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Correlation of multiple patient-reported outcome measures across follow-up in patients undergoing primary shoulder arthroplasty

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Background: Multiple validated outcome scores are used to assess patients undergoing shoulder arthroplasty. The purpose of this study was to determine whether a correlation exists between 3 commonly used patient-reported outcome (PRO) measures in this population: Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Assessment Form, and Simple Shoulder Test (SST).

Methods: We performed a retrospective review of a shoulder arthroplasty database that routinely collects SPADI, ASES, and SST scores at each visit prospectively. Patients undergoing primary shoulder arthroplasty were identified. Assessments of correlation coefficients (Pearson correlation coefficient for ASES and SPADI scores and Spearman correlation coefficient for SST score) between each combination of PROs were performed overall and at each time point (preoperatively and 3, 6, 12, and 24 months postoperatively) to determine the level of association between PROs.

Results: In total, 848 shoulder arthroplasty procedures were performed in 754 patients with 2796 unique clinical encounters. Preoperative correlations among PROs were moderate to strong (range, 0.66-0.77) but had the lowest correlation among all comparisons. Postoperative correlations were strong for all PRO comparisons (range, 0.73-0.94). Postoperative PRO correlations continued to strengthen over longer follow-up, with all values exceeding 0.78 at 2 years postoperatively. Conversion equations between PROs were calculated based on these highly correlated data.

Conclusion: After primary shoulder arthroplasty, there exists a high degree of correlation among all 3 studied PROs. Correlations were stronger postoperatively and improved with longer follow-up. Surgeons may use this information to minimize the number of questionnaires patients answer at each follow-up time point, and the conversion equations can be used for study comparison in meta-analyses.

This study was performed under institutional review board approval from the University of Florida (No. IRB201702710).

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The use of both anatomic total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RSA) has increased dramatically over the past decade.[13,21] Patients undergoing shoulder arthroplasty often have significant impairment in shoulder function and activities of daily living (ADLs) prior to surgery. Therefore, relying solely on independent objective variables, such as range of motion or strength, to measure postoperative improvement is difficult and often inaccurate. This has led to an increased emphasis on patient satisfaction as a measure of improvement after shoulder arthroplasty, given the recent focus on cost-effective health care utilization.

Currently, there are many commonly used patient-reported outcome (PRO) measures to assess shoulder function.[22] The use of individual PROs varies drastically from one study to another and is often based on geographic or institutional preferences. There remains neither a single commonly used functional outcome score nor consensus as to which score is best to assess shoulder arthroplasty outcomes. Several studies have examined the correlation between various outcome measures after shoulder trauma, rotator cuff repair, and other arthroscopic procedures about the shoulder.[1-7,20,23,25,27] However, the correlation among outcome measures for shoulder arthroplasty has been less commonly studied.[8,9,12,19,24,26]

The collection of multiple patient-reported questionnaires at each clinic visit is both time intensive and labor intensive. In addition, comparison of studies using different outcome measures is difficult. Therefore, determining whether a correlation exists between various accepted shoulder outcome scores at given time intervals before and after shoulder arthroplasty may allow for more streamlined collection of data and comparison between studies that use different PROs. The purpose of this study was to determine whether a correlation exists between 3 commonly used PRO measures in patients undergoing shoulder arthroplasty: Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Assessment Form, and Simple Shoulder Test (SST).

Materials and methods

Study design and setting

We performed a retrospective review of a single institution's prospectively collected shoulder arthroplasty database from February 2003 to December 2014. The database included information on all patients undergoing shoulder arthroplasty by 1 of 4 fellowship-trained surgeons. Patients were evaluated preoperatively and at routine postoperative time points: 2 weeks, 6 weeks, 3 months, 6 months, 1 year, and 2 years postoperatively. At all visits outside of the immediate postoperative visits (2- and 6-week visits), patients completed 3 PRO measures: SPADI, ASES Assessment Form, and SST.

Participants

Identification of eligible subjects was performed via a query of the shoulder arthroplasty database. The study inclusion criteria were adult patients undergoing primary TSA or reverse total shoulder arthroplasty (RSA) with completion of the ASES, SPADI, and SST scores at each clinical follow-up time point. Patients undergoing revision surgery and who had time points without completed questionnaires were excluded.

Outcome scores

The ASES Assessment Form is composed of a physician assessment section and a patient self-evaluation section.[17] The physician assessment section includes demographic information, range-of-motion evaluation, physical signs, stability, and strength. None of the information in the physician assessment section is a component of the ASES score. The patient self-evaluation section contains pain and instability scales and an ADL index. The pain and function scales are weighted equally for a combined score out of 100, with 0 being the worst score and 100 being the best.[17]

The SPADI is a patient questionnaire developed to measure shoulder pain and disability in an outpatient setting.[18] The questionnaire contains 13 items, 5 of which evaluate shoulder pain whereas 8 assess shoulder disability. Responses are summed and transformed into a combined score out of 100, with 0 indicating the least shoulder impairment and pain and 100 indicating the greatest shoulder impairment and pain.[18]

The SST is a patient questionnaire focusing on assessing the shoulder function of patients with pathologic shoulder conditions.[12] It consists of 12 equally weighted binary yes-or-no questions about whether patients can perform ADLs without significant pain that can be performed by people with normally functioning shoulders. Responses are summed out of a maximum score of 12, with 0 being the worst score and 12 being the best.[12]

Surgical procedure

All procedures were performed with patients under general anesthesia in the lazy beach-chair position. A deltopectoral approach was used in all cases. The long head of the biceps tendon routinely underwent tenodesis to the pectoralis major tendon if present. The decision to perform TSA vs. RSA was made based on preoperative imaging in conjunction with the clinical appearance of the rotator cuff at the time of surgery. For TSA, a lesser tuberosity osteotomy or subscapularis peel was performed based on surgeon discretion. For RSA, the subscapularis was often left as a tenotomy unless the subscapularis was easily repaired without tension in 20° to 30° of external rotation. Arthroplasty was performed in standard fashion. Closure was performed in multiple layers with absorbable suture. The rehabilitation protocol was the same in all patients and consisted of a home exercise program under the direction of an occupational therapist. Shoulder range of motion was restricted for 3 weeks. External rotation was limited to neutral in RSA patients and to 30° in TSA patients for 6 weeks. Internal rotation was limited to the abdomen for 6 weeks. A sling was used at all times for the first 6 weeks except for elbow range of motion and hygiene purposes. Strengthening was started 12 weeks postoperatively.

Statistical methods

All statistical analyses were performed using SPSS software (version 25.0; IBM, Armonk, NY, USA). Descriptive statistics were performed to analyze cohort demographic characteristics. For each PRO, the average score with the standard deviation was calculated overall, at every clinical time point, and for each procedure type (TSA and RSA). Scatter plots were created for each pair-wise PRO comparison overall and at each clinical time point. Correlative strength for ASES vs. SPADI score comparisons was assessed using the Pearson correlation coefficient. The SST score was treated as an ordinal variable requiring use of the Spearman correlation coefficient to assess correlative strength with the ASES score and with the SPADI score. Correlation coefficients of 0.4 to 0.7 were considered moderate, whereas scores greater than 0.7 were considered strong.[10] Conversion equations were calculated using the best-fit line for each PRO comparison. Equations were developed in 75% of the sample and subsequently tested in the remaining 25%. These samples were selected via stratified randomization to ensure that development and testing samples had similar characteristics (age, sex, TSA or RSA, and time of measurement). In the testing sample (25%), mean differences with 95% confidence intervals were calculated between actual values for each PRO and their corresponding predicted values from conversion equations. Pearson correlations between actual and predicted values were also calculated. Furthermore, within-individual differences between actual and predicted values were computed.

Results

Complete data sets meeting the inclusion criteria were available for 848 shoulders in 754 patients with a total of 2796 clinical encounters. We excluded 1381 encounters linked to 169 shoulders in 142 patients because of incomplete PRO scores or revision surgical procedures. The average age of included patients was 67.9 years (range, 35-93 years), with a female-to-male ratio of 1.1:1. The majority of subjects (74.8%) had not undergone prior shoulder surgery. The most common diagnosis was degenerative joint disease, seen in 352 patients. Demographic data are shown in Table I.

The average preoperative ASES, SPADI, and SST scores for patients were 67.3 ± 14.9, 37.3 ± 15.3, and 3.8 ± 2.5, respectively. Two years after surgical treatment, the scores improved to 78.5 ± 19.3, 22.4 ± 20.5, and 9.6 ± 2.8, respectively. Tables II-IV summarize PRO score breakdowns by clinical follow-up time point and procedure type.

Scatter plots with trend lines for each PRO dyad are shown in Figure 1 (SPADI score vs. ASES score), Figure 2 (SPADI score vs. SST score), and Figure 3 (ASES score vs. SST score). Correlations were strong overall for the SPADI score vs. ASES score (–0.937, $P < .001$, N = 2796), SPADI score vs. SST score (–0.906, $P < .001$, N = 2796), and ASES score vs. SST score (0.884, $P < .001$, N = 2796). Preoperative correlation was moderate for the ASES score vs. SST score and strong for the SPADI score vs. ASES score and the SPADI score vs. SST score. Two-year postoperative scores conferred strong correlations for all scoring dyads. Summaries of Pearson (SPADI score vs. ASES score) and Spearman (SPADI score vs. SST score

Table I Demographic characteristics of analyzed shoulder arthroplasty cohort (by shoulder)

	Mean ± SD (range) or n (%)
Age, yr	67.9 ± 9.0 (35-93)
BMI, kg/m^2	30.3 ± 6.9 (16.3-60.8)
Sex	
Male	404 (52.4)
Female	444 (47.6)
Laterality	
Right	482 (56.8)
Left	366 (43.1)
Prior surgery	
Yes	214 (25.2)
No	634 (74.8)
Comorbidities	
Inflammatory arthritis	89 (10.5)
Hypertension	413 (48.7)
Heart disease	134 (15.8)
DM [insulin dependent]	147 (27) [17.3 (3.2)]
Smoker	69 (8.1)
Shoulder diagnosis	
DJD	352 (41.5)
CTA	233 (27.5)
DJD with cuff insufficiency	70 (8.3)
Inflammatory arthropathy	51 (6.0)
Fracture sequelae	45 (5.3)
MRCT	37 (4.4)
Fracture	26 (3.1)
Dislocation arthropathy	18 (2.1)
AVN	14 (1.7)
Tumor	2 (0.2)
Surgery	
TSA	374 (44.1)
RSA	474 (55.9)

SD, standard deviation; *BMI*, body mass index; *DM*, diabetes mellitus; *DJD*, degenerative joint disease; *CTA*, cuff tear arthropathy; *MRCT*, massive rotator cuff tear; *AVN*, avascular necrosis; *TSA*, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty.

Table II Shoulder pain and disability index; score and ASES score correlation

Time point	n	SPADI score, mean ± SD	ASES score, mean ± SD	*R* coefficient	*P* value
Overall	2796	36.9 ± 25.8	65.2 ± 24.2	−0.937	<.001
TSA	1182	33.0 ± 25.8	68.2 ± 24.3	−0.942	<.001
RSA	1614	39.8 ± 25.4	63.0 ± 23.8	−0.932	<.001
Preoperatively	624	67.3 ± 14.9	37.3 ± 15.3	−0.735	<.001
TSA	259	65.2 ± 14.1	38.9 ± 14.8	−0.678	<.001
RSA	365	68.9 ± 15.2	36.2 ± 15.6	−0.767	<.001
12 weeks	513	36.5 ± 19.7	66.4 ± 17.8	−0.895	<.001
TSA	212	33.0 ± 19.1	68.7 ± 17.7	−0.893	<.001
RSA	301	39.1 ± 19.8	64.7 ± 17.8	−0.895	<.001
6 mo	622	28.2 ± 20.8	72.7 ± 19.2	−0.923	<.001
TSA	258	24.3 ± 19.7	76.0 ± 19.0	−0.931	<.001
RSA	364	32.1 ± 20.9	70.4 ± 19.0	−0.915	<.001
1 yr	583	24.2 ± 21.3	75.8 ± 21.1	−0.922	<.001
TSA	252	20.5 ± 20.7	79.3 ± 20.5	−0.943	<.001
RSA	331	27.8 ± 21.3	73.1 ± 21.2	−0.905	<.001
2 yr	454	22.4 ± 20.5	78.5 ± 19.3	−0.930	<.001
TSA	201	18.6 ± 20.5	81.7 ± 19.1	−0.942	<.001
RSA	253	25.4 ± 20.0	76.0 ± 19.2	−0.918	<.001

SPADI, Shoulder Pain and Disability Index; *ASES*, American Shoulder and Elbow Surgeons; *SD*, standard deviation; *TSA*, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty.

Table III Shoulder pain and disability index; score and simple shoulder test score correlation

Time point	n	SPADI score, mean ± SD	SST score, mean ± SD	*R* coefficient	*P* value
Overall	2796	36.9 ± 25.8	7.6 ± 3.6	−0.906	<.001
TSA	1182	33.0 ± 25.8	8.2 ± 3.6	−0.904	<.001
RSA	1614	39.8 ± 25.4	7.2 ± 3.5	−0.900	<.001
Preoperatively	624	67.3 ± 14.9	3.8 ± 2.5	−0.759	<.001
TSA	259	65.2 ± 14.1	4.2 ± 2.5	−0.738	<.001
RSA	365	68.9 ± 15.2	3.6 ± 2.5	−0.762	<.001
12 weeks	513	36.5 ± 19.7	7.5 ± 2.9	−0.813	<.001
TSA	212	33.0 ± 19.1	8.2 ± 2.9	−0.824	<.001
RSA	301	39.1 ± 19.8	7.1 ± 2.9	−0.794	<.001
6 mo	622	28.2 ± 20.8	8.7 ± 3.0	−0.861	<.001
TSA	258	24.3 ± 19.7	9.3 ± 2.9	−0.840	<.001
RSA	364	32.1 ± 20.9	8.3 ± 3.0	−0.851	<.001
1 yr	583	24.2 ± 21.3	9.2 ± 3.0	−0.838	<.001
TSA	252	20.5 ± 20.7	9.8 ± 2.9	−0.805	<.001
RSA	331	27.8 ± 21.3	8.7 ± 3.0	−0.839	<.001
2 yr	454	22.4 ± 20.5	9.6 ± 2.8	−0.826	<.001
TSA	201	18.6 ± 20.5	10.0 ± 2.7	−0.776	<.001
RSA	253	25.4 ± 20.0	9.2 ± 2.8	−0.840	<.001

SPADI, Shoulder Pain and Disability Index; *SST*, Simple Shoulder Test; *SD*, standard deviation; *TSA*, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty.

and ASES score vs. SST score) correlation coefficients for each clinical time point are detailed in Tables II-IV. The strength of correlation was significantly greater among TSA procedures than RSA procedures for the SPADI score vs. ASES score and the ASES score vs. SST score (Table V), but correlations remained strong for the RSA procedures. No significant differences were found for the SPADI score vs. SST score regarding TSA compared with RSA procedures.

Conversion equations between the studied PROs along with the mean differences between the actual values from each PRO and their corresponding predicted values, as well as correlation coefficients, are presented in Table VI. The mean differences between actual and predicted values for

Table IV ASES score and simple shoulder test score correlation

Time point	n	ASES score, mean ± SD	SST score, mean ± SD	*R* coefficient	*P* value
Overall	2796	65.2 ± 24.2	7.6 ± 3.6	0.884	<.001
TSA	1182	68.2 ± 24.3	8.2 ± 3.6	0.894	<.001
RSA	1614	63.0 ± 23.8	7.2 ± 3.5	0.870	<.001
Preoperatively	624	37.3 ± 15.3	3.8 ± 2.5	0.697	<.001
TSA	259	38.9 ± 14.8	4.2 ± 2.5	0.657	<.001
RSA	365	36.2 ± 15.6	3.6 ± 2.5	0.714	<.001
12 weeks	513	66.4 ± 17.8	7.5 ± 2.9	0.767	<.001
TSA	212	68.7 ± 17.7	8.2 ± 2.9	0.799	<.001
RSA	301	64.7 ± 17.8	7.1 ± 2.9	0.733	<.001
6 mo	622	72.7 ± 19.2	8.7 ± 3.0	0.825	<.001
TSA	258	76.0 ± 19.0	9.3 ± 2.9	0.813	<.001
RSA	364	70.4 ± 19.0	8.3 ± 3.0	0.816	<.001
1 yr	583	75.8 ± 21.1	9.2 ± 3.0	0.829	<.001
TSA	252	79.3 ± 20.5	9.8 ± 2.9	0.824	<.001
RSA	331	73.1 ± 21.2	8.7 ± 3.0	0.812	<.001
2 yr	454	78.5 ± 19.3	9.6 ± 2.8	0.816	<.001
TSA	201	81.7 ± 19.1	10.0 ± 2.7	0.787	<.001
RSA	253	76.0 ± 19.2	9.2 ± 2.8	0.813	<.001

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SD*, standard deviation; *TSA*, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty.

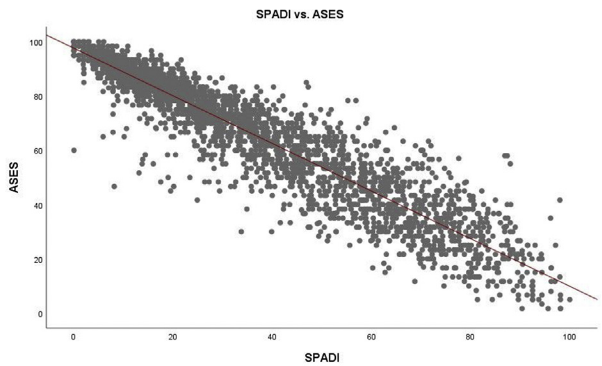

Figure 1 Scatter plot showing correlation between Shoulder Pain and Disability Index (*SPADI*) and American Shoulder and Elbow Surgeons (*ASES*) scores.

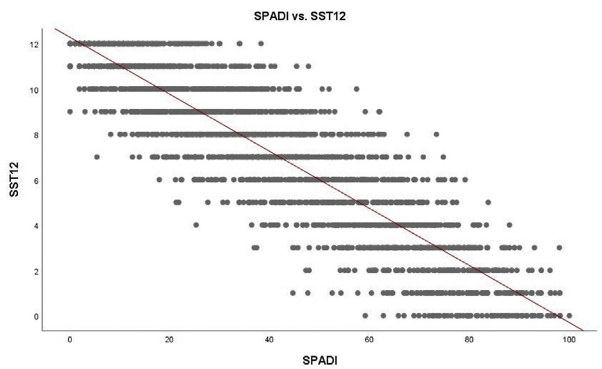

Figure 2 Scatter plot showing correlation between Shoulder Pain and Disability Index (*SPADI*) and Simple Shoulder Test (*SST12*) scores.

each PRO were near zero (with the 95% confidence interval overlapping with 0), with high correlations between actual and predicted values. However, the differences between actual and predicted values for each PRO in any given individual varied widely.

Discussion

This study identified a high degree of correlation among 3 commonly used PRO measures in a large cohort of patients undergoing primary shoulder arthroplasty. The strength of observed correlations increased postoperatively and with longer follow-up. Correlations of each score dyad were slightly stronger among patients undergoing TSA vs. RSA, but both increased in a similar fashion over time. These findings provide useful information regarding the overlapping information provided by these scoring systems and add to the growing body of literature exploring score correlations in this patient population.

These findings support work by previous authors showing strong correlations with multiple PROs in shoulder arthritis patients. Minoughan et al[16] demonstrated a strong-moderate correlation between Patient-Reported Outcomes Measurement Information System (PROMIS) and SST scores and a moderate correlation between PROMIS and ASES scores in patients with shoulder arthritis. They also showed that the time needed to complete the PROMIS was significantly less than that needed to complete the ASES Assessment Form or SST, although these differences were small and therefore may not be clinically important. Hapuarachchi and Poon[8] used their institution's joint

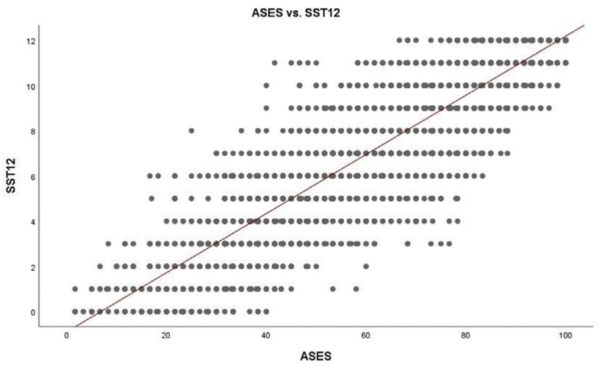

Figure 3 Scatter plot showing correlation between American Shoulder and Elbow Surgeons (*ASES*) and Simple Shoulder Test (*SST12*) scores.

Table V Total shoulder arthroplasty vs. reverse shoulder arthroplasty correlation comparison overall

Comparison	TSA correlation	RSA correlation	*P* value
SPADI score vs. ASES score	−0.942	−0.932	.032
SPADI score vs. SST score	−0.904	0.900	.58
ASES score vs. SST score	0.890	0.870	.0047

TSA, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *SPADI*, Shoulder Pain and Disability Index; *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test.

arthroplasty database to demonstrate a strong correlation between the ASES score and Oxford Shoulder Score in patients undergoing RSA. Furthermore, they developed a regression model that allowed prediction of the ASES score from the Oxford Shoulder Score with good accuracy.

The use of PROs after shoulder surgery is becoming increasingly important in the modern era. Harreld et al[9] showed that physician-assessed objective measures such as strength and range of motion did not correlate well with PROs using subjective questions after shoulder arthroplasty, which highlights the ongoing need for PROs. However, because there is no universally agreed on scoring tool, surgeons continue to use numerous scoring systems to track patients' progress. This variability has made meaningful comparisons across studies or institutions very difficult.[8] Therefore, determining correlations between the commonly used shoulder scoring systems along with conversion equations would be beneficial to compare various shoulder arthroplasty outcome studies.

Our results showed that ASES, SPADI, and SST scores correlated well, regardless of type of surgery, within the studied population. This high correlation offers several potential clinical applications. It allows for relatability of different institutional databases that collect different PROs in assessing patient improvement. It can also allow for cross-study comparison of outcomes in which different PROs are reported by use of the conversion equations. Second, PROs have the advantage of being able to be completed remotely. In the future, these questionnaires may allow for remote assessment of patients postoperatively to further decrease the clinical follow-up burden after shoulder arthroplasty. Decreasing in-person follow-up has previously been proposed. Hsu et al[11] showed that radiographic evidence of component loosening correlated with poor patient outcomes. Therefore, a declining PRO score may be suggestive of an implant-related problem and alert the surgeon to the need for a closer evaluation.[11] Further study is needed to identify such cutoff drops for each PRO. PRO scores significantly worse than the patient population's average could be used as an indicator for possible surgical complications, akin to glenoid component failure being a common complication of TSA.[11]

To our knowledge, this is the only study examining the correlation between the ASES, SST, and SPADI scores before and after primary shoulder arthroplasty. The results of this study show a high correlation among all 3 of the shoulder outcome scores studied. We found that correlations between scores were stronger postoperatively than preoperatively and became even stronger with longer follow-up. This finding is fairly consistent with the findings of other studies showing higher correlation coefficients in the postoperative period compared with the preoperative evaluation in shoulder arthroscopy patients.[2,14] Although it is unclear why correlations improved with longer follow-up, one explanation is that patients exhibit a wider range of pathology and function prior to surgery. For example, some scoring systems are more heavily weighted toward ADLs and overall function whereas others focus more on pain and disability (Table VII).[15] All of these variables may tend to normalize after shoulder arthroplasty for the conditions studied, resulting in tighter correlations postoperatively.

Limitations and future directions

The limitations of this study include an inability to standardize the treatment groups, given the retrospective nature of the study. In addition, some patients had incomplete data at various time points, and those data were excluded from the study. The conversion equations were calculated based on a best-fit line; however, individual patient scores varied dramatically. These conversion equations are best used to compare means from pooled data (eg, in systematic reviews or meta-analyses) and are not accurate when trying to predict scores of individual patients. In addition, although all patients underwent a similar operative technique and rehabilitation protocol, the effect of variations in the technique and rehabilitation protocols is unknown regarding

Table VI Conversion equations and testing results between different shoulder scores for shoulder arthroplasty

Conversion desired	Conversion equation	Mean difference between actual and predicted (95% CI)	Correlation between actual and predicted	Within-individual differences between actual and predicted, range
ASES score to SST score	SST score = (ASES score × 0.14) − 1.2	0.07 (−0.05 to 0.19)	0.90	−6.1 to 6.4
ASES score to SPADI score	SPADI score = 102 − ASES score	−0.43 (−1.10 to 0.25)	0.94	−35.2 to 41.0
SST score to ASES score	ASES score = 19.3 + (SST score × 6)	−0.24 (−1.04 to 0.55)	0.90	−43.7 to 39.3
SST score to SPADI score	SPADI score = 87.4 − (SST score × 6.6)	−0.07 (−0.86 to 0.72)	0.91	−30.2 to 36.1
SPADI score to ASES score	ASES score = 97.6 − (SPADI score × 0.88)	−0.27 (−0.90 to 0.37)	0.94	−33.2 to 34.7
SPADI score to SST score	SST score = 12.3 − (SPADI score × 0.13)	0.02 (−0.09 to 0.13)	0.91	−4.9 to 4.9

CI, confidence interval; *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SPADI*, Shoulder Pain and Disability Index.

Table VII Details on patient-reported outcome scores evaluated in study

Score	Individual completing measure	No. of questions	Scale	Time to complete (McClure and Michener,[15] 2003), min	Domains evaluated
ASES	Patient	11	0 (worst) to 100 (best)	4	Pain (50%) Function or daily activities (50%)
SST	Patient	12	0 (worst) to 12 (best)	3	Pain (2 of 12 questions) Function (7 of 12 questions) ROM (3 of 12 questions)
SPADI	Patient	13	0 (best) to 100 (worst)	7	Pain (50%) Function or disability (50%)

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SPADI*, Shoulder Pain and Disability Index; *ROM*, range of motion.

correlation of PROs. The strength of this study is the number of patients and clinical encounters evaluated.

Strong correlations among the scores evaluated suggest that changes in any of these scores represent similar functional changes after shoulder arthroplasty. This allows for easier interpretation of functional status from one study to another, regardless of the scoring system used. In addition, the conversion equations can be used to assist with future comparisons between studies such as those performed in meta-analyses.

Conclusion

This study identified a high degree of correlation among 3 PRO measures used commonly in the shoulder arthroplasty population: ASES Assessment Form, SPADI, and SST. Correlations were stronger postoperatively and with longer periods of follow-up. These findings can assist with patient outcome comparisons across the shoulder arthroplasty literature, and they suggest that the patient questionnaire burden can be decreased, especially postoperatively, without sacrificing the quality of care.

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