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Original research

Surgical selection criteria compliance is associated with a lower risk of periprosthetic joint infection in total hip arthroplasty

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ABSTRACT

Background: Periprosthetic joint infection (PJI) is a devastating complication of total hip arthroplasty (THA). Patient optimization represents an important target for PJI prevention. Unfortunately, best practice screening guidelines are not consistently followed by all surgeons. Our study aimed to determine both the degree and the effect that compliance with our institutional preoperative surgical selection criteria had on PJI rates for patients undergoing elective primary THA.

Methods: A retrospective review was conducted on 455 elective primary THA procedures performed at an academic tertiary care center over a 2-year period. Institutional preoperative surgical selection criteria included the following: body mass index $\leq$40 kg/m^2, hemoglobin A1c $\leq$7.5%, hemoglobin $\geq$12 g/dL, albumin $\geq$3.5 g/dL, no smoking within 30 days prior to surgery, and completion of a decolonization protocol if a nasal polymerase chain reaction was positive for *Staphylococcus aureus*. PJI was assessed for a minimum 1-year follow-up using Musculoskeletal Infection Society criteria from 2011. Rates of compliance and PJI were compared using a chi-squared test.

Results: Surgeon compliance with institutional preoperative selection criteria was 62.4% and ranged from 0.0% to 83.9%. Five of 455 patients developed a PJI. The total PJI rate was 1.1%. The compliant patient cohort had a PJI rate of 0.0%, while the noncompliant cohort had a PJI rate of 2.9% ($P = .0038$).

Conclusions: This study identified a statistically significant decrease in PJI rates among patients who met all preoperative screening criteria.

Introduction

Periprosthetic joint infection (PJI) following primary total hip arthroplasty (THA) is a devastating complication for patients and healthcare providers. Despite its low incidence (crude rate complex surgical site infection [SSI] = 0.69 [1], incidence of PJI = 0.88% [2]), postoperative infection remains the costliest complication seen in the 90-day postoperative period, often necessitating readmission and reoperation [3,4]. In an era of publicly reported data and bundled payments, more attention has been directed toward patient optimization as a means to decrease such complications and to improve the value of care [5-9].

Although evidence exists regarding optimization strategies to prevent PJI, there is no universally accepted standard for surgeons to follow [10]. Furthermore, best practice screening guidelines are not consistently followed by all surgeons [11]. This may be, in part, due to a lack of understanding of the importance of adherence to best practice guidelines as it relates to the risk of PJI. Compounding this problem is the lack of an externally validated risk stratification tool that can, with a high predictive ability, inform clinical decision-making given a patient's specific risk profile [12-14].

The primary aim of this study is to determine the degree of compliance with our institutional surgical selection criteria for patients undergoing elective primary THA. The secondary aim is to determine whether the degree of compliance influenced PJI rates. We hypothesized that compliance with our institution's surgical selection criteria would influence PJI rates.

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Material and methods

A retrospective review was conducted on all elective primary THA procedures performed at an academic tertiary care center over a 2-year period from December 1, 2015 to December 1, 2017. Current Procedural Terminology codes 27130 and 27132 were used to query the electronic medical record and billing database. In total, 670 cases were identified. One hundred two cases were excluded as revision, secondary, or nonelective procedures due to trauma or malignancy, and 113 more were excluded for incomplete or missing data in the medical record, leaving 455 cases for analysis. There were 56 patients who underwent both right and left elective primary THA procedures within the study period. Patients who had 2 procedures performed on the same day were counted as one set of data while those with procedures performed in a staged fashion were considered as separate data sets. A total of 9 surgeons were included in the study. Institutional preoperative selection criteria were determined by a multidisciplinary team of experts following a systematic review of current literature. Data collection was modeled according to our institutional preoperative selection criteria for elective primary THA, including body mass index (BMI) $\leq$40 kg/m^2, hemoglobin A1c (HbA1c) $\leq$7.5%, hemoglobin (Hb) $\geq$12 g/dL, albumin $\geq$3.5 g/dL, no smoking within 30 days prior to surgery, and completion of a decolonization protocol if a nasal polymerase chain reaction screening was positive for *Staphylococcus aureus*. These sources dated within 30 days of the day of surgery, otherwise the last recorded value before the operation was used. An estimated HbA1c was calculated for some patients who had no measured HbA1c level using available blood glucose measurements and the estimated average glucose/HbA1c conversion calculator provided by the American Diabetes Association [15]. Verification of smoking status and completion of the decolonization protocol were completed on the day of surgery and entered into the preoperative nursing assessment as a field-based entry into the electronic medical record. PJI was assessed for a minimum of 1 year following the operation and was defined using Musculoskeletal Infection Society (MSIS) criteria from 2011 as data were collected and analyzed prior to the most recent criteria update [16,17]. Each variable was considered dichotomous for the purposes of analysis and was categorized as compliant or noncompliant. Similarly, subjects were divided into 2 groups for pooled analysis. Compliance was defined as having met all preoperative screening criteria within the guidelines, while noncompliance was defined as having one or more variables outside the guidelines. Compliance with guidelines was also assessed for each surgeon. Chi-squared and Fisher's exact tests were used to compare patient demographics, compliance rates, and rates of PJI. Alpha was set to 5%. Institutional review board approval was obtained for this study.

Results

Our study population had no statistically significant difference among gender, BMI, or prevalence of diabetes between the compliant and noncompliant patient cohorts (Table 1). There was, however, a statistically significant difference in age ($P = .00049$), with the noncompliant patient cohort consisting of a higher proportion of patients in the 18 to 65-year-old category (Table 1). Smoking within 30 days prior to the operation was the most common reason for lack of compliance, present in 19% of cases (Table 2). Anemia (Hb < 12 g/dL) was the second most common reason for lack of compliance, present in 16% of cases (Table 2). Of the 5 patients who developed PJIs, each was noncompliant from either smoking or anemia (Table 3). There were 17 patients noncompliant across more than 1 category. Only 4 of the 5 patients who developed PJI underwent reoperation. The patient who has not undergone reoperation is currently on chronic suppressive antibiotics and has declined surgical intervention due to a lack of constitutional symptoms or significant pain.

Table 1
Comparison of demographics among compliant and noncompliant patient cohorts who underwent elective primary THA.

	Patient demographics			
	Compliant	Noncompliant	Total	*P* value
Age				.00049
18-65	178	137	315	
66-85	103	33	136	
86-95	3	1	4	
Gender				.89
Male	136	83	219	
Female	148	88	236	
BMI				.37[a]
<30	162	97	259	
30-40	122	61	183	
>40	0	13	13	
Diabetes				.16
Yes	39	32	71	
No	245	139	384	
Total	284	171	455	

[a] *P*-value determined by chi-square of <30 and 30-40 categories.

Surgeon compliance with institutional preoperative selection criteria was 62.4% and ranged from 0.0% to 83.9% (Table 4). The compliance rate and corresponding rate of infection of Surgeon 1 was the only one to individually reach statistical significance ($P = .0010$) (Table 4). Five patients developed a PJI from the 455 cases reviewed and all were noncompliant in at least 1 category (Table 3). The average latency of infection was 34 days. The total PJI rate among the 455 cases was 1.1%, with compliant and noncompliant cohort PJI rates of 0.0% and 2.9%, respectively (Table 4). The difference in PJI rate between compliant and noncompliant patient cohorts was statistically significant ($P = .0038$) (Table 4).

Discussion

PJI remains a serious threat to patients undergoing elective primary THA [18]. Managing modifiable risk factors is an important step toward reducing a patient's risk for infection [11,19-21]. Pruzansky et al. [22] reported 300 hip and knee arthroplasties and found the top 5 modifiable risk factors to be obesity (46%), anemia (29%), malnutrition (26%), diabetes mellitus (20%), and smoking (10%). Bullock et al. [20] implemented a bundled protocol for

Table 2
Compliance and noncompliance (group averages included) to each institutional preoperative screening criteria for elective primary THA.

	Institutional preoperative selection criteria		
	Compliant (average)	Noncompliant (average)	Compliance rate
BMI (kg/m^2)			
$\leq$40	442 (29.0)	13 (43.1)	97.1
Comorbidity			
HbA1c (%) $\leq$7.5	446 (5.70)	9 (8.11)	98.0
Hb (g/dL) $\geq$12	382 (14.0)	73 (11.0)	84.0
Albumin (g/dL) $\geq$3.5	450 (4.33)	5 (3.26)	98.9
Smoking	369	86	81.1
Decolonization[a]	125	2	98.4
Total	284	171	62.4

[a] All patients were screened for *Staphylococcus aureus* with nasal polymerase chain reaction. Compliance was defined as having completed a preoperative decolonization protocol only if a nasal polymerase chain reaction was positive.

Table 3
Combined characteristics of preoperative surgical selection criteria for patients who developed a periprosthetic joint infection.

Characteristics of surgical selection criteria for infected patients											
Patient PJI	Diabetes	Surgeon	Age	Gender	BMI	Smoking	Albumin	HbA1c	Hb	Decolonized	Culture
1	No	1	65-85	Female	**52.9**	No	4.2	5.8	**10.8**	N/A	*Enterococcus faecalis*
2	No	1	18-65	Male	31.5	**Yes**	4.7	5.6	14.1	N/A	*Propionibacterium acnes*
3	No	2	18-65	Female	18.2	No	3.7	5.9	**10.7**	Yes	*Staphylococcus aureus*
4	No	4	18-65	Male	26.4	**Yes**	4.2	5.1	**9.9**	N/A	*Staphylococcus aureus*
5	No	9	18-65	Male	32.4	**Yes**	4.4	5.7	15.3	Yes	*Propionibacterium granulosum*

N/A, not applicable.
Values in bold indicate noncompliance.

primary THA and total knee arthroplasty (TKA) that included patient optimization of modifiable preoperative risk factors including poor dentition, BMI, diabetes mellitus, HbA1c, tobacco abuse, methicillin-resistant Staphylococcus aureus screening, wound assessment, anticoagulant use, obstructive sleep apnea, history of deep vein thrombosis/pulmonary embolus, and reported a reduction in incidence of PJIs from 1.43% to 0.11% for TKAs and 1.56% to 0.59% for THAs. Nussenbaum et al. [19] implemented preoperative screening criteria for primary elective THAs performed among a population of Veterans and saw a reduction in total complication rates from 42.4% to 14.2% and a reduction in SSI rates from 3.8% to 1.2%. The results of our study further support that compliance with evidence-based institutional preoperative surgical selection criteria is associated with a reduced patient risk of PJI.

Guidelines based on expert consensus outlining risk factors for development of postoperative infection after elective total joint arthroplasty were published in the Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection. Significant risk factors reported as contraindications to elective total joint arthroplasty include active infection of the arthritic joint, presence of septicemia, and/or presence of active infection of local cutaneous, subcutaneous, or deep tissue. Potential risk factors include poorly controlled diabetes (glucose >200 mg/L or HbA1c >7%), malnutrition, BMI >40 kg/m^2, excessive smoking (>1 pack/d), excessive alcohol consumption (>40 units/wk), intravenous drug abuse, active liver disease, chronic renal disease, recent hospitalization, extended stay in a rehabilitation facility, male gender, diagnosis of post-traumatic arthritis, inflammatory arthropathy, prior surgical procedure in the affected joint, and severe immunodeficiency [23]. Our study focused on preoperative modifiable risk factors to assess if current institutional guidelines are reducing our patients' risk of PJI and our results suggest they are.

Table 4
Comparison of compliance rates to preoperative screening criteria and periprosthetic joint infection by surgeon.

Compliance and infection rates by surgeon						
Surgeon	Compliance rate (%)	PJI rate (%)	PJI cases	Caseload	Cases removed	*P*-value
1	83.9	3.2	2	62	25	.0010
2	78.5	0.6	1	181	23	.056
3	55.8	0.0	0	95	8	–
4	41.5	2.4	1	41	15	.39
5	38.5	0.0	0	39	16	–
6	21.1	0.0	0	19	9	–
7	7.1	0.0	0	14	5	–
8	0.0	0.0	0	0	11	–
9	0.0	25	1	4	1	–
Compliant	100	0.0	0	284	–	.0038
Noncompliant	0.0	2.9	5	171	–	
Total	62.4	1.1	5	455	113	–

P-values indicate statistical association between compliance rate and PJI rate.

Compliance

Lack of physician and patient compliance to evidence-based guidelines poses a unique and challenging threat to reducing the risk of PJI. Physician barriers to compliance specific to orthopedics are not well studied, but in general include personal factors (deficiencies of physician knowledge or attitudes), guideline-related factors (lack of evidence or applicability), and external factors (organizational constraints, lack of resources or collaboration, or social/clinical norms) [24-26]. Furthermore, in volume-based reimbursement environments such as at our institution, surgeon financial incentives are aligned to procedural volume rather than quality outcomes. In bundled payment environments, value-based decision-making might lead to different behaviors, as monetary accountability to 90-day costs attributed to the episode would include readmission or reoperation for infection, which was identified on average at 34 days postoperatively in this study. Project JOINTS, a bundle-based quality improvement project to reduce SSI conducted by the Institute for Healthcare Improvement, reported a compliance rate of 55%, with the top 3 barriers to compliance being lack of physician buy-in and staff resistance, cost of intervention, and logistical difficulty of following the interventions [25].

Barriers to compliance also exist for patients and are typically divided into 5 categories: socioeconomic factors (social support, employment status, social stigma of disease), healthcare team/system-related factors (access to care, physician/patient relationship), condition-related factors (presence of symptoms, disease severity, clinical improvement), therapy-related factors (adverse effects, drug effectiveness, dosing schedule), and patient-related factors (age, gender, marital status, ethnicity) [27,28]. Pressure to overcome these barriers and improve patient outcomes continues to increase with further implementation of value-based compensation models, and the influence of infection rates on hospital ratings by organizations such as Vizient, Centers for Medicare and Medicaid Services, and US News and World Report [5,29,30].

Limitations

There are several limitations of this study. First, the strength of evidence provided by a retrospective single-institution study is inherently limited. Future prospective studies will be necessary to more completely assess the impact of our institutional preoperative selection criteria on PJI rates for both elective primary THA and TKA. Another limitation is that some risk factors assessed, such as smoking, relied on self-reported data which may have introduced a response bias. There is also a possibility that risk factors involving preoperative labs could have changed in the days or weeks leading up to surgery. Furthermore, because patients were not directly contacted to assess for loss of follow-up, there is a possibility that some may have developed an infection and went on to receive further care or a reoperation at an outside healthcare facility not included in this study. Despite efforts to standardize data collection

and analysis, the 113 patient cases that were excluded due to lack of completeness may have introduced a selection bias. Of note, the excluded patient group had a higher incidence of BMI >40, which was statistically significant ($P = .008$). Another limitation exists in the variation of compliance and caseload among the multiple surgeons who operated on the patients involved in this study. It is also important to point out that this study relied on the 2011 MSIS criteria for PJI, as the criteria were recently updated after our data had already been collected and analyzed [17]. The 2018 MSIS criteria were reported to have a sensitivity of 97.7% (an increase of 18.4% from the 2011 criteria) with an unchanged specificity of 99.5%. Future studies may improve internal validity by incorporating American Society of Anesthesiologists Score or Charlson Comorbidity Index, and by employing cohort matching techniques to account for confounding differences not controlled for in this study. Finally, while this study did demonstrate significant findings, given the low incidence of PJI, a larger sample size would be needed to adequately power a surgeon-specific correlation between compliance and infection rate, which would potentially be more granularly informative and assist in quality improvement efforts at the institutional level.

Conclusions

This study identified statistically significant lower PJI rates among patients who met all institutional preoperative selection criteria compared to those who did not meet them. These findings support our hypothesis that compliance with our institution's preoperative selection criteria would influence PJI rates. Future studies will prospectively assess the effects of institutional preoperative selection criteria on PJI rates following both elective primary THA and TKA.

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