Rheumatoid Arthritis Does Not Increase Risk of Short-term Adverse Events after Total Knee Arthroplasty: A Retrospective Case-control Study

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ABSTRACT. ***Objective.*** More adverse events (AE) are reported after total knee arthroplasty (TKA) for patients with rheumatoid arthritis (RA) than for patients with osteoarthritis (OA). This study evaluates 6-month postoperative AE in a high-volume center in a contemporary RA cohort.

Methods. Patients with RA in an institutional registry (2007–2010) were studied. AE were identified by self-report and review of office and hospital charts. Subjects with RA were matched to 2 with OA by age, sex, and procedure. RA-specific surgical volume was determined. Baseline characteristics and AE were compared and analyzed.

Results. There were 159 RA TKA and 318 OA. Of the patients with RA, 88.0% were women, 24.5% received corticosteroids, 41.5% received biologics, and 67% received nonbiologic disease-modifying antirheumatic drugs (DMARD). There was no difference in comorbidities. RA-specific surgical volume was high; 64% of cases were performed by surgeons with ≥ 20 RA cases during the study period. Patients with RA had worse baseline pain and function and lower perceived health status (EQ-5D 0.59 vs 0.65, $p < 0.01$). There were no deep infections in either group and no difference in superficial infection (9.4% RA vs 10.1% OA, $p = 0.82$), myocardial infarction (0.7% RA vs 0% OA, $p = 0.33$), or thromboembolism (1.3% RA vs 0.6% OA, $p = 0.60$).

Conclusion. In a high-volume center, with high RA-specific experience, RA does not increase postoperative AE. Despite worse preoperative function and high steroid and DMARD use, complications were not increased. However, further study to determine generalizability is needed. (First Release May 1 2015; J Rheumatol 2015;42: 1123–30; doi:10.3899/jrheum.141251)

Key Indexing Terms:
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The role of orthopedic surgery in the management of patients with rheumatoid arthritis (RA) is well established. During the course of their illness, 30–58% of patients with RA undergo orthopedic procedures[1,2], and the most common joint replaced is the knee (57%)[3]. Moreover, despite the widespread use of potent disease-modifying antirheumatic drugs (DMARD) and biologic DMARD such as tumor necrosis factor inhibitors (TNFi), as well as improved health status in patients with RA[4,5], rates of total knee arthroplasty (TKA) in patients with RA are increasing[6,7]. While improved overall health status might improve the outcomes of TKA, the effect of potent DMARD and biologics on the complication rates of patients with RA undergoing TKA remains unclear[8,9,10,11,12].

Patients with RA have been reported to have a higher risk of postoperative adverse events (AE) after TKA[13]. An

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increased risk of infection has been consistently described for patients with RA undergoing both hip and knee arthroplasty[14,15,16], and was confirmed in a recent metaanalysis using a large administrative database[17]. Increased thromboembolic events have also been described within the general RA population, although the literature is inconsistent regarding postoperative risk[18,19,20,21,22]. Although recent studies using large databases demonstrate that risk of readmission for infection for patients with RA after arthroplasty continues to increase, high-volume centers have fewer AE, and surgical experience specifically with RA decreases the risk of postoperative complications[23,24,25].

The purpose of our study was to evaluate short-term AE after TKA in patients with RA compared with those with osteoarthritis (OA) to assess whether RA remains a risk factor for increased AE in a contemporary cohort in a high-volume orthopedic hospital with high RA-specific volume.

MATERIALS AND METHODS

This is a retrospective case-control study of patients enrolled in a single high-volume institutional TKA registry between May 1, 2007, and December 31, 2010. Patients provided demographic self-reported data including the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[26], Medical Outcomes Study Short Form-36 (SF-36)[27], and EQ-5D[28]. The Charlson/Deyo Comorbidity Index was calculated excluding diagnosis of RA. RA was identified by self-report and the International Classification of Diseases, 9th ed code (ICD-9) 714.0, and the diagnosis was confirmed by chart review. RA was confirmed if it was diagnosed by a rheumatologist, or if it was diagnosed by an internist and the patient was receiving a DMARD or biologic. OA controls were taken from the same registry after excluding those without 6-month self-reported data and those with another ICD-9 coded autoimmune disease or fracture. Two controls were matched to each RA case based on age ± 5 years, sex, as well as type of TKA procedure (primary vs revision surgery). Simultaneous bilateral TKA were included and counted as a single procedure. In the event that a patient had a staged bilateral TKA (contralateral TKA within 6 mos) and both surgeries were recorded in the registry, only the first procedure was included in the analysis. Only subjects who had hospital charts, office charts, and 6-month self-reported event data were eligible for this analysis. Any patient with an ICD-9 code for fracture was excluded. RA-specific surgical volume was ascertained for the surgeons contributing cases to the study, and the association of complications with RA-specific volume was analyzed.

Major medical AE included pulmonary embolus (PE), deep vein thrombosis (DVT; defined by positive ultrasound if in the hospital chart, phone call validation if self-reported, or physician-reported if in the office chart), deep surgical site infection, a major bleeding event (requiring blood transfusion), pneumonia, stroke, myocardial infarction (MI), fracture, dislocation, reoperation, and death. Major surgical AE included surgical manipulation, revision, or reoperation. Minor AE included minor bleeding, superficial infection, ecchymosis, transient neuropathy, incision site drainage, poor wound healing, erythema, and atelectasis.

Data collection. AE were identified by review of office and hospital charts and by self-reported answers to a questionnaire 6 months after surgery. The inpatient hospital chart was reviewed for events occurring prior to discharge. The outpatient orthopedic surgeon chart was reviewed for additional AE recorded within 6 months. Of the self-reported AE from the 6-month questionnaire, only those validated by chart review or phone call were included. Baseline characteristics of patients with RA and OA were collected preoperatively, including WOMAC Pain and Function scores, SF-36 Physical (PCS) and Mental components, EQ-5D, Lower Extremity Activity Scale (LEAS), American Society of Anesthesiologists (ASA) class[29], and Charlson/Deyo Index comorbidities. The WOMAC is a validated knee-specific patient-reported outcome measure used to assess pain, stiffness, and function, with higher scores indicating better outcomes[26]. The SF-36 is a validated instrument used to assess perceived health-related mental and physical limits[27]. The EQ-5D is a patient-reported outcome measure used to assess the value patients place on their health status on a 1–100 scale with higher numbers indicating better health. The EQ-5D score indicates a state of perfect health (1) or death (0)[28]. The LEAS is a validated scale composed of 12 questions and correlates well with measures such as WOMAC Pain and Function scores. Scores ranged from 1 (bedbound) to 18 (up and about at will and participating in vigorous sports)[30]. Osteoporosis was identified by ICD-9 coding. Medications were recorded in RA cases by chart review and self-report.

This study was approved by the hospital's Institutional Review Board.

Statistical analysis. Descriptive statistics were performed on matching variables, patient baseline characteristics, baseline function outcomes, and surgery-related outcomes. Means and SD were calculated for continuous variables and frequency distributions for categorical variables. Continuous variables were compared between RA cases and OA controls using the Student t test, whereas categorical variables were compared using Pearson chi-square or Fisher's exact test as appropriate. The results of short-term AE from hospital charts, office charts, and patient self-reports were summarized using frequencies. Pearson chi-square or Fisher's exact test was used to assess the differences between RA cases and OA controls. Multiple logistic regressions were performed to assess the differences between RA cases and OA controls and to identify variables independently associated with short-term AE. The multiple logistic regression included variables found to be significant in the univariate analysis ($p < 0.05$). All tests were 2-sided with significance level of 0.05, and all analyses were conducted using SAS for Windows 9.2 (SAS Institute Inc.).

RESULTS

Of 728 potential RA cases identified by ICD-9 or self-report, 252 cases were validated as RA (34.6%). Of these eligible cases, 181 (70.2%) had self-reported data at 6 months. One hundred and fifty-nine of these also had available hospital charts and office charts (63.1%), and were included in our study. There were no significant differences in age (61.1 ± 11.6 vs 63.5 ± 11.7, $p = 0.11$), sex (86% female vs 88% female, $p = 0.64$), or preoperative pain or function (WOMAC Pain 43.9 ± 17.5 vs 47.2 ± 18.9, $p = 0.26$; WOMAC Function 42.5 ± 19.7 vs 43.8 ± 19.6, $p = 0.68$) between the 93 validated RA cases excluded from the study because of missing data and the RA cases included. However, excluded cases reported worse preoperative stiffness (WOMAC stiffness 33.12 ± 22.4 vs 41.0 ± 23.7, $p = 0.03$), had worse ASA status (43% ≥ class 3 vs 27.9%, $p = 0.01$), and were less likely to be white (66% vs 83.7%, $p = 0.003$). Because of these differences, AE during the hospital admission and medication use were determined for the excluded patients. There was no significant difference in the number of AE between groups. Of the apparent 93 excluded cases, 7 were duplicates, leaving 86 cases. Hospital charts were available for review for 62 of the excluded cases and there was no difference in the in-hospital AE compared with those in the included cases. For serious AE, there was 1 case of pneumonia and 1 case of atrial fibrillation in the excluded cases. For minor AE, there was 1 urinary tract infection, 1 superficial surgical site infection, and 1 corneal abrasion, differences which were not signifi-

cant between groups. We additionally determined the medications used by the excluded cases. Fewer excluded cases were treated with TNFi: 19 (30%) of the excluded were receiving TNF-α inhibitors versus 66 (41%) of the included cases, but this was not statistically significant (p = 0.17). Methotrexate (MTX) use was equivalent between groups: 73 (45.9%) of included versus 27 (45%) of excluded. The difference in nonbiologic DMARD use was not statistically significant: 107 (67.3%) of included cases versus 33 (53%), p = 0.06. Corticosteroid use in combination was significantly different between groups; more excluded cases were receiving therapy with corticosteroids: excluded 31 (50%) versus included 39 (24.5%), p = 0.0004.

One patient with RA had a TKA within 6 months after the first, and only the first surgery was included. RA-specific surgical volume was determined for the 34 individual surgeons contributing cases to the study. Of the cases, 22/159 (14%) were performed by surgeons who operated on ≥ 50 RA cases during the course of the study. Another 30% (48/159) of cases were performed by surgeons with ≥ 40 RA cases, and 64% of cases (102/159) were performed by surgeons who had operated on ≥ 20 RA cases during the study period. AE were equally distributed.

Of potential OA controls, 89.0% had self-reported data at 6 months and accessible office and hospital charts. There were no statistically significant differences between the included OA and the excluded OA cohort in all demographics, including age; sex; preoperative pain, function, and stiffness; type of surgery; ASA status; or race. None of the OA controls had a contralateral TKA within 6 months.

Mean age of the RA cases was 63 years (range 22–92), 88% were women, and 82.9% were primary TKA (Table 1). Patients with RA had significantly lower body mass index (BMI; 28.2 vs 30.8, p < 0.001) and were less likely to be white (83.7% vs 88.4%, p = 0.04). Patients with RA had no more Charlson/Deyo comorbidities than patients with OA (p < 0.64) and ASA class was no different between RA and OA (p = 0.28). Patients with RA were significantly more likely to have osteoporosis (29.6% vs 12.0%, p < 0.001).

Of the patients with RA, 41.5% were treated with TNFi, of whom 60.6% were receiving etanercept, 19.7% adalimumab, 18.2% infliximab, and 1.5% golimumab; 45.9% were treated with MTX, 67.3% were receiving 1 or more nonbiologic DMARD, and 4.4% were receiving a non-TNFi biologic (either alone or in combination with other medications). Corticosteroids were given to 24.5% patients, and 20.1% received supraphysiologic "stress dose" steroids after surgery, which in our institution was given as 100 mg of hydrocortisone intravenously in the operating room with the dose repeated 8 h later and tapered to the baseline dose within 36 h. There was no consistency in the interval between stopping TNFi and surgery. Of the patients with RA, 14.5% were not receiving any TNFi, DMARD, biologic, or steroid medication (Table 2).

Preoperative WOMAC Pain and Function were statistically significantly worse for patients with RA than OA (47.1 vs 53.7, p < 0.001, and 43.8 vs 54.2, p < 0.001). However, the difference was not clinically meaningful for pain[31,32]. Patients with RA had worse health status on the EQ-5D (0.59 vs 0.65, p = 0.006), and also lower SF-36 PCS (29.3 vs 33.3, p < 0.001). Similarly, patients with RA had significantly lower median scores on the LEAS (8 vs 9, p < 0.001). Operative time (144.3 min RA vs 146.0 min OA, p = 0.66) and postoperative stay [5 days with interquartile range (IQR) 5–6 RA vs 5 days with IQR 4–6 OA, p = 0.09] were not different between both groups (Table 1).

The data collected from the hospital charts (Appendix 1) revealed no significant differences in major AE prior to discharge. Differences in pneumonia (0.6% vs 0.3%, p = 0.56), DVT (0.6% vs 0.9%, p = 0.80), and PE (0.0% vs 0.3%, p = 0.99) were all nonsignificant. Neither group had any fractures, deep surgical site infections, or deaths prior to discharge. For minor AE, ecchymoses were encountered more frequently in patients with RA (4.4% vs 1.3%, p = 0.036).

Data collected from outpatient charts show that patients with OA had significantly higher rates of major surgical AE (1.9% vs 8.8%, p = 0.02), attributable mostly to manipulations (1.3% vs 7.2%, p = 0.006). There were no significant differences in major medical AE or minor AE. Using data derived from the 6-month self-reported questionnaire, there was no significant difference between patients with RA and OA in either major or minor AE, fracture (0.6% vs 0.6%, p = 0.70), pneumonia (1.3% vs 0.3%, p = 0.26), DVT (0.0% vs 2.2%, p = 0.99), PE (0.6% vs 0.3%, p = 0.56), stroke (0.0% vs 0.3%, p = 0.99), MI (0.6% vs 0%, p = 0.33), surgical site infections (0.6% vs 1.9%, p = 0.94), or minor bleeding episodes (1.3% vs 1.6%, p = 0.74). No deep surgical site infections were reported in either group.

When cumulative major AE (Table 3) from all 3 sources were compared (counting each unique AE only once), patients with OA had significantly more major AE (RA 6.9% vs OA 14.5%, p = 0.02), driven by major surgical events (RA 2.5% vs OA 8.2%, p = 0.02). There was no significant difference in 6-month, postoperative mortality (1.3% vs 0.6%, p = 0.41), major medical AE (4.4% vs 6.3%, p = 0.40), or cumulative minor events (56.7% vs 55.3%, p = 0.79). No significant difference in AE was observed in patients with RA when stratified by type of immunosuppressive medication (Table 4).

Multivariate regression was performed evaluating risk of major AE and death, controlling for basic demographic and preoperative health status variables that were found to be significant on univariate analysis, including diagnosis (OA vs RA), race, BMI, SF-36 PCS, preoperative WOMAC Pain, and preoperative WOMAC Function. OA increased the risk of major complication and death with an adjusted OR of 3.39 (95% CI 1.25–9.20). Being white decreased the risk of

Table 1. Patient characteristics. Not all patients contributed to every variable because of missing data. Values are n (%) or mean ± SD unless otherwise specified.

Characteristics	RA Cases, n = 159	OA Cases, n = 318	p
Matching criteria			
Age, yrs, mean ± SD (range)	63.6 ± 11.7 (22–92)	63.8 ± 11.2 (22–93)	0.87
Female	139 (88.0)	278 (87.7)	0.93
Surgical procedure			0.96
Primary	131 (82.9)	263 (82.7)	
Revision	27 (17.1)	55 (17.3)	
Baseline characteristics			
BMI	28.2 ± 6.6	30.8 ± 7.1	**< 0.001**
White, %	83.7	88.4	**0.04**
Education			0.54
High school or less	36 (24.7)	64 (20.1)	
Some college or college degree	67 (45.9)	153 (48.1)	
Advanced degree	43 (29.5)	101 (31.8)	
Charlson/Deyo Comorbidity Index*, %			0.64
0	74.2	74.2	
1–2	23.3	24.5	
3+	1.9	0.9	
ASA class, %			0.28
I or II	72.2	76.7	
≥ III	27.9	23.3	
Osteoporosis, %	29.6	12.0	**< 0.001**
Previous THA or TKA	59 (37.1)	125 (39.3)	0.64
Baseline function			
WOMAC			
Pain	47.1 ± 19.0	53.7 ± 19.1	**< 0.001**
Stiffness	41.0 ± 23.7	44.8 ± 22.7	0.10
Function	43.8 ± 19.6	54.2 ± 17.8	**< 0.001**
LEAS, median (IQR)	8 (6–10)	9 (7–11)	**< 0.001**
EQ-5D score	0.59 ± 0.20	0.65 ± 0.18	**0.006**
SF-36			
PCS	29.3 ± 7.7	33.3 ± 8.5	**< 0.001**
MCS	47.3 ± 13.7	50.4 ± 12.2	**0.02**
Surgical characteristics			
Operation time, min	144.3 ± 41.1	146.0 ± 38.2	0.66
Procedure time, min	93.9 ± 34.1	94.5 ± 32.9	0.87
Length of hospital stay, days, median (IQR)	5 (5–6)	5 (4–6)	0.09
Anesthesia type			
Neuraxial	151 (95.0)	311 (97.8)	0.10
General	4 (2.5)	9 (2.8)	0.84
Regional	1 (0.6)	0 (0.0)	0.33
Regional + block	120 (75.5)	271 (85.2)	**0.01**

Significant data are in bold face. * Comorbidity Index excluding RA. RA: rheumatoid arthritis; OA: osteoarthritis; BMI: body mass index; ASA: American Society of Anesthesiologists; THA: total hip arthroplasty; TKA: total knee arthroplasty; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; LEAS: Lower Extremity Activity Scale; IQR: interquartile range; SF-36: Medical Outcomes Study Short Form-36; PCS: physical component summary; MCS: mental component summary; IQR: interquartile range.

complications and death with an adjusted OR of 0.34 (95% CI 0.12–0.96). Worse preoperative WOMAC Pain slightly increased the risk of major complication with an adjusted OR of 1.04 (95% CI 1.00–1.08; Table 5).

DISCUSSION

For patients with RA undergoing TKA in a high-volume tertiary care center with surgeons who have high RA-specific surgical volume, RA does not increase the incidence of postoperative AE. In fact, OA increased the risk of AE compared with RA, primarily because of increased rates of post-TKA manipulation. In spite of worse preoperative function, worse health status, higher comorbidity scores, and higher steroid and DMARD use, infection and wound healing complications were not increased in patients with RA.

An increase in RA prosthetic joint infection is described in multiple series, but the highest risks of infection are seen when older studies are included[16,33,34]. A 2012 metaanalysis that included both total hip arthroplasty (THA) and TKA reported an increased incidence in joint infection. However,

Table 2. Medications in RA cases.

Medication	Percentage of RA Cases (n)
No TNFi, DMARD, biologic, or steroid	14.5 (23)
TNFi	41.5 (66)
Etanercept	60.6 (40)
Adalimumab	19.7 (13)
Infliximab	18.2 (12)
Golimumab	1.5 (1)
Methotrexate	45.9 (73)
Nonbiologic DMARD	67.3 (107)
1 nonbiologic DMARD	78.5 (84)
2 nonbiologic DMARD	19.6 (21)
3 nonbiologic DMARD	1.9 (2)
Non-TNFi biologics	4.4 (7)
Corticosteroids in combination	24.5 (39)
Corticosteroids alone	4.4 (7)
Supraphysiologic perioperative steroid	20.1 (32)

RA: rheumatoid arthritis; TNFi: tumor necrosis factor inhibitors; DMARD: disease-modifying antirheumatic drugs.

Table 3. Adverse events. Values are n (%) unless otherwise specified.

Adverse Events	RA Cases, n = 159	OA Controls, n = 318	p
Major medical AE	7 (4.4)	20 (6.3)	0.40
Fracture	1 (0.62)	3 (0.94)	0.99
Pneumonia	3 (1.9)	2 (0.63)	0.34
DVT	1 (1.9)	11 (3.5)	0.07
PE	1 (1.9)	3 (0.94)	0.99
Stroke	0 (0.0)	1 (0.31)	0.99
MI	1 (1.9)	0 (0.0)	0.33
Deep surgical site infection	0 (0.0)	0 (0.0)	—
Major bleeding episode	0 (0.0)	0 (0.0)	—
Major surgical AE	4 (2.5)	26 (8.2)	**0.02**
Manipulation	2 (1.3)	23 (7.2)	**0.01**
Revision	1 (1.9)	3 (0.94)	0.99
Other operation	1 (1.9)	0 (0.0)	0.33
Major AE excluding death	11 (6.9)	46 (14.5)	**0.02**
Death	2 (1.3)	2 (0.6)	0.60
Minor AE	90 (56.7)	176 (55.3)	0.79
Minor infection	13 (8.2)	42 (13.2)	0.10
Superficial surgical site infection	8 (5.0)	30 (9.4)	0.09
Other minor infection	5 (3.1)	12 (3.8)	0.73
Transient neuropathy	3 (1.9)	6 (1.9)	0.99
Incision drainage	50 (31.4)	87 (27.4)	0.35
Erythema	8 (5.0)	17 (5.3)	0.88
Ecchymosis	7 (4.4)	7 (2.2)	0.25
Atelectasis	2 (1.3)	5 (1.6)	0.99
Hematoma	2 (1.3)	2 (0.63)	0.60
Minor bleeding episode	5 (3.1)	10 (3.1)	0.99

Significant data are in bold face. AE: adverse events; DVT: deep vein thrombosis; PE: pulmonary embolus; MI: myocardial infarction; RA: rheumatoid arthritis; OA: osteoarthritis.

the most recent of the 5 studies that contributed data on infections included cases from 1998 to 2005[15,35]. Moreover, only 3 of the 40 studies included in the metaanalysis discuss the establishment of the diagnosis of RA based on the American College of Rheumatology (ACR) criteria or diagnosed by referring rheumatologist or internist. Our study included only patients operated on between 2007 and 2010, and therefore better reflected the effect of current surgical, anesthetic, and medical treatment. Additionally, RA-specific surgical volume was assessed, which decreases the risk of complications for patients with RA[25]. RA was also carefully validated because self-reported RA has notoriously poor accuracy[36,37]. Using more recent data, Ravi, *et al* evaluated infection rates within 2 years after first primary TKA in a large cohort from 2002–2009[38]. This study defined RA using an established algorithm based on the ICD-10 coding without chart review. While they did report an increase in infection rate in RA after 2 years, they found no significant difference in infection rates between RA and OA within 90 days of the operation, consistent with our findings. This shorter interval may better reflect the risk related to surgery. The type of infections and rates of occurrence in that study are not specified. Given that deep implant infections are rare, and wound complications are strongly associated with deep implant infection[39], we included superficial wound complications to increase the sensitivity of our analysis. We found no difference in rates of superficial or deep infections or wound complications between groups. There was also no increase in thromboembolic complications, cardiac complications, or postoperative mortality.

It is intriguing that RA cases had lower reported manipulation rates. A speculative explanation is the ligamentous laxity in patients with RA. Additionally, osteoporosis, which is a clinical concern for the surgeon prior to manipulation, was significantly higher in RA and may have influenced the manipulation rate. The increased rate of manipulations in OA influenced the multivariate analysis in which a diagnosis of OA increased the risk of a major AE.

Strengths of our study include a large cohort of validated patients with RA at a major referral center, all with standardized prospective collection of self-report health status measures with detailed information on comorbidities and medications. Ascertainment of RA-specific surgical volume adds validity to our findings. All surgery was performed within a relatively short time period, and our study was limited to TKA, increasing the specificity of our findings. Our data reflect results in nonurgent cases, and arthroplasties are almost always planned elective surgeries.

Our study is limited by the lack of the ACR definition of RA[40] because this is a tertiary referral hospital often without access to the primary chart. However, data support the accuracy of ICD-9 codes and RA medication as an algorithm to validate a diagnosis of RA[41,42,43,44]. Additionally, we do not have information regarding RA-specific disease activity scores, and active RA increases the risk for infection[45]. Although the rheumatologists at the hospital advised patients to discontinue the TNFi prior to orthopedic surgery, there was no consistency in the withhold interval, so this could not be

Table 4. AE in patients with RA according to medication. Values are n (%) unless otherwise specified.

Adverse Events	No Immunosuppressive Medications, n = 23	TNFi, ± Other DMARD or Steroids, n = 66	Non-TNFi Biologics, ± Other DMARD or Steroids, n = 7	Nonbiologic DMARD, ± Steroids, n = 56	Steroids Alone, n = 7	p
Any major or minor AE	14 (60.9)	27 (40.9)	3 (42.9)	27 (48.2)	4 (57.1)	0.53
Any major AE	1 (4.4)	5 (7.6)	1 (14.3)	2 (3.6)	1 (14.3)	0.37
Major surgical AE	1 (4.4)	3 (4.6)	0 (0.0)	0 (0.0)	0 (0.0)	0.50
Major medical AE	0 (0.0)	3 (4.6)	1 (14.3)	2 (3.6)	1 (14.3)	0.21
Any minor AE	13 (56.5)	25 (37.9)	3 (42.9)	25 (44.6)	4 (57.1)	0.56

AE: adverse events; RA: rheumatoid arthritis; TNFi: tumor necrosis factor inhibitors; DMARD: disease-modifying antirheumatic drugs.

Table 5. Multiple logistic regression analysis of risk factors for major complications and death.

Putative Risk Factors	Adjusted OR (95% CI)	p
OA vs RA	3.39 (1.25–9.20)	**0.02**
White vs nonwhite	0.34 (0.12–0.95)	**0.04**
Preoperative BMI > 30 vs ≤ 30	0.89 (0.38–2.05)	0.78
Preoperative SF-36 PCS	0.99 (0.92–1.05)	0.68
Preoperative WOMAC pain	1.04 (1.00–1.08)	0.03
Preoperative WOMAC function	0.97 (0.93–1.01)	0.10
Preoperative LEAS	1.15 (0.99–1.34)	0.08
Preoperative SF-36 MCS	0.98 (0.95–1.02)	0.27
Preoperative EQ-5D index score	0.87 (0.05–16.24)	0.93

Multiple logistic regression controlling for diagnosis, race, BMI, SF-36 PCS, preoperative WOMAC Pain, preoperative WOMAC Function, preoperative LEAS, preoperative SF-36 MCS, and preoperative EQ-5D index score. Significant data are in bold face. OA: osteoarthritis; RA: rheumatoid arthritis; BMI: body mass index; SF-36: Medical Outcomes Study Short Form-36; PCS: physical component summary; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; LEAS: Lower Extremity Activity Scale; MCS: mental component summary.

analyzed. Our sample size provided only a 28% power to detect a difference between the groups for a combined superficial surgical site and other infection rate of 4.4% (with the significance level set at 0.05). We estimate that 55,890 cases would be needed to demonstrate an increase in deep surgical site infections[46], and given our hospital's extremely low standardized infection ratio for THA (0.46), it is not feasible[47]. Results from our high-volume specialized center should not be generalized to smaller centers where most TKA are currently performed because increased surgeon experience both overall as well as specifically with RA surgery has been linked to a reduced risk of complications[25] and the majority of our cases were performed by surgeons with high RA-specific experience. However, although our study lacks power to identify differences between rates of severe AE in RA and OA TKA, these data provide reassurance to patients with RA that under optimal conditions, postoperative AE rates do not appear to be as high as previously reported.

RA cases excluded from the analysis because of the lack of followup data had worse ASA status and were less likely to be white, and may have been more likely to develop AE. To optimize identification of AE, 100% of OA controls included in our study had 6-month self-reported data. For RA, only 70.2% of cases had 6-month self-reported data, and those without data were excluded. However, 100% of RA cases had hospital and office records accessible for review. This may have led to an overreporting of AE among OA controls. However, when considering only the self-reported data, there were no significant differences in any AE. The only significant differences observed between groups were seen in the differences in hospital and office chart data. Moreover, AE during the hospitalization were ascertained for the excluded cases to further evaluate differences between the included cases versus the excluded group because patients with poorer outcomes are less likely to have followup, which may lead to bias. No difference in AE was seen. Additionally, while excluded cases were less likely to be treated with TNFi, this was not statistically significant. More excluded cases were receiving therapy with corticosteroids than included cases, but this would be expected to raise infection risk.

Our paper found that short-term complication rates for patients with RA undergoing TKA are low, similar to OA, when performed under optimal conditions in a high-volume tertiary referral center with high RA-specific surgical experience. DMARD and biologic use was not a risk factor for complications. This is important information because the rate of TKA among RA appears to be increasing. These data will be useful to orthopedic surgeons and patients with RA contemplating TKA.

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APPENDIX 1. AE by source. Values are n unless otherwise specified.

Adverse Events	RA Cases, n = 159				OA Controls, n = 318				p
	Prior to Discharge	Office Chart	6-mo Self-report	Total	Prior to Discharge	Office Chart	6-mo Self-report	Total	
Major medical AE	2	0	5	7	5	3	12	20	0.40
Fracture	0	0	1	1	0	1	2	3	0.99
Pneumonia	1	0	2	3	1	0	1	2	0.34
DVT	1	0	0	1	3	1	7	11	0.07
PE	0	0	1	1	1	1	1	3	0.99
Stroke	0	0	0	0	0	0	1	1	0.99
MI	0	0	1	1	0	0	0	0	0.33
Deep surgical site infection	0	0	0	0	0	0	0	0	—
Major bleeding episode	0	0	0	0	0	0	0	0	—
Major surgical AE	0	3	1	4	0	26	0	26	**0.02**
Manipulation	0	2	0	2	0	23	0	23	**0.01**
Revision	0	1	0	1	0	3	0	3	0.99
Other reoperation	0	0	1	1	0	0	0	0	0.33
Major AE, excluding death	2	3	6	11	5	29	12	46	**0.02**
Death	0	0	2	2	0	0	2	2	0.60
Minor AE	75	12	3	90	129	36	11	176	0.79
Minor infection	4	8	1	13	11	25	6	42	0.10
Superficial surgical site infection	2	5	1	8	3	21	6	30	0.09
Other minor infection	2	3	0	5	8	4	0	12	0.73
Transient neuropathy	2	1	0	3	3	3	0	6	0.99
Incision drainage	50	0	0	50	87	0	0	87	0.35
Erythema	8	0	0	8	17	0	0	17	0.88
Ecchymosis	7	0	0	7	4	3	0	7	0.25
Atelectasis	2	0	0	2	5	0	0	5	0.99
Hematoma	2	0	0	2	2	0	0	2	0.60
Minor bleeding episode	0	3	2	5	0	5	5	10	0.99

Significant data are in bold face. AE: adverse events; RA: rheumatoid arthritis; OA: osteoarthritis; DVT: deep vein thrombosis; PE: pulmonary embolus; MI: myocardial infarction.