

Research Article

Evaluating the Baseline Risk Factors and Post-operative Outcomes of Patients Internally Referred to a Subspecialist Surgeon for Total Knee Arthroplasty: A Pilot Study

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INTRODUCTION

Orthopaedic surgeons who perform primary total knee arthroplasty (TKA) may often refer more complex patients to specialty-trained arthroplasty surgeons for definitive treatment. While this practice is often appropriate for optimal patient care, these internal referrals may represent a population that is associated with higher baseline risk and worse outcomes. This study aims to identify the risk factors and outcomes associated with primary TKA patients who are referred to subspecialists.

METHODS

This is an IRB-approved retrospective cohort study of all patients who underwent primary elective total knee arthroplasty by a fellowship trained adult reconstruction surgeon from 2020-2022 in a high-volume tertiary referral urban orthopaedic hospital. Internal referrals were defined as patients referred from same practice surgeons who perform primary TKAs to the subspecialist surgeon. Controls were patients who came to the subspecialist surgeon independently or from referral by a physician who does not perform TKAs.

RESULTS

The internal referral group had a significantly higher rate of chronic kidney disease requiring hemodialysis (1.7% vs. 0%, $p = 0.02$). However, other preoperative risk factors including type 1 diabetes, osteoporosis, and retained knee hardware failed to meet statistical significance. Post-operatively, unscheduled clinic visits and office contacts were also not found to be statistically significant. However, internal referrals experienced higher 90-day knee-related readmissions (19.2% vs. 10.6%, $p = 0.02$), reoperations (22.5% vs. 14.7%, $p = 0.04$), and manipulations under anesthesia due to stiffness (15% vs. 9.1%, $p = 0.04$).

CONCLUSION

While the results of this study indicate that internally referred patients undergoing primary TKA do not have a more complex preoperative risk profile, they may experience higher rates of certain adverse postoperative outcomes compared to their control counterparts. This study can serve as a pilot for future studies that are better powered or designed to detect a difference among internal referrals and further support these findings.

INTRODUCTION

Total knee arthroplasty (TKA) is the most common inpatient surgery performed on Medicare beneficiaries, with

over 700,000 performed annually at a cost exceeding \$12 billion in the United States (Molloy et al. 2017; Porter et al. 2025). Given its prevalence and economic impact, TKA is a common target for quality improvement and cost reduction efforts from policymakers and payers (Schwartz et al. 2019).

tional meetings. She could not do this without the support of her family, her husband Jeff and daughter Annalise and her parents, the late John W. Metcalf MD and her mom, Theresa Metcalf. Her favorite role is "soccer mom" to her daughter playing Division I soccer after an ACL reconstruction.

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Specifically, the Affordable Care Act implemented 90-day bundled payments for TKA reimbursement, and as a result, readmissions within 90 days of surgery has become a widely accepted quality metric. At many institutions, including our own, quality metrics like this are tied to surgeon compensation and insurance network status.

While intended to improve outcomes and reduce costs, these metrics often lack adequate adjustment for baseline patient risk. Medical comorbidities such as obesity, heart failure, and anticoagulation therapy, as well as surgical complexities such as prior hardware and surgeries are known to be associated with poorer outcomes following TKA, yet these risks are not fully captured in current quality measures (De Mauro et al. 2025; Mahajan et al. 2021; Ricciardi et al. 2017; Rhee et al. 2018). As a result, surgeons who accept more complex or higher-risk patients may be penalized, while those who avoid such cases may be rewarded. This creates incentives for patient deselection, as these high-risk TKA cases are frequently referred internally from less specialized orthopaedic surgeons to fellowship-trained adult reconstruction surgeons who may be willing or obligated to accept them.

The purpose of this study was to identify the risk factors and outcomes associated with primary TKA patients who were referred to a fellowship-trained adult reconstruction surgeon by other surgeons who also perform TKAs. We hypothesized that internally referred patients would have a higher burden of baseline risk factors and, consequently, worse outcomes than their control counterparts.

MATERIALS AND METHODS

This retrospective cohort study was conducted at a high-volume, urban tertiary orthopaedic hospital and received institutional review board approval through our hospital. There were 626 patients who underwent primary, elective TKA by a single fellowship-trained adult reconstruction surgeon between 2020 and 2022. Patients were excluded if they had a history of ipsilateral or contralateral TKA or underwent simultaneous bilateral TKA. After exclusions, 461 patients met criteria. Patients were categorized into two cohorts based on referral source. The internal referral group comprised of individuals with documented prior evaluation for knee osteoarthritis by another orthopaedic surgeon who performs primary TKAs. The control group included patients who either independently sought care or were referred by a physician not performing TKAs. Referral source was verified through manual review of clinic notes and the electronic medical record.

Baseline demographic variables collected included age, sex, race, ethnicity, body mass index (BMI), living status, smoking status, alcohol use, and illicit drug use. Comorbidities included coronary artery disease, heart failure, hypertension, type 1 or type 2 diabetes, osteoporosis, chronic kidney disease requiring hemodialysis, chronic obstructive pulmonary disease, Charlson Comorbidity Index (CCI) score, and anticoagulant use, including direct oral anticoagulants (DOACs) and other agents. Surgical history vari-

ables included prior knee surgery and retained hardware in the operative knee.

Postoperative outcomes assessed included hospital length of stay, discharge disposition, number of unscheduled clinic visits, total clinic visits within 90 days, patient-initiated contacts, telecommunication encounters, and opioid prescription refills. Surgical complications included venous thromboembolism, superficial infection, deep infection, implant loosening, and revision surgery. All-cause and knee-related emergency department visits, hospital readmissions, and reoperations within 90 days were recorded. For patients undergoing reoperation, the type of procedure (manipulation under anesthesia, irrigation and debridement, open reduction and internal fixation, revision arthroplasty) and indication were documented.

DATA COLLECTION AND ANALYSES

Comprehensive baseline risk factors and postoperative outcomes were manually abstracted from the EMR and entered into a secure database. Comparative statistical analysis between the two groups was conducted using independent t-tests for continuous level data and Mann-Whitney non-parametric tests for ordinal level data. Chi square statistics including risk assessed using odds ratios with confidence intervals were used for nominal data. The statistical significance was defined at $p < 0.05$.

RESULTS

BASELINE RISK FACTORS

Of 461 patients, 120 were in the internal referral group and 341 in the control group. [Table 1](#) shows the baseline demographics and risk factors of the two groups. Of note, the internal referral group had a significantly higher prevalence of male patients, and the ethnicity distribution was found to be significant for more Hispanic patients in the control group. Racial and ethnic compositions as well as age and BMI were similar between the two groups. Most patients lived independently preoperatively in both groups. Social risk factors including smoking status, alcohol use and drug use were also similar between the groups. Several comorbidities associated with increased risk in TKA, including coronary artery disease, heart failure, hypertension, and type II diabetes had no meaningful differences in prevalence between the two groups. Additionally, overall medical complexity indicated by the Charlson Comorbidity Index (CCI) was not different between the two groups. The only risk factor that was statistically more prevalent in the internal referrals group was chronic kidney disease patients on hemodialysis. However, several other notable risk factors including type I diabetes, osteoporosis, anticoagulant use, discharge to rehab, prior knee surgery, and retained hardware were notably more prevalent in the internal referrals group, though they did not reach statistical significance ([Table 2](#)).

Table 1. Patient Demographics of the Control and Internal Referral Population

	Controls		Internal Referrals		
	Total	Percentage	Total	Percentage	P Value
Overall	341	-	120	-	
Sex					0.01
Male	137	40.2	64	53.3	
Female	204	59.8	56	46.7	
Race*					0.77
White	213	62.5	77	64.2	
Asian	4	1.2	1	0.8	
Black	106	31.1	39	32.5	
Other	17	5.0	3	2.5	
Ethnicity*					0.03
Non-hispanic	313	91.8	117	97.5	
Hispanic	23	6.7	3	2.5	
Other	5	1.5	0	0.0	

Chi square, *Mann-Whitney, p <0.05

Table 2. Baseline Risk of the Control and Internal Referral Populations

	Controls		Internal Referrals			
	Total	Percentage	Total	Percentage	Odds Ratio (95% CI)	p Value
BMI by Category*						0.90
18.5 – 24.9	18	5.3	6	5.0		
25 – 29.9	87	25.5	29	24.0		
30 – 39	203	59.5	76	62.5		
>40	33	9.7	10	8.3		
Living Independently	337	98.8	120	100.0	0.74 (0.70 – 0.78)	0.30
Smoking Status*						0.79
Never	208	61.0	75	62.5		
Former	121	35.5	42	35.5		
Current	12	3.5	3	2.5		
Alcohol Use	185	54.3	57	47.3	0.76 (0.50 – 1.16)	0.20
Drug Use	16	4.7	7	5.8	1.25 (0.50 – 3.11)	0.64
Coronary Artery Disease	23	6.7	8	6.7	0.98 (0.43 – 2.25)	0.96
Heart Failure	17	5.0	4	3.3	0.65 (0.22 – 1.98)	0.45
Hypertension	193	56.6	71	59.2	1.10 (0.72 – 1.66)	0.69
Diabetes Mellitus, type 1	1	0.3	2	1.7	0.78 (0.51 – 63.59)	0.11
Diabetes Mellitus, type 2	69	20.2	29	24.2	1.24 (0.76 – 2.04)	0.39
Taking DOAC	19	5.6	11	9.2	1.70 (0.78 – 3.67)	0.18
Taking other anticoagulant	7	2.1	3	2.5	1.21 (0.31 – 4.77)	0.78
COPD	16	4.3	5	5.0	1.18 (0.49 – 2.86)	0.81
On Hemodialysis***	0	0.0	2	1.7	0.26 (0.22 – 0.30)	0.02
Prior Knee Surgery	116	34.0	49	40.8	1.32 (0.86 – 2.02)	0.20
Retained Hardware	29	8.5	14	11.7	1.42 (0.72 – 2.79)	0.31
Discharged to Rehab	9	2.6	5	4.1	1.59 (0.52 – 4.84)	0.41
	Average	Standard Deviation	Average	Standard Deviation		p value
Age at Date of Surgery**	60.4	10.5	58.6	10.7	-	0.12
BMI**	32.5	5.3	32.4	4.8	-	0.77
Charlson Comorbidity Index**	2.3	3.3	2.1	1.6	-	0.48

All Chi Square, p<0.05 except those with *non-parametric Mann Whitney test, p<0.05, **Independent t test, ***Odds Ratio reported in inverse

Table 3. Comparison of Post-operative Resource Utilization Outcomes between Control and Internal Referral Populations

	Controls		Internal Referrals		Odds Ratio (95% CI)	p Value
	Mean	Standard Deviation	Mean	Standard Deviation		
Length of Stay (days)	1.1	1.4	1.3	2.0		0.47
Post-op Clinic Utilization						
Unscheduled clinic visits	0.8	1.3	1.0	1.6		0.14
Clinic visits within 90 days of surgery	1.7	1.0	1.8	1.3		0.18
Post-op Office Communication						
Unscheduled contacts	4.0	4.2	4.5	4.2		0.23
Post-op Tele-communications <90 days from surgery	5.5	4.1	6.1	5.5		0.18
Opioid Refills	2.6	3.3	2.8	3.5		0.53

Independent t tests

RESOURCE UTILIZATION OUTCOMES

The resource utilization outcomes between the groups are shown in [Table 3](#). No resource utilization outcomes met statistical significance between the internal referrals and controls. Hospital length of stay and opioid refills were comparable between groups. Unplanned clinic visits and post-op telecommunications within 90 days, as well as total clinic visits and total patient-initiated office contacts were slightly increased in the internal referrals population, though not statistically significant.

POSTOPERATIVE COMPLICATIONS

As shown in [Table 4](#), there were no differences in venous thromboembolism, superficial infections, deep infections, or emergency department utilization between groups. However, the 90-day readmission rate was significantly higher in the internal referral group (19.2% vs. 10.6%, $p = 0.02$), and the total reoperation rate on the surgical knee was more frequent in the internal referral group (22.5% vs. 14.7%, $p = 0.04$). This difference was largely due to increased rates of manipulations under anesthesia and irrigation and debridement procedures in the internal referrals group. Open reduction internal fixation and revision arthroplasty as a cause for reoperation were comparable between groups. Pain was the primary indication for reoperation in both groups. Revision surgery rates and implant loosening were comparable between groups. All-cause mortality higher in the internal referrals group but not statistically significant.

DISCUSSION

This study yields a mixed conclusion to the common observation among fellowship-trained joint reconstruction surgeons that internally referred patients often represent a more complex population to manage. While the internally referred patients appeared to experience poorer outcomes in some areas after surgery, the study did not consistently identify a significantly higher baseline comorbidity burden to fully account for these findings. While reason for referral

was not able to be collected in this study due to inadequate referring provider documentation, these reasons may have some correlation with the observed mixed results. However, regardless of the source of these possibly increased adverse outcomes in the internal referrals group, the findings of this exploratory study introduce the potential unintended consequences of quality measurement within an increasingly value-based healthcare system. Current policies that do not account for referral-related case complexity may inadvertently disadvantage both patients by limiting access to appropriately specialized care, and the subspecialist surgeons best equipped to manage these cases, by negatively influencing reported outcomes and payer participation.

While the increased rate of adverse postoperative outcomes was not overwhelming, the presence of significantly different outcomes and the absence of statistically significant baseline risk differences raises important questions. First, our study may simply not have detected a statistically significant difference in preoperative risk factors among the groups because, as a newer surgeon, the control group may have itself represented a higher baseline risk than the typical established surgeon performing primary TKA (Penn LDI 2019). Indeed, many of the patients from our control group could have been referred from the emergency room or other potentially high-risk sources. Future studies could use the primary TKAs that were performed by the referring providers, as this would truly represent the control group (i.e. patients that were not deselected by referring surgeons who perform TKA). Unfortunately, this data was not available for this study. Secondly, if internal referrals do not reflect a substantially higher measured comorbidity burden as the results suggest, alternative contributors to adverse outcomes should be considered. Potentially relevant risk factors not explored in this study such as psychiatric comorbidities, specific type of prior knee surgery, or unmeasured functional or social drivers of health may better explain these findings. It is also possible that this study was sufficiently powered to detect differences in postoperative outcomes but underpowered to identify differences in less prevalent comorbidities. Several risk factors, including osteopenia, type 1 diabetes, prior surgery, and retained hardware, were more common among internally referred

Table 4. Comparison of Post-operative Complication Outcomes between Controls and Internal Referral Populations

	Controls		Internal Referrals		Odds Ratio (95% CI)	p Value
	Total	Percentage	Total	Percentage		
DVT/PE	5	1.5	0	0.0	0.74 (0.70 – 0.77)	0.18
Infection						
Superficial	7	2.1	5	4.1	2.06 (0.64 – 6.61)	0.21
Deep	8	2.3	4	3.3	1.42 (0.42 – 4.81)	0.57
Emergency Room Utilization within 90 days						
At least 1 ER visit	53	15.5	16	13.3	0.81 (0.44 – 1.47)	0.49
Related to knee	23	6.7	6	5.0	0.78 (0.25 – 2.47)	0.68
Unrelated to knee	30	8.8	10	8.3	0.77 (0.57 – 1.07)	0.52
Readmissions within 90 days						
Overall	54	15.9	30	25.0		0.68
Related to knee	36	10.6	23	19.2		0.02
Unrelated to knee	18	5.3	7	5.8		0.83
Reoperation within 90 days*						0.04
Overall	50	14.7	27	22.5		
MUA	31	9.1	18	15.0		
I&D	1	0.3	3	2.5		
ORIF	1	0.3	0	0.0		
Revision	15	4.4	5	4.2		
Other	2	0.6	1	0.8		
Reason for Reoperation within 90 days*						0.04
Pain	3	0.9	1	0.8		-
Stiffness	30	8.8	18	15.0		-
Loosening	8	2.3	3	2.5		-
Infection	7	2.1	4	3.3		-
Fracture	2	0.6	1	0.8		-
Other	0	0.0	0	0.0		-
Patients with at least 1 revision (Total)	16	4.7	8	6.7	1.44 (0.60 – 3.45)	0.41
Implant Loosening (Total)	7	2.1	4	3.3	1.63 (0.47 – 5.67)	0.44
Death	10	2.9	5	4.2	1.43 (0.48 – 4.26)	0.52

All Chi Square, except those with *non-parametric Mann Whitney test, p<0.05

patients and may reach statistical significance in larger cohorts. Similarly, although postoperative resource utilization did not differ significantly, these measures were consistently more frequent in the internally referred group and may represent clinically meaningful differences not detectable in a smaller sample. Even in the absence of statistically higher baseline risk, the outcome disparities found in this exploratory study demonstrate one example of referral patterns that may be disproportionately penalizing subspecialized surgeons for accepting internally referred patients under current value-based frameworks. Although these findings represent one referral ecosystem and are not sufficient for nationwide generalizability, they may generate further hypotheses about the instances of these patterns on a broader level.

Only two prior studies have specifically examined referral bias in primary TKA. Both used travel distance as a proxy for case complexity. Bergen et al. found higher complication and revision rates among patients traveling >75 miles for arthroplasty, presumably having been deselected by surgeons closer to their home (Bergen et al. 2021). This study similarly failed to show statistically significant preoperative risk factors and comorbidities associated with long distance patients, possibly due to confounding from healthier patients self-referring for specialized care. Kremers et al. alternatively reported that distant referrals to their tertiary

healthcare facility had higher rates of prior surgery and retained hardware compared to more local patients, indicating a higher baseline risk profile which differed from the findings in our study (Maradit Kremers et al. 2017). However, the only adverse outcomes that the more distant referrals experienced were longer operative times, and the authors were not able to demonstrate other statistically significant negative outcomes.

Broader registry and referral studies indicate the necessity for further studies in this area to demonstrate elevated baseline risk in the referral population. One study of the American Joint Registry found that most patients who required revision after primary TKA migrated to a tertiary, academic hospital for their revision TKA (Lawson et al. 2021). The effect of this referral bias leads to a higher prevalence of more medically complex patients in tertiary and large teaching hospitals (Lawson et al. 2021). Another study that investigated the baseline risk characteristics of TKA patients found that high volume TKA centers have a higher percentage of high risk patients than centers that do a medium or low volume of TKAs (Anis et al. 2020). The study also found that patients with a Charlson Comorbidity Index of over 4 are more likely to be treated at a high volume center (Anis et al. 2020). While we did not investigate the outcomes of revisions between controls and internally referred patients, revision TKA referral patterns are likely

to mirror internal referral patterns. Our results did not consistently indicate a statistically significant increase in medical complexity among the internally referred population, though further research with larger sample sizes is needed to explore this further.

Outside of the orthopaedic literature, multiple studies have examined the relationship between high complexity referrals and other patient demographics and outcomes. In the critical care setting, referral patients demonstrated higher rates of comorbidities and higher mortality rates (Seferian et al. 2008; Laupland et al. 2022). Other studies have demonstrated higher complexity and worse outcomes among distant referral patients compared to local patients for hysterectomies, pancreatic, and colorectal surgeries (Heisler et al. 2010; Jackson et al. 2014; 2013). Similar trends were noted in patients undergoing coronary bypass graft operations, as patients with increased travel distance for surgery tended to be riskier and experienced an increased rate of serious adverse events (Etzioni et al. 2015; Chou et al. 2014). While our findings, though based on internal referrals rather than geographic proxies, do not align with the pre-operative complexity patterns, they do indicate poorer outcomes among referred patients.

This study has notable strengths, including detailed pre-operative risk factor assessment, outcome analysis, and evaluation of outpatient care burden. Importantly, it is the first study to directly examine internal referrals for primary TKA rather than using distance or tertiary referral center status as surrogates. The main weakness of this study is the relatively small sample size, which may have limited the ability to detect differences across several clinically relevant variables. Another significant weakness of our study was the single surgeon design. While the internally referred patients were sourced by 10 different local surgeons who lacked subspecialty training in adult reconstruction, we evaluated a single fellowship trained surgeon who received these referrals. The single surgeon profile limits external validity, but unfortunately, we did not have a way to identify the internal referral patients made to the only other subspecialty arthroplasty surgeon in the group. However, as the more junior surgeon in the group, the included arthroplasty surgeon was the likely recipient of most high-risk internal referrals, so this population was likely adequately represented.

Additionally, no patient-reported outcome measures (PROMs) were reported in this study which may have more adequately described the internal referrals population. We initially aimed to include these measures, but they were unable to be consistently collected in retrospective chart review, so they were omitted from analysis. Finally, “reason for referral” was unfortunately not able to be captured during retrospective chart review due to inconsistency of referring providers including this information in their documentation. However, since all potential referring providers practiced within the same tertiary health system, insurance, logistical, or geographic variables are unlikely to contribute to the reasons for internal referral. Because of the relative control for these variables, the remaining reasons for internal referral are primarily clinical in origin, though these reasons for referral should be more explicitly studied in future studies to determine how they correlate to post-operative outcomes. While the above factors limit generalizability of these findings, we feel that this paper has meaningful strengths that make it an intriguing exploratory study in an understudied but commonly encountered area of orthopedic practice.

CONCLUSIONS

In conclusion, our study demonstrated that internally referred patients for primary TKA had largely comparable pre-operative risk profiles yet may experience elevated rates of adverse outcomes compared to other patients. This topic remains important to explore in an increasingly value-based landscape where providers are evaluated on outcomes. This pilot study aims to inform future, larger multi-cohort analyses that may more definitively characterize differences in preoperative risk factors among internally referred populations, evaluate specific clinical indications for referral, incorporate PROMs, and more robustly assess the association between internal referral status and adverse postoperative outcomes.

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