ORIGINAL ARTICLE

Nr 2022;12 (3):404-410

A Discussion on The Utility of Discharge Location Prediction Models for Total Joint Arthroplasty Surgery

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DOI:
10.32098/mltj.03.2022.16

LEVEL OF EVIDENCE: 4

SUMMARY

Objective. Total Joint Arthroplasty (TJA) remains one of the highest frequency elective surgical procedures. Medicare is expected to spend close to $ 50 Billion on TJAs by 2030. Predicting discharge location could allow for cost mitigation and the ability to set appropriate expectations for patients preoperatively. Our aim is to determine the validity of one predictive model. We hypothesize that this tool will demonstrate comparable predictive value as in the pilot study.
Methods. We conducted a cross-sectional study of unilateral, primary, total joint replacements from January 2020 through February 2021. Nine variables were input into a predictive model at https://dukeriskcalculators.shinyapps.io/Dispo/ and percent likelihood of discharge to SNF/rehabilitation facility was recorded and analyzed. Receiver operating characteristics curve (ROC) analysis was utilized to evaluate the model's predictive capability.
Results. Our cohort consisted of 264 patients. 9.1% of patients were discharged to an SNF/rehabilitation facility. ROC analysis demonstrated an area under the curve (AUC) of 0.72 indicating good predictive value. The mean percent likelihood of discharge to SNF/rehab was 31% ± 9% (mean ± 95% confidence interval) for patients whose final discharge location was an acute rehabilitation facility; The mean percent likelihood of discharge to SNF/rehab was 15% ± 2% for patients who were discharged home.
Conclusions. The predictive model analyzed uses nine easily accessible variables and demonstrates good predictive capability. Discharge to acute rehabilitation is a costly and often unnecessary intervention. Predictive models can reduce discharge to these facilities, reduce healthcare costs, and improve patient outcomes.

KEY WORDS

Joint replacement; arthroplasty; acute rehabilitation; skilled nursing facility; discharge location.

INTRODUCTION

Total Joint Arthroplasty (TJA) remains one of the highest frequency elective procedures in United States with estimates of over one-million joint replacement surgeries to be performed annually by 2030 (1). In 2014, total annual costs related to TJAs approached $7 billion (2), and Medicare is expected to spend closer to $ 50 Billion on TJAs by 2030 (3). To mitigate costs and improve quality, alternative payment models such as the Bundled Payments for Care Improvement Initiative (BPCI) and the Comprehensive Care for Joint Replacement (CJR) were established by the Centers for Medicare and Medicaid (CMS), the major contributor to TJA payments (4). Under these models, providers are either rewarded or penalized if costs of the index procedure through postoperative care deviate from a predetermined value (2). Promising results have led Medicare to adopt this relatively new payment method in place of the fee-for-service model (5). Evidence demonstrates cost, lengths of stay, and readmission rate improvements for TJA patients (5, 6). Moreover, patient outcomes are not negatively impacted by resource consumption reductions (7).

Our group has previously demonstrated that post-discharge costs are significantly higher for patients discharged to an acute rehabilitation center compared to those discharged home following TJA; yet, both cohorts have comparable short-term outcomes (8). Others show that skilled nursing and rehabilitation facilities (SNF/rehab) discharge is associated with significant complications and morbidity (9). Bozic and Ward *et al*. estimate that post discharge care can cost over one third of total costs in TJA (10). Likewise, Slover and Mullaly *et al*. demonstrate that extended acute hospital care is financially preferable to acute care discharge with no negative ramifications (11). Such evidence has led to successful reduction of SNF/rehab discharge, some demonstrating this to be the greatest single contributor to recent TJA cost reduction (12, 13). In attempt to further reduce discharge to acute rehabilitation facilities, several publications have proposed discharge location predication models (14, 15). Validation of these models are necessary because they allow providers to determine at-risk patients, direct their discharge location, and adjust their preoperative expectations (14). Ideally, modifiable risk factors can be addressed to improve their outcomes and lower total cost.

Goltz and Ryan *et al.* recently developed a predictive model which they describe as both convenient and highly accurate (16). Our aim is to determine the validity of this tool. We intend to determine if the tool is as predictive as in the initial study. We hypothesize that this tool will demonstrate comparable predictive value.

METHODS

Study protocol

The current study was conducted in accordance with the Declaration of Helsinki and institutional ethical standards. Institutional Review Board Policy and Procedure Committee (IRB) approval was obtained from the University of Miami Hospital (20210388 - Date of approval: May 2021). The study is an observational cross-sectional study and was completed in accordance with STROBE guidelines. Data was collected through a retrospective chart review. All collected information was deidentified. Patient consent was not required by our institutions IRB.

Setting and eligibility criteria

University of Miami Hospital electronic medical records were reviewed for information on TJA patients between January 2020 and February 2021. Patients were included if they were over the age of 18 and had undergone a primary, unilateral total joint replacement. Patients were excluded if their index procedure involved revision, bilateral, emergent, oncological, and partial joint replacement surgery. The final cohort of 264 patients included all patients meeting inclusion criteria with available data in the specified timeframe.

Data collection

Nine preoperative data points were collected through retrospective chart review. These included age, marital status, American Society of Anesthesiologists (ASA) score, body mass index (BMI), gender, neurologic disease status, electrolyte disorder status, paralysis status, and pulmonary circulation disease status. All quantitative variables were defined using the Elixhauser Comorbidity Index.

Each patient's data was entered into a discharge location prediction model at the following website https://dukerisk-calculators.shinyapps.io/Dispo/. Using these nine variables, the model determined a percent likelihood of discharge to an SNF/rehab facility with a 95% confidence interval. Patient's medical records were then reviewed for discharge location following TJA (home or acute rehabilitation). Variables of interest included predicted likelihood of discharge to acute rehabilitation and true discharge location. These data points were recorded and compared as described in the statistical analysis section.

Statistical analysis

Data was summarized using descriptive statistics for continuous and categorical variables. Inpatients were defined as a patient admitted to our orthopaedic unit from the Post-Anesthesia Care Unit (PACU).

Statistical analysis was completed in SPSS (27.0.1.0, 2020). A P-value of < 0.05 was used as a cut off for statistical significance.

The predictive accuracy of the model was assessed using a receiver operating characteristic curve (ROC) analysis. A ROC curve was created using predicted likelihood of discharge to acute rehabilitation and true discharge location. The final outcome measure of predictive accuracy was the area under the curve. An area under the curve of 0.7 or greater definied good predictive value (16). Data was also demonstrated through the use of a scatter plot.

RESULTS

Patient demographics

264 patients met inclusion criteria and were included in the final cohort. Patient demographics are presented in **table I**. Inpatients demographics are described in **table II**.

Results syntheses

ROC curve analysis demonstrated an AUC of 0.72 ($p < 0.05$), thus indicating good predictive value of the model (**figure 1**). Using Youden's method, the optimal cutoff off for sensitivity and specificity occurred at 10.9% (0.79 and 0.60, respectively). Stratified analysis for inpatients demonstrated an AUC of 0.75 ($p < 0.05$), indicating good predictive value.

The mean percent likelihood of discharge to SNF/rehab was 31% ± 9% (mean ± 95% confidence interval) for patients whose true discharge location was an acute rehabilitation facility; The mean percent likelihood of discharge to SNF/rehab was 15% ± 2% for patients who were discharged home (**figure 2**).

Table I. Descriptive summary of entire cohort.

Variable of Interest	N	Prevalence or mean
Cohort	264	
Discharged to SNF/rehab	24	9.1%
Inpatient	90	34.10%
Hips	135	51.10%
Gender (Female)	156	59.1%
Age		63.80
BMI		30.10
ASA (% 1/2/3/4)	(1/133/128/2)	2.49
Marital Status (single/divorced/widowed)	132	50.0%
Elixhauser Comorbidity Index		
other neurological disorders	11	4.2%
electrolyte disorder	1	0.4%
paralysis	2	0.8%
pulmonary circulation disease	0	0.0%

Table II. Descriptive summary of inpatients.

Variable of Interest	N	Prevalence or mean
Inpatients	90	
Discharged to SNF/rehab	16	17.8%
Hips	58	64.4%
Gender (Female)	53	58.9%
Age		68.00
BMI		29.70
ASA (% 1/2/3/4)	(0/40/49/1)	2.47
Marital Status (single/divorced/widowed)	43	47.8%
Elixhauser Comorbidity Index		
other neurological disorders	9	10.0%
electrolyte disorder	0	0.0%
paralysis	2	2.2%
pulmonary circulation disease	0	0.0%

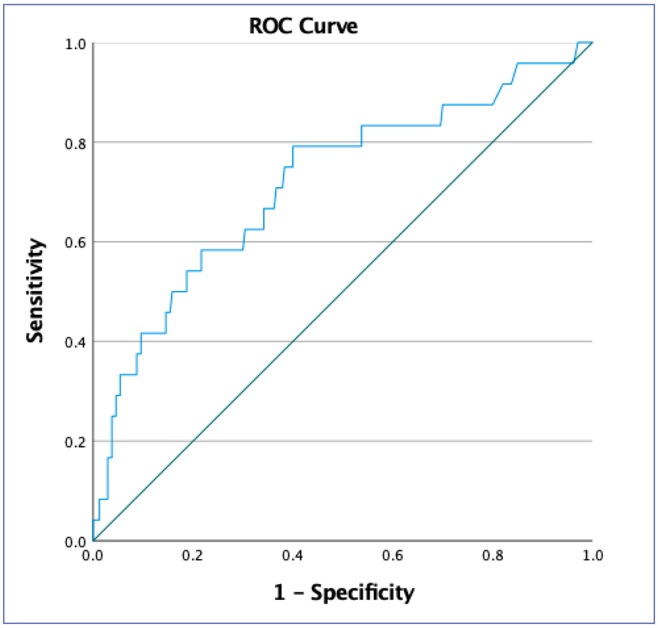

Figure 1. Entire cohort receiver operating characteristic curve analysis of Goltz and Ryan *et al.*'s calculator.

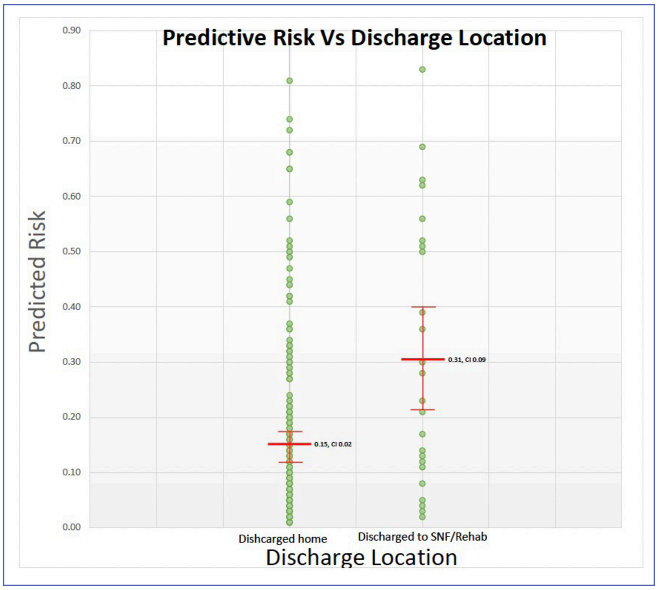

Figure 2. Scatter Plot of predicted risk *vs* discharge location.

DISCUSSION

Arthritis is one of the most common debilitating conditions in the United States (17). Joint replacement surgery is a cost-effective intervention for the disease, which restores patient function and quality of life (18). Unfortunately, patients often elect for surgical intervention late in the course of their disease, therefore mitigating the treatment's full potential (19). Delay is associated with poor baseline pain and function (19). These patients require extensive postoperative physical therapy and rehabilitation (19). Though most achieve adequate function, some will never achieve the maximal benefits of surgery. As a result, orthopaedic surgeons aim to optimize modifiable factors to ensure adequate outcomes.

Advances in surgical muscle sparing techniques and rapid recovery protocols have increased the effectiveness of arthroplasty surgeries (20, 21). Nowadays, patients can be discharged the same day as their surgery (22). Despite this progress, many patients have comorbidities, social issues, and medical conditions which require long inpatient stays and discharge to acute rehabilitation facilities (23). For this population, there has been an increased emphasis on advanced preoperative planning pathways and risk stratification (24, 25).

Predictive models are useful to practitioners in facilitating optimal patient recovery and in reducing care costs (26). For example, the well-studied RAPT score has demonstrated an ability to reduce hospital lengths of stay (27). Literature shows that patients' discharge preference has the strongest impact on discharge location and that lack of education influences these preferences (28). Preoperative risk assessment may allow surgeons to better counsel their patients regarding recovery expectation.

A recent model published in 2021 by Goltz and Ryan *et al.* sought to predict post-operative discharge location following TJA. Their model uses nine easily accessible variables and has demonstrated high predictive utility (16). Unlike other models, this model emphasizes objective preoperative variables to ensure its applicability in preoperative planning (16). Conversely, the 6-Clicks score requires a postoperative physical therapy assessment and the RAPT score entails collection of challenging variables (27, 29). Other models have proven less predictive under similar statistical analyses (14, 30). Though Goltz and Ryan *et al.*'s calculator seems promising, it has yet to be validated by an outside source. Our article adds to the literature by evaluating this recently published model for predictive accuracy and discussing its application into current practice.

Our data demonstrates that the predictive model developed by Goltz and Ryan *et al.* has "good" predictive value (AUC 0.72) (**figure 1**) (16). This finding indicates the model has enough predictive capability to be used in practice. Though encouraging, our findings are less impressive than in the pilot paper (16). The originally published paper found an AUC of 0.82 following the same methodology, thus indicating excellent predictive capability (16). However, given the simplicity of the calculator and easy accessibility of the data points, "good" may be sufficient from an effort *vs* benefit perspective. Furthermore, we have demonstrated promising results in an alternative manner. We found that patients who were discharged to an acute rehabilitation facility had a mean predicted percent of discharge to SNF/rehab of 31%, more than double when compared to patients who were discharged home (15%) (**figure 2**); the large dichotomy between the two groups supports this model's use in clinical practice. Upon subgroup ROC analysis, the model demonstrated better predictive capability for inpatients than for the complete cohort (AUC 0.75 *vs* AUC 0.72, respectively). Thus, practitioners may benefit from the model's use both preoperatively, as intended, and postoperatively when counselling patients on their discharge course. The model may also be beneficial in reducing global healthcare costs.

Given the growing financial burden associated with TJA, it is imperative to minimize costs without compromising patient care (1–3). In recent years, medical care has begun shifting from a fee-for-service model to alternative payment services (31). The initiative has demonstrated effective cost control and improved surgical outcomes (5, 6, 32–34). Under new payment plans, expensive discharge to post-acute care has been minimized without negatively affecting patient outcomes (10, 11). Factors, such as age, ASA score, and the presence of a Medicare Major Complications/ Comorbid Conditions (MCC) modifier are valuable predictors of cost. Some have suggested that bundled payment compensation should be adjusted upwards for high-risk individuals, though these implementations have yet to be incorporated (35). Predictive models which include such factors can help healthcare providers to optimize patients pre- and post-operatively to ultimately improve their chances of a successful and cost-effective recovery (36). Goltz and Ryan *et al.*'s model may provide the greatest benefit for the effort required to implement it (14, 15, 29, 36). Overall, we found this discharge calculator to have good predictive value in determining discharge location. While the calculator did not produce "excellent" predictive utility as in the pilot paper, this may be due to limitation within our study.

Notable limitations include our cohort's relatively small size of 264 patients. Using a larger population, such as that in Goltz and Ryan *et al*. (10, 15), could have produced stronger results (16). Additionally, we analyzed patients from January 2020-February 2021 during the COVID-19 pandemic, which may have contributed to a selection bias. During the early stages of the pandemic, many elective procedures were canceled, and orthopaedic surgeons transitioned to outpatient TJAs. Per International Census Group and Research Committee of the American Association of Hip and Knee Surgeons guidelines, it was recommended that elective surgeries be deferred for patients with significant comorbidities (37). Predictive models have been determined to be less useful for intermediate risk patients, which may have contributed to our lower AUC compared to the initial study. Our institution also had a relatively small number of patients discharged to SNF/rehab (9.1%) compared to Goltz and Ryan *et al*.'s 17.6%. This may indicate a positive trend of our institutions reduced discharge to acute rehabilitation brought on by the pandemic. Our study was completed retrospectively and in one facility, which decreases the generalizability of our findings. Lastly, with a retrospective chart review study there is an inability to determine the temporal relationship of data points. For example, a patient with a documented neurological disease may have been diagnosed after their TJA therefore inflating the predicted percent of discharge to an acute rehabilitation facility. However, this is unlikely as the data collection was completed within a few months of all index procedures. Future validation studies using a prospective cohort may result in more accurate findings.

Goltz and Ryan *et al.*'s model may provide an accurate way for orthopaedic surgeons to determine discharge location preoperatively. The models use in current practice could allow for cost mitigations associated with reduced discharge to acute rehabilitation as has been demonstrated in the literature. Additionally, patients would benefit from improved post-surgical outcomes. To fully validate this model, we recommend a prospective cohort be used; this would determine if the model is truly useful in real time.

CONCLUSIONS

In summary, our data showed Goltz and Ryan *et al*.'s predictive model has good predictive value (AUC 0.72). Our findings indicate better utility for inpatients (AUC 0.75). Given the model's easy use, predictive value, and potential for reducing costs and managing patient expectations, we advocate for its judicious implementation into current practice.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

All authors contributed equally to this work.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. Sloan M, Premkumar A, Sheth NP. Projected Volume of Primary Total Joint Arthroplasty in the U.S., 2014 to 2030. J Bone Joint Surg Am 2018;100:1455–60.
2. Rudy MD, Bentley J, Ahuja N, Rohatgi N. Determinants of Cost Variation in Total Hip and Knee Arthroplasty: Implications for Alternative Payment Models. J Am Acad Orthop Surg 2020;28:e245–54.
3. Wilson NA, Schneller ES, Montgomery K, Bozic KJ. Hip and knee implants: Current trends and policy considerations. Health Aff 2008;27:1587–98.
4. Lopez CD, Boddapati V, Neuwirth AL, Shah RP, Cooper HJ, Geller JA. Hospital and Surgeon Medicare Reimbursement Trends for Total Joint Arthroplasty. Arthroplast Today 2020;6:437–44.
5. Iorio R, Clair AJ, Inneh IA, Slover JD, Bosco JA, Zuckerman JD. Early Results of Medicare's Bundled Payment Initiative for a 90-Day Total Joint Arthroplasty Episode of Care. J Arthroplasty 2016;31:343–50.
6. Rondon AJ, Phillips JLH, Fillingham YA, Gorica Z, Austin MS, Courtney PM. Bundled Payments Are Effective in Reducing Costs Following Bilateral Total Joint Arthroplasty. J Arthroplasty 2019;34:1317–1321.e2.
7. Manickas-Hill O, Feeley T, Bozic KJ. A Review of Bundled Payments in Total Joint Replacement. JBJS Rev 2019;7:e1.
8. Lavernia CJ, D'Apuzzo MR, Hernandez VH, Lee DJ, Rossi MD. Postdischarge costs in arthroplasty surgery. J Arthroplasty J Arthroplasty 2006;21:144–50.
9. Owens JM, Callaghan JJ, Duchman KR, Bedard NA, Otero JE. Short-term Morbidity and Readmissions Increase With Skilled Nursing Facility Discharge After Total Joint Arthroplasty in a Medicare-Eligible and Skilled Nursing Facility–Eligible Patient Cohort. J Arthroplasty 2018;33:1343–7.
10. Bozic KJ, Ward L, Vail TP, Maze M. Bundled payments in total joint arthroplasty: Targeting opportunities for quality improvement and cost reduction knee. Clin Orthop Relat Res 2014;472:188–93.
11. Slover JD, Mullaly KA, Payne A, Iorio R, Bosco J. What is the Best Strategy to Minimize After-Care Costs for Total Joint Arthroplasty in a Bundled Payment Environment? J Arthroplasty 2016;31:2710–3.
12. Dummit LA, Kahvecioglu D, Marrufo G, *et al*. Association between hospital participation in a medicare bundled payment initiative and payments and quality outcomes for lower extremity joint replacement episodes. JAMA 2016;316:1267–78.
13. Finkelstein A, Ji Y, Mahoney N, Skinner J. Mandatory Medicare Bundled Payment Program for Lower Extremity Joint Replacement and Discharge to Institutional Postacute Care: Interim Analysis of the First Year of a 5-Year Randomized Trial. JAMA 2018;320(9):892–900.
14. Gholson JJ, Pugely AJ, Bedard NA, Duchman KR, Anthony CA, Callaghan JJ. Can We Predict Discharge Status After Total Joint Arthroplasty? A Calculator to Predict Home Discharge. J Arthroplasty 2016;31:2705–9.
15. Barsoum WK, Murray TG, Klika AK, *et al*. Predicting patient discharge disposition after total joint arthroplasty in the United States. J Arthroplasty 2010;25:885–92.
16. Goltz DE, Ryan SP, Attarian DE, Jiranek WA, Bolognesi MP, Seyler TM. A Preoperative Risk Prediction Tool for Discharge to a Skilled Nursing or Rehabilitation Facility After Total Joint Arthroplasty. J Arthroplasty 2021;36:1212–9.
17. Brooks PM. Impact of osteoarthritis on individuals and society: how much disability? Social consequences and health economic implications. Curr Opin Rheumatol Curr Opin Rheumatol 2002;14:573–7.
18. Ethgen O, Bruyère O, Richy F, Dardennes C, Reginster J-Y. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. J Bone Joint Surg Am 2004;86:963–74.
19. Fortin PR, Penrod JR, Clarke AE, *et al*. Timing of total joint replacement affects clinical outcomes among patients with osteoarthritis of the hip or knee. Arthritis Rheum 2002;46:3327–30.
20. Stambough JB, Nunley RM, Curry M, Steger-May K, Clohisy JC. Rapid Recovery Protocols for Primary Total Hip Arthroplasty Can Safely Reduce Length of Stay Without Increasing Readmissions. J Arthroplasty 2015;30:521–6.
21. Moskal JT, Capps SG, Scanelli JA. Anterior muscle sparing approach for total hip arthroplasty. World J Orthop 2013;4:12–8.
22. Scully RD, Kappa JE, Melvin JS. "Outpatient"-Same-calendar-day Discharge Hip and Knee Arthroplasty. J Am Acad Orthop Surg 2020;28:e900–9.
23. Fang C, Lim SJ, Tybor DJ, Martin J, Pevear ME, Smith EL. Factors Determining Home Versus Rehabilitation Discharge Following Primary Total Joint Arthroplasty for Patients Who Live Alone. Geriatrics (Basel) 2020;5:7.
24. Tanzer M, Makhdom AM. Preoperative Planning in Primary Total Knee Arthroplasty. J Am Acad Orthop Surg 2016;24:220–30.
25. Gronbeck C, Cote MP, Lieberman JR, Halawi MJ. Risk stratification in primary total joint arthroplasty: the current state of knowledge. Arthroplast today 2019;5:126–31.
26. Benedetti MG, Sarti D, Stagni SB, Mariani E. Setting, Clinical Pathways, Fast-Track and Rehabilitation Following Primary Knee Arthroplasty: A Literature Review. Open Rehabil J 2015;8:17–24.
27. Sconza C, Respizzi S, Grappiolo G, Monticone M. The Risk Assessment and Prediction Tool (RAPT) after Hip and Knee Replacement: A Systematic Review. Joints 2019;7:41–5.
28. Oldmeadow LB, McBurney H, Robertson VJ. Predicting risk of extended inpatient rehabilitation after hip or knee arthroplasty. J Arthroplasty J Arthroplasty; 2003;18:775–9.
29. Menendez ME, Schumacher CS, Ring D, Freiberg AA, Rubash HE, Kwon YM. Does "6-Clicks" Day 1 Postoperative Mobility Score Predict Discharge Disposition After Total Hip and Knee Arthroplasties? J Arthroplasty 2016;31:1916–20.
30. Sen RK, Kumar A, Tripathy SK, Aggarwal S, Khandelwal N, Manoharan SRR. Risk of postoperative venous thromboembolism in Indian patients sustaining pelvi-acetabular injury. Int Orthop 2011;35:1057–63.
31. Burwell SM. Setting Value-Based Payment Goals — HHS Efforts to Improve U.S. Health Care. N Engl J Med 2015;372:897–9.
32. Rana AJ, Bozic KJ. Bundled Payments in Orthopaedics. Clin Orthop Relat Res 2015;473:422–5.
33. Siddiqi A, White PB, Murphy W, Terry D, Murphy SB, Talmo CT. Cost Savings in a Surgeon-Directed BPCI Program for Total Joint Arthroplasty. Surg Technol Int 2018;33:319–25.

34. McAsey CJ, Johnson EM, Hopper RH, Engh CA. Bundled Payments for Care Improvement: Health System Experience With Lower Extremity Joint Replacement at Higher and Lower Volume Hospitals. J Arthroplasty 2019;34:2284–9.
35. Clement RC, Derman PB, Kheir MM, *et al*. Risk adjustment for medicare total knee arthroplasty bundled payments. Orthopedics 2016;39:e911–6.
36. Cizmic Z, Feng JE, Anoushiravani AA, Borzio RW, Schwarzkopf R, Slover JD. The Risk Assessment and Prediction Tool Is Less Accurate in Extended Length of Stay Patients Following Total Joint Arthroplasty. J Arthroplasty 2019;34:418–21.
37. Parvizi J, Gehrke T, Krueger CA, *et al*.; International Consensus Group (ICM) and Research Committee of the American Association of Hip and Knee Surgeons (AAHKS). Resuming Elective Orthopaedic Surgery During the COVID-19 Pandemic: Guidelines Developed by the International Consensus Group (ICM). J Bone Joint Surg Am 2020;102:1205–12.