JB&JS OPEN ACCESS

# Shoulder Arthroplasty Outcomes After Prior Non-Arthroplasty Shoulder Surgery

Rachel M. Frank, MD, Simon Lee, MD, MPH, Shelby Sumner, MPH, Justin Griffin, MD, Timothy Leroux, MD, Nikhil N. Verma, MD, Brian J. Cole, MD, MBA, Gregory P. Nicholson, MD, and Anthony A. Romeo, MD

*Investigation performed at the Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois*

**Background:** The purpose of this retrospective study was to compare outcomes and complications in patients with and patients without a history of non-arthroplasty surgery on the ipsilateral shoulder who later underwent total shoulder arthroplasty (TSA) or reverse total shoulder arthroplasty (RTSA). We hypothesized that patients who had undergone prior surgery would have more complications and worse clinical outcomes.

**Methods:** Consecutive patients who had undergone shoulder arthroplasty and had been followed for a minimum of 2 years were evaluated with the American Shoulder and Elbow Society scoring system (ASES), Simple Shoulder Test (SST), and Visual Analog Scale (VAS) assessments and with physical examination, including range-of motion assessments. Complications and outcomes in patients who had undergone prior surgery on the ipsilateral shoulder (PS group) were compared with those in patients without such a history (NPS group).

**Results:** Data on 506 shoulder arthroplasties (263 TSA and 243 RTSA) were available for analysis. A total of 144 patients (28%) had an average of 1.9 ± 1.0 surgical procedures on the ipsilateral shoulder before arthroplasty. The average age in the PS group was significantly younger at the time of arthroplasty compared with the NPS group (61.6 ± 10.2 years compared with 68.2 ± 8.6 years, $p = 0.035$). At an average follow-up of 42.8 ± 16.4 months, both groups had significant improvements in ASES, SST, VAS, and range-of-motion values ($p < 0.05$ for all). All outcome scores in the PS group were significantly lower than those in the NPS group ($p < 0.001$ for all). The PS group also had a significantly higher complication rate than the NPS group (19.4% compared with 4.4%, $p < 0.001$), and multivariate regression analysis revealed that prior surgery was a significant independent predictor of postoperative complications. There were no differences between the PS and NPS groups in the number of postoperative infections ($p = 0.679$), reoperations ($p = 0.553$), or transfusions ($p = 0.220$).

**Conclusions:** Patients who have a history of prior surgery on the ipsilateral shoulder derive benefit from shoulder arthroplasty, but their magnitude of improvement and final scores are lower than those of patients who do not have such a history. This information can be used to counsel this challenging patient population on expected outcomes following shoulder arthroplasty.

**Level of Evidence:** Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

There is a growing trend in the utilization of both total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RTSA)[1-5]. For the vast majority of patients, shoulder arthroplasty is associated with a predictably good or excellent clinical outcome and a relatively low complication rate[6-8]. Nevertheless, poor outcomes do occur, and they can be problematic for both patient and surgeon. There is growing interest in better understanding of the factors associated with both positive and negative outcomes following shoulder arthroplasty.

One factor that has been discussed in the literature on hip and knee arthroplasty is the impact of prior surgery on the ipsilateral joint on outcomes after later arthroplasty[9-18]. Given the growth in volume of non-arthroplasty shoulder surgery being performed annually in the United States, it is particularly important to understand any implications of these procedures

**Disclosure:** There was no external source of funding for this study. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A58).

on the outcomes for patients who later have a shoulder arthroplasty[19-21].

To date, there have been few reports concerning the impact of a history of non-arthroplasty surgery on the ipsilateral shoulder on outcomes following later TSA and RTSA[22-25]. We sought to determine the impact of such a history by comparing the outcomes and complications in patients who and did not have prior surgery on the ipsilateral shoulder. We hypothesized that a history of prior surgery on the ipsilateral shoulder would be associated with increased complications and inferior clinical outcomes.

## Materials and Methods

This study was approved by our institutional review board. Consecutive patients for whom inpatient primary TSA or RTSA had been performed by 1 of 2 senior, fellowship-trained shoulder surgeons between 2010 and 2014 were identified from a prospectively collected database. Patients who had a history of conversion of prior fixation of a fracture of the proximal part of the humerus or prior open stabilization were included; patients who had undergone primary hemiarthroplasty, revision TSA, or revision RTSA were excluded.

Data collected for all patients included demographic information, preoperative and postoperative physical examination and patient-reported outcome (PRO) assessments, description of prior surgery on the ipsilateral shoulder, complications, and reoperations. Any operation on the ipsilateral shoulder prior to arthroplasty was considered a single prior surgical event. If multiple procedures, such as rotator cuff repair (RCR) with biceps tenodesis, were performed during a single operative session, this was documented, but the operation was counted as a single event. This allowed for analysis of all relevant procedures on the ipsilateral shoulder prior to arthroplasty without "double-counting" any patient. Demographic information included age, sex, race, body mass index (BMI), smoking status, insurance status, and medical comorbidities. The following preoperative and postoperative assessments were used for all patients: physical examination, American Shoulder and Elbow Society (ASES) score, Simple Shoulder Test (SST), and visual analog scale (VAS) score (measured on a scale of 0 to 10). Postoperative physical examination and PRO assessments were conducted at a minimum of 2 years after arthroplasty. Physical examination with goniometric assessment of ranges of active forward elevation (FE) and active external rotation (ER) was performed by a physician assistant or surgical fellow at the time of follow-up. The postoperative examinations were done in blinded fashion, with the examiner unaware of the patient's status regarding prior surgery on the shoulder. For all patients, the numbers of complications, transfusions, and reoperations were tabulated to permit analysis based on the type of arthroplasty (RTSA or TSA) that was performed and whether or not the shoulder had been operated on previously. Pain was classified as a complication if it was persistent, localized to the ipsilateral shoulder, and not attributable to mechanical failure or to instability of the implant, neurovascular injury, or another structural problem. Transient or intermittent pain that

**TABLE I Patient Demographics***

| | No Prior Surgery (N = 362) | Prior Surgery (N = 144) | P Value |
|---|---|---|---|
| Sex *(F/M)* | 201/161 | 69/75 | 0.074 |
| Age† *(yr)* | 68.2 ± 8.6 | 61.6 ± 10.2 | 0.035 |
| BMI† *(kg/m²)* | 30.9 ± 6.3 | 32.3 ± 17.1 | 0.022 |
| TSA *(no.)* | 198 (55%) | 65 (45%) | 0.033 |
| RTSA *(no.)* | 164 (45%) | 79 (55%) | 0.033 |
| Smoking status† *(no.)* | | | 0.032 |
| Nonsmoker | 177 | 98 | |
| Smoker | 8 | 14 | |
| Former smoker | 44 | 29 | |
| Insurance type† *(no.)* | | | <0.001 |
| Medicare/Medicaid | 202 (56%) | 46 (32%) | |
| Private | 150 (41%) | 75 (52%) | |
| Self pay | 5 (1.4%) | 1 (0.7%) | |
| Workers' Compensation | 5 (1.4%) | 22 (15.3%) | |
| Medical comorbidities† *(no.)* | 5.4 ± 3.3 | 4.4 ± 3.2 | 0.196 |
| Diabetes *(no.)* | 50 (13.8%) | 23 (16.0%) | 0.372 |

*BMI = body mass index, TSA = total shoulder arthroplasty, and RTSA = reverse total shoulder arthroplasty. †The values are given as the mean and standard deviation. The category includes diabetes, which is also listed separately. ‡Smoking status and insurance type were not recorded for all patients.

JBJS Open Access • 2018:e0055. openaccess.jbjs.org 

**TABLE II Prior Surgical Procedures (N = 144 Patients)***

| | No. of Procedures | % of Patients |
|---|---|---|
| Arthroscopy (including arthroscopic joint debridement) | 83 | 58 |
| Rotator cuff repair | 96 | 67 |
| Subacromial decompression, acromioplasty, and/or Mumford procedure | 38 | 26 |
| Putti-Platt, Bristow, and/or Latarjet procedure | 10 | 7 |
| Capsular release | 7 | 5 |
| Fracture fixation, proximal part of humerus | 13 | 9 |
| Anterior labral repair, posterior labral repair, and/or superior labrum anterior to posterior repair | 18 | 13 |
| Proximal biceps tenodesis | 11 | 8 |

*Multiple patients had undergone ≥1 prior procedure on the shoulder (average of 1.9 ± 1.0 procedures on the ipsilateral shoulder prior to arthroplasty).

did not require any intervention was not considered to be a complication.

### *Statistical Analysis*

Statistical analysis was performed using 1-way univariate analysis, bivariate correlation, and multivariate analyses of covariates (ANCOVA/MANCOVA), adjusting for age, and the chi-square or Fisher exact test. SPSS version 22.0 (IBM) was used for all analyses, with $p < 0.05$ considered significant.

## Results

Of a total of 715 consecutive patients who met the inclusion criteria, data on 506 patients (71%) were available for analysis at an average of 42.8 ± 16.4 months following arthroplasty. Patients were considered lost to follow-up and not included in the analysis if they remained unreachable after ≥5 phone and/or e-mail attempts and/or they did not complete postoperative surveys. Of the 506 patients, 263 had undergone TSA and 243 had undergone RTSA. There were 236 men (47%) and 270 women (53%), and the average age (and standard deviation) at the time of arthroplasty was 66.4 ± 9.5 years (range, 33 to 88 years) (Table I). A total of 144 patients (28%) had a history of an average of 1.9 ± 1.0 surgical procedures on the ipsilateral shoulder prior to arthroplasty (PS group); 362 patients (72%) had not undergone surgery on the ipsilateral shoulder prior to arthroplasty (NPS group). In the PS group, 79 patients (55%) had RTSA and 65 (45%) had TSA. PS patients were significantly younger than NPS patients at the time of arthroplasty (an average age of 61.6 ± 10.2 years compared with 68.2 ± 8.6 years, $p = 0.035$). For the PS patients, the most common prior surgical procedure was RCR (performed in 67% of patients) (Table II).

### *Clinical Outcomes*

At the time of final follow-up, compared with their preoperative values, both the PS group and the NPS group showed significantly improved scores for the ASES (from 40.4 to 81.7 ± 22.9, $p < 0.001$), SST (from 3.5 to 8.9 ± 3.5, $p < 0.001$), and VAS (from 5.3 to 1.2 ± 3.2, $p < 0.001$). Patients in both groups also demonstrated significant improvements in range of motion compared with preoperative values: active FE improved from 91.2° ± 36.2° to 140.1° ± 28.7° ($p < 0.001$) and active ER increased from 27.4° ± 18.8° to 51.6° ± 16.7° ($p < 0.001$). Univariate analysis demonstrated significantly lower outcome scores at final follow-up in the PS group compared with the NPS group for the ASES (PS group, 73.2 ± 21.7 and NPS group, 84.9 ± 16.9; $p < 0.001$), SST (PS group, 7.7 ± 3.5 and NPS group, 9.3 ± 2.7; $p < 0.001$), and VAS (PS group, 2.0 ± 3.1 and NPS group, 0.9 ± 1.8; $p < 0.001$) (Table III). Postoperative FE values were significantly lower for patients in the PS group than they were for patients in the NPS group (PS group, 133.8° ± 33.4° and NPS group, 142.3° ± 26.4°; $p < 0.001$). Preoperative FE and ER for the 2 groups were not significantly different (FE for the PS group, 89.4 ± 40.3 and for the NPS group, 90.93 ±

**TABLE III Comparison of Patient-Reported Outcomes for Patients with and without Prior Surgery on the Ipsilateral Shoulder***

| | No Prior Surgery (N = 362) | Prior Surgery (N = 144) | P Value |
|---|---|---|---|
| VAS preop. | 5.4 ± 2.5 | 5.2 ± 2.5 | 0.426 |
| VAS postop. | 0.9 ± 1.8 | 2.0 ± 3.1 | <0.001 |
| SST preop. | 3.5 ± 2.6 | 3.5 ± 2.6 | 0.287 |
| SST postop. | 9.3 ± 2.7 | 7.7 ± 3.5 | <0.001 |
| ASES preop. | 40.6 ± 17.2 | 40.1 ± 18.1 | 0.520 |
| ASES postop. | 84.9 ± 16.9 | 73.2 ± 21.7 | <0.001 |
| FE preop. *(°)* | 91.6 ± 34.3 | 89.4 ± 40.3 | 0.002 |
| FE postop. *(°)* | 142.3 ± 26.4 | 133.8 ± 33.4 | <0.001 |
| ER preop. *(°)* | 26.2 ± 17.2 | 30.0 ± 23.3 | <0.001 |
| ER postop. *(°)* | 52.3 ± 16.5 | 49.9 ± 18.1 | 0.493 |

*The values are given as the mean and standard deviation. VAS = visual analog scale, SST = Simple Shoulder Test, ASES = American Shoulder and Elbow Society score, FE = active forward elevation, and ER = active external rotation.

**TABLE IV Comparison of Patient-Reported Outcomes Based on Type of Prior Surgery (N = 144)***

| | RCR (N = 96) | Other Prior Surgery (N = 48) | P Value |
|---|---|---|---|
| VAS preop. | 5.3 ± 2.6 | 5.1 ± 2.5 | 0.907 |
| VAS postop. | 1.9 ± 2.5 | 2.1 ± 3.6 | 0.852 |
| SST preop. | 2.6 ± 2.2 | 4.5 ± 2.6 | 0.026 |
| SST postop. | 6.8 ± 3.6 | 8.6 ± 3.3 | 0.286 |
| ASES preop. | 37.9 ± 17.3 | 42.4 ± 18.7 | 0.510 |
| ASES postop. | 70.8 ± 21.7 | 75.8 ± 21.6 | 0.927 |
| FE preop. *(°)* | 75.3 ± 35.9 | 103.7 ± 39.7 | 0.086 |
| FE postop. *(°)* | 124.1 ± 34.1 | 143.4 ± 29.9 | 0.132 |
| ER preop. *(°)* | 31.6 ± 23.4 | 28.9 ± 23.4 | 0.936 |
| ER postop. *(°)* | 47.6 ± 18.6 | 51.9 ± 17.6 | 0.833 |

*The values are given as the mean and standard deviation. RCR = rotator cuff repair, VAS = visual analog scale, SST = Simple Shoulder Test, ASES = American Shoulder and Elbow Society score, FE = active forward elevation, and ER = active external rotation.

34.5; p = 0.0002; ER for the PS group, 30.0 ± 23.3 and for the NPS group, 26.2 ± 17.2; p < 0.001). Bivariate correlation subanalysis of the PS group revealed that postoperative values for FE, ER, and VAS were not affected by the number of prior surgical procedures (p > 0.05). However, postoperative scores for the SST and ASES decreased significantly as the number of prior surgical procedures increased: for the SST, the Pearson correlation was −0.273 (p = 0.01) and for the ASES, the Pearson correlation was −0.195 (p = 0.05). For patients in the PS group, no significant differences in outcome scores or magnitudes of change in outcomes were detected between patients who had a history of RCR compared with any of the other procedures (p > 0.05 for all) (Table IV).

### *Results After TSA Compared with RTSA*

There were no significant differences between patients who had TSA and those who had RTSA with regard to postoperative scores for the ASES (p = 0.720), SST (p = 0.595), or VAS (p = 0.071). There were also no significant differences in values for postoperative ER (p = 0.312) (Table V). Patients who underwent TSA had significantly more postoperative FE than those who had RTSA (TSA, 147.2° ± 25.2° and RTSA, 132.1° ± 30.3°; p = 0.004). There were no significant differences between patients who had TSA and those who had RTSA with regard to overall complications (p = 0.627), infections (p = 0.658), or reoperations (p = 0.564). Of the patients who had RTSA, 16 (7%) needed transfusion, significantly more than the 3 patients (1%) who underwent TSA (p = 0.003) (Table V).

### *Complications and Reoperations*

A total of 44 complications occurred, for a complication rate of 8.7%, and 15 reoperations were performed, for a rate of 3.0% (Tables V and VI). The overall infection rate was 0.8% (n = 4), and the overall transfusion rate was 3.8% (n = 19). One deep and 2 superficial infections occurred in the NPS group, and there was 1 deep infection in the PS group. In the PS group, 28 patients (19.4%) had a postoperative complication and 5 (3.5%) had a reoperation; in the NPS group, there were 16 postoperative complications (4.4%) and 10 reoperations (2.8%). The rate of complications in the PS group (19.4%) was significantly higher than that in the NPS group (4.4%) (p < 0.001); this difference was largely driven by minor complications (Table VI). There was no significant difference between the PS and NPS groups in the number of major complications, including infection (p = 0.679), reoperation (p = 0.553), and the need for transfusion (p = 0.220). Seven patients had postoperative instability: 1 patient in the NPS group who had RTSA and 6 patients in the PS group, 2 of whom had TSA and 4 of whom had RTSA.

### *Multivariate Regression Analysis*

In an attempt to account for these individual variables, multivariate regression analysis was performed. This revealed that prior surgery was a significant independent predictor of postoperative complications and that the patient's sex, type of arthroplasty (TSA or RTSA), and BMI were not. Patients in the NPS group had 1.144 times lower odds of postoperative complications than patients in the PS group (p = 0.003, 95% confidence interval [CI] = 0.151 to 0.671). Older age was weakly associated with greater odds of complications (p = 0.005, odds ratio during the study period = 1.059, 95% CI = 1.018 to 1.105).

### *Subset Analysis of RTSA Patients*

Compared with patients in the NPS group, those in the PS group who underwent RTSA had significantly worse outcomes as measured by the ASES (71.4 ± 20.1 compared with 82.3 ± 15.6, p = 0.004), SST (7.0 ± 3.4 compared with 8.6 ± 2.6,

**TABLE V Comparison of Outcomes After RTSA and TSA***

| | RTSA (N = 243) | TSA (N = 263) | P Value |
|---|---|---|---|
| VAS postop.† | 1.1 ± 1.9 | 1.4 ± 2.7 | 0.071 |
| SST postop.† | 8.0 ± 3.0 | 9.6 ± 3.0 | 0.595 |
| ASES postop.† | 78.6 ± 18.0 | 84.1 ± 19.9 | 0.720 |
| FE postop.† *(°)* | 132.1 ± 30.3 | 147.2 ± 25.2 | 0.004 |
| ER postop.† *(°)* | 45.7 ± 16.3 | 56.8 ± 15.9 | 0.312 |
| Infections *(no.)* | 2 | 2 | 0.658 |
| Complications *(no.)* | 20 | 24 | 0.627 |
| Reoperations *(no.)* | 8 | 7 | 0.564 |
| Transfusions *(no.)* | 16 | 3 | 0.003 |

*RTSA = reverse total shoulder arthroplasty, TSA = total shoulder arthroplasty, VAS = visual analog scale, SST = Simple Shoulder Test, ASES = American Shoulder and Elbow Society score, FE = active forward elevation, and ER = active external rotation. †The values are given as the mean and standard deviation.

**JBJS Open Access** • 2018:e0055. **openaccess.jbjs.org** 5

**TABLE VI Complications and Reoperations***

| | No Prior Surgery (N = 362) | Prior Surgery (N = 144) | P Value |
|---|---|---|---|
| Complications *(no. of patients)* | 16 (4.4%) | 28 (19.4%) | <0.001 |
| Infection | 3 (2 superficial, 1 deep) | 1 (late, deep infection) | 0.679 |
| Stiffness | 3 | 2 | |
| Pain | 6 | 12 | |
| Instability/dislocation | 1 | 6 | |
| Aseptic loosening of glenoid component | 1 | 1 | |
| Periprosthetic fracture | 1 | 0 | |
| Subscapularis failure | 0 | 2 | |
| Axillary nerve neurapraxia | 1 | 0 | |
| Cubital tunnel syndrome due to sling use (no symptoms preop.) | 0 | 1 (required surgery – ulnar nerve transposition) | |
| Unexplained weakness | 0 | 1 | |
| Lymphedema | 0 | 1 | |
| Acromial stress reaction | 0 | 1 | |
| Reoperations | 10 (2.8%) | 5 (3.5%) | 0.553 |
| Arthroscopic repair of rotator cuff | 1 | 0 | |
| Irrigation and debridement with polyethylene exchange for deep infection | 1 | 0 | |
| Irrigation and debridement for superficial infection | 2 | 0 | |
| Arthroscopic capsular release | 2 | 1 | |
| Arthroscopic irrigation and debridement with spacer placement | | 0 | |
| Periprosthetic fracture ORIF | 1 | 1 | |
| Revision RTSA | 1 | 2 | |
| Conversion of TSA to RTSA | 1 | 1 | |
| Conversion of arthroplasty to hemiarthroplasty | 1 | 0 | |
| Transfusions | 4 | 15 | 0.220 |

*ORIF = open reduction and internal fixation, RTSA = reverse total shoulder arthroplasty, and TSA = total shoulder arthroplasty.

p = 0.003), VAS (1.7 ± 2.3 compared with 0.8 ± 1.6, p < 0.001), and postoperative FE (121.7 ± 33.4° compared with 137.2 ± 27.5°, p = 0.006). There was no difference in postoperative ER values (44.4° ± 18.9° compared with 46.3° ± 15.1°, p = 0.089). In the PS group, the clinical outcomes following arthroplasty for patients who had a history of ≥1 prior RCR were worse than those for patients who had not undergone RCR, including worse values for postoperative FE (121.0° ± 34.8° compared with 135.8° ± 27.9°, p = 0.004), VAS (1.7 ± 2.3 compared with 0.9 ± 1.7, p = 0.011), SST (6.7 ± 3.4 compared with 8.5 ± 2.7, p < 0.001), and ASES (70.7 ± 19.8 compared with 81.5 ± 16.4, p < 0.001). Postoperative ER was not affected by prior RCR status (p = 0.752). In addition, among the patients who underwent RTSA, those in the PS group had a significantly higher rate of overall postoperative complications (15 of 79, 19.0%) than patients in the NPS group (5 of 164, 3.0%, p < 0.001), although there were no significant differences in the number of infections (1 in each group, p = 0.545), reoperations (3 compared with 5, p = 0.513), or the need for transfusion (4 compared with 12, p = 0.350).

### *Subset Analysis of TSA Patients*

Compared with patients in the NPS group, those in the PS group who underwent TSA had significantly worse outcomes as measured by the ASES (75.5 ± 23.6 compared with 87.0 ± 17.6, p = 0.001), SST (8.5 ± 3.5 compared with 10.0 ± 2.7, p = 0.006), and VAS (2.3 ± 3.9 compared with 1.0 ± 2.0, p = 0.001). There was no difference in postoperative FE (149.0° ± 26.6° compared with 146.7° ± 24.7°, p = 0.947) or ER (55.8° ± 15.3° compared with 57.1° ± 16.0°, p = 0.485). In contrast to the patients who had RTSA, in patients who had had TSA there were no significant differences in any PRO or range-of-motion outcome (p > 0.05 for all) between patients in the PS group with a history of ≥1 prior RCR and patients who had not had a prior RCR. This result may be attributable to the small sample size of patients in the TSA group who had a history of RCR (n = 12) in comparison with the large number without such a history (n = 251). In addition, of the patients who had TSA, those in the PS group had significantly more postoperative complications overall (11 of 65, 16.9%) than patients in the NPS group (10 of 198, 5.1%, p = 0.002), although there were no

significant differences in the number of postoperative infections (0 compared with 2, p = 0.566), reoperations (2 compared with 7, p = 0.207), or transfusions (0 compared with 3, p = 0.617).

## Discussion

The principal findings of this study support the hypothesis that prior surgery on the ipsilateral shoulder negatively affects outcomes following shoulder arthroplasty. Specifically, the data demonstrate that while patients who have a history of surgery on the ipsilateral shoulder derive benefit from shoulder arthroplasty, their magnitude of improvement and final PRO scores are significantly lower than those of patients who do not have such a history. Furthermore, patients who undergo shoulder arthroplasty after prior shoulder surgery have a significantly higher complication rate than patients who have not had such prior surgery. Notably, patients who have a history of RCR prior to shoulder arthroplasty do not have higher rates of major complications, including infection, compared with patients who have undergone other (non-RCR) types of shoulder surgery prior to arthroplasty. Finally, in our study, the patients who had a history of prior surgery on the ipsilateral shoulder were, on average, 7 years younger than the patients who had not undergone such surgery.

In 2016, Matsen et al.[22] analyzed the 2-year clinical outcomes of 275 patients who had undergone hemiarthroplasty, TSA, RTSA, or so-called ream-and-run arthroplasty. The authors found that positive prognostic factors associated with better clinical outcomes included class-I status in the rating system of the American Society of Anesthesiologists (ASA), a non-work-related diagnosis, a lower baseline SST score, no radiographic evidence of superior displacement of the humeral head, a glenoid type other than A1, and no history of surgery on the ipsilateral shoulder. Simmen et al.[23] found that a history of shoulder surgery and an age of >75 years were risk factors for unsuccessful outcomes in 140 patients 1 year after TSA. Importantly, a successful outcome, as defined by a Constant score of ≥80, was achieved in only 34% of that entire cohort of patients. In 2017, Werthel et al.[24] assessed the results in 4,577 patients who had undergone shoulder arthroplasty at the Mayo Clinic between 1970 and 2012 and determined the influence of prior non-arthroplasty surgery on the shoulder (813 patients; 18%) on the risk of infection after shoulder arthroplasty. The rate of postoperative deep infection in the shoulder was 1.49% (n = 68), and the risk of infection was significantly higher in patients who had a history of prior shoulder surgery (2.46% compared with 1.28%, p = 0.0094). This result is in contrast to the findings of the present study, which did not find prior surgery on the ipsilateral shoulder to be a significant risk factor for the development of infection after shoulder arthroplasty. The difference in our findings may be attributable to our study being underpowered to detect differences in infection rate, given the low overall incidence of infection in the study cohort. In a separate study, Leschinger et al.[25] assessed the impact of several patient-specific factors on complications in 275 patients who underwent anatomic TSA for primary osteoarthritis. Those authors reported an overall complication rate of 9.8% (n = 27), with factors including an ASA class of III and positive smoking status to be predictive of complications. A history of prior non-arthroplasty shoulder surgery was not found to be associated with complications.

Because of the overall low infection rate following shoulder arthroplasty, estimated to be 1.1% to 1.4%[26,27], it is possible that the sample size of the present study is too small, and thus underpowered, to allow detection of a difference in infection rate based on the presence or absence of prior shoulder surgery. As determined by an a priori power analysis based on historical controls[26,27], using a power of 0.8, detection of even a small clinical difference in infection rate between the PS and NPS groups would require a sample size of at least 1,238 patients in each group.

With respect to overall clinical outcomes, patients in the present study who had undergone prior surgery on the ipsilateral shoulder benefited from shoulder arthroplasty, but their final PRO scores were significantly lower than those of patients without such prior surgery. Importantly, as described by Tashjian et al.[28], the minimal clinically important differences for the PROs evaluated in the present study were 20.9 for the ASES, 2.4 for the SST, and 1.4 for the VAS. While overall outcomes were better in the NPS group, patients in both groups met the minimal clinically important difference for all 3 PROs; thus, the clinical importance of the superior scores in the NPS group is unclear.

There were several important differences between the PS and NPS groups. For patients in the PS group, the average BMI was significantly higher (32.3 compared with 30.9 kg/m$^2$), the average age was significantly younger (61.6 compared with 68.2 years), and proportionally more RTSAs than TSAs were performed (55% compared with 45%). Multivariate regression analysis revealed that prior surgery was a significant independent predictor of postoperative complications; sex, arthroplasty type, and BMI were not independent predictors. Additionally, postoperative active FE was significantly greater in the NPS group than in the PS group (142.3° ± 26.4° compared with 133.8° ± 33.4°, p < 0.001), although prior to arthroplasty the active FE had not differed between the groups (91.6° ± 34.3° compared with 89.4° ± 40.3°). Interestingly, postoperative active ER was not different between the groups at the time of final follow-up. It is unclear why patients with a history of prior surgery would have less active FE, but not less ER, compared with patients who had not undergone such surgery. Taken together, these findings emphasize that patients with a history of surgery on the ipsilateral shoulder who later undergo shoulder arthroplasty may not achieve the same results as patients without such a history. This information may better inform surgeons when counseling patients on their expectations with respect to outcomes and complications following shoulder arthroplasty.

This study had several limitations, including relatively short follow-up of the patients and the loss to follow-up of 29%, which may have introduced bias. While specific descriptions of prior procedures were available in the medical records of the majority of patients with a history of surgery on the ipsilateral

shoulder, "other" arthroscopic procedures accounted for nearly one-third of the prior operations, and thus a more detailed analysis of the impact of these earlier procedures could not be performed. In addition, for some patients procedures such as RCR were listed, but the record did not state if the procedure was performed arthroscopically or open. For these reasons, we were unable to compare the impact of prior open procedures with that of arthroscopic surgery in the PS group. No single category of prior surgery was found to negatively impact outcomes or complications in our study. Similarly, due to vague reporting of the details of prior surgery in many of the medical records, we were unable to analyze the impact of the timing of prior surgery on outcomes following arthroplasty; such information might be helpful in counseling patients.

In conclusion, patients who have undergone prior surgery on the ipsilateral shoulder derive benefit from shoulder arthroplasty, but compared with patients who do not have such a history they are significantly younger and their magnitude of improvement and final scores are significantly lower. This information can be used to counsel patients about expected outcomes following shoulder arthroplasty. ■

Rachel M. Frank, MD[1]
Simon Lee, MD, MPH[2]
Shelby Sumner, MPH[3]
Justin Griffin, MD[4]
Timothy Leroux, MD[5]
Nikhil N. Verma, MD[6]
Brian J. Cole, MD, MBA[6]
Gregory P. Nicholson, MD[6]
Anthony A. Romeo, MD[7]

[1]Department of Orthopaedic Surgery, University of Colorado School of Medicine, Boulder, Colorado

[2]Department of Orthopaedic Surgery, University of Michigan, Ann Arbor, Michigan

[3]Department of Orthopaedic Surgery, Northwestern University, Evanston, Illinois

[4]Jordan-Young Institute, Virginia Beach, Virginia

[5]Department of Surgery, University of Toronto, Toronto, Ontario, Canada

[6]Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois

[7]Rothman Institute, New York, NY

E-mail address for R.M. Frank: Rachel.frank@ucdenver.edu

ORCID iD for R.M. Frank: 0000-0002-1120-0521
ORCID iD for S. Lee: 0000-0002-3378-9605
ORCID iD for S. Sumner: 0000-0003-2711-4852
ORCID iD for J. Griffin: 0000-0002-1234-9889
ORCID iD for T. Leroux: 0000-0002-5417-2372
ORCID iD for N.N. Verma: 0000-0001-9875-2769
ORCID iD for B.J. Cole: 0000-0002-4006-2113
ORCID iD for G.P. Nicholson: 0000-0002-3975-1958
ORCID iD for A.A. Romeo: 0000-0003-4848-3411

## References

**1.** Jain NB, Yamaguchi K. The contribution of reverse shoulder arthroplasty to utilization of primary shoulder arthroplasty. J Shoulder Elbow Surg. 2014 Dec;23(12):1905-12. Epub 2014 Oct 7.

**2.** Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. J Bone Joint Surg Am. 2011 Dec 21;93(24):2249-54.

**3.** Padegimas EM, Maltenfort M, Lazarus MD, Ramsey ML, Williams GR, Namdari S. Future patient demand for shoulder arthroplasty by younger patients: national projections. Clin Orthop Relat Res. 2015 Jun;473(6):1860-7. Epub 2015 Mar 11.

**4.** Schwartz BE, Savin DD, Youderian AR, Mossad D, Goldberg BA. National trends and perioperative outcomes in primary and revision total shoulder arthroplasty: trends in total shoulder arthroplasty. Int Orthop. 2015 Feb;39(2):271-6. Epub 2014 Dec 6.

**5.** Trofa D, Rajaee SS, Smith EL. Nationwide trends in total shoulder arthroplasty and hemiarthroplasty for osteoarthritis. Am J Orthop (Belle Mead NJ). 2014 Apr;43(4):166-72.

**6.** Carter MJ, Mikuls TR, Nayak S, Fehringer EV, Michaud K. Impact of total shoulder arthroplasty on generic and shoulder-specific health-related quality-of-life measures: a systematic literature review and meta-analysis. J Bone Joint Surg Am. 2012 Sep 5;94(17):e127.

**7.** Kiet TK, Feeley BT, Naimark M, Gajiu T, Hall SL, Chung TT, Ma CB. Outcomes after shoulder replacement: comparison between reverse and anatomic total shoulder arthroplasty. J Shoulder Elbow Surg. 2015 Feb;24(2):179-85. Epub 2014 Sep 9.

**8.** Leschinger T, Raiss P, Loew M, Zeifang F. Predictors of medium-term clinical outcomes after total shoulder arthroplasty. Arch Orthop Trauma Surg. 2017 Feb;137(2):187-93. Epub 2016 Dec 7.

**9.** Charles R, LaTulip S, Goulet JA, Pour AE. Previous arthroscopic repair of femoroacetabular impingement does not affect outcomes of total hip arthroplasty. Int Orthop. 2017 Jun;41(6):1125-9. Epub 2016 Oct 26.

**10.** Haughom BD, Plummer DR, Hellman MD, Nho SJ, Rosenberg AG, Della Valle CJ. Does hip arthroscopy affect the outcomes of a subsequent total hip arthroplasty? J Arthroplasty. 2016 Jul;31(7):1516-8. Epub 2016 Jan 21.

**11.** Morag G, Kulidjian A, Zalzal P, Shasha N, Gross AE, Backstein D. Total knee replacement in previous recipients of fresh osteochondral allograft transplants. J Bone Joint Surg Am. 2006 Mar;88(3):541-6.

**12.** Pearse AJ, Hooper GJ, Rothwell A, Frampton C. Survival and functional outcome after revision of a unicompartmental to a total knee replacement: the New Zealand National Joint Registry. J Bone Joint Surg Br. 2010 Apr;92(4):508-12.

**13.** Piedade SR, Pinaroli A, Servien E, Neyret P. Is previous knee arthroscopy related to worse results in primary total knee arthroplasty? Knee Surg Sports Traumatol Arthrosc. 2009 Apr;17(4):328-33. Epub 2008 Dec 20.

**14.** Piedade SR, Pinaroli A, Servien E, Neyret P. TKA outcomes after prior bone and soft tissue knee surgery. Knee Surg Sports Traumatol Arthrosc. 2013 Dec;21(12):2737-43. Epub 2012 Jul 25.

**15.** Preston S, Howard J, Naudie D, Somerville L, McAuley J. Total knee arthroplasty after high tibial osteotomy: no differences between medial and lateral osteotomy approaches. Clin Orthop Relat Res. 2014 Jan;472(1):105-10.

**16.** Ramappa M, Anand S, Jennings A. Total knee replacement following high tibial osteotomy versus total knee replacement without high tibial osteotomy: a systematic review and meta analysis. Arch Orthop Trauma Surg. 2013 Nov;133(11):1587-93.

**17.** Spencer-Gardner LS, Camp CL, Martin JR, Sierra RJ, Trousdale RT, Krych AJ. Does prior surgery for femoroacetabular impingement compromise hip arthroplasty outcomes? J Arthroplasty. 2016 Sep;31(9):1899-903. Epub 2016 Feb 24.

**18.** Frank RM, Della Valle CJ, Plummer DR, Chalmers PN, Cole BJ. Does prior cartilage restoration impact outcomes following knee arthroplasty? Orthop Clin North Am. 2017 Jul;48(3):265-73. Epub 2017 Apr 5.

**19.** Colvin AC, Egorova N, Harrison AK, Moskowitz A, Flatow EL. National trends in rotator cuff repair. J Bone Joint Surg Am. 2012 Feb 1;94(3):227-33.

**20.** Frank RM, Chalmers PN, Moric M, Leroux T, Provencher MT, Romeo AA. Incidence and trends of shoulder stabilization in the United States. Presented at the 2016 French Arthroscopy Society Annual Meeting; 2016 Dec 1; Paris, France. Poster no. 8334.

**21.** Frank RM, Rosas S, Law TY, Weber A, Provencher MT, Verma NN, Cole BJ, Romeo AA, McCormick F. Trends in the national utilization of Latarjet versus Bankart repair: analysis of 26,573 patients. Presented as a poster exhibit at the 2016 AAOS Annual Meeting; 2016 March 1; Orlando, FL. Poster no. P467.

**22.** Matsen FA 3rd, Russ SM, Vu PT, Hsu JE, Lucas RM, Comstock BA. What factors are predictive of patient-reported outcomes? A prospective study of 337 shoulder arthroplasties. Clin Orthop Relat Res. 2016 Nov;474(11):2496-510. Epub 2016 Jul 25.

**23.** Simmen BR, Bachmann LM, Drerup S, Schwyzer HK, Burkhart A, Goldhahn J. Development of a predictive model for estimating the probability of treatment success one year after total shoulder replacement - cohort study. Osteoarthritis Cartilage. 2008 May;16(5):631-4. Epub 2007 Dec 3.

**24.** Werthel JD, Hatta T, Schoch B, Cofield R, Sperling JW, Elhassan BT. Is previous nonarthroplasty surgery a risk factor for periprosthetic infection in primary shoulder arthroplasty? J Shoulder Elbow Surg. 2017 Apr;26(4):635-40. Epub 2017 Jan 12.

**25.** Leschinger T, Raiss P, Loew M, Zeifang F. Total shoulder arthroplasty: risk factors for intraoperative and postoperative complications in patients with primary arthritis. J Shoulder Elbow Surg. 2017 Mar;26(3):e71-7. Epub 2016 Oct 10.

**26.** Dillon MT, Ake CF, Burke MF, Singh A, Yian EH, Paxton EW, Navarro RA. The Kaiser Permanente shoulder arthroplasty registry: results from 6,336 primary shoulder arthroplasties. Acta Orthop. 2015 Jun;86(3):286-92. Epub 2015 Mar 2.

**27.** Stone GP, Clark RE, O'Brien KC, Vaccaro L, Simon P, Lorenzetti AJ, Stephens BC, Frankle MA. Surgical management of periprosthetic shoulder infections. J Shoulder Elbow Surg. 2017 Jul;26(7):1222-9. Epub 2017 Feb 2.

**28.** Tashjian RZ, Hung M, Keener JD, Bowen RC, McAllister J, Chen W, Ebersole G, Granger EK, Chamberlain AM. Determining the minimal clinically important difference for the American Shoulder and Elbow Surgeons score, Simple Shoulder Test, and visual analog scale (VAS) measuring pain after shoulder arthroplasty. J Shoulder Elbow Surg. 2017 Jan;26(1):144-8. Epub 2016 Aug 18.