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Original research

Adult Reconstruction Surgeons Manage Patients With Higher Medical Complexities and Still Achieve Comparable Outcomes to Sports Medicine Surgeons Following Total Knee Arthroplasty

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ABSTRACT

Background: Orthopaedic surgeons who are fellowship-trained in adult reconstruction (AR) specialize specifically in total joint arthroplasty, including total knee arthroplasty (TKA). However, TKA procedures are not only performed by AR surgeons. The purpose of this study was to compare the patient demographics and postoperative outcomes of patients who had a TKA procedure performed by an AR surgeon vs a sports medicine (SM) surgeon.

Methods: A retrospective cohort study was conducted using a national insurance database. Patients who underwent a primary elective TKA procedure by an AR surgeon (n = 56,570) and an SM surgeon (n = 72,888) were identified. Patient demographics, rates of joint complications within 2 years, and medical complications within 90 days postoperatively were compared using multivariable logistic regression.

Results: Compared to the cohort of patients undergoing TKA by SM surgeons, the patient cohort of AR surgeons had a higher mean Elixhauser comorbidity index (4.2 vs 4.0, $P < .001$), and had significantly higher rates of several comorbidities. Within 90 days, patients of AR surgeons demonstrated significantly lower rates of acute kidney injury and transfusions. When compared to patients of SM surgeons, patients of AR surgeons demonstrated significantly lower rate of manipulation under anesthesia or lysis of adhesions within 2 years. Rates of all other joint-related complications were statistically comparable between the 2 cohorts.

Conclusions: As a cohort, AR surgeons perform TKA on a higher-risk cohort of patients compared to sports medicine surgeons. Despite the higher-risk patient population, outcomes of TKA by AR surgeons appear equivalent compared to their SM colleagues.

Introduction

Total knee arthroplasty (TKA) is a highly successful and cost-effective treatment for end-stage osteoarthritis of the knee [1,2]. TKA is one of the most common orthopaedic procedures done in the United States, with the annual volume of projected to grow to 1.26 million by 2030 [3]. However, both medical and joint-related complications can occur following the procedure. Such medical complications include infection, deep vein thrombosis, pulmonary embolisms, and myocardial infarctions, among others [4]. Likewise, possible joint-related complications include stiffness, periprosthetic joint infections (PJI), prosthesis loosening and revisions [5]. One study evaluated outcomes of total hip arthroplasties performed by experienced orthopedic surgeons (>15 years) compared to those with fewer years in practice and found no difference in patient-reported outcome measures [6].

Orthopedic surgeons who are fellowship-trained in adult reconstruction (AR) specialize specifically in total joint arthroplasty, including TKA [7]. In 2018, 14.4% of orthopaedic surgeons considered their primary specialty to be total joint arthroplasty [8]. However, total knee arthroplasty procedures are not only performed by AR surgeons. Recent literature has demonstrated that sports medicine-trained (SM) surgeons also often perform AR

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cases, and those who are early in their career are likely to perform >40% of their cases outside of the sports medicine subspecialty [9]. As 18.2% of orthopaedic surgeons in 2018 stated that their primary specialty was sports medicine, many AR cases, such as TKA, are being performed by these specialists in the United States [8].

However, no literature has evaluated the difference in outcomes between fellowship-trained total joints surgeons, and sports medicine surgeons who are not focused primarily on AR. As such, the purpose of this study was to (1) compare the patient demographics of patients who had a TKA procedure performed by an AR a SM surgeon and (2) compare the postoperative medical and joint-related complications following TKA between the 2 surgeon groups. We hypothesized that fellowship trained joint surgeons would have more complicated patient demographics than their non−fellowship-trained colleagues and, as such, would have higher complication rates.

Material and methods

Data source and study design

Patient records were queried from the PearlDiver Mariner Database (PearlDiver Inc, Colorado Springs, CO), a commercially available administrative claims database which contains deidentified patient data from the inpatient and outpatient settings. The database contains the medical records of patients across the United States from 2010 through the third quarter of 2021 which are collected by an independent data abstractor. This study utilized the "M157Ortho" data set within PearlDiver, which contains a random sample of 157 million patients. All health insurance payors are represented including commercial, private, and government plans. Researchers extract data using Current Procedural Technology and International Classification of Diseases, Ninth and Tenth revision diagnosis and procedural codes. Institutional review board exemption was granted as provided data were deidentified and compliant with the Health Insurance Portability and Accountability Act. No outside funding was received for this study.

A retrospective cohort study was performed to compare the comorbidity profile and postoperative outcomes of patients who underwent a TKA procedure by an AR surgeon vs those who underwent a TKA procedure by a SM surgeon. SM surgeons were chosen for the comparison group instead of general orthopaedic surgeons due to the possibility that fellowship-trained AR surgeons who practice general orthopaedics could be in the general orthopaedic surgeon cohort in PearlDiver. Both SM and AR surgeon groups were defined by provider reported specialty on database claims. TKA was defined with Current Procedural Technology 27447 and associated International Classification of Diseases, Ninth and Tenth revision procedural codes. In order to include only primary TKA, patients with a record of prior unicompartmental knee arthroplasty, other knee reconstructive procedures, revision arthroplasty, or diagnosis codes reflecting the presence of an artificial knee joint before the index TKA were excluded. Patients with knee infections and distal femur and/or proximal tibia fractures at the time of the primary TKA were also excluded. In order to ensure that postoperative complications tied back to the index TKA, patients who underwent contralateral knee reconstruction procedures during the 2-year follow-up were excluded. To limit potential transfer bias, patients without continuous database enrollment for 3 months prior and 2 years following their TKA procedure were excluded.

Demographic data and clinical characteristics

Baseline demographic data for the 2 cohorts were obtained. Clinical characteristics queried included age, sex, Elixhauser comorbidity index [10], rates of obesity, diabetes, hypertension, chronic kidney disease, chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, rheumatoid arthritis, and osteoporosis.

Complications

Rates of medical complications within 90 days postoperatively were compared between the 2 cohorts. The medical complications queried included deep vein thrombosis, acute kidney injury, blood transfusion, myocardial infarction, wound disruption, and readmission.

Rates of joint-related complications within 2 years postoperatively were compared between the 2 cohorts. Specific complications queried included aseptic loosening, joint stiffness (defined by manipulation under anesthesia or lysis of adhesions), revision arthroplasty, and prosthetic joint infection (PJI). All-cause revision TKA included revision of the femoral and/or tibial components, implant removal, liner exchange, and insertion/removal of an antibiotic spacer. Knee PJI was defined as a 1-stage or 2-stage revision for PJI.

Statistical analysis

Statistical analyses were performed using R statistical software (version 4.1.0; R Project for Statistical Computing, Vienna, Austria) integrated within the PearlDiver software with an α level set to 0.05. Categorical variables were compared with a chi-square test and continuous variables were compared with Welch's t test or the Mann-Whitney U test. Rates of postoperative complications after primary TKA were compared using multivariable logistic regression with several controls. All demographic variables that were significantly different between each study cohort, as seen in Table 1, were controlled for in the appropriate regressions.

Results

Demographics

In the database, there were 2,170,280 patients who underwent TKA that were identified. Of these patients, 118,403 underwent a TKA by an AR surgeon and 144,474 underwent a TKA by an SM surgeon. After applying exclusion criteria, 56,570 patients who underwent a TKA by an AR surgeon and 72,888 patients who underwent a TKA by a SM surgeon were included in the final study. Compared to the cohort of patients undergoing TKA by SM surgeons, the patient cohort of AR surgeons had significantly higher percentage of female individuals, had a higher mean Elixhauser comorbidity index (4.2 vs 4.0, $P < .001$), and had significantly higher rates of comorbidities including obesity (53.6 vs 51.9% $P < .001$), diabetes (47.6 vs 46.4%, $P < .001$), congestive heart failure (9.4 vs 8.9%, $P = .012$), rheumatoid arthritis (7.2 vs 6.3%, $P < .001$), osteoporosis (35.2 vs 32.7%, $P < .001$), and preoperative opioid use within 90-days of surgery (3.1 vs 2.4%, $P < .001$). Patients of SM surgeons had significantly higher rates of with hypertension (85.7 vs 85.3%, $P < .001$) and chronic pulmonary obstructive disease (33.8 vs 32.8%, $P < .001$) than patients of AR surgeons.

Medical complications

When compared to patients of SM surgeons, patients of AR surgeons demonstrated significantly lower rates of acute kidney injury (2.15 vs 2.35%, odds ratio [OR] 0.91, 95% confidence interval [CI]: 0.85-0.99) and transfusions (3.09 vs 3.31%, OR 0.92, 95% CI: 0.87-0.98) following TKA (Table 2). The patients of AR surgeons

Table 1
Demographics of patients who underwent total knee arthroplasty by adult reconstruction surgeons and sports medicine surgeons.

Demographic	Adult reconstruction (n = 56,570)		Sports (n = 72,888)		
	n	%	n	%	*P*-value
Age (y), mean +SD	65.7 + 8.8	-	65.4 + 8.6	-	**<.001**
Women	35,562	62.9%	44,987	61.7%	**<.001**
ECI, mean +SD	4.2 + 3.0	-	4.0 + 2.9	-	**<.001**
Obesity	30,304	53.6%	37,817	51.9%	**<.001**
Diabetes	26,917	47.6%	33,837	46.4%	**<.001**
Hypertension	48,232	85.3%	62,462	85.7%	**.001**
COPD	18,558	32.8%	24,605	33.8%	**<.001**
Chronic kidney disease	11,471	20.3%	15,718	21.6%	**<.001**
Congestive heart failure	5291	9.4%	6522	8.9%	**.012**
Coronary artery disease	19,276	34.1%	24,755	34.0%	.679
Rheumatoid arthritis	4071	7.2%	4586	6.3%	**<.001**
Osteoporosis	19,904	35.2%	23,847	32.7%	**<.001**
Preoperative 90-d opioid use	1744	3.1%	1749	2.4%	**<.001**

Bold values indicate statistical significance.

were significantly more likely to have an inpatient readmission following TKA compared to patients of SM surgeons (5.11 vs 4.08%, OR 1.26, 95% CI: 1.19-1.33).

Joint complications

When compared to patients of SM surgeons, patients of AR surgeons demonstrated significantly lower rate of manipulation under anesthesia or lysis of adhesions within 2 years (3.88 vs 4.88%, OR 0.79, 95% CI: 0.75-0.84) (Table 3). Rates of all other joint-related complications were statistically comparable between the 2 cohorts.

Inpatient vs outpatient TKA trends

SM surgeons performed TKA in the outpatient setting at a significantly higher rate every year from 2010 to 2019 (all $P < .05$) (Fig. 1). In 2019 specifically, SM surgeons performed 34.4% of TKA procedures outpatient compared to 26.3% for AR surgeons.

Discussion

This study demonstrated that the cohort of patients operated on by AR surgeons had significantly higher rates of medical comorbidities than the cohort operated on by SM surgeons. Many of the comorbidities which were higher in the AR cohort have been demonstrated to be associated with worse outcomes following total joint arthroplasty [11-14]. A single institution study by Mahure et al [15] demonstrated that fellowship-trained AR surgeons were more likely to operate on older patients, but less likely to operate on smokers and those with a higher body mass index. While a study at the same institution by Singh et al [16] demonstrated no differences in terms of sex or body mass index, but again demonstrated AR surgeons operated on older patients and higher percentage nonsmokers. The results in this study may be explained by surgeon comfortability when performing a TKA on higher-risk patients, or referral patterns for higher complexity patients to AR surgeons. Podmore et al [17] demonstrated that patient comorbidities predominantly increased the risk of hospital readmissions and mortality following total hip and total knee arthroplasties. As these comorbidities may affect planning and outcomes of surgery, surgeon experience may also play a factor in patient selectivity. Yin et al [18] additionally demonstrated that fellowship training has a significantly higher impact than residency alone on specific field-related decision making. One study demonstrated that surgeons in AR fellowships recorded 1.7-2.0 times the amount of arthroplasty cases, of which the majority were TKA procedures, in their 1 year of fellowship compared to 5 years of residency [19]. As such, additional operative experience in TKA specifically may influence AR surgeon confidence in operating on higher acuity patients.

This study demonstrated that, despite AR surgeons operating on higher-risk patients with more comorbidities, other than rates of manipulation under anesthesia or lysis of adhesions, all other joint-related complications were equivalent between the SM and AR cohorts. Prior studies on this topic have not examined 2-year joint-related complications. However, Singh et al [16] demonstrated shorter surgical times and greater improvements in the Knee Injury and Osteoarthritis Outcome Score for Joint Replacement and the Veterans RAND-12 Physical and Mental components scores in their AR cohort compared to the non-AR cohort. The same study demonstrated no difference in all-cause 90-day revisions between the 2 cohorts [16]. In hip fracture patients treated with hemi or total hip arthroplasty, Deangelis et al. demonstrated equivalent rates of reoperations between AR and non-AR surgeons but lower rates of PJI in patients of AR surgeons [20]. In hip fracture patients treated

Table 2
Medical complications within 90-days in patients who underwent total knee arthroplasty by adult reconstruction surgeons vs sports medicine surgeons.

Medical complication	Adult recon (n = 56,570)		Sports (n = 72,888)		OR (95% CI) (Ref group: Adult recon)
	n	%	n	%	
DVT	294	0.52%	369	0.51%	0.94 (0.81-1.10)
AKI	1219	2.15%	1714	2.35%	**0.91 (0.85-0.99)**
Transfusion	1746	3.09%	2409	3.31%	**0.92 (0.87-0.98)**
MI	1349	2.38%	1724	2.37%	1.00 (0.93-1.08)
Wound disruption	443	0.78%	612	0.84%	0.92 (0.82-1.04)
Admit	2892	5.11%	2971	4.08%	**1.26 (1.19-1.33)**

AKI, acute kidney injury; DVT, deep vein thrombosis; CI, confidence interval; MI, myocardial infarction; OR, odds ratio.
Bolded *P* values indicate significant results.

Table 3
Joint-related complications within 2 years in patients who underwent total knee arthroplasty by adult reconstruction surgeons vs sports medicine surgeons.

Joint-related complication	Adult recon (n = 56,570)		Sports (n = 72,888)		OR (95% CI) (ref group: Adult recon)
	n	%	n	%	
Loosening	274	0.48%	388	0.53%	0.92 (0.79-1.08)
Stiffness	2196	3.88%	3557	4.88%	**0.79 (0.75-0.84)**
PJI	467	0.83%	606	0.83%	1.00 (0.89-1.13)
Revision	1019	1.80%	1328	1.82%	1.00 (0.92-1.09)

CI, confidence interval; OR, odds ratio; PJI, periprosthetic joint infection.
Bolded *P* values indicate significant results.

with hemiarthroplasty, Mabry et al demonstrated AR surgeons had a lower 90-day and 1-year total surgical complication risk compared to general orthopaedists [21].

This study demonstrated that TKA patients operated on by AR surgeons had significantly lower-risk of acute kidney injury and transfusions within 90 days postoperatively, but higher-risk of being readmitted to the hospital when compared to patients of SM surgeons. Prior literature is mixed on medical outcomes when comparing patients of orthopaedic surgeons of different subspecialties undergoing the same procedure. Specifically, studies have demonstrated fellowship-trained AR surgeons had fewer postoperative medical complications compared to general and trauma trained orthopaedic surgeons when performing a hip hemiarthroplasty for hip fracture [21]. Additionally, multiple studies have demonstrated that AR surgeons had shorter TKA surgical time than non-AR surgeons and longer operative time has been associated with worse outcomes [15,16,22-25]. Furthermore, Singh et al [16] demonstrated no difference in 90-day all-cause readmissions, emergency department visits, or length of stay between patients of AR surgeons vs non-AR surgeons. Considering the greater number of comorbidities in the AR cohort in this study, it is surprising that the rates of medical complications, such as acute kidney injury and transfusions were lower than the SM cohort. However, patients of AR surgeons were also more likely to require readmission within 90 days. One possible explanation for this is the higher comorbidity burden in the AR cohort.

This study demonstrated that SM surgeons performed more outpatient TKAs than AR surgeons at all timepoints from 2010 to 2019. The primary cause of the inflection point observed in both the AR and SM cohort in this study was secondary to TKA being removed in 2018 from the inpatient-only list for Medicare beneficiaries and then being added to the ambulatory surgery centered covered procedures list [26]. By 2019, SM surgeons were performing 34.4% of TKA procedures outpatient compared to 26.3% for AR surgeons, a difference of 31%. Outcomes of outpatient total joint arthroplasty have been demonstrated to be equivalent in select patients [27-29]. However, not all patients are appropriate for outpatient TKA. Older patients, those with high ASA classification, multiple or poorly controlled comorbidities, chronic opioid consumption, or high body mass index are not considered appropriate [30]. As this study showed, the AR cohort had a higher comorbidity burden on average which may explain the lower rate of outpatient surgery in the AR cohort.

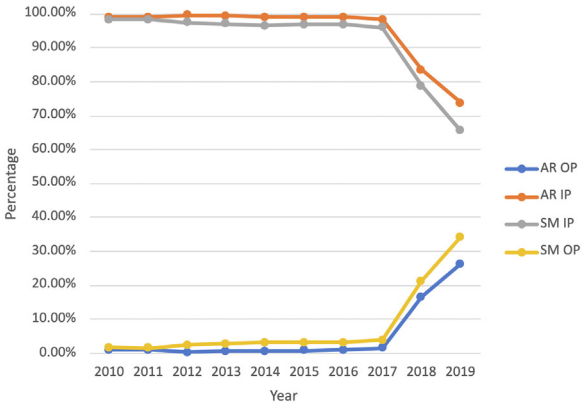

Figure 1. Percentage of inpatient vs outpatient TKA for adult reconstruction vs sports medicine surgeons from 2010 to 2019. TKA, total knee arthroplasty.

Limitations

There are several limitations to this study. First, by only evaluating complications within 2 years, this analysis is limited to short-term outcomes. Second, the possibility of coding errors is inherent with any analysis of administrative claims data. However, such instances are rare and made up only 0.7% of Medicare and Medicaid payments in 2021 [31]. Another coding-related limitation is that it is possible surgeons were improperly assigned to AR vs sports medicine by insurers. The subspecialty designation is given to the PearlDiver database by the insurers and the database does not audit this information for accuracy. Beyond this, there is additional uncertainty whether the AR cohort consisted only of fellowship-trained AR surgeons or included surgeons without an AR fellowship that primarily do AR. It is possible surgeons who have done a fellowship in both AR and SM were included in the SM cohort.

Conclusions

As a cohort, AR surgeons perform TKA on a higher-risk group of patients compared to SM surgeons. However, despite operating on a higher-risk patient population, both medical and joint-related outcomes in patients following TKA by AR surgeons are equivalent to their SM colleagues with a lower rate of manipulation under anesthesia or lysis of adhesions, lower rate of acute kidney injury, and lower rate of transfusion.

Conflicts of interest

Dr. William F. Sherman, MD, is a paid consultant for Stryker, an editorial board member for *Arthroplasty Today* and is an American Academy of Orthopaedic Surgery knee committee member.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101287.

CRediT authorship contribution statement

Lacee K. Collins: Data curation, Formal analysis, Methodology, Writing – original draft. **Julianna E. Winter:** Writing – original draft, Writing – review & editing. **Bela P. Delvadia:** Writing – original draft, Writing – review & editing. **Matthew W. Cole:** Data curation, Formal analysis, Methodology, Writing – original draft,

Writing – review & editing. **William F. Sherman:** Conceptualization, Writing – review & editing.

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