Undergoing an Arthroscopic Procedure Prior to Shoulder Arthroplasty is Associated With Greater Risk of Prosthetic Joint Infection

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Purpose: To utilize a national all-payer claims dataset to understand whether a history of a prior shoulder arthroscopy is associated with adverse outcomes or complications after the index shoulder arthroplasty itself. **Methods:** The Symphony Integrated DataVerse, an all-payer claims database, was used to identify patients undergoing primary shoulder arthroplasty (hemiarthroplasty, anatomic total shoulder arthroplasty, or reverse total shoulder arthroplasty) between 2017 to 2018. *Current Procedural Terminology* codes were used to identify patients who had undergone a shoulder arthroscopic procedure on the ipsilateral side within 2 years before the arthroplasty. Multivariate logistic regression analyses were used to assess whether prior shoulder arthroscopy was associated with higher risks of wound complications, postoperative stiffness, mechanical complications, prosthetic joint infection, revision surgery and readmissions within 90 days of the arthroplasty. **Results:** In total, 19,429 patients were included, of which 837 (4.3%) had undergone shoulder arthroscopy within 2 years before the arthroplasty. Prior shoulder arthroscopy was associated with a significantly higher risk of prosthetic joint infection (odds ratio [OR] 2.74 [95% confidence interval {CI} 1.51-4.69]; $P < .001$) within 90 days of the arthroplasty. The greatest risk of prosthetic joint infection was associated with arthroscopies that took place within 3 months before the arthroplasty (OR 5.32 [95% CI 1.42-15.14]; $P = .005$). **Conclusions:** Undergoing an arthroscopic procedure of the ipsilateral shoulder before undergoing an arthroplasty was associated with greater risk of prosthetic joint infection. Furthermore, it appears that patients who received arthroscopy within the 3 months before arthroplasty had the highest risk of prosthetic joint infections. Physicians should not only anticipate possible inferior outcomes in patients who have had prior arthroscopy, but also consider delaying the arthroplasty by at least 3 months after the arthroscopy to mitigate the risks of experiencing this costly adverse event. **Level of Evidence:** III

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Introduction

Significant advances in implant designs and surgical techniques, coupled with changing patient demographics, have led to a rise in the use of shoulder arthroplasty across the nation.[1-5] Currently, shoulder arthroplasties, either in the form of hemiarthroplasties (HA), anatomic total shoulder arthroplasties (TSA), and reverse shoulder arthroplasties (RSA), are being performed for a variety of indications, such as fractures, degenerative rotator cuff arthropathy, or glenohumeral osteoarthritis. Although the majority of patients undergoing primary shoulder arthroplasty undergo the procedure on treatment-naïve (i.e., never operated on) glenohumeral joints, a fair proportion of individuals undergoing surgery also have a history of a prior non–arthroplasty surgery, such as an arthroscopic procedure. Arthroscopic procedures of the shoulder remain one of the most commonly performed procedures in the realm of shoulder and elbow surgery.[6,7] Improvements in surgical techniques, better understanding of shoulder biomechanics, and expanding indications have resulted in arthroscopic surgery being a mainstay in the management of numerous shoulder disorders (such as rotator cuff repairs, shoulder

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stabilizations, biceps tenodesis, debridement, etc.).[8-10] With a growing use of shoulder arthroscopy in the nation, there have been concerns about whether prior arthroscopy may be associated with a higher rate of postoperative complications or greater resource use for patients who end up receiving an arthroplasty (i.e., HA, TSA or RSA) on the same shoulder. Much of these concerns stem from prior hip/knee literature showing prior arthroscopy of the ipsilateral joint to be associated with greater rates of revision, peri-prosthetic joint infections and complications following the index total joint arthroplasty.[11,12]

The purpose of our study was to use a national all-payer claims dataset to understand whether a history of a prior shoulder arthroscopy is associated with adverse outcomes or complications after the index shoulder arthroplasty itself. We hypothesized that a history of a prior arthroscopic procedure would be associated with higher complication rates within 90 days of the index shoulder arthroplasty.

Methods

Database and Patient Selection

This was a retrospective case-control study carried out using the Symphony Health Integrated DataVerse (IDV) database, accessed through the PearlDiver (Colorado Springs, CO) research software. The Symphony Health IDV derives data from multiple sources, including prescription claims, inpatient, and outpatient records from multiple payers across the nation. The data can be queried using International Classification of Diseases 9th/10th Edition (ICD-9/ICD-10) diagnosis and procedure codes, as well as *Current Procedural Terminology* codes. All data are made available to researchers on a deidentified basis, and therefore the study was exempt from Institutional Review Board approval.

The 2015 to 2018 Symphony Health IDV data was queried in June 2020 using ICD-10 procedure codes to identify patients undergoing primary shoulder arthroplasty (hemiarthroplasty, anatomic total shoulder arthroplasty, or reverse total shoulder arthroplasty) between January 2017 to May 2018. Patients undergoing revision arthroplasty or those receiving bilateral arthroplasties were excluded from the cohort. The database switched from the ICD-9 diagnosis coding to ICD-10 diagnosis coding in 2015. Patients who underwent surgery within 2015 to 2016 were removed from the cohort, because preoperative 2-year data capture of these patients would involve the years 2013—2014 and thus would have involved the use of ICD-9 diagnosis codes that, unlike ICD-10 diagnosis codes, do not have associated laterality modifiers to identify whether patients received an arthroscopy on the ipsilateral joint. Although *Current Procedural* (CPT) codes can be used to identify laterality, the Symphony Health database does not report modifiers associated with CPT codes. Therefore only shoulder arthroplasties performed between 2017 to 2018 were analyzed to allow identification of laterality of procedures up to 2 years before surgery using ICD-10 codes. CPT codes were used to identify patients who had a history of an arthroscopic procedure for any indication (i.e., rotator cuff repair, biceps tenodesis, shoulder stabilization, etc.) on the ipsilateral side within 2 years before the arthroplasty. The laterality of the procedure was determined by assessing the associated ICD-10 diagnosis that was coded alongside the CPT code. A complete list of relevant codes used to retrieve patient records can be found in the Appendix. To ensure that we were only identifying patients who had received surgery on the ipsilateral side, patients who underwent arthroscopic procedures on the contralateral side were removed from the study. The study cohort was divided into 2 groups: (1) Those who had a prior shoulder arthroscopy versus (2) Those who did not have a prior shoulder arthroscopy. A complete description of how the study sample was arrived at can be seen in Fig 1. Outcomes that were assessed as part of the study included wound complications, postoperative stiffness, mechanical complications related to the implant, prosthetic joint infections, revision arthroplasty and readmissions within 90 days of the arthroplasty. Relevant ICD-10 codes used to identify the aforementioned complications can be found in the Appendix.

Statistical Analysis

Descriptive analyses, using Pearson χ^2 tests, were used to assess for differences in baseline demographics and procedural characteristics between patients who had receive prior arthroscopy versus those who did not. Multivariate logistic regression analyses were used to assess whether a history of a shoulder arthroscopy was associated with higher risks of wound complications, postoperative stiffness, mechanical complications, prosthetic joint infection, revision surgery, and readmissions within 90 days of the arthroplasty. For outcomes that were significant, an additional sensitivity analysis was used to assess whether the timing of the shoulder arthroscopy was associated with differences in rates of complications. For this sensitivity analysis, the timing of arthroscopy was divided into 4 distinct groups: (1) 0 to 3 months before arthroplasty, 2) 3 to 6 months before arthroplasty, (3) 6 to 12 months before arthroplasty, and (4) 1 to 2 years before arthroplasty. This timing was based off arbitrary divisions, as performed in a prior study on knee arthroscopy.[11] All logistic regression models were adjusted for the following covariates: age, gender, region, Elixhauser Comorbidity Index, specific comorbidities (diabetes mellitus, obesity, smoking), prior shoulder steroid injection within the last 2 years, a history of a prosthetic joint infection of

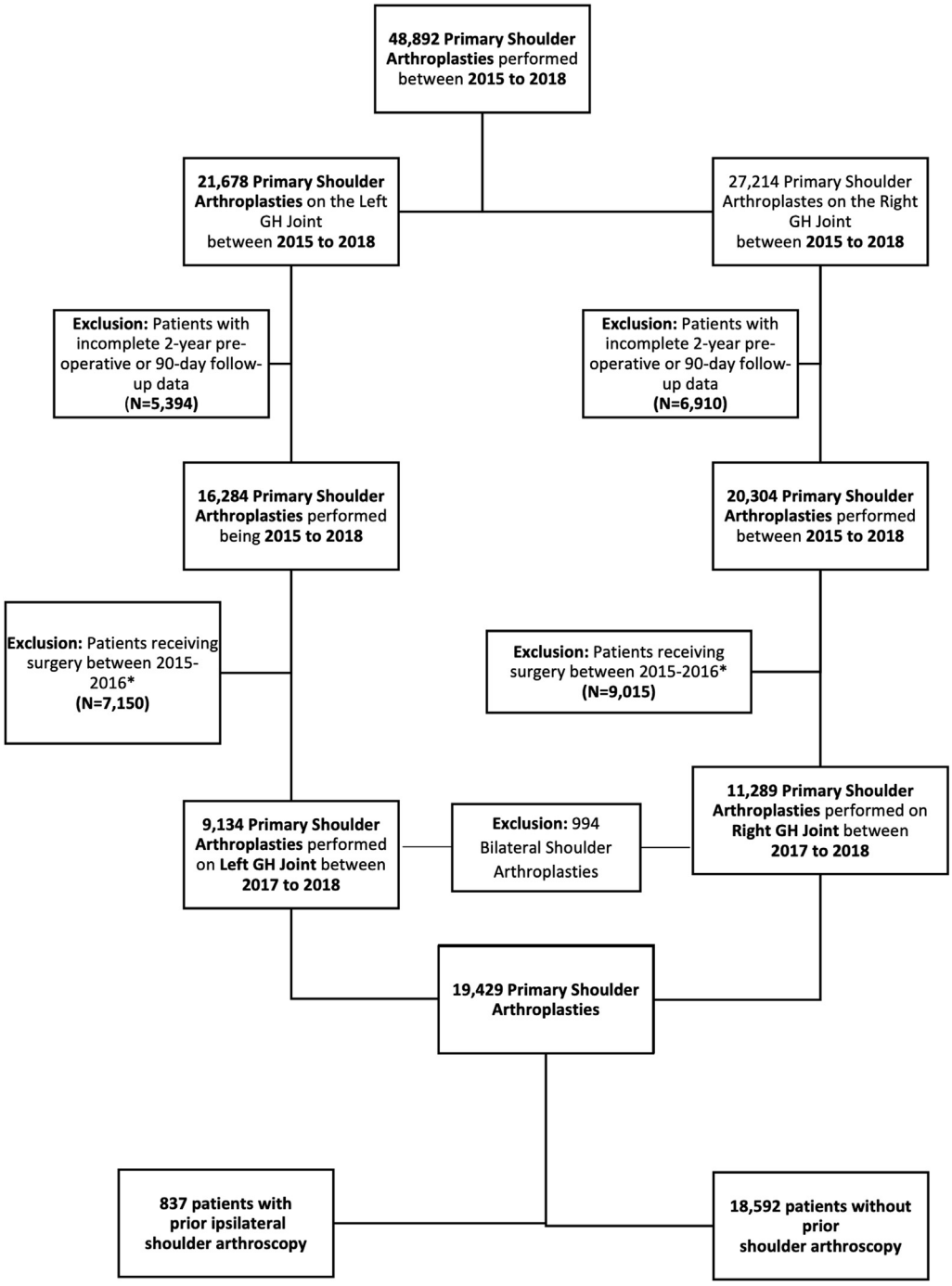

Fig 1. Study process. *Patients undergoing surgery in 2015-2016 were removed because preoperative capture of these patients would have extended up to 2013 and thus would have involved ICD-9 diagnosis codes that do not have associated laterality modifiers to identify whether patients received an arthroscopy on the ipsilateral joint.

any other joint in the last 2 years, type of arthroplasty (HA, TSA, or RSA), and diagnosis/indication for the shoulder arthroplasty. All statistical analysis was carried out using the R-statistics software (R-Core Team, Auckland, New Zealand), provided by the PearlDiver research program. For all statistical purposes where comparisons where comparisons were carried out between 2 groups, a P value $<.05$ was considered statistically significant. Because more than 2 comparison groups were being assessed in the sensitivity analysis that assessed the impact of the timing of the arthroscopy, a Bonferroni correction was applied, and a P value $<.0125$ was considered statistically significant.

Results

Based on our inclusion/exclusion criteria, 19,429 patients were included in the study, of which 837 (4.3%) had received an arthroscopic procedure of the shoulder within 2 years before the shoulder arthroplasty. Patients who had undergone prior arthroscopy were more likely to be younger, of female gender, and were from the Midwest region (Table 1). A complete list

Table 1. Baseline Demographics of the Patient Population

	Prior Shoulder Arthroscopy	No Prior Shoulder Arthroscopy	*P* value
Patients (N)	837	18,592	—
Age, in years, median [IQR]	65 [59-71]	71 [65-77]	<.001
Gender			<.001
Female	543 (64.9%)	11,568 (62.2%)	
Male	294 (35.1%)	7,024 (37.8%)	
Region			<.001
Midwest	313 (37.4%)	5,862 (31.5%)	
Northeast	130 (15.5%)	3,423 (18.4%)	
South	289 (34.%)	6,511 (35.0%)	
West	105 (12.5%)	2,786 (15.0%)	
Unknown	0 (0%)	10 (<0.1%)	
Elixhauser Comorbidity Index (ECI), Mean [SD]	7.3 [3.9]	7.3 [3.9]	.499
Obesity	161 (19.2%)	3,341 (18.0%)	.352
History of smoking	83 (9.9%)	1,019 (5.5%)	<.001
Diabetes Mellitus	192 (22.9%)	4,259 (22.9%)	.998
Type of Arthroplasty			<.001
Anatomic TSA	126 (15.1%)	3,511 (18.9%)	
Reverse TSA	608 (72.6%)	11,475 (61.7%)	
Hemiarthroplasty	103 (12.3%)	3,606 (19.4%)	
Diagnosis/Indication			<0.001
Fracture	2 (0.2%)	1,222 (6.6%)	
Osteonecrosis	8 (1.0%)	130 (0.7%)	
Rheumatoid Arthritis	1 (0.1%)	45 (0.2%)	
Degenerative rotator cuff pathology/osteoarthritis	826 (98.7%)	17,195 (92.5%)	
History of shoulder steroid injection within the past 2 years	334 (39.9%)	4,401 (23.7%)	<.001
History of prosthetic joint infection of other joints within the past 2 years	22 (2.6%)	218 (1.1%)	<.001

of arthroscopic procedures performed in this cohort can be seen in Table 2. Readers should note that most patients received more than 1 type of arthroscopic procedure (i.e., rotator cuff repair combined with biceps tenodesis or debridement etc.). Most of the patients who had undergone prior arthroscopy (vs. those with no prior arthroscopy) received a reverse TSA (72.6% vs 61.7%). Furthermore, patients who had undergone prior arthroscopy were more likely to undergo arthroplasty for degenerative rotator cuff pathology or shoulder osteoarthritis.

After multivariate analysis, patients who had undergone prior arthroscopy (vs. those who did not receive any arthroscopy) were more likely to experience prosthetic joint infections (2.2% vs. 0.6%; odds ratio [OR] 2.74 [95% confidence interval {CI} 1.51-4.69]; *P* <

Table 2. Different Types of Arthroscopic Procedures That Were Performed on Patients*

Type	Number of patients
Arthroscopy shoulder diagnostic with or without synovial biopsy (separate procedure)	18
Arthroscopy shoulder surgical; capsulorrhaphy	40
Arthroscopy shoulder surgical; repair of SLAP lesion	27
Arthroscopy shoulder surgical; with removal of loose body or foreign body	42
Arthroscopy shoulder surgical; synovectomy partial	19
Arthroscopy shoulder surgical; synovectomy complete	12
Arthroscopy shoulder surgical; debridement limited	179
Arthroscopy shoulder surgical; debridement extensive	360
Arthroscopy shoulder surgical; distal claviculectomy including distal articular surface (Mumford procedure)	224
Arthroscopy shoulder surgical; with lysis and resection of adhesions with or without manipulation	48
Arthroscopy shoulder surgical; decompression of subacromial space with partial acromioplasty with or without coracoacromial release	510
Arthroscopy shoulder surgical; with rotator cuff repair	411
Arthroscopy shoulder surgical; biceps tenodesis	103

*Most patients, however, received more than one type of arthroscopic procedure. The numbers reported here represent only the primary CPT code, and not adjunct secondary procedures.

Table 3. Adjusted 90-Day Outcomes Between Patients Who Had a History of a Prior Shoulder Arthroscopy Vs Those Who Did Not Undergo a Prior Shoulder Arthroscopy

Complications	Prior Shoulder Arthroscopy	No Prior Shoulder Arthroscopy	Adjusted OR* [95% CI]	*P* value
Wound complications	13 (1.6%)	232 (1.2%)	1.03 [0.54-1.80]	.921
Postoperative stiffness	99 (11.8%)	1,660 (8.9%)	1.20 [0.96-1.49]	.108
Mechanical complications related to implant	7 (0.8%)	88 (0.5%)	1.51 [0.62-3.13]	.315
Prosthetic joint infection	18 (2.2%)	113 (0.6%)	2.74 [1.51-4.69]	<.001
Revision arthroplasty	7 (0.8%)	146 (0.8%)	1.15 [0.48-2.32]	.731
Readmissions	31 (3.7%)	732 (3.9%)	0.93 [0.62-1.35]	.706

*Adjustment carried out for the following covariates: age, gender, region, ECI, specific comorbidities (smoking, diabetes, obesity), prior shoulder steroid injection within the last 2 years, prior history of prosthetic joint infection within the last 2 years, type of arthroplasty and diagnosis/indication.

.001) within 90 days of the arthroplasty (Table 3). There were no significant association between prior arthroscopy and 90-day rates of wound complications ($P = .921$), postoperative stiffness ($P = .108$), mechanical complications related to the implant ($P = .315$), revision arthroplasty ($P = .731$), and readmissions ($P = .706$). Sensitivity analysis showed that patients who had undergone arthroscopy within the 3 months before the shoulder arthroplasty had the highest risk of experiencing prosthetic joint infections (OR 5.32 [95% CI 1.42-15.14]; $P = .005$) (Table 4). No significant associations were noted between arthroscopies performed at other time periods (i.e., 3 months to 2 years before the arthroplasty) and prosthetic joint infections.

Discussion

Using national insurance claims data from an all-payer database, the findings of our study show that undergoing an arthroscopic procedure of the ipsilateral shoulder before undergoing an arthroplasty was associated with a greater risk of prosthetic joint infection. These observations add on to current, yet limited, evidence showing prior arthroscopic surgery of the shoulder to be associated with inferior outcomes after index arthroplasty.[13-15] Furthermore, on the basis of our findings, it appears that allowing a 3-month delay between the arthroscopy and subsequent arthroplasty is effective in mitigating the risk of experiencing a prosthetic joint infection.

The majority of the prior literature assessing the impact of prior nonarthroplasty surgery on outcomes after shoulder arthroplasty is limited to single-institution studies and investigations limited mainly to functional outcomes. In their study involving 506 shoulder arthroplasties, Frank et al.[13] noted that patients who had not received nonarthroplasty surgery were more likely to have lower odds of postoperative complications after the arthroplasty, as compared to patients who had received prior surgery. Because of a lack of power (secondary to small sample size), the authors were unable to assess individual complications (i.e., mechanical loosening, prosthetic joint infections, stiffness, etc.). In another study that investigated more than 4,500 patients undergoing shoulder arthroplasty, Werthel et al.[16] found that prior nonarthroplasty surgery (defined as arthroscopic procedures, open reduction internal fixations, hardware removals, and other unspecified surgeries) was an independent risk factor associated with prosthetic joint infections after the shoulder arthroplasty itself. Although the findings of both studies are supportive of our conclusions, it is important to note that in both instances, the authors defined nonarthroplasty surgery, because arthroscopies and other procedures, such as prior fracture fixations and revision arthroplasties, which may have skewed their findings. In contrast, our study analyzed patients undergoing primary arthroplasties. Furthermore, we only investigated the impact of prior arthroscopic procedures and excluded patients who had undergone

Table 4. Adjusted Odds of Experiencing a Prosthetic Joint Infection, Based on Time Between Arthroscopic Procedure and Shoulder Arthroplasty

Timing	Number (%)	Adjusted OR* [95% CI]	*P* value†
No arthroscopy	0	Ref.	—
Arthroscopy within prior 3 months	87 (10.3%)	5.32 [1.42-15.14]	.005
Arthroscopy within prior 3-6 months	191 (22.8%)	2.95 [0.86-7.56]	.045
Arthroscopy within prior 6-12 months	318 (38.0%)	1.85 [0.54-4.69]	.255
Arthroscopy within prior 1-2 years	241 (28.8%)	2.62 [0.88-6.26]	.050

*Adjustment carried out for the following co-variates: age, gender, region, ECI, specific comorbidities (smoking, diabetes, obesity), prior shoulder steroid injection within the last 2 years, prior history of prosthetic joint infection within the last 2 years, type of arthroplasty and diagnosis/indication.

†Through Bonferroni correction for multiple comparisons, a *P* value < .0125 was considered significant.

prior fracture fixations. This was done to ensure that we were effectively minimizing confounding being imposed by certain nonarthroplasty surgeries that may have a stronger effect on rates of adverse events (i.e., revision arthroplasties will undoubtedly have a higher rate of postoperative complications).[17] From a non–shoulder surgery perspective, our findings are also in line with current evidence showing prior hip or knee arthroscopy to be associated with greater risks of prosthetic joint infections.[11,12]

The higher rate of prosthetic joint infections seen in patients with prior arthroscopic surgery could have been due to low-grade organisms, such as *Cutibacterium acnes*, that can colonize the joint at the time of arthroscopy.[18-20] These organisms may remain quiescent for a period of time until the arthroplasty is performed, thus providing the bacteria an ideal environment for causing a prosthetic joint infection. However, it is interesting to note that a 3-month delay between the arthroscopy and subsequent arthroplasty appears to mitigate the risk of prosthetic joint infection significantly. Although this could be due to the gradual clearance of the colonized bacteria from the joint by the immune system, surgeons should strongly consider delaying the arthroplasty (if possible) by at least 3 months.

Limitations

There are several limitations to the study that need to be taken into context when interpreting the findings into clinical practice. First, despite having a large sample size of more than 19,000 patients, our study may be underpowered to detect any statistically significant differences in the rate of certain low-incidence complications (i.e., revision arthroplasties) between the 2 groups. Given the small number of patients in the arthroscopy cohort, we cannot entirely rule out selection bias that is inherently present and cannot be entirely accounted for in retrospective studies. Because of a national change in coding algorithms from ICD-9 to ICD-10 (that allows us to identify laterality of the procedure) in 2015, we used a 2-year preoperative time period to identify patients who had a history of arthroscopy before the shoulder arthroplasty. However, readers should note that a number of patients might have received an arthroscopy procedure beyond the 2-year period before the arthroplasty. Because of the relatively low number of patients with a history of arthroscopy, as well as significant overlap in the type of procedures performed (i.e., rotator cuff repair, combined with debridement, or biceps tenodesis), we were unable to conduct a separate analysis to assess whether differing procedures (i.e., debridement only vs biceps tenodesis vs rotator cuff repair, etc.) was an independent risk factor for poor postoperative outcomes. We also did not evaluate the role of arthroscopic debridement in preventing or delaying the need for arthroplasty, because that was beyond the objective of the current study. Finally, insurance claims databases do not contain functional outcome scores that prevents us from analyzing functional scores or quality of life in patients who had an arthroscopy before the shoulder arthroplasty.

Conclusions

Undergoing an arthroscopic procedure of the ipsilateral shoulder before undergoing an arthroplasty was associated with greater risk of prosthetic joint infection. Furthermore, it appears that patients who received arthroscopy within the 3 months before arthroplasty had the highest risk of prosthetic joint infections. Physicians should not only anticipate possible inferior outcomes in patients who have had prior arthroscopy but also consider delaying the arthroplasty by at least 3 months after the arthroscopy to mitigate the risks of experiencing this costly adverse event.

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Supplementary Data

Appendix Table 1

Description/Category	Codes
Shoulder arthroscopies	CPT-29805, CPT-29806, CPT-29807, CPT-29819, CPT-29820, CPT-29821, CPT-29822, CPT-29823, CPT-29824, CPT-29825, CPT-29826, CPT-29827, CPT-29828
Shoulder arthroplasty	ICD-10-P-0RRJ00Z, ICD-10-P-0RRJ0JZ, ICD-10-P-0RRJ0J6, ICD-10-P-0RRK00Z, ICD-10-P-0RRK0J6, ICD-10-P-0RRK0JZ
Proximal humerus fracture	ICD-10-D-M80021A, ICD-10-D-M80022A, ICD-10-D-S42201A, ICD-10-D-S42201B, ICD-10-D-S42202A, ICD-10-D-S42202B, ICD-10-D-S42211A, ICD-10-D-S42211B, ICD-10-D-S42212A, ICD-10-D-S42212B, ICD-10-D-S42209A, ICD-10-D-S42209B, ICD-10-D-S42213A, ICD-10-D-S42214A, ICD-10-D-S42214B, ICD-10-D-S42215A, ICD-10-D-S42216A, ICD-10-D-S42216B, ICD-10-D-S42221A, ICD-10-D-S42221B, ICD-10-D-S42222A, ICD-10-D-S42222B, ICD-10-D-S42223A, ICD-10-D-S42224A, ICD-10-D-S42225A, ICD-10-D-S42226A, ICD-10-D-S42231A, ICD-10-D-S42231B, ICD-10-D-S42232A, ICD-10-D-S42232B, ICD-10-D-S42239A, ICD-10-D-S42239B, ICD-10-D-S42241A, ICD-10-D-S42241B, ICD-10-D-S42242A, ICD-10-D-S42242B, ICD-10-D-S42249A, ICD-10-D-S42249B
Rheumatoid arthritis of the shoulder	ICD-10-D-M05611, ICD-10-D-M05612, ICD-10-D-M05619, ICD-10-D-M05711, ICD-10-D-M05712, ICD-10-D-M05719, ICD-10-D-M05811, ICD-10-D-M05812, ICD-10-D-M05819, ICD-10-D-M06011, ICD-10-D-M06012, ICD-10-D-M06019
Osteonecrosis of shoulder	ICD-10-D-M87811, ICD-10-D-M87812
Wound complications	ICD-10-D-M96842, ICD-10-D-L7634, ICD-10-D-M96840, ICD-10-D-M96841, ICD-10-D-L089, ICD-10-D-T814XXA, CPT-11042, CPT-11043, CPT-11044
Postoperative stiffness	ICD-10-D-M25611, ICD-10-D-M25612, ICD-10-D-M25619
Mechanical complications related to the implant	ICD-10-D-T84018A, ICD-10-D-T84019A, ICD-10-D-T84029A, ICD-10-D-T84038A, ICD-10-D-T84039A, ICD-10-D-T84048A, ICD-10-D-T84058A, ICD-10-D-T84059A, ICD-10-D-T84068A, ICD-10-D-T84069A, ICD-10-D-T84098A, ICD-10-D-T84099A
Prosthetic joint infections	ICD-10-D-T8450XA, ICD-10-D-T8459XA
Revision arthroplasty	CPT-23473, CPT-23474, ICD-10-P-0RWJ0JZ, ICD-10-P-0RWJ3JZ, ICD-10-P-0RWJ4JZ, ICD-10-P-0RWJXJZ, ICD-10-P-0RWK0JZ, ICD-10-P-0RWK3JZ, ICD-10-P-0RWK4JZ, ICD-10-P-0RWKXJZ