The Journal of Arthroplasty 31 (2016) 36–41

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

# Predictors of Facility Discharge, Range of Motion, and Patient-Reported Physical Function Improvement After Primary Total Knee Arthroplasty: A Prospective Cohort Analysis

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ARTICLE INFO

*Article history:*
Received 29 June 2015
Accepted 1 September 2015

*Keywords:*
total knee arthroplasty
patient-reported measures
patient-reported outcomes
physical function
range of motion
discharge disposition

ABSTRACT

*Background:* Patients are discharged to home or inpatient settings after primary unilateral total knee arthroplasty (TKA). Few studies have compared patient outcomes following these 2 rehabilitation models for TKA patients. We identified predictors of inpatient discharge, 3-month postoperative range of motion (ROM), and 3-month postoperative patient-reported physical function improvement (Veterans RAND 12-Item Physical Component Score [PCS]) between these discharge settings.
*Methods:* We studied prospectively collected cohort data for 738 TKAs between April 2011 and April 2013 at a high-volume tertiary academic medical center in a rural setting. All patients followed a standardized care pathway that involved prospective data collection as part of routine clinical care. Adjusting variables included age, sex, preoperative PCS, surgeon, modified Charlson Comorbidity Index, preoperative body mass index, laterality, and preoperative ROM; the 3-month models also included length of stay and discharge disposition as adjusters.
*Results:* Significant adjusted predictors of inpatient discharge included older age, female sex, surgeon, comorbidity, lower PCS, and body mass index greater than 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.
*Conclusion:* Discharge to home-based rehabilitation after TKA, rather than inpatient facility, is associated with higher physical function at 3 months postsurgery and shows no difference with 3-month ROM. Total knee arthroplasty inpatient discharge should be based on patient care requirements rather than perceived benefit of improved ROM and physical function.



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]. Total knee arthroplasties 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 health care 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 after TKA depends on many factors. Patient characteristics and preferences, baseline living situation, regional practice patterns, and clinician preferences are considered in planning discharge disposition [9,11,12]. Receipt of rehabilitative care in an inpatient setting is estimated to cost between 2 and 10 times 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 2 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, an investigation completed in 2010 has identified higher 90-day readmission rates and complication rates for patients sent to skilled nursing facilities [15].

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.09.002.

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[1] Dr Keeney is partially funded on this project by the Multidisciplinary Clinical Research Center in Musculoskeletal Diseases at Dartmouth College (NIAMS P60-AR048094 and P60-AR062799).

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http://dx.doi.org/10.1016/j.arth.2015.09.002
0883-5403/

More information regarding patient outcomes and discharge setting may inform the decisions made by patients and clinicians after 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 after unilateral primary TKA. In addition, we hypothesized that there would be no differences in the complication rates between these 2 populations after risk adjustment.

## Materials and Methods

This study reports a retrospective analysis of prospectively collected cohort data for primary unilateral TKAs 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 no. 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 postoperative ambulatory capabilities and potential need for postdischarge services to the unilateral TKA population. There were no exclusions based on age, sex, or comorbidity profile.

Our initial query on procedural data at the institution identified 746 unilateral primary TKAs among 716 patients. We removed 2 non-TKA surgeries that were incorrectly labeled as TKAs, 5 bilateral simultaneous procedures were removed for being incorrectly labeled as unilateral TKAs, and 1 surgery involved a preexisting 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, which were included in our analysis.

Variables including age, sex, race, ethnicity, body mass index (BMI), discharge disposition, length of stay (LOS), 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. To calculate a preoperative Charlson Comorbidity Index score, individual patient charts were reviewed as of the time of admission [16]. Complications, hospital readmissions within 30 days of surgery, manipulation under anesthesia procedures, and reoperations on the index joint within 90 days of surgery were similarly collected from individual review of the patient's medical records.

**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%) |

The repeated measures of BMI, ROM, and PROMs were captured prospectively at 2 periods relative to the surgery: these periods were defined as baseline (180-0 days before surgery) and 3 months postoperatively (57-110 days after surgery). If a patient had these measures repeated within each 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 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, intraoperative ROM, and postoperative ROM were prospectively collected. Complications were defined as deep infection within 1 year of surgery and the following adverse events occurring within 90 days postoperation: death, superficial infection, periprosthetic fracture, other fracture, deep vein thrombosis, and pulmonary embolism. *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 intraarticular infection confirmed by the Infectious Diseases Society of America criteria [17].

As a part of daily clinical practice, prospectively administered PROM responses were collected at least once preoperatively and at multiple postoperative time points. Patient-reported outcome measure assessments were made using the Veterans RAND 12-item (VR-12) questionnaire. 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 PCSs indicate poorer self-reported physical function, whereas lower MCSs indicate more role limitations due to emotional concerns. Both scores are normalized to an adult American population at a score of 50 and an SD 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 after primary unilateral TKA. Linear regression was used for predicting ROM and VR-12 physical function change at 3 months postoperatively; 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 LOS and discharge disposition as adjusting variables). Because 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, 2012; StataCorp LP, College Station, TX).

**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 |
| Preop BMI | 33.0 | 27.6-37.0 | 17.7-66.1 |
| 3-month BMI | 32.2 | 26.2-36.2 | 19.4-67.1 |
| Preop 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 to 17.8 | −31.4 to 37.3 |
| Preop MCS | 48.6 | 35.0-61.7 | 20.8-73.5 |
| 3-month MCS | 53.8 | 46.6-63.1 | 13.6-73.0 |
| LOS | 3.3 d | 2.4-3.4 | 1.2-13.5 |
| Preop ROM | 106° | 95-120 | 30-145 |
| Intraop ROM | 117° | 110-125 | 90-145 |
| 3-month ROM | 110° | 100-120 | 25-140 |

Abbreviations: IQR, interquartile range (25th to 75th percentile of values); Preop, preoperative (latest visit before surgery date, up to 180 days earlier); 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, ROM in angle degrees of the operated knee (higher has larger range); Intraop, ROM taken during the surgery.
Length of stay here is derived from minutes; in later analyses, it is defined in whole days.