



Original Research

Knee Arthrodesis: An Analysis of Surgical Risk Factors and Complications Using a National Database

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ABSTRACT

Background: Knee arthrodesis is predominantly a salvage procedure. In present time, knee arthrodesis is mostly considered for cases of unreconstructable failed total knee arthroplasty after prosthetic joint infection or trauma. Knee arthrodesis has shown better functional outcomes than amputation for these patients but has a high complication rate. The purpose of this study was to characterize the acute surgical risk profile of patients undergoing a knee arthrodesis for any indication.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried to determine 30-day outcomes after knee arthrodesis between 2005 and 2020. Demographics, clinical risk factors, and postoperative events were analyzed, along with reoperation and readmission rates.

Results: A total of 203 patients that underwent a knee arthrodesis were identified. Forty-eight percent of patients had at least 1 complication. The most common complication was acute surgical blood loss anemia requiring a blood transfusion (38.4%), followed by organ space surgical site infection (4.9%), superficial surgical site infection (2.5%), and deep vein thrombosis (2.5%). Smoking was associated with higher rates of reoperation and readmission (odds ratio 9, $P < .01$, and odds ratio 6, $P < .05$).

Conclusions: Overall, knee arthrodesis is a salvage procedure that has a high rate of early postoperative complications and is most often performed in patients at higher risk. Early reoperation is strongly associated with a poor preoperative functional status. Smoking places patients at higher risk of early complications.

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Introduction

Historically, knee arthrodesis was a mainstay for treating conditions including septic arthritis, neuropathic arthropathy, tuberculosis, and posttraumatic arthritis [1]. Advances in medical and surgical treatment have obviated the need to proceed directly to arthrodesis for these conditions. In the present day, knee arthrodesis is predominantly a salvage procedure. The most common indication for knee arthrodesis is a failed, unrevisable total knee arthroplasty (TKA), most often in the setting of prosthetic joint infection (PJI) but also secondary to irreparable extensor

mechanism damage, inadequate bone stock, or massive soft-tissue damage [2,3]. Additional indications include tumor resection where other forms of reconstruction are not possible and neuropathic arthropathy [4–8]. The goal of knee arthrodesis is to preserve the limb and provide a stable weight-bearing extremity.

The alternative treatment option in the setting of unreconstructable failed TKA is typically transfemoral amputation. Transfemoral or above-the-knee amputation confers worse functional outcomes and ambulatory status than knee arthrodesis, particularly in those patients who are unable to be fit with a prosthesis following amputation [9,10]. Additionally, amputation in the context of failed TKA is an independent risk factor for mortality [11]. Patients unable to undergo surgical treatment at all for a failed TKA due to PJI are often treated with long-term suppressive antibiotics or resection arthroplasty [12,13]. Given the significant complications and poorer functional outcomes associated with the alternative surgical treatment options, it is

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Table 1
Demographic factors for patients undergoing knee fusion.

Operative factors	Total (n = 203)	
	N	%
Gender		
Female	105	51.7
Male	98	48.3
Age		
<50 y	32	15.76
50-80 y	160	78.82
>80 y	11	5.42
BMI		
Normal	36	17.7
Overweight	43	21.2
Obese I	43	21.2
Obese II	40	19.7
Obese III	41	20.2
Race		
White	145	71.4
Black	39	19.2
Other	3	1.5
Unknown	16	7.9
DM		
No	142	70
Yes	61	30
HTN		
No	83	40.9
Yes	120	59.1
CHF		
No	198	97.5
Yes	5	2.5
Dialysis		
No	195	96.1
Yes	8	3.9
COPD		
No	188	92.6
Yes	15	7.4
Bleeding disorders		
No	184	90.6
Yes	19	9.4
Smoking		
No	162	79.8
Yes	41	20.2
Functional status		
Dependent	33	16.3
Independent	166	81.8
Unknown	4	2
ASA classification		
1 to 2	42	20.7
3 to 5	161	79.3
Wound classification		
1 or 2	137	67.5
3 or 4	66	32.5
Flap coverage		
No	192	94.6
Yes	11	5.4
Resection arthroplasty		
No	174	85.7
Yes	29	14.3

BMI, body mass index; DM, diabetes; HTN, hypertension; COPD, chronic obstructive pulmonary disease; ASA classification, American Society of Anesthesiologist classification.

reasonable to consider knee arthrodesis for these complicated cases.

Given the complexity and high rate of complications in knee arthrodesis, it is important to be able to identify patients with the highest risk of poor outcomes after this procedure. The purpose of this study was to use the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) to describe surgical risk factors and postoperative complications, including 30-day readmission and reoperation rates, in patients undergoing knee arthrodesis for any indication. The hypothesis was that this

Table 2
Thirty-day postoperative events for patients undergoing knee arthrodesis.

Postoperative events	Total	
	N	%
Return to OR		
No	190	93.6
Yes	13	6.4
Unplanned readmission		
No	190	93.6
Yes	13	6.4
Death (30 d)		
Unknown	1	0.5
No	198	97.5
Yes	4	2
Any complication		
No	104	51.2
Yes	99	48.8
Infection		
Any	21	10.3
Superficial SSI	5	2.5
Deep SSI	2	1
Organ/space SSI	10	4.9
Sepsis	4	2
Septic shock	2	1
Respiratory		
Any	5	2.5
Pneumonia	2	1
Unplanned intubation	3	1.5
Hematologic		
Any	80	39.4
Pulmonary embolism	1	0.5
DVT	5	2.5
Blood transfusion	78	38.4
Genitourinary		
Any	4	2
Acute renal failure	1	0.5
Urinary tract infection	3	1.5
Cardiac		
Any	3	1.5
Cardiac arrest	3	1.5
Discharge disposition		
Rehab	28	13.8
Home	102	50.2
SNF	53	26.1
Unknown	17	8.4

OR, operating room; SNF, skilled nursing facility; SSI, surgical site infection; DVT, deep vein thrombosis.

procedure would be associated with a high complication rate and that patients with more comorbidities would be at higher risk.

Material and methods

Data acquisition and patient selection

A retrospective review of data collected by the ACS-NSQIP was performed, querying data from 2005 to 2020. The ACS-NSQIP is a large international multi-institutional quality-improvement database that tracks numerous outcome variables for surgeries in a standardized database. Designed to provide data for patient outcome improvement, the use of this database has been shown to improve outcomes at participating institutions. A major strength of the NSQIP database is that data are abstracted by thoroughly trained "nurse reviewers" who use a standardized set of definitions and inclusion and exclusion criteria. The interrater reliability of data extraction by these reviewers has been proven to be consistent [14,15]. Studied cases consisted of patients with primary or concurrent Current Procedural Terminology (CPT) code 27580 (knee arthrodesis). Patients who underwent a resection arthroplasty or flap coverage under the same anesthesia were identified using the

CPT codes 27488 and 15738, respectively. Concurrent CPT codes 27488 and 15738 were used to identify patients undergoing resection arthroplasty or flap coverage. Patients were excluded if they had incomplete data for studied factors including sex, age, body mass index, wound classification, or American Society of Anesthesiologists (ASA) classification. Approval for this study was obtained through the Loyola University Medical Center institutional review board. The ACS-NSQIP database is deidentified and does not pose a risk to the participants.

Preoperative and outcome variables

Collected demographics data included age, sex, race, weight, height, wound classification, ASA classification, functional status, as well as comorbidity data including diabetes, hypertension, congestive heart failure, chronic obstructive pulmonary diseases, bleeding disorders, and smoking. Body mass index was calculated using the National Institutes of Health conversion formula using height and weight data. ASA physical status classification was condensed into groups 1 and 2 and 3-5 to classify patients' fitness before surgery. Wound classification was condensed into groups 1 and 2 (clean and clean-contaminated) and into 3 and 4 (contaminated and dirty). For all patients, postoperative

complications were evaluated, along with 30-day reoperation and readmission rates.

Statistical analysis

Frequency tables were generated to report demographic factors for patients undergoing knee arthrodesis, as well as their post-operative complications. Chi-square and Fisher exact tests were performed to identify the effect of preoperative factors on the risk of reoperations and readmissions. Both univariate and multivariate analyses were performed for reoperation and readmission risk factors. Firth's Penalized Likelihood correction was used to reduce the small sample size bias. Statistical significance was set at $P < .05$. A statistical analysis was performed using SAS (SAS Institute Inc., Cary, NC).

Results

Demographics and risk factors

A total of 203 patients met the inclusion and exclusion criteria, and their data are shown on [Table 1](#). The patient population consisted of 105 women (51.7%), 145 patients identified as white

Table 3
Risk factors for 30-day reoperation in patients undergoing knee arthrodesis.

Risk factors	Number of reoperations, n (%)		Univariate <i>P</i> value	OR (95% CI)	Multivariate <i>P</i> value
Gender					
Female	5	4.8	.3958		.2625
Male	8	8.2			
Age			.2552		.05
<50 y	12	7.5			
50-80 y	1	9.1			
>80 y	1	9.1	.473		.6579
BMI					
<40	12	7.4			
>40	1	2.4			
DM			.7583		.845
No	10	7			
Yes	3	4.9			
HTN			.6897		.3154
No	6	7.2			
Yes	7	5.8			
CHF			.2842		.1558
No	12	6.1			
Yes	1	20			
COPD			.2474		.4274
No	11	5.9			
Yes	2	13.3			
Smoking			.09	8.97 (1.75 - 45.9)	.0085
No	8	4.9			
Yes	5	12.2			
Functional status			.0282	5.38 (1.5 - 18.9)	.0087
Independent	8	4.8			
Dependent	5	15.2			
ASA classification			.3106		.7416
1 to 2	1	2.4			
3 to 5	12	7.5			
Wound classification			.2293		.1458
1 or 2	11	8			
3 or 4	2	3			
Resection arthroplasty			1		.5096
No	12	6.9			
Yes	1	3.4			
Flap coverage			1		.4531
No	13	6.8			
Yes					

BMI, body mass index; DM, diabetes; HTN, hypertension; COPD, chronic obstructive pulmonary disease; ASA classification, American Society of Anesthesiologist classification; CI, confidence interval.

Significant *P* values in bold.

(71.4%) or black (19.2%), and had a mean age of 61.4 years. The most common comorbidity was obesity, present in 124 patients (60.6%). Other comorbidities included diabetes (30%), hypertension (59.1%), and smoking (20.2%). Most patients were considered to have poor fitness before surgery, with 161 patients classified as having an ASA 3 to 5 (79.3%). There were 29 patients (14.3%) who underwent a resection arthroplasty and 11 patients (5.4%) who had a flap coverage at the same time as the knee arthrodesis. Sixty-six patients (32.5%) had a wound classification of 3 or 4.

Postoperative events are described in Table 2. Thirteen patients (6.4%) were reoperated and/or readmitted within 30 days of their procedure. Four patients (2%) expired within this 30-day postoperative period. At least 1 complication was present in 99 patients (48.8%), with the most common complication being hematologic ($n = 80$, 39.4%), followed by infectious ($n = 21$, 10.3%), respiratory ($n = 5$, 2.5%), genitourinary ($n = 4$, 2%), and cardiac ($n = 3$, 1.5%). Most patients were discharged home (50.2%) or to a skilled nursing facility (26.1%).

Reoperation and readmission

A univariate analysis was performed comparing risk factors for reoperation and is presented in Table 3. Functional status was the only preoperative variable associated with a higher reoperation rate ($P < .03$), with smoking approaching significance. We then

performed a multivariate logistic regression model controlling for all preoperative variables. Significant risk factors on the multivariate analysis included being a smoker (odds ratio [OR] 8.97, $P < .009$) and classified as being dependent on functional status (OR 5.4, $P < .009$). Resection arthroplasty, wound classification 3 or 4, or flap coverage was not associated with a higher reoperation rate. Similarly, the univariate analysis was performed to identify risk factors for readmission, shown in Table 4. Female sex was associated with higher readmission ($P < .02$), with smoking again approaching significance. When controlling for preoperative variables with multivariate logistic regression, smokers (OR 6.3, $P < .01$) and female sex (OR 4.4, $P < .02$) were found to be significantly associated with higher readmission rates.

Discussion

Knee arthrodesis is a salvage procedure that is often performed to address unreconstructable failed TKA due to PJI. Given the increasing number of TKA procedures being performed, a proportionate increase in the number of failed TKAs and ultimate need for salvage procedures such as knee arthrodesis will also increase [16]. Thus, it is important to understand preoperative risk factors and characteristics that predict complications and failure of this procedure to limit the burden on health-care systems.

Table 4
Risk factors for 30-day readmission in patients undergoing knee arthrodesis.

Risk factors	Number of readmission, n (%)		Univariate <i>P</i> value	OR (95% CI)	Multivariate <i>P</i> value
Gender			.0194	4.4 (1.2 - 15.97)	.0242
Female	11	10.5			
Male	2	2			
Age			.5235		
<50 y	1	3.1			.0823
50-80 y	11	6.9			
>80 y	1	9.1			.0868
BMI			.7285		.5584
<40	10	6.2			
>40	3	7.3			
DM			.3516		.1517
No	11	7.7			
Yes	2	3.3			
HTN			.6897		.9666
No	6	7.2			
Yes	7	5.8			
CHF			1		.7603
No	13	6.6			
Yes					
COPD			.2474		.7165
No	11	5.9			
Yes	2	13.3			
Smoking			.09	6.3 (1.49 - 26.66)	.0124
No	8	4.9			
Yes	5	12.2			
Functional status			1		.6348
Independent	11	6.6			
Dependent	2	6.1			
ASA classification			1		.7988
1 to 2	2	4.8			
3 to 5	11	6.8			
Wound classification			1		.8168
1 or 2	9	6.6			
3 or 4	4	6.1			
Resection arthroplasty			1		.8849
No	11	6.3			
Yes	2	6.9			
Flap coverage			1		.4841
No	13	6.8			
Yes					

BMI, body mass index; DM, diabetes; HTN, hypertension; COPD, chronic obstructive pulmonary disease; ASA classification, American Society of Anesthesiologist classification; CI, confidence interval.
Significant *P* values in bold.

The patient population undergoing this procedure in this multicenter database has high rates of comorbidities including obesity, diabetes, hypertension, smoking, and poor ASA scores. This cohort is also of a relatively young age with a mean age of 61.4 years, consistent with prior literature and registry data demonstrating higher rates of revision in younger patients [17,18]. This is the population at higher risk of failing primary and revision procedures, necessitating a salvage procedure such as knee arthrodesis [19–25].

This study is the largest reported cohort of patients undergoing knee arthrodesis. This is concurrent with prior literature on smaller cohorts demonstrating high complication rates following this procedure, with 48.8% of patients experiencing at least 1 complication in the acute postoperative period [26,27]. A previous cohort of 23 patients undergoing knee arthrodesis for a failed two-stage revision arthroplasty had a 65% complication rate, with 3 patients subsequently requiring above-the-knee amputation [28]. However, knee arthrodesis was able to provide a stable limb with bony union in 80%, with the majority of those able to ambulate without pain [28]. Another small cohort of 17 patients with a chronically infected TKA undergoing knee arthrodesis with an intramedullary ante-grade nail demonstrated a similarly high overall complication rate of 47% and mortality rate of 33% within 2 years of fusion [29].

Factors identified in this study should guide risk-benefit discussions with patients starting from the initial primary TKA. Young, obese patients should be extensively counseled on the risk of revision arthroplasty in the future and the high rate of complications associated with multiple arthroplasty procedures. Specific to knee arthrodesis, patients with a poor functional status should be counseled on their increased risk of early reoperation and complications. Patients who are smokers should be advised to quit prior to undergoing knee arthrodesis. While there is a high rate of early medical complications, prior data suggest knee arthrodesis is a durable option to provide patients with a stable, infection-free extremity that allows mobility and avoids amputation [2,27–29].

There are several limitations to this study. This database only records data in the acute 30-day postoperative period, meaning that any further complications past this time point are not captured. Although the ACS-NSQIP database includes data relevant to most surgical patients, including risk factors, rates of readmission, and rates of reoperation, it does not consider variables of interest specific to orthopedic patients and care providers. For example, the NSQIP does not report radiologic data or patient-reported outcomes, valuable information for the treating surgeon. Furthermore, the NSQIP does not distinguish among different surgical techniques, materials used in arthrodesis procedures, and how many prior procedures the patients had undergone. Additionally, this study does not give specific details on the indication for knee arthrodesis for each patient, past surgical history on the operated knee, and surgeons' experience or hospital resources. This study also does not provide information on patients' ambulatory or functional recovery or achievement of a stable limb. Finally, miscoding by medical staff is possible and cannot be ruled out in this study design. Only a segment of hospitals (706 as of January 2020) participate in NSQIP, which somewhat limits the generalizability of study findings.

Further studies are necessary to elucidate whether the high complication rate seen in knee arthrodesis is more closely related to associated comorbidities in this high-risk population, specific to the procedure itself in a healthier cohort or a combination of both. Additionally, studies should identify the ideal operative technique to reduce complications, achieve high union rates, and for infection eradication as there is no current consensus [1,27]. Larger cohorts of patients undergoing knee arthrodesis are needed with long-term follow-up to assess survivability and functional outcomes. Future

studies should also compare outcomes between knee arthrodesis and above-knee amputation in patients with a poor preoperative functional status.

Conclusion

Overall, this study is the largest cohort of patients undergoing knee arthrodesis and identifies important preoperative characteristics including poor functional status and smoking that are associated with early postoperative complications, which will help guide risk-benefit discussions to allow informed shared decision-making.

Conflicts of interest

Dr. N. B. Brown is a paid consultant for Corin and DePuy and is in the AAOS OKU committee and AAOS AJRR committee. The other authors declare no potential conflicts of interest.

For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2023.101098>.

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