# Can a Total Knee Arthroplasty Perioperative Surgical Home Close the Gap Between Primary and Revision TKA Outcomes?

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**Abstract**

Given the steady increase in the number of primary and revision total knee arthroplasties (TKAs) performed in the United States, we wanted to determine if an evidence-based TKA perioperative surgical home could close the perioperative morbidity gap between primary and revision TKAs.

We conducted a prospective cross-sectional cohort study comparing outcomes of patients who had primary TKA (n = 235) with outcomes of patients who had revision TKA (n = 50). We measured several perioperative outcomes: length of stay, discharge disposition, 30-day readmission rate, and 30-day reoperation rate.

Mean length of stay was 2.55 days for primary TKA and 2.92 days for revision TKA ($P = .061$). Eighty (34%) of the 235 primary TKA patients and 21 (41%) of the 51 revision TKA patients were discharged to a subacute nursing facility ($P = .123$). One primary TKA patient (0.4%) and 2 revision TKA patients (4%) were readmitted within 30 days after surgery ($P = .081$). None of the primary TKAs and 2 (4%) of the revision TKAs underwent reoperation ($P = .993$). There was no difference in perioperative outcomes between the primary and revision TKA groups in our Total Joint Replacement Perioperative Surgical Home (TJR-PSH) cohort.

Advances in multidisciplinary co-management of TKA patients are highlighted in the TJR-PSH. The similarity in primary and revision TKA outcomes has significant implications regarding costs and potential increased patient satisfaction.

Total knee arthroplasty (TKA) is an efficacious procedure for end-stage knee arthritis. Although TKA is cost-effective and has a high rate of success,[1-6] TKAs fail and may require revision surgery. Failure mechanisms include periprosthetic fracture, aseptic loosening, wear, osteolysis, instability, and infection.[7-9] In these cases, revision arthroplasty may be needed in order to restore function.

There has been a steady increase in the number of primary and revision TKAs performed in the United States.[8,10,11] Revision rates are 4% at 5 years after index TKA and 8.9% at 9 years.[12] However, surgical techniques and improved implants have led to improved outcomes after primary TKA, as evidenced by the reduction in revisions performed for polyethylene wear and osteolysis.[13] Given the continuing need for revision TKAs (despite technical improvements[13]), evidence-based standard protocols that improve outcomes after revision TKA are necessary.

The Total Joint Replacement Perioperative Surgical Home (TJR-PSH) implemented and used by surgeons and anesthesiologists at our institution has shown that an evidence-based perioperative protocol can provide consistent and improved outcomes in primary TKA.[14-16] TJR-PSH is a clinical care pathway that defines and standardizes preoperative, intraoperative, postoperative, and postdischarge management for patients who

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undergo elective primary total knee and total hip arthroplasty.[14,15] The clinical pathway developed by the TJR-PSH team is briefly described in **Appendixes A and B**.

Garson and colleagues[14] and Chaurasia and colleagues[15] found that patients who underwent primary TKA in a TJA-PSH had a predicted short length of stay (LOS): <3 days. About half were discharged to a location other than home, and 1.1% were readmitted within the first 30 days after surgery. There were no major complications and no mortalities. Conversely, as shown in different nationwide database analysis,[17,18] mean LOS after primary unilateral TKA was 5.3 days, 8.2% of patients had procedure-related complications, 30-day readmission rate was 4.2%, and the in-hospital mortality rate was 0.3%. As with TJA-PSH, about half the patients were discharged to a place other than home.

We conducted a study to test the effect of the TJA-PSH clinical pathway on revision TKA patients. Early perioperative outcomes, such as LOS, readmission rate, and reoperation rate, are invaluable tools in measuring TKA outcomes and correlate with the dedicated orthopedic complication grading system proposed by the Knee Society.[14,15,17,19] We hypothesized that the TJR-PSH clinical pathway would close the perioperative morbidity gap between primary and revision TKAs and yield equivalent perioperative outcomes.

## Materials and Methods

In this study, which received Institutional Review Board approval, we performed a prospective cross-sectional analysis comparing the perioperative outcomes of patients who underwent primary TKA with those of patients who underwent revision TKA. Medical records and our institution's data registry were queried for LOS, discharge disposition, readmission rates, and reoperation rates.

The study included all primary and revision TKAs performed at our institution since the inception of TJA-PSH. Unicompartmental knee arthroplasties and exchanges of a single component (patella, tibia, or femur) were excluded. We identified a total of 285 consecutive primary or revision TKAs, all performed by a single surgeon. Three cases lacked complete data and were excluded, leaving 282 cases: 235 primary and 50 revision TKAs (no simultaneous bilateral TKAs). The demographic data we collected included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, calculated Charlson Comorbidity Index (CCI), LOS, and discharge disposition.

Table. **Patient Demographics**

| Variable | Total Knee Arthroplasty | | |
|---|---|---|---|
| | Primary (n = 235) | Revision (n = 50) | *P* |
| Mean (SD) age, y | 65.8 (12.3) | 62.1 (12.8) | .169 |
| <65 | 103 (44%) | 26 (52%) | |
| ≥65 | 133 (56%) | 24 (48%) | |
| Male sex | 86 (37%) | 21 (43%) | — |
| Mean (SD) body mass index | 30.5 (6.1) | 30.9 (6.5) | .701 |
| <30 | 119 (51%) | 26 (52%) | |
| ≥30 | 115 (49%) | 24 (48%) | |
| Mean (SD) ASA score | 2.86 (0.45) | 2.85 (0.63) | .914 |
| 1-2 | 57 (24%) | 20 (40%) | |
| 3 | 178 (75%) | 30 (60%) | |

Abbreviation: ASA, American Society of Anesthesiologists.

The same established perioperative surgical home clinical pathway was used to care for all patients, whether they underwent primary or revision TKA. The primary outcomes studied were LOS, discharge disposition (subacute nursing facility or home), 30-day orthopedic readmission, and return to operating room. All reoperations on the same knee were analyzed.

### Statistical Analysis

Primary and revision TKAs were compared on LOS (with an independent-sample *t* test) and discharge disposition, 30-day readmissions, and reoperations ($\chi^2$ Fisher exact test). Multivariate regression analysis was performed with each primary outcome, using age, sex, BMI, ASA score, and CCI as covariates. Statistical significance was set at $P \leq .05$. All analyses were performed with SPSS Version 16.0 (SPSS Inc.) and Microsoft Excel 2011 (Microsoft).

## Results

Mean (SD) age was 66 (13.2) years for primary TKA patients and 62 (12.8) years for revision TKA patients. The cohort had more women (62.5%) than men (37.5%). There was no statistical difference in patient demographics with respect to age ($P = .169$) or BMI ($P = .701$) between the 2 groups. There was an even age distribution within each group and between the groups (**Table**). There was no statistically significant difference in mean ASA score between the groups ($P = .914$).

There was no statistically significant difference in LOS between the groups. Mean (SD) LOS was

2.55 (1.25) days for primary TKA and 2.92 (1.24) days for revision TKA ($P = .061$; 95% confidence interval [CI], 0.017-0.749). Regression analysis showed a correlation between ASA score and LOS for primary TKAs but not revision TKAs. For every unit increase in ASA score, there was a 0.39-day increase in LOS for primary TKA ($P = .46$; 95% CI, 0.006-0.781). There was no correlation between ASA score and LOS for revision TKA when controlling for covariates ($P = .124$). Eighty (34%) of the 235 primary TKA patients and 21 (41%) of the 50 revision TKA patients were discharged to a subacute nursing facility; the difference was not significant ($P = .123$). No patient was discharged to an acute inpatient rehabilitation unit. In addition, there was no significant difference in 30-day readmission rates between primary and revision TKA ($P = .081$). One primary TKA patient (0.4%) and 2 revision TKA patients (4%) were readmitted within 30 days after surgery ($P = .081$). The primary TKA readmission was for severe spasticity and a history of cerebral palsy leading to a quadriceps avulsion fracture from the superior pole of the patella. One revision TKA readmission was for acute periprosthetic joint infection, and the other for periprosthetic fracture around a press-fit distal femoral replacement stem. There was no significant difference in number of 30-day reoperations between the groups ($P = .993$). None of the primary TKAs and 2 (4%) of the revision TKAs underwent reoperation. Of the revision TKA patients who returned to the operating room within 30 days after surgery, one was treated for an acute periprosthetic joint infection, the other for a femoral periprosthetic fracture.

## Discussion

Advances in multidisciplinary co-management of TKA patients and their clinical effects are highlighted in the TJR-PSH.[14] TJR-PSH allows the health team and the patient to prepare for surgery with an understanding of probable outcomes and to optimize the patient's medical and educational standing to better meet expectations and increase satisfaction.

Previous studies have focused on the etiologies of revision TKA[7,8] and on understanding the factors that may predict increased risk for a poor outcome after primary TKA and indicate a possible need for revision.[8,12] The present study focused on practical clinical processes that could potentially constitute a standardized perioperative protocol for revision TKA. An organized TJR-PSH may allow the health team to educate patients that LOS, rehabilitation and acute recovery, risk of acute (30-day) complications, and risk of readmission and return to the operating room within the first 30 days after surgery are similar for revision and primary TKAs, as long as proper preoperative optimization and education occur within the TJR-PSH.

Studies have found correlations between revision TKA and significantly increased LOS and postoperative complications.[20,21] In contrast, we found no significant difference in LOS between our primary and revision TKA groups. LOS was 2.6 days for primary TKA and 2.9 days for revision TKA—a significant improvement in care and cost for revision TKA patients. That the reduced mean LOS for revision TKA is similar to the mean LOS for primary TKA also implies a reduction in the higher cost of care in revision TKA.[20] In addition to obtaining similar LOS for primary and revision TKA, TJR-PSH achieved an overall reduction in LOS.[17,22]

Our results also showed no difference in discharge disposition between primary and revision TKA in our protocol. Discharge disposition also did not correlate with age, sex, BMI, ASA score, or CCI. In TJR-PSH, discharge planning starts before admission and is patient-oriented for optimal recovery. About 66% of primary TKA patients and 58% of revision TKA patients in our cohort were discharged home—implying we are able to send a majority of our postoperative patients home after a shorter hospital stay, while obtaining the same good outcomes. Discharging fewer revision TKA patients to extended-care facilities also indicates a possible reduction in the cost of postoperative care, bringing it in line with the cost in primary TKA. Early individualized discharge planning in TJA-PSH accounts for the similar outcomes in primary and revision TKAs.

There was no significant difference in 30-day readmission rates between our primary and revision TKA patients. An important component of the TJR-PSH pathway is the individualized postdischarge recovery plan, which helps with optimal recovery and reduces readmission rates. Our cohort's 30-day readmission rate was 0.4% for primary TKA and 4% for revision TKA ($P = .081$). Thirty-day readmission is a good indicator of postoperative complications and recovery from surgery. We have previously reported on primary TKA outcomes.[14,15,,18,22,23] In a study using an NSQIP (National Surgical Quality Improvement Program) database, 11,814 primary TKAs had a 30-day readmission rate of 4.2%.[18] In an outcomes study of 17,994 patients who underwent primary TKA in a

single fiscal year, the 30-day readmission rate was 5.9%.[9] In addition, in a single-institution cohort study of 1032 primary TKA patients, Schairer and colleagues[23] found a 30-day unplanned readmission rate of 3.4%. Compared with primary TKA, revision TKA traditionally has had a higher postoperative complication rate.[20,21] There is also concern that shorter hospital stays may indicate that significant complications of revision TKAs are being missed. In this study, however, we established that the equal outcomes obtained in the perioperative period carry over to the 30-day postoperative period in our revision TKA group. Good postoperative follow-up and planning are important factors in readmission reduction. Readmissions also have significant overall cost implications.[24]

There was no statistical difference in 30-day reoperation rates between our primary and revision TKA patients. The primary TKA patients had no 30-day reoperations. Previous studies have found reoperation rates ranging from 1.8% to 4.7%.[25,26] Revision TKA patients are up to 6 times more likely than primary TKA patients to require reoperation.[20] Our study found no significant difference in outcomes between primary and revision TKAs.

Comparison of the outcomes of primary TKA and revision TKA in TJR-PSH showed no difference in acute recovery from surgery. LOS and discharge disposition, 30-day readmission rate, and 30-day return to the operating room were the same for primary and revision TKAs. The morbidity gap between primary and revision TKA patients has been closed in our research cohort. This outcome is important, as indications for primary TKA continue to expand and more primary TKAs are performed in younger patients.[18,23] The implication is that, in the future, more knees will need to be revised as patients outlive their prostheses.

Our study had some limitations. First, it involved a small sample of patients, operated on by a single surgeon in a well-organized TJR-PSH at a large academic center. This population might not represent the US patient population, but that should not have adversely affected data analysis, because patients were compared with a similar population. Second, the data might be incomplete because some patients with complications might have sought care at other medical facilities, and we might not have been aware of these cases. Third, we focused on objective clinical outcomes in order to measure the success of TKAs. We did not include any subjective, patient-reported data, such as rehabilitation advances and functioning levels. Fourth, multiple parameters can be used to address complication outcomes, but we used LOS, discharge disposition, 30-day readmission rate, and 30-day reoperation rate because current payers and institutions often consider these variables when assessing quality of care. These parameters can be influenced by factors such as inpatient physical therapy goals, facility discharge practices, individual social support structure, and hospital pay-for-performance model. The implication is that different facilities have different outcomes in terms of LOS, discharge disposition, readmissions, and reoperations. However, we expect proportionate similarities in these parameters as patient perioperative outcomes become more complicated. Nevertheless, a multicenter study would be able to answer questions raised by this limitation. Fifth, our statistical analysis might have been affected by decreased power of some of the outcome variables.

TJR-PSH has succeeded in closing the perioperative morbidity and outcomes gap between primary and revision TKAs. Outcome parameters used to measure the success of TJR-PSH are standard measures of the immediate postoperative recovery and short-term outcomes of TKA patients. These measures are linked to complication rates and overall outcomes in many TKA studies.[14,15,17,19] Also important is that hospital costs can be drastically cut by reducing LOS, readmissions, and reoperations. Presence of any complication of primary or revision TKA raises the cost up to 34%. This increase can go as high as 64% in the 90 days after surgery.[27]

## Conclusion

The major challenge of the changing medical landscape is to integrate quality care and a continually improving healthcare system with the goal of cost-effective delivery of healthcare. Surgical care costs can be significantly increased by evitable hospital stays, complications that lead to readmissions, and unplanned returns to the operating room after index surgery. The new perioperative surgical home created for TJA has helped drastically reduce LOS, discharge disposition, 30-day readmission rate, and 30-day reoperation rate in revision TKA. This study demonstrates similar outcomes in our revision TKA patients relative to their primary TKA counterparts.

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*This paper will be judged for the Resident Writer's Award.*

## Appendix A. Clinical Pathway for the Perioperative Surgical Home

**Preoperative**
- Clinic visit 2 to 4 weeks before surgery
- Laboratory testing, ECG, MRSA screening
- Joint replacement education class, postoperative expectations management, discharge planning initiated
- Pain, surgical site infection, VTE management protocol:
  - Celecoxib 200 mg twice a day for 2 days before surgery date
  - Chlorhexidine showers for 3 nights before surgery date
  - Ferrous sulfate ($FeSO_4$) 325 mg/day for 2 to 3 weeks before surgery date
  - Multivitamin 1 tablet/day for 2 to 3 weeks before surgery date
  - Warfarin 5 mg

***Holding area***
- Initiate oral pain protocol
  - Acetaminophen 1000 mg orally
  - Oxycodone 10 mg (sustained-release) orally
  - Gabapentin 300 mg orally
  - Celecoxib 200 mg orally
- Initiate IV antibiotics within 1 hour before surgical start time
- Avoid IV benzodiazepines unless warranted
- Surgical site clipping and chlorhexidine wash in holding area

**Intraoperative**
- Spinal anesthetic is preferred; 0.75% bupivacaine 1.4 to 1.6 mL with fentanyl 20 µg with low-dose propofol IV infusion
- Goal-directed therapy fluid management with noninvasive monitoring of cardiac indices
- Upper body air warming device, fluid warmers
- Tranexamic acid 1 g before incision, 1 g after capsule closed or tourniquet released except if contraindicated
- Transfer to PACU
- Encourage oral fluids intake in PACU
- First physical therapy session, full weight-bearing, afternoon or evening of postoperative day 0

**Postoperative**

***Day 1***
- Physical therapy twice a day
- Occupational therapy session once a day
- Pain management protocol: oral NSAIDs, opioids, tramadol, gabapentin, and acetaminophen; IV narcotics *only* for breakthrough pain
- Antiemetic 3 times a day or as needed
- VTE prophylaxis with warfarin to target INR 1.8 to 2.3
- Normal diet
- Remove Foley catheter at 8:00 a.m.
- Discharge locations and plans initiated with family/caregiver
- Laboratory testing of CBC count, INR

***Day 2***
- Physical therapy twice a day
- Occupational therapy session once a day
- Pain management protocol: oral NSAIDs, opioids, tramadol, gabapentin, and acetaminophen; IV narcotics *only* for breakthrough pain
- Antiemetic 3 times a day or as needed
- VTE prophylaxis with warfarin to target INR 1.8 to 2.3
- Normal diet
- Discharge locations and plans finalized with family/caregiver
- Laboratory testing of CBC count, INR
- Avoid IV narcotics
- Discharge of select patients on day 2: finalize discharge plans; home exercise program, outpatient physical therapy, anticoagulation clinic follow-up, orthopedic clinic follow-up, option for telemedicine follow-up

***Day 3***
- Physical therapy session morning of discharge
- VTE prophylaxis with warfarin to target INR 1.8 to 2.3
- Finalize discharge plans; home exercise program, outpatient physical therapy, anticoagulation clinic follow-up, orthopedic clinic follow-up, option for telemedicine follow-up
- Patients and family verbalize wound care, DVT prophylaxis treatment, home exercise, and patient safety and review *Personal Recovery Pathway* brochure
- Review expectations, care, satisfaction
- Discharge

**Postdischarge**
- Anticoagulation clinic follow-up 1 day after discharge
- Orthopedic clinic follow-up 2 weeks after surgical date
- Nursing follow-up by phone 1 week after discharge

Abbreviations: CBC, complete blood cell; DVT, deep vein thrombosis; ECG, electrocardiogram; INR, international normalized ratio; IV, intravenous; MRSA, methicillin-resistant *Staphylococcus aureus*; NSAID, nonsteroidal anti-inflammatory drug; PACU, postanesthesia convalescent unit; VTE, venous thromboembolism.

Appendix B. **General Elements of Care of Perioperative Surgical Home**

| Phase | Element of Care | Perioperative Surgical Home |
|---|---|---|
| Preoperative | Patient education | Mandatory joint replacement education classes, written educational materials, mind/body classes for optimal perioperative healing |
| | Testing | Clinic visit with protocolized laboratory and ECG testing, MRSA swab, anemia management protocols |
| | NPO guidelines | NPO to solids after midnight and clear liquids up to 2 hours before arrival at hospital |
| | Standardized order sets | Standardized electronic order sets for VTE prophylaxis and preoperative initiation of multimodal pain regimen |
| | Discharge planning | DME purchase (and patient education), identification of postoperative caregiver, engagement of home health agencies |
| Intraoperative | Anesthesia | Standardized anesthesia protocols with spinal as preferred anesthetic |
| | Equipment, implants, prosthesis | Goal-directed therapy as standard for fluid management; standardized equipment per procedure cards, single vendor for most implants and prosthesis |
| | Pain regimen | Multimodal with intra-articular analgesia |
| Postoperative | Pain management | Standard postoperative multimodal pain management protocol, with emphasis on oral medication and avoidance of opiates |
| | Physical therapy | Early mobilization with full weight-bearing on day 2 |
| | Nutrition | Advance to normal diet |
| | Protocols for escalation of care | Decision tree for rapid escalation of care in the event of medical deterioration |
| Postdischarge | Recovery plan | Standardized personal recovery plan, including physical therapy, ambulation, anticoagulation management, and wound care |
| | Follow-up protocol | Follow-up includes telemedicine by surgeon, nurse navigator |
| Monitoring | Audit plan | Aggressive audit schedule for quality measures and adherence to care path |

Abbreviations: DME, durable medical equipment; ECG, electrocardiogram; MRSA, methicillin-resistant *Staphylococcus aureus;* NPO, nil per os (nothing by mouth); VTE, venous thromboembolism.