Contents lists available at ScienceDirect

# JSES International

journal homepage: www.jsesinternational.org

# Sex-related differences in PROMs prior to the outcome: comparison of preoperative PROMIS physical function scores in female vs. male patients undergoing shoulder arthroplasty

Cara H. Lai, MD[a], Shreya Chandak, BS[b], Pragnya Karlapudi, BA[b], John Tokish, MD[a,*]

[a]Department of Orthopaedic Surgery, Mayo Clinic, Phoenix, AZ, USA
[b]University of Arizona, Tucson, AZ, USA

**Background:** Patient-reported outcome measures (PROMs) are increasingly used to evaluate outcomes in patients undergoing shoulder arthroplasty. The Patient-Reported Outcome Measures Information System (PROMIS) is popular due to low cost and question burden. Females have been reported to have lower postoperative PROMIS scores after shoulder surgery, but studies have not focused on a dedicated cohort of shoulder arthroplasty patients or examined upstream differences in preoperative scores. This study aimed to characterize sex differences in baseline PROMIS scores among anatomic total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (rTSA) patients.

**Methods:** Data were collected over a 9-month period. Demographics, Charlson Comorbidity Index (CCI), smoking status, BMI, American Shoulder and Elbow Surgeons (ASES) scores, PROMIS Pain, Physical Function (PF), Upper Extremity, Depression, and Anxiety scores, as well as Single Assessment Numeric Evaluation (SANE) scores were collected. Student t-tests were performed to determine correlation with baseline PROMs. A minimal clinically important difference (MCID) of 4 was used to determine if a PROMIS score difference between groups was clinically important. Significance was set as $P < .05$.

**Results:** A total of 88 females (34 TSAs 54 rTSA) and 99 males (35 TSA, 64 rTSA) were enrolled. Only sex showed a correlation with preoperative PROMIS score. In rTSA patients, females had significantly lower preoperative PROMIS PF scores ($P < .05$). Among females undergoing TSA vs. rTSA, lower preoperative PROMIS PF scores were found in rTSA ($P < .05$). These differences exceeded the MCID of 4. The same difference was not found in men undergoing TSA vs. rTSA.

**Conclusion:** Preoperative sex-based differences in PROMIS scores are underappreciated in the shoulder arthroplasty literature. This is the largest study to date focusing on sex-based differences among a dedicated cohort of TSA and rTSA patients, showing a difference in baseline PROMIS scores between males and females above the MCID. These findings suggest that PROMIS scores are affected by sex-based baseline differences in rTSA patients. Further study should investigate sex-based differences in baseline scores to determine their effects on ultimate outcome.

Patient-reported outcome measures (PROMs) are increasingly used to evaluate outcomes in patients undergoing shoulder arthroplasty. The Patient-Reported Outcome Measures Information System (PROMIS) initiative has led to widespread adoption of PROMIS due to its low cost and question burden on patients, and has been previously validated for use in orthopedic patients with upper extremity pathology.[1,2,8] Although PROMs were originally developed for research purposes, they are increasingly being used in the orthopedic clinical setting as a way to counsel patients about expectations before and after surgery.

Previous literature has demonstrated that females have lower postoperative PROMIS scores after shoulder surgery. Female patients are frequently counseled that they may have worse outcomes compared to males following total shoulder arthroplasty whether it is an anatomic total shoulder arthroplasty (TSA) or a reverse TSA (rTSA).[6,10,12] These studies have primarily focused on the comparison between preoperative and postoperative scores, or have not

encompassed both TSA and rTSA.[3] Wong et al collected PROMs before and after rTSA in 117 patients and hypothesized that there would be a difference in scores between females and males before surgery, and while they demonstrated that females did in fact have lower preoperative scores, this difference did not reach significance.[12] Understanding the potential preoperative differences in function that may exist are clinically important, as preoperative PROMs after both TSA and rTSA have been shown to correlate with postoperative outcomes.[4,13] Patient counseling of expected outcomes after surgery should be guided by individual baseline functional status, and knowledge of sex-based baseline differences in function can be an important part of accurately setting patient expectations.

The aim of this study was to characterize sex differences in baseline PROMIS scores among patients undergoing anatomic total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (rTSA) patients. We also sought to examine if these differences, if any, reached the threshold of the minimal clinically important difference (MCID). We hypothesized that females would have lower preoperative PROMIS scores compared to their male counterparts in both TSA and rTSA.

## Methods

This retrospective review examined prospectively collected data from all patients undergoing shoulder arthroplasty over a 9-month period between September 2020 and May 2021 at a major academic institution. At the preoperative evaluation approximately 1 month before the patient underwent TSA or rTSA, patients were asked to complete baseline PROMs. Demographics, medical comorbidities including a Charlson Comorbidity Index (CCI), smoking status, and Body Mass Index (BMI) were also collected on each patient. Indications for surgery (osteoarthritis, rotator cuff arthropathy, rheumatoid arthritis, fracture, or other) were also collected. Patients were divided into 4 main groups: females undergoing anatomic TSA, males undergoing anatomic TSA, females undergoing rTSA, and males undergoing rTSA. This study followed protocol approved in accordance with our institutional review board guidelines.

### PROMIS instrument

The PROMIS Computer Adaptive Test V2.0 Physical Function score (HealthMeasures) was administered using an iPad at the preoperative visit. This PROM relies on a large question bank, with each consecutive question that is displayed dependent on the previous answer, and each subsequent question answered reducing the potential for error. Patients must complete a minimum of 4 questions to receive a score, and the test ends when the error drops below a specified level or a patient has answered a maximum of 12 questions.

### Statistical analysis

Student t-tests were performed to determine whether sex or other demographics or comorbid conditions were correlated with baseline PROMs, by comparing females and males within each type of arthroplasty, and then comparing the 2 types of arthroplasty within each sex. An MCID of 4 was used to determine if the PROMIS score difference between groups was considered clinically important, as reported in existing literature.[5,9,11] Significance was set as $P < .05$.

## Results

A total of 187 patients who were scheduled for either TSA or rTSA were included, with 88 females and 99 males. Among females,

**Table I**

Demographics and PROMIS scores in females vs. males undergoing shoulder arthroplasty.

| | Females | Males | P value |
|---|---|---|---|
| Anatomic TSA | | | |
| N | 34 | 35 | |
| Age (years) | 70.4 ± 8.3 | 68.0 ± 11.7 | .33 |
| Race (N) | | | |
| White | 33 | 34 | |
| Other | 1 | 1 | |
| Body mass index | 29.4 ± 7.7 | 29.9 ± 5.0 | |
| Charlson comorbidity index | 4.8 ± 1.9 | 5.0 ± 3.0 | .81 |
| Surgical indication (N) | | | |
| Osteoarthritis | 33 | 34 | |
| Rotator cuff arthropathy | 1 | 1 | |
| Rheumatoid arthritis | | | |
| Fracture | | | |
| Other | | | |
| PROMIS physical function score | 38.8 ± 7.3 | 37.9 ± 7.2 | .68 |
| Reverse TSA (rTSA) | | | |
| N | 54 | 64 | |
| Age (years) | 72.1 ± 7.3 | 72.8 ± 8.7 | .65 |
| Race (N) | | | |
| White | 53 | 62 | |
| Other | 1 | 2 | |
| Body mass index | 28.6 ± 6.9 | 28.7 ± 6.0 | |
| Charlson comorbidity index | 5.4 ± 2.1 | 6.0 ± 2.3 | .11 |
| Surgical indication (N) | | | |
| Osteoarthritis | 18 | 21 | |
| Rotator cuff arthropathy | 29 | 42 | |
| Rheumatoid arthritis | 1 | | |
| Fracture | 6 | | |
| Other | | 1 | |
| PROMIS physical function score | 32.4 ± 6.3 | 40.2 ± 8.3 | <.01 |

*PROMIS*, patient-reported outcome measures information system; *TSA*, total shoulder arthroplasty.

there were 34 anatomic TSAs and 54 reverse TSAs, and among males there were 35 anatomic TSAs and 64 reverse TSAs. The average age for anatomic TSA was 70 and 68 years for females and males respectively, and 72 and 73 years for rTSA. Demographics and PROMIS PF scores are reported in Table I. Among all demographics and comorbid factors, only sex showed a correlation with preoperative PROMIS score. The majority of patients (56%) underwent surgery due to osteoarthritis, followed by rotator cuff arthropathy (39%). Six patients underwent surgery due to fracture, 1 patient had rheumatoid arthritis, and 1 due to infection.

### PROMIS vs. sex

Among all patients undergoing rTSA, females had significantly lower preoperative PROMIS PF scores compared to males ($P < .05$). In TSA patients, the same difference was not found between males and females. Among all females undergoing TSA vs. rTSA, females undergoing rTSA also had lower preoperative PROMIS PF scores ($P < .05$). In both comparisons (female patients undergoing rTSA vs. TSA, and female patients undergoing rTSA vs. males undergoing rTSA), the difference in mean score exceeded the MCID of 4. The same difference was not found in men undergoing TSA vs. rTSA. No differences were observed between PROMIS scores and the patient's CCI score, BMI, or smoking status.

## Discussion

Although the PROMIS initiative has led to its widespread adoption as both a clinical and research tool in orthopedic surgery, preoperative sex-based differences in PROMIS scores is underappreciated in the shoulder arthroplasty literature. This is the largest study to date focusing on sex-based differences among a dedicated

cohort of TSA and rTSA patients that also shows a difference in baseline PROMIS scores between males and females that is above the MCID threshold. Our 4 groups were similar with regard to all demographics and comorbid factors, with sex being the sole variable that was predictive of a lower preoperative PROMIS score.

Indications for anatomic and rTSA are markedly different, but it is generally accepted that patients who undergo rTSA tend to have worse baseline function. This can likely be attributed largely due to rotator cuff dysfunction being one of the primary indications for choosing an rTSA over an anatomic TSA. Simovitch et al prospectively studied a cohort of 1183 patients who underwent either anatomic or rTSA, and reported on preoperative and postoperative outcomes using the Simple Shoulder Test (SST), University of California Los Angeles (UCLA), American Shoulder and Elbow Surgeons (ASES), Constant, and Shoulder Pain and Disability Index (SPADI) scores as well as range of motion. Although the authors did not separate the cohorts by sex, their data showed that patients undergoing rTSA had worse preoperative scores in 4 out of the 5 scores, and 3 of 4 range of motion measurements.

In a follow-up study, Friedman et al looked at a subset of the dataset focusing on only rTSA and compared male and female patients. While the study mainly focused on postoperative outcomes, it was again reported that female patients undergoing rTSA had worse preoperative scores in 5 out of 5 outcome score categories.[3] In our study including both anatomic and rTSA patients and separating by sex, we demonstrated a similar finding that only females undergoing rTSA have lower PROMIS PF scores compared to males undergoing rTSA. However, we additionally found that females undergoing rTSA also have a lower preoperative score compared to their female anatomic TSA counterparts but that the same is not true for males. In fact, males undergoing rTSA actually had the highest mean PROMIS PF score in all 4 groups. This suggests that the comparison between rTSA and TSA patients may not lie solely in the presence of pathology such as rotator cuff dysfunction, but that sex itself may play a role in preoperative function regardless of surgical indication. The reasons that may explain this phenomenon are beyond the scope of this study, but may be related to pain or functional thresholds that patients reach before they present for surgical evaluation. This has been reported in the total hip and knee arthroplasty literature, but to our knowledge has not been found to be true in shoulders.[7] Additionally, given that PROMIS relies on patients' own assessments of their functional level, physiologic differences that may explain our findings could still be present. Nevertheless, our findings in this study suggest that females undergoing rTSA start with worse lower physical function, and that additionally within the population of female shoulder arthroplasty patients there is particularly low function in those who undergo rTSA.

Sex-based preoperative differences are an important area of study, because they represent an upstream factor in how patient populations may differ prior to surgery and can be predictive of postoperative performance. To our knowledge, this study is the first to focus on preoperative differences between female and male patients in both anatomic and rTSA, and to show a difference that exceeds the MCID. The limitations of this study include those inherent to a retrospective review, and that the collection of PROMs is only part of the preoperative assessment and cannot reflect every aspect of a patient's functional level. While outcome metrics remain an important indicator of procedure success, it can be difficult to assess if postoperative differences present between cohorts are due to factors inherent to the operation or patient-specific factors. All of the patients in our study had greater than 1-year follow-up, but we chose to omit their outcome data in order to focus on what we believe is an important finding of an upstream difference in scores, present at baseline and regardless of the surgical intervention

ultimately performed. Lastly, it should be noted that several different versions of the PROMIS instrument exist, and this study focuses on the PROMIS CAT PF instrument. However, this is only one of the many different instruments that can be used. Further studies should investigate the relationship between preoperative expectations of function and PROMIS scores among female patients, to identify if lower preoperative PROMIS scores affect patient perception and expectations of improvement after surgery.

## Conclusion

Sex-based preoperative differences may represent an upstream factor in outcomes in total shoulder arthroplasty. This study identified a difference in preoperative differences between female and male patients in both anatomic and rTSA that exceeds the MCID.

## Disclaimers:

## References

1. Döring A-C, Nota SPFT, Hageman MGJS, Ring DC. Measurement of upper extremity disability using the patient-reported outcomes measurement information system. J Hand Surg Am 2014;39:1160-5. https://doi.org/10.1016/j.jhsa.2014.03.013.
2. Dowdle SB, Glass N, Anthony CA, Hettrich CM. Use of PROMIS for patients undergoing primary total shoulder arthroplasty. Orthop J Sports Med 2017;5:2325967117726044. https://doi.org/10.1177/2325967117726044.
3. Friedman RJ, Cheung EV, Flurin P-H, Wright T, Simovitch RW, Bolch C, et al. Are age and patient gender associated with different rates and magnitudes of clinical improvement after reverse shoulder arthroplasty? Clin Orthop Relat Res 2018;476:1264-73. https://doi.org/10.1007/s11999.0000000000000270.
4. Friedman RJ, Eichinger J, Schoch B, Wright T, Zuckerman J, Flurin P-H, et al. Preoperative parameters that predict postoperative patient-reported outcome measures and range of motion with anatomic and reverse total shoulder arthroplasty. JSES Open Access 2019;3:266-72. https://doi.org/10.1016/j.jses.2019.09.010.
5. Gordon D, Pines Y, Ben-Ari E, As R, Kwon YW, Zuckerman JD, et al. Minimal clinically important difference, substantial clinical benefit, and patient acceptable symptom state of PROMIS upper extremity after total shoulder arthroplasty. JSES Int 2021;5:894-9. https://doi.org/10.1016/j.jseint.2021.05.003.
6. Hung NJ, Wong SE. Gender Influences on shoulder arthroplasty. Curr Rev Musculoskelet Med 2022;15:21-6. https://doi.org/10.1007/s12178-021-09737-0.
7. Kennedy D, Stratford PW, Pagura SMC, Walsh M, Woodhouse LJ. Comparison of gender and group differences in self-report and physical performance measures in total hip and knee arthroplasty candidates. J Arthroplasty 2002;17:70-7. https://doi.org/10.1054/arth.2002.29324.
8. Kolade O, Ghosh N, Luthringer TA, Rosenthal Y, Kwon YW, Rokito AS, et al. Correlation of patient reported outcome measurement information system (PROMIS) with American shoulder and Elbow Surgeon (ASES), and Constant (CS) scores in idiopathic adhesive capsulitis. J Shoulder Elbow Surg 2021;30:554-60. https://doi.org/10.1016/j.jse.2020.05.040.
9. Lee DJ, Calfee RP. The minimal clinically important difference for PROMIS physical function in patients with Thumb Carpometacarpal arthritis. Hand (N Y) 2021;16:638-43. https://doi.org/10.1177/1558944719880025.
10. Okoroha KR, Muh S, Gabbard M, Evans T, Roche C, Flurin P-H, et al. Early outcomes of shoulder arthroplasty according to sex. JSES Open Access 2019;3:43-7. https://doi.org/10.1016/j.jses.2018.12.001.
11. Sandvall B, Okoroafor UC, Gerull W, Guattery J, Calfee RP. Minimal clinically important difference for PROMIS physical function in patients with distal radius fractures. J Hand Surg 2019;44:454-459.e1. https://doi.org/10.1016/j.jhsa.2019.02.015.
12. Wong SE, Pitcher AA, Ding DY, Cashman N, Zhang AL, Ma CB, et al. The effect of patient gender on outcomes after reverse total shoulder arthroplasty. J Shoulder Elbow Surg 2017;26:1889-96. https://doi.org/10.1016/j.jse.2017.07.013.
13. Wong SE, Zhang AL, Berliner JL, Ma CB, Feeley BT. Preoperative patient-reported scores can predict postoperative outcomes after shoulder arthroplasty. J Shoulder Elbow Surg 2016;25:913-9. https://doi.org/10.1016/j.jse.2016.01.029.