiary academic medical center in northern New England. We obtained approval for this study from the local Institutional Review Board (Committee for the Protection of Human Subjects #28157), which waived the requirement for individual informed consent. One author was partially supported by this project by a federal grant through the National Institute of Arthritis and Musculoskeletal and Skin Diseases; there were no other funding sources for this research. Simultaneous bilateral TKAs were excluded due to anticipated differences in post-operative ambulatory capabilities and potential need for post-discharge services to the unilateral TKA population. There were noexclusions based on age, gender, or comorbidity profile.

Our initial query on procedural data at the institution identified 746 unilateral primary TKAs among 716 patients. We removed two non-TKA surgeries that were incorrectly labeled as TKAs, five bilateral simultaneous procedures were removed for being incorrectly labeled as unilateral TKAs, and one surgery involved a pre-existing condition that required a concurrent plastic surgery procedure at the time of TKA. This patient required immobilization of the knee after surgery and additional treatments not consistent with "primary" TKA. These removals resulted in a total of 738 TKAs, among 708 patients, that were included in our analysis.

Variables including age, sex, race, ethnicity, body mass index (BMI), discharge disposition, length of stay, range of motion (ROM) measurements, and patient-reported outcome measure (PROM) responses were queried from electronic medical records (EMR) through the institution's centralized data warehouse. Our EMR and data warehouse includes both hospital and clinic records from our institution and its affiliates. Reflecting the region's demographics, both race and ethnicity were 99% white and were not used in analyses. Manual review of the EMR was conducted as needed to confirm values. In order to calculate a pre-operative Charlson Comorbidity Index (CCI) score, individual patient charts were reviewed as of the time of admission[16]. Complications, hospital readmissions within 30 days of surgery, manipulation under anesthesia (MUA) procedures and reoperations on the index joint within 90 days of surgery were similarly collected from individual review of the patient's medical records.

The repeated measures of BMI, ROM, and PROMs were captured prospectivelyat two time periods relative to the surgery: these time periods were defined as baseline (180 – 0 days before surgery) and 3-months post-operative (57 – 110 days after surgery). If a patient had these measures repeated within each time period, then the completed value later in time (closer to the surgery preoperative, further away from the surgery postoperatively) was selected to be the value for that time period.

Primary outcomes included discharge disposition, ROM, complications, and PROM scores. Discharge disposition was classified as home-based rehabilitation or inpatient rehabilitation, as shown in Table 1. Baseline ROM, intra-operative ROM, and post-operative ROM were prospectively collected. Complications were defined as deep infection within one year of surgery and the following adverse events occurring within 90 days post-operation: death, superficial infection, periprosthetic fracture, other fracture, deep vein thrombosis (DVT), and pulmonary embolism (PE). Superficial infection was defined as any infection adjacent to the knee within 90 days of surgery that did not require surgical treatment. Deep infection was defined as an intra-articular infection confirmed by the Infectious Diseases Society of America criteria[17].

As a part of daily clinical practice, prospectively administered PROM responseswere collected at least once preoperatively and at multiple postoperative time points. PROM assessments were made using the Veterans RAND 12-item (VR-12). The VR-12 is a nonproprietary patient questionnaire that evaluates patient limitations due to physical and emotional problems. Patient responses are used to quantify a physical component score (PCS) and a mental component score (MCS). Lower PCS scores indicate poorer self-reported physical function while lower MCS scores indicate more role limitations due to emotional concerns. Both scores are normalized to an adultAmerican population at a score of 50 and a standard deviation of 10 points. This questionnaire and its scoring algorithms were developed from the Short Form 36 (SF-36®)[18-20].

We conducted multivariate predictive models for predicting outcomes following primary, unilateral TKA. Linear regression was used for predicting ROM and VR-12 physical function change at 3-months post-operative; logistic regression was used for predicting inpatient discharge. The discharge model only includes variables that were obtainable before hospital admission for the TKA. The 3-month models include variables known at the time of hospital discharge (including length of stay and discharge disposition as adjusting variables). Since 30 patients had separate surgeries in the data set, we clustered on the patient. Not all patients returned for 3-month follow-ups and the cluster effect was not necessary in the ROM and VR-12 change models. All analyses were conducted using Stata MP 12 (Stata Statistical Software. Version 12. College Station, TX: StataCorp LP; 2012).

Results

A total of 738 unilateral TKAs in 708 patients performed between April 1st, 2011 and April 30th, 2013 were included in the study. Patients had a mean age of 64.7 years and a mean preoperative BMI of 32.2. Fifty-seven percent were female. Following TKA, 74.4% (549) of patients were discharged to home-based rehabilitation and 25.6% (189) were discharged to inpatient rehabilitation. Additional information is available in Table 2 and the results tables (Tables 3-5).

We conducted t-tests and chi-squared analyses to determine whether there were any significant preoperative differences between our three patient groups: all surgeries (N=738), patients with 3-month postoperative ROM (429), and patients with both preoperative and 3-month postoperative VR-12 PCS (358). There were no differences in preoperative BMI, PCS score, age at surgery, or gender between the three groups. However, both of the patient groups for the ROM and PCS models had higher mean preoperative VR-12 MCS than the surgeries as a whole (ROM model 50.2 vs. 46.3, P=0.001; PCS model 49.9 vs. 46.9, P=0.012). Both of the sub-models also had higher mean preoperative ROM of the operated knee (ROM model 107.6 degrees vs. 103.8, P=0.016; PCS model 107.9 vs. 104.3, P=0.022).

Table 3 illustrates a multivariate model predicting inpatient discharge following primary TKA. When compared to home-based care, adjusted predictors of discharge to inpatient settings included age over 65 in a dose-response relationship, female gender, presence of at least one comorbid condition, preoperative PCS score from 20-30, and morbid obesity. PCS score under 20 trended for predicting inpatient discharge, but was not statistically significant (P=0.075). Surgeon 1 performed the most TKAs in the time period and was selected as individual of reference. Compared with Surgeon 1, three participating surgeons were significantly less likely to discharge patients to an inpatient rehabilitation setting. In addition to surgeon, two days of the week for the surgery (Tuesday and Thursday, compared to Monday) and right knee laterality were protective against inpatient discharge.

Table 4 displays our model predicting 3-month ROM following primary unilateral TKA. Compared to home rehabilitation, inpatient discharge was not predictive of higher ROM (P=0.143). Compared to age < 55, ages 55 – 59, 70 – 74, and 80+ had higher 3-month ROM; however, these did not follow a pattern in all age groups. Two surgeons had higher post-operative ROM compared to Surgeon 1; two other surgeons also trended for higher ROM. As expected, lower pre-operative ROM was highly predictive of lower post-operative ROM. Gender, length of stay, pre-operative VR-12 physical function, Charlson comorbidity index, pre-operative BMI, and TKA laterality were not predictive of post-operative ROM.

Table 5 indicates predictors of the VR-12 PCS change score at 3-months post-operative (PCS at 3 months minus PCS preoperative). Inpatient discharge and longer LOS were predictive of less improvement in PCS, while lower preoperative PCS (in a strong dose-response relationship), several surgeons compared to Surgeon 1, and lower preoperative ROM were associated with greater PCS improvement. Age, gender, Charlson comorbidity, BMI, and laterality were not significant. This model included 358 surgeries because we restricted it to only patients that completed both preoperative and 3-month postoperative VR-12 questionnaires.

The short-term known complications noted in this population of primary TKAs were minimal and comparable to previous studies[21-23]. Within the 90-day postoperative period, there were no deaths, one periprosthetic fracture (0.1%), five superficial infections (0.7%), six DVTs (0.9%), and three patients diagnosed with pulmonary embolism (0.4%). Twenty-nine patients (4.1%) underwent MUA within 90 days of their initial intervention. There were five readmissions (0.7%) within 30 days of surgery. At one-year follow-up, fiveknownpatients (0.7%) among all 708 patients and 738 surgerieshad acquired a deep infection within the joint. Due to these low counts, we did not pursue individual predictive models of complications.

Discussion

The demand for TKA is projected to increase significantly in the next decade[8] and discharge disposition greatly influences the total cost of care following TKA. Patient-reported outcome measures are becoming increasingly important in comparative effectiveness research. They highlight issues that areof significant interest to patients and may inform patient expectations of what improvements they can anticipate following a procedure. When the adjusted outcomes of home-based and inpatient rehabilitation following primary TKA were compared, we found that inpatient-based programs predicted lower patient reported physical function improvement changes, no difference in postoperative VR-12 mental component score (results not shown), and no difference in achieved knee ROM at three months after surgery. These findings reinforce the notion that inpatient-based rehabilitation does not to appear to improve on patient physical function or range of motion when adjusted for other factors over home-based care, despite some widespread arguments.

Apart from race and ethnicity, reflecting the geographic region, demographic and baseline data of patients included in this study do not appear to differ significantly compared to previous studies[1,13,24]. Patients electing to undergo TKA at our institutionare enrolled in a prospective data registry linked to a quality-based clinical pathway which is based on literature and consensus-based best practices[25]. Our patients receive care according to a highly standardized regimen with prospective clinical data collection in order to measure and compare treatment effectiveness. Patients also participate in a formalized shared decision-making process to ensurethose receiving TKA have failed nonsurgical management of their joint disease and are appropriately informed of the risks and benefits of joint replacement. When compared to similar studies using retrospective review of patient data, an equal or higher proportion of our patients were discharged directly home following their surgery [1,3,14]. When all of these conditions are considered, this study population presents an acceptable sample of patients with appropriate data capture in the current healthcare environment from which to draw conclusions regarding the efficacy of different discharge scenarios.

We identified the following predictors of inpatient dischargein our prospective cohort: older age groups compared to age < 55 in a dose-response relationship, female gender, operating surgeon, presence of at least one comorbid condition, preoperative PCS score of 20-30 (with PCS <20 trending but not significant) compared to PCS≥40, BMI over 40, right laterality, and surgeryday of the week. Previous studies also identified the association with age, gender, and the presence of comorbidities with discharge to inpatient rehabilitation [3,9,24,26]. The association between BMI and discharge disposition has been less well documented. One study recently reported that morbidly obese patients (BMI>40) undergoing TKA were slightly more likely to be discharged from the hospital to a rehabilitation facility than their overweight (BMI<30) counterparts[27]. Our findings suggest a much higher association of morbid obesity and discharge to an inpatient rehabilitation setting. The odds of morbidly obese patients being discharged to inpatient rehabilitation were 4.26 times greater than patients with preoperative BMI<30. (P=0.004).

Our findings also demonstrated that discharge disposition does not predict achieved ROM at three months following TKA. Among our adjusting factors, only baseline ROM had a consistent predictive value, where smaller ROM pre-operatively highly predicted smaller ROM post-operatively. While not surprising, it is worth noting the difficulty of both determining what can predict ROM change, and the difficulty of truly improving upon baseline ROM. To our knowledge, no other study has investigated the relationship between achieved ROM following TKA and discharge disposition. Restoring adequate ROM is an important goal of arthroplasty and is one of the few clinical measures that a surgeon can use to compare outcomes [28,29]. The lack of difference in ROM gains between patients discharged home and to inpatient rehabilitation further reinforces the need to carefully evaluate this use of healthcare resources.

We are unaware of any previous study that has reported a prediction between discharge disposition and change in VR-12 physical function between pre- and postoperative time periods. This study demonstrates a statistically significant, and arguably clinically significant, association between discharge to home-based rehabilitation and improved PCS scores when compared to inpatient rehabilitation. PCS scores in patients discharged to home-based rehabilitation had a greater PCS improvement of 4.5 compared to inpatient discharges at 3-months post-operative, among patients that had both baseline and 3-month PCS scores. This model adjusted for age at surgery, gender, length of stay, baseline VR-12, surgeon, comorbidities, baseline BMI, baseline ROM, and laterality. We also note that adjusted PCS change was largely predicted by baseline PCS in a strong dose-response relationship: patients with lower baseline scores improve much more than patients with higher baseline scores. Further studies should investigate the merit of performing primary TKAs on patients with self-reported physical function that is already above the normal American adult score of 50.

In a randomized controlled trial published in 2008, Mahomed et al. found no significant differences in SF-36 PCS or MCS scores at three months and one year in primary TKA patients randomized to an inpatient or home rehabilitation arm. Patients assigned to either inpatient or home-based rehabilitation were similar on all measured outcomes except for health systems costs, which were significantly higher in the inpatient arm. The patients, however, were only compared using WOMAC and SF-36 scores and not other factors like age, gender, or BMI. The mean LOS was 6.3 and 7.0 days for each arm, while our mean LOS was only 3.3 days, making these populations difficult to compare[13]. Peiris et al. recently reported in a prospective observational study that adults receiving inpatient rehabilitation for lower limb orthopaedic conditions are largely inactive and not meeting physical activity guidelines for older adults[28]. When combined with the findings in our study, we hope to inform patient and provider expectations of what improvements in physical function can be made in various rehabilitation settings, as well as the necessity of obtaining physical function both pre- and post-operatively.

We acknowledge several limitations to this study. First, the generalizability of these results may be limited by the homogenous demographics of this patient populationand to patients undergoing primary TKA at large, high-volume institutions. However, the race and ethnicity of our patients largely reflects the rural New England region, as well as national estimates of the population undergoing primary TKA[29]. Although not racially or ethnically diverse, our general TKA patient population also presents a wide range of household incomes and achieved education (data not shown). Secondly, we have significant missingness in certain variables, especially ROM, particularly at follow-up visits. While not rare for observational data in a real-world setting, analyses have decreasing numbers over time due to patients lost to follow-up, failure to complete surveys, or lack of full provider participation in postoperative data collection. Given our attempt to study the unselected population of patients rather than a selective group, this issue was not unexpected. Our 3-month follow-up models only included patients that had completed baseline and follow-up ROM and VR12, respectively. Currently, we have limited capability to determine whether any complications occurred at other institutions. All reported complications were treated by our institution; as the only tertiary referral institution in the region, we anticipate that we have captured most patient complications among our local population. Despite these limitations, including the patient populations of all of our attending arthroplasty surgeons in our analysis permit the data to reflect the outcomes of an entire population undergoing a single procedure and should decrease the chance of selection bias. Additionally, and common with observational prospective cohortdata, we may have omitted variable bias that may further explain some differences between our home and inpatient discharge populations, such as baseline living situation and other sociodemographic variables, measures of frailty, medication use, and laboratory results. Other variables, particularly ROM and BMI (height), may vary widely in accuracy and precision by the clinical personnel recording them.

Conclusions

These findings challenge the notion that inpatient rehabilitation offers improved outcomes for patients electing to undergo total knee replacement. Our work demonstrates that discharge to home-based rehabilitation following TKA may provide previously unidentified benefits for patients resulting in higher PROM scores, similar complication rates, and similar knee ROM. While a certain percentage of patients will likely require post-discharge inpatient services going forward, those should be based on patient care requirements rather than the perceived benefit of improved surgical outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

acknowledgement

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References

1. Mahomed NN, Koo Seen Lin MJ, Levesque J, Lan S, Bogoch ER. Determinants and outcomes of inpatient versus home based rehabilitation following elective hip and knee replacement. The Journal of rheumatology. Jul; 2000 27(7):1753–1758. [PubMed: 10914863]
2. Khan F, Ng L, Gonzalez S, Hale T, Turner-Stokes L. Multidisciplinary rehabilitation programmes following joint replacement at the hip and knee in chronic arthropathy. The Cochrane database of systematic reviews. 2008; (2):CD004957. [PubMed: 18425906]
3. Tribe KL, Lapsley HM, Cross MJ, Courtenay BG, Brooks PM, March LM. Selection of patients for inpatient rehabilitation or direct home discharge following total joint replacement surgery: a comparison of health status and out-of-pocket expenditure of patients undergoing hip and knee arthroplasty for osteoarthritis. Chronic illness. Dec; 2005 1(4):289–302. [PubMed: 17152453]
4. Sharareh B, Le NB, Hoang MT, Schwarzkopf R. Factors Determining Discharge Destination for Patients Undergoing Total Joint Arthroplasty. The Journal of arthroplasty. Feb 10.2014
5. Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality; 2011. https://http://www.hcup-us.ahrq.gov/nisoverview.jsp. [May 9, 2014]
6. Weinstein AM, Rome BN, Reichmann WM, et al. Estimating the burden of total knee replacement in the United States. The Journal of bone and joint surgery. Mar 6; 2013 95(5):385–392. American volume. [PubMed: 23344005]
7. Losina E, Walensky RP, Kessler CL, et al. Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. Archives of internal medicine. Jun 22; 2009 169(12):1113–1121. discussion 1121-1112. [PubMed: 19546411]

8. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. The Journal of bone and joint surgery. American volume. Apr; 2007 89(4):780–785.
9. Bozic KJ, Wagie A, Naessens JM, Berry DJ, Rubash HE. Predictors of discharge to an inpatient extended care facility after total hip or knee arthroplasty. Journal of Arthroplasty. Sep; 2006 21(6): 151–156. [PubMed: 16950078]
10. Stolee P, Lim SN, Wilson L, Glenny C. Inpatient versus home-based rehabilitation for older adults with musculoskeletal disorders: a systematic review. Clinical rehabilitation. May; 2012 26(5):387–402. [PubMed: 21971753]
11. Barsoum WK, Murray TG, Klika AK, et al. Predicting patient discharge disposition after total joint arthroplasty in the United States. The Journal of arthroplasty. Sep; 2010 25(6):885–892. [PubMed: 19729270]
12. Chimenti CE, Ingersoll G. Comparison of home health care physical therapy outcomes following total knee replacement with and without subacute rehabilitation. Journal of geriatric physical therapy. 2007; 30(3):102–108. [PubMed: 18171493]
13. Mahomed NN, Davis AM, Hawker G, et al. Inpatient compared with home-based rehabilitation following primary unilateral total hip or knee replacement: a randomized controlled trial. The Journal of bone and joint surgery. American volume. Aug; 2008 90(8):1673–1680.
14. Ramos NL, Karia RJ, Hutzler LH, Brandt AM, Slover JD, Bosco JA. The effect of discharge disposition on 30-day readmission rates after total joint arthroplasty. The Journal of arthroplasty. Apr; 2014 29(4):674–677. [PubMed: 24183369]
15. Bini SA, Fithian DC, Paxton LW, Khatod MX, Inacio MC, Namba RS. Does discharge disposition after primary total joint arthroplasty affect readmission rates? The Journal of arthroplasty. Jan; 2010 25(1):114–117. [PubMed: 19150214]
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. Journal of chronic diseases. 1987; 40(5):373–383. [PubMed: 3558716]
17. Osmon DR, Berbari EF, Berendt AR, et al. Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the Infectious Diseases Society of America. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America. Jan; 2013 56(1):e1–e25. [PubMed: 23223583]
18. Selim AJ, Rogers W, Fleishman JA, et al. Updated U.S. population standard for the Veterans RAND 12-item Health Survey (VR-12). Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation. Feb; 2009 18(1):43–52.
19. Kazis LE, Selim A, Rogers W, Ren XS, Lee A, Miller DR. Dissemination of methods and results from the veterans health study: final comments and implications for future monitoring strategies within and outside the veterans healthcare system. The Journal of ambulatory care management. Oct-Dec;2006 29(4):310–319. [PubMed: 16985389]
20. Kazis, LE.; Selim, A.; Rogers, W.; Ren, XS.; Lee, A.; Miller, DR. Veterans RAND 12 item Health Survey (VR-12): A white paper summary. Available online at: http://www.hosonline.org/surveys/hos/download/Veterans_RAND_12_Item_Health_Survey_White_Paper_Summary.pdf.
21. Belmont PJ Jr. Goodman GP, Waterman BR, Bader JO, Schoenfeld AJ. Thirty-day postoperative complications and mortality following total knee arthroplasty: incidence and risk factors among a national sample of 15,321 patients. The Journal of bone and joint surgery. Jan 1; 2014 96(1):20–26. American volume. [PubMed: 24382720]
22. Mahomed NN, Barrett J, Katz JN, Baron JA, Wright J, Losina E. Epidemiology of total knee replacement in the United States Medicare population. The Journal of bone and joint surgery. Jun; 2005 87(6):1222–1228. American volume. [PubMed: 15930530]
23. SooHoo NF, Lieberman JR, Ko CY, Zingmond DS. Factors predicting complication rates following total knee replacement. The Journal of bone and joint surgery. Mar; 2006 88(3):480–485. American volume. [PubMed: 16510811]
24. Mallinson TR, Bateman J, Tseng HY, et al. A comparison of discharge functional status after rehabilitation in skilled nursing, home health, and medical rehabilitation settings for patients after

lower-extremity joint replacement surgery. Archives of physical medicine and rehabilitation. May; 2011 92(5):712–720. [PubMed: 21530718]

25. Dartmouth-Hitchcock.. Dartmouth-Hitchcock "GreenCare". 2015. http://lebanon.dhortho.org/dartmouth-hitchcock-green-care/
26. Jain NB, Guller U, Pietrobon R, Bond TK, Higgins LD. Comorbidities increase complication rates in patients having arthroplasty. Clinical orthopaedics and related research. Jun.2005 (435):232–238. [PubMed: 15930944]
27. D'Apuzzo MR, Novicoff WM, Browne JA. The John Insall Award: Morbid Obesity Independently Impacts Complications, Mortality, and Resource Use After TKA. Clinical orthopaedics and related research. Jan; 2015 473(1):57–63. [PubMed: 24818736]
28. Peiris CL, Taylor NF, Shields N. Patients receiving inpatient rehabilitation for lower limb orthopaedic conditions do much less physical activity than recommended in guidelines for healthy older adults: an observational study. Journal of Physiotherapy. 2013; 59(1):39–44. [PubMed: 23419914]
29. Singh JA, Lu X, Rosenthal GE, Ibrahim S, Cram P. Racial disparities in knee and hip total joint arthroplasty: An 18-year analysis of national Medicare data. Ann Rheum Dis. 2014; 73:2107–2115. [PubMed: 24047869]

Table 1

Definition and counts of home and inpatient discharge, as reported in EMR.

Discharge Type	Count	%	Discharge Category
Custodial Care	1	0.1	Home
Home	20	2.7	Home
Home with Visiting Nurse	528	71.5	Home
Intermediate Care Facility	1	0.1	Inpatient
Rehabilitation Center –Acute Care	11	1.5	Inpatient
Rehabilitation Center –Stand Alone	11	1.5	Inpatient
Skilled Nursing Facility	80	10.8	Inpatient
Swing Bed	86	11.7	Inpatient
Total	738	100	Home 549 (74.4%), Inpatient 189 (25.6%)

Table 2

Background information on our population (N=738) unavailable in Tables 1 and 3.

Variable	Mean	IQR (25-75%)	Range
Age at Surgery	64.7 (SD 10.4)	57.8 – 71.3	30.3 – 89.9
Pre-Op BMI	33.0	27.6 – 37.0	17.7 – 66.1
3-month BMI	32.2	26.2 – 36.2	19.4 – 67.1
Pre-Op PCS	32.6	23.6 – 40.3	9.1 – 71.8
3-month PCS	40.9	32.0 – 50.1	11.9 – 73.5
3-month PCS change	8.3 (SD 12.8)	−0.1 – 17.8	−31.4 – 37.3
Pre-Op MCS	48.6	35.0 – 61.7	20.8 – 73.5
3-month MCS	53.8	46.6 – 63.1	13.6 – 73.0
Length of Stay	3.3 days	2.4 – 3.4	1.2 – 13.5
Pre-Op ROM	106 degrees	95 – 120	30 – 145
Intra-Op ROM	117 degrees	110 – 125	90 – 145
3-month ROM	110 degrees	100 – 120	25 – 140

IQR indicates interquartile range (25^{th} to 75^{th} percentile of values); SD, standard deviation; Pre-Op, pre-operative (latest visit prior to surgery date, up to 180 days earlier); BMI, body mass index; 3-month, visit closest to 3-months after surgery date, defined as 57-110 days from surgery date); PCS, Veterans RAND 12-Item Physical Component Score (normalized to 50 on a 1-100 scale, higher is healthier); MCS, Veterans RAND 12-Item Mental Component Score (normalized to 50 on a 1-100 scale, higher is healthier); ROM, range of motion in angle degrees of the operated knee(higher has larger range); Intra-op, ROM taken during the surgery.

Length of stay here is derived from minutes; in later analyses, it is defined in whole days.

Table 3

Multivariate model predicting inpatient discharge following primary unilateral total knee arthroplasty

Variable	Home Discharge n=547, %(#)	Inpatient Discharge n=186, %(#)	Adjusted OR	Adjusted 95% CI	Adjusted P-Value
Age Group (ref = <55)	87 (110)	13 (17)			
55-59	85 (99)	15 (18)	1.35	0.57-3.23	0.496
60-64	84 (112)	16 (21)	1.46	0.63-3.38	0.381
65-69	76 (111)	24 (36)	3.06	1.41-6.64	**0.005**
70-74	65 (55)	35 (29)	4.95	2.08-11.78	**<0.001**
75-79	53 (38)	47 (34)	11.13	4.61-26.84	**<0.001**
80+	41 (24)	59 (34)	16.12	6.38-40.69	**<0.001**
Surgery Day (ref = Monday)	73 (105)	27 (39)			
Tuesday	79 (214)	21 (57)	0.44	0.20-0.98	**0.044**
Wednesday	65 (68)	35 (36)	0.66	0.28-1.54	0.337
Thursday	75 (124)	25 (41)	0.30	0.13-0.74	**0.009**
Friday	70 (38)	30 (16)	0.58	0.21-1.59	0.291
Gender (ref = Male)	83 (263)	17 (53)			
Female	68 (286)	32 (136)	2.67	1.68-4.23	**<0.001**
VR-12 PCS (ref = 40+)	81 (130)	18 (29)			
30-40	82 (124)	18 (27)	0.99	0.51-1.90	0.972
20-30	68 (153)	32 (71)	2.37	1.32-4.25	**0.004**
<20	69 (55)	31 (25)	2.01	0.93-4.35	0.075
Surgeon (ref=Surgeon 1)	65 (119)	35 (64)			
Surgeon 2	70 (86)	30 (36)	0.66	0.32-1.38	0.274
Surgeon 3	65 (72)	35 (39)	2.11	0.88-5.02	0.092
Surgeon 4	74 (37)	26 (13)	0.21	0.07-0.61	**0.004**
Surgeon 5	87 (138)	13 (21)	0.26	0.12-0.54	**<0.001**
Surgeon 6	86 (97)	14 (16)	0.37	0.15-0.90	**0.028**
Charlson (ref=0)	82 (348)	18 (78)			
1-3	74 (73)	26 (25)	2.51	1.35-4.70	**0.004**
4-5	66 (97)	34 (50)	1.76	1.01-3.05	**0.046**
6-9	45 (29)	55 (35)	2.44	1.22-4.88	**0.011**
BMI Group (ref = Normal – Overweight <30)	80(109)	20 (27)			
Obese 30-39	79 (97)	21 (26)	0.94	0.44-2.00	0.868
Morbid Ob 40+	58 (32)	42 (23)	4.26	1.81-10.03	**0.001**
Pre-Op ROM Group (ref = >110)	82(130)	18 (29)			
90-110	72 (151)	28 (59)	1.43	0.76-2.69	0.273
<90	61 (30)	39 (19)	1.85	0.78-4.34	0.160
Laterality (ref = left)	72 (249)	28 (98)			

Variable	Home Discharge n=547, %(#)	Inpatient Discharge n=186, %(#)	Adjusted OR	Adjusted 95% CI	Adjusted P-Value
Right	77 (300)	23 (91)	0.63	0.43-0.92	**0.016**

Missing values for each variable were included in the model, but not displayed. Hence, numbers and percentages may not add up to 738 and 100 for each variable and value. CI indicates confidence interval; OR, odds ratio; ref, reference group; Charlson, Charlson Comorbidity Index; Ob, obesity.

Clustered on the 708 individual patients among the 738 primary unilateral TKAs.

Table 4

Multivariate linear regression model predicting 3-month ROM following primary unilateral total knee arthroplasty.

Variable	Count % of variable (n)	Adjusted 3-month ROM (degrees)	95% CI	P-Value
Discharge (ref = home)	77 (331)			
Non-Home	23 (98)	−2.74	−6.40 – 0.93	0.143
Age Group (ref = <55)	17 (74)			
55-59	16 (67)	5.07	0.38 – 9.76	**0.034**
60-64	18 (79)	4.00	−1.20 – 9.20	0.131
65-69	21 (89)	3.81	−0.95 – 8.56	0.116
70-74	11 (48)	5.66	0.09 – 11.23	**0.046**
75-79	9 (40)	2.98	−3.82 – 9.78	0.390
80+	8 (32)	7.62	1.63 – 13.61	**0.013**
Gender (ref = Male)	43 (183)			
Female	57 (246)	−1.12	−3.89 – 1.64	0.425
Length of Stay (ref 1-2)	36 (155)			
3	43 (186)	−2.82	−5.86 – 0.23	0.070
4	13 (57)	−0.69	−5.44 – 4.05	0.774
5+	7 (31)	0.84	−5.34 – 7.02	0.789
VR-12 Pre-Op PCS (ref = 40+)	20 (86)			
30-40	24 (104)	1.36	−2.79 – 5.51	0.520
20-30	32 (138)	2.25	−1.71 – 6.20	0.265
<20	10 (41)	1.52	−3.89 – 6.93	0.582
Surgeon (ref=Surgeon 1)	7 (31)			
Surgeon 2	19 (82)	10.17	2.82 – 17.52	**0.007**
Surgeon 3	20 (86)	9.62	2.75 – 16.50	**0.006**
Surgeon 4	8 (33)	4.61	−3.17 – 12.39	0.245
Surgeon 5	28 (120)	5.74	−1.08 – 12.56	0.099
Surgeon 6	18 (77)	6.34	−1.14 – 13.82	0.097
Charlson (ref=0)	58 (250)			
1-3	14(59)	−1.11	−4.90 – 2.68	0.565
4-5	21 (89)	−0.53	−4.56 – 3.50	0.796
6-9	7 (31)	3.26	−0.87 – 7.39	0.122
Pre-Op BMI Group (ref = Normal <25)	43 (81)			
Moderate Obes 30-34	42 (79)	−0.09	−4.20 – 4.01	0.965
Morbidly Obes 40+	16 (30)	1.44	−4.12 – 6.99	0.612
Pre-Op ROM Group (ref = >110)	43 (103)			
90-110	48 (115)	−5.39	−8.81 – −1.97	**0.002**
<90	10 (24)	−15.33	−23.03 – −7.63	**<0.001**
Laterality (ref = Left)	46 (196)			

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Variable	Count % of variable (n)	Adjusted 3-month ROM (degrees)	95% CI	P-Value
Right	54 (233)	0.94	−1.65 – 3.53	0.476

Due to incomplete follow-up at 3 months, 429 of the initial surgeries are included in this Table. There was no cluster effect because no individual had complete follow-up at 3 months separately for multiple surgeries. Since this is a subpopulation of the original 738 surgeries, we are also reporting the counts.Missing values for each variable were included in the model, but not displayed. Percentages and counts may not add up to 100 and 429, respectively, due to missingness.

Table 5

Multivariate linear regression model predicting VR-12 change between 3-month postoperative and baselinePCS scores.

Variable	Count % of variable (n)	Adjusted VR-12 PCS change score	95% CI	P-Value
Discharge (ref = home)	78 (281)			
Non-Home	22 (77)	−4.48	−6.84 – −2.13	**<0.001**
Age Group (ref = <55)	17 (60)			
55-59	16 (57)	0.16	−3.96 – 4.29	0.937
60-64	18 (64)	2.06	−1.97 – 6.09	0.316
65-69	22 (80)	3.46	−0.31 – 7.23	0.072
70-74	13 (45)	2.81	−1.71 – 7.32	0.223
75-79	8 (29)	3.18	−2.20 – 8.56	0.246
80+	6 (23)	−1.47	−6.72 – 3.79	0.584
Gender (ref = Male)	43 (153)			
Female	57 (205)	1.52	−0.85 – 3.88	0.209
Length of Stay (ref 1-2)	39 (139)			
3	41 (147)	−3.79	−6.35 – −1.24	**0.004**
4	15 (52)	−4.70	−8.64 – −0.76	**0.020**
5+	6 (20)	−2.73	−8.33 – 2.87	0.338
VR-12 Pre-Op PCS (ref = 40+)	25 (90)			
30-40	27 (97)	10.55	7.51 – 13.60	**<0.001**
20-30	38 (135)	16.93	14.12 – 19.74	**<0.001**
<20	10 (36)	23.95	19.87 – 28.03	**<0.001**
Surgeon (ref=Surgeon 1)	5 (19)			
Surgeon 2	23 (81)	4.75	0.13 – 9.38	**0.044**
Surgeon 3	23 (82)	5.40	1.01 – 9.79	**0.016**
Surgeon 4	4 (15)	4.58	−2.20 – 11.36	0.185
Surgeon 5	23 (81)	7.15	2.20 – 12.09	**0.005**
Surgeon 6	22 (80)	4.23	−0.51 – 8.96	0.080
Charlson (ref=0)	57 (205)			
1-3	14 (49)	−2.73	−6.48 – 1.02	0.153
4-5	22 (78)	−1.28	−4.28 – 1.72	0.403
6-9	7 (26)	−0.74	−4.56 – 3.07	0.702
Pre-Op BMI Group (ref = Normal <25)	45 (66)			
Moderate Obes (30-34)	40 (59)	−1.90	−5.81 – 2.00	0.339
Morbidly Obes 40+	15 (22)	−2.22	−6.47 – 2.02	0.304
Pre-Op ROM Group (ref = >110)	44 (85)			
90-110	46 (89)	3.78	0.49 – 7.07	**0.025**
<90	11 (21)	3.12	−2.14 – 8.38	0.244
Laterality (ref = Left)	46 (166)			

Variable	Count % of variable (n)	Adjusted VR-12 PCS change score	95% CI	P-Value
Right	54 (192)	0.86	−1.48 – 3.20	0.469

The surgeries are restricted to patients who completed both baseline and postoperative VR-12 questionnaires (n=358). There was no cluster effect because no individual had complete follow-up at 3 months separately for multiple surgeries. Since this is a subpopulation of the original 738 surgeries, we are also reporting the counts. Missing values for each variable were included in the model, but not displayed. Percentages and counts may not add up to 100 and 358, respectively, due to missingness.