Quantifying Success after Total Shoulder Arthroplasty: the Substantial Clinical Benefit

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ABSTRACT

Background: An understanding of the substantial clinical benefit (SCB) after total shoulder arthroplasty(TSA) may help to gauge a minimum threshold beyond which a patient perceives their outcome as being substantially better. This study quantifies SCB for seven outcome metrics and active motion measurements after shoulder arthroplasty and determines how these values vary based on prosthesis type, patient age at surgery, gender, and length of follow-up.

Methods: 1,568 shoulder arthroplasties with 2 year minimum follow-up were performed by 13 shoulder surgeons and enrolled in a multicenter registry. The SCB for the ASES, Constant, UCLA, SST, SPADI, global shoulder function, and VAS pain scores as well as active abduction, flexion, and external rotation were calculated for different patient cohorts using an anchor-based method.

Results: The anchor-based SCB for the ASES score = 31.5 ± 2.0, Constant score = 19.1 ± 1.7, UCLA score = 12.6 ± 0.5, SST score = 3.4 ± 0.3, SPADI score = 45.4 ± 2.2, global shoulder function = 3.1 ± 0.2, VAS = 3.2 ± 0.3, active abduction = 28.5 ± 3.1, active forward flexion = 35.4 ± 3.5°, and active external rotation = 11.7 ± 1.9°. aTSA patients, male patients, and patients of longer follow-up duration were associated with higher SCB values as compared to females, rTSA, and patients of shorter follow-up duration.

Conclusion: Our analysis demonstrated 2/3 of patients achieved the SCB threshold after TSA. Generally, a change of 30% of the total possible score for each outcome metric approximates or exceeds this SCB threshold.

Level of Evidence: II

Key Words: Substantial Clinical Benefit, SCB, anatomic total shoulder arthroplasty, reverse total shoulder arthroplasty, shoulder arthroplasty, shoulder replacement

INTRODUCTION

Usage of total shoulder arthroplasty has steadily increased over time and has found broad indications for degenerative joint disease and rotator cuff insufficiency. The outcomes associated with total shoulder arthroplasty, including anatomic total shoulder (aTSA) and reverse shoulder arthroplasty (rTSA) have been demonstrated to be reliably favorable and durable.[3-8, 13-15, 17,19,20, 24, 25, 27] Most clinical studies have examined patient-reported and objective measures in the context of statistical significance. However, assessment of outcome based only on statistical evaluation can be prone to statistical error as the determination is heavily influenced by sample size and other study-power related variables.[11] Furthermore, statistical significance does not necessarily correlate with clinical relevance or what is perceived to be important or satisfactory to the patient.

To evaluate outcomes in the context of what is clinically-relevant to the patient, the concept of Minimal Clinically Important Difference (MCID) was introduced by Jaeschke et al.[10] in 1989. MCID defines the minimum threshold over which a patient has determined their clinical outcome to be beneficial and meaningful. This has been applied to the study of clinical metric outcomes for the nonoperative management of rotator cuff tears and after total shoulder arthroplasty.[18, 21-23, 26] While MCID describes the minimum value for meaningful improvement, substantial clinical benefit (SCB) describes the value for substantial improvement.[9, 12] SCB was first described by Glassman et al.[9] as the value where patients exceed the minimum threshold of improvement. Their premise was that orthopedic surgeons do not seek results that meet a minimum threshold but instead, results that exceed that minimal threshold. Werner et al.[26] has described Substantial Clinical Benefit (SCB) values after shoulder arthroplasty for the American Shoulder and Elbow Surgeons (ASES) score. To date, this is the only study which has examined SCB values for clinical outcome metrics after shoulder arthroplasty, though SCB has also been defined for the Disabilities of the Arm, Shoulder and Hand (DASH) and Pennsylvania Shoulder Score following rehabilitation for shoulder impingement.[12]

The ability to differentiate MCID and SCB metric values after shoulder arthroplasty is useful, as it helps identify the denominator of a cost:benefit ratio for the appropriateness of performing a shoulder arthroplasty, it aids counseling patients pre-operatively, and also helps interpret clinical outcome studies at various follow-up intervals. While we previously reported on the MCID values for the ASES, Constant, SST, SPADI, UCLA, VAS and global shoulder function scores as well as active range of motion after shoulder arthroplasty[18], the purpose of this study is to determine the SCB values for those same metrics. Furthermore, we will quantify the effect of prosthesis type, patient age at the time of surgery, gender, and length of follow-up on the SCB for each of the aforementioned outcome metrics.

METHODS

This was a retrospective outcome study focused on patients treated with aTSA and rTSA who were enrolled in a multicenter international registry by 13 fellowship-trained shoulder surgeons. Two thousand fifty-seven patients undergoing total shoulder arthroplasty were enrolled between February 2001 and February 2015. For the purposes of this study, inclusion criteria was any aTSA performed for osteoarthritis (OA) or rheumatoid arthritis (RA) or any rTSA performed for cuff tear arthropathy (CTA) or OA with a rotator cuff tear with greater than 2 year follow-up. Exclusion criteria were all cases performed for fracture as well as revisions. The application of all inclusion and exclusion criteria yielded a study population of 1,856 patients (average age = 69.6 ± 8.8 yrs) of which 911 were aTSA (488F/423M; average age = 66.5 ± 9.1 yrs) and 945 were rTSA (610F/335M; average age = 72.5 ± 7.5 yrs). The average follow-up was 44.9 ± 23.8 months (range: 24-157), where the average follow-up for aTSA patients was 49.7 ± 27.5 months and the average follow-up for rTSA patients was 40.2 ± 18.6 months.

Each patient was evaluated pre-operatively and at latest follow-up with seven metrics: ASES, Constant, SST, SPADI, UCLA, VAS pain, and global shoulder function scores. Additionally, the procedural surgeon, physical therapist, or research coordinator measured active range of motion (flexion, abduction, external rotation) and strength pre-operatively and at latest follow-up. Substantial effort was made to standardize the method of data collection. Range of motion was assessed with the patient standing, using a goniometer. The difference between each pre-operative and latest follow-up metric score and range of motion measurement was recorded as improvement.

At latest follow-up, a global anchor question was also asked: each patient rated their shoulder as “worse, unchanged, better, or much better” relative to their pre-operative condition.

We quantified the SCB as the minimum difference in pre-to-post-operative outcome that resulted in a patient describing their treatment as "much better" as compared to "worse" or "unchanged". As a result, patients who responded as being "better" were excluded because their treatment did not meet this minimum threshold for substantial clinical benefit. The mean outcome metrics at latest follow-up for the unchanged group ("worse" + "unchanged") and the changed group ("much better") were compared to the mean pre-operative metrics for each group to quantify the improvement associated with each group for a given metric. The SCB for each metric was then calculated as the difference in mean improvement between groups. Finally, the study cohort was stratified according to 4 different variables: prosthesis type, patient age, gender, and follow-up duration to determine their effect on SCB. In order to compare the SCB of 5 metric scores with different ranges (ASES, Constant, UCLA, SST, SPADI), those without a 100 point scale were normalized to a 100 point scale (SST: Score *100/12, UCLA: Score*100/35, and SPADI: Score*(100/130).

A two-tailed, unpaired t-test identified statistical differences between pre-operative, post-operative, and pre-to-post-operative improvement values for all metrics. Statistical significance was set at $p<0.05$. We also used 95% confidence intervals to compare differences in SCB for each metric and for each study cohort.

RESULTS

The distribution of the 1,856 patient responses to the global anchor question at latest follow-up is described in Table 1, stratified according to the 4 variables: prosthesis type, patient age, gender, and follow-up duration. Additionally, the clinical improvement at latest follow-up for aTSA (Table 2) and rTSA (Table 3) patients for each outcome metric and range of motion measurement is presented, stratified according to the 4 variables: prosthesis type, patient age, gender, and follow-up duration. Regarding the anchor question, 90.4% of patients responded as being "much better" (n = 1390) or "better" (n = 288) after total shoulder arthroplasty, with only 9.6% of patients responding as being “unchanged” (n=113) or "worse" (n = 65) after treatment. We excluded the 288 patients who responded as only “better”, as their result was not utilized in the SCB determination, this yielded 1,568 patients for this SCB analysis, having an average follow-up of 44.2 ± 23.4 months (range: 24-157).

The SCB values for the combined aTSA + rTSA cohort were ASES score = 31.5 ± 2.0 [95% CI = 31.4 to 31.6], Constant score = 19.1 ± 1.7 [95% CI = 19.0 to 19.2], UCLA score = 12.6 ± 0.5 [95% CI = 12.58 to 12.63], SST score = 3.4 ± 0.3 [95% CI = 3.39 to 3.42], SPADI score = 45.4 ± 2.2 [95% CI = 45.3 to 45.5], global shoulder function = 3.1 ± 0.2 [95% CI = 3.09 to 3.11], VAS = 3.2 ± 0.3 [95% CI = 3.19 to 3.22], active abduction = 28.5 ± 3.1° [95% CI = 28.4 to 28.7], active forward flexion = 35.4 ± 3.5° [95% CI = 35.2 to 35.6], and active external rotation = 11.7 ± 1.9° [95% CI = 11.6 to 11.8]. The percentage of change for the SCB value relative to the maximum score for the ASES, Constant, UCLA, SST, SPADI, global shoulder function and pain VAS metrics were 31%, 19%, 36%, 28%, 35%, 31% and 32% respectively with an average change of 30%. Thus, a change in 30% of the maximum possible score for each outcome metric approximates or exceeds the SCB after total shoulder arthroplasty.

Applying these anchor-based SCB thresholds to the overall dataset of 1,856 patients demonstrated that 79.5% of patients achieved the SCB for the ASES score, 84.9% achieved the SCB for the Constant score, 81.3% achieved the SCB for the UCLA score, 81.7% achieved the SCB for the SST score, and 73.4% achieved the SCB for the SPADI score. Additionally, 66.8% of patients achieved the SCB for the global shoulder function score and 71.6% achieved the SCB for the pain VAS score. Finally, 65.3% of patients achieved the SCB for active abduction, 62.0% achieved the SCB for active forward flexion, and 69.2% achieved the SCB for active external rotation.

Tables 4, 5, 6 and 7 present the anchor-based SCB scores for each metric stratified according to prosthesis type, patient age, gender, and length of follow-up, respectively. Figure 1 graphically represents how ASES SCB varies for these four variables, as an example. To permit a more direct comparison of SCB between metrics, the SPADI, UCLA, and SST scores were normalized to a 100 point scale, like the ASES and Constant scores: ASES = 31.5 ± 2.0, Constant = 19.1 ± 1.7, UCLA = 36.0 ± 1.4, SST = 28.3 ± 2.5, and SPADI = 34.9 ± 1.7; doing so, demonstrated the UCLA had the largest relative SCB value whereas the Constant had the smallest.

DISCUSSION

MCID values for various outcome metrics after total shoulder arthroplasty has been reported in several different studies.[18, 21-23,26] However, SCB values have only been reported in one previous study.[26] Werner et al.[26] reported on the SCB value for the ASES metric but not for any other metric or range of motion measurement after total shoulder arthroplasty. SCB differs from MCID as it represents the minimum improvement threshold of a given metric necessary to achieve a substantial clinical benefit as reported by the patient, as opposed to only a minimum threshold for a patient to perceive a meaningful change by a given treatment. Said another way, SCB represents a target level of improvement, whereas, MCID represents a floor threshold.[9] Differentiating between minimal benefit and substantial benefit to a patient after total shoulder arthroplasty is important for quantifying outcome success and also value to a patient.

We previously reported on the MCID values for ASES = 13.6 ± 2.3 [95% CI = 13.4 to 13.8], Constant = 5.7 ± 1.9 [95% CI = 5.5 to 5.9], SST = 1.5 ± 0.3 [95% CI = 1.4 to 1.6], SPADI = 20.6 ± 2.6 [95% CI = 20.4 to 20.8], UCLA = 8.7 ± 0.6 [95% CI = 8.6 to 8.8], VAS = 1.6 ± 0.3 [95% CI = 1.57 to 1.63], global shoulder function = 1.4 ± 0.3 [95% CI = 1.37 to 1.43], and range of motion (active abduction = 6.7 ± 3.6° [95% CI = 6.4 to 7.0°]; active forward flexion = 11.6 ± 4.1° [95% CI = 11.2 to 12.0°]; active external rotation = 3.2 ± 2.3° [95% CI = 3.0 to 3.4°]) following aTSA and rTSA.[18] The SCB values were approximately double the MCID values for ASES, Constant, SST, SPADI, UCLA, VAS pain, and global shoulder function scores in the same cohort of patients. Additionally, these SCB values were two to three times the MCID values for active abduction, flexion, and external rotation as determined in the same cohort. Furthermore, our analysis revealed that an average improvement of 30% of the total metric value for each of the seven outcome metrics evaluated in this study would achieve or exceed the SCB threshold; this information has widespread application for shoulder surgeons counseling their patients regarding expectations after total shoulder arthroplasty.

The SCB value for the ASES metric reported in this study (31.5 ± 2.0 [95% CI = 31.4 to 31.6]) was similar to that reported by Werner et al.[26] (36.6 ± 3.8 (95% CI, 29.1 – 44.1), being only 16% different. There are several explanations for the variability between these two studies. Differences in the SCB for the ASES metric is most likely due to the slightly different anchor questions utilized between the two studies and also due to the larger sample size in our study (1568 vs 490 patients). However, the difference between the ASES SCB values may also be due to differences in the study cohorts related to the frequency of prosthesis type (e.g. aTSA vs rTSA), gender distribution, differences in patient age, and different durations of follow-up.

In our study, prosthesis type, patient age, gender, and follow-up duration were all associated with variation in the SCB for each metric, with the most significant differences observed in prosthesis type and follow-up duration. aTSA, males, and patients with longer follow-up duration demonstrated higher SCB values for nearly every metric compared to their rTSA, female, and shorter follow-up duration counterparts, respectively. Age at the time of surgery demonstrated a variable effect on the SCB. The SCB values for ASES, Constant, UCLA, VAS and active flexion and external rotation peaked in the 60-70year-old cohort compared to the younger and older cohorts. This trend was not seen for the other metrics studied. The variation noted in SCB for each metric when stratified according to prosthesis type, age, gender, and length of follow-up demonstrates that SCB values cannot be indiscriminately applied to other studies which may be comprised of patients with different proportions of gender and prosthesis type as well as age distribution and length of follow-up attributes.

Based on a comparison of the normalized SCB scores, the Constant score had a substantially lower SCB value while the other metrics showed little variability relative to each other. This finding emphasizes that different metrics utilized across and within studies cannot be conflated without the possibility of introducing error.

The ability to differentiate between MCID and SCB after total shoulder arthroplasty is useful for patients and healthcare providers to establish patient expectations for improvement in outcomes and also to assess the possible benefits associated with total shoulder arthroplasty relative to its financial cost. There has been greater focus on quality measures and patient reported outcome measures due to pay for performance and bundled payment initiatives.[1, 2, 16] The clinical benefit of total shoulder arthroplasty as perceived by the patient must be factored into this cost/benefit equation. This economic evaluation of total shoulder arthroplasty outcomes and the associated MCID and SCB thresholds for the different outcome metrics stratified according to prosthesis type, patient age, gender, and follow-up duration can aid in this determination. This information is useful for patient counseling regarding expectations for improvement after surgery as well. Assuming the results and trends of this large-scale outcomes study of 1568 patients from 13 shoulder surgeons is representative and translatable, then these results are generalizable: 2/3 of patients receiving total shoulder arthroplasty will be satisfied with their outcomes and achieve a 30% increase in the maximum possible score of a given outcome metric, thereby meeting or exceeding the SCB threshold.

There are several limitations to this study. The calculation of SCB utilizes an anchor question. The choice of anchor question can influence the stratification of results and hence the value obtained for SCB. The anchor question utilized in our study is slightly different from the anchor question utilized by Werner et al.[26] Future endeavors should evaluate the effect of different anchor questions on SCB variation for outcome metrics and triangulate towards the ideal anchor question for total shoulder arthroplasty. Additionally, this study utilized data from an international multicenter registry using one particular platform shoulder prosthesis, which is subject to enrollment bias. The results obtained from our analysis may not be generalizable to all implant systems. However, the use of such a registry has several distinct advantages for this study. Primarily, the registry provides a substantially larger cohort of patients than the previous analysis of SCB after shoulder arthroplasty and permits a simultaneous evaluation of multiple metrics, as compared to the Werner et al.[26] study which solely evaluated the SCB for ASES score. Additionally, the registry enrolled patients from 13 shoulder surgeons from high volume academic and community practices, increasing the likelihood that the SCB values derived from this data is applicable across shoulder arthroplasty patients in general, and not just those undergoing surgery in a particular practice or setting. Finally, the average follow-up of this study (44.2 ± 23.4 months) was relatively short-term, with only 13.5% of patients having >72 months follow-up; additional and longer term follow-up is necessary to confirm these findings and better understand how SCB changes with follow-up duration after total shoulder arthroplasty.

CONCLUSION

We identified the values for substantial clinical benefit of seven outcome metrics and three ranges of active motion measurements after total shoulder arthroplasty. Our analysis demonstrated that approximately 2/3 of the patients studied achieved the SCB threshold for the outcome metrics. Additionally, a change of approximately 30% of the total possible score of each of seven metrics (ASES, Constant, UCLA, SST, SPADI, global shoulder function, and pain VAS) approximates or exceeds SCB after total shoulder arthroplasty. Finally, SCB was higher for aTSA as compared to rTSA, higher for males as compared to females, and patients of longer follow-up duration as compared to those of shorter follow-up duration.

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LEGEND

Figure Legend

Figure 1. Graphical demonstration of SCB stratified according to time of follow-up, age, gender, and prosthesis type for ASES score.

Table Legend

Table 1. Distribution of the anchor question response for each cohort.

Table 2. Average pre-to-post outcome improvement for the aTSA cohort at latest follow-up, stratified by the anchor question response (n=911).

Table 3. Average pre-to-post outcome improvement for the rTSA cohort at latest follow-up, stratified by the anchor question response (n=945).

Table 4. SCB stratified according to prosthesis type.

Table 5. SCB stratified according to age at time of surgery.

Table 6. SCB stratified according to gender.

Table 7. SCB stratified according to length of follow-up.

Patient Satisfaction	**% of aTSA Cohort**	**% of rTSA Cohort**	**% of Female Cohort**	**% of Male Cohort**	**% <60yro Cohort**	**% 60-70yro Cohort**	**70-80 yro Cohort**	**>80yro Cohort**	**<36 month follow-up cohort**	**36-72 month follow-up cohort**	**>72 month follow-up cohort**
Worse	38 of 911 (4.2%)	27 of 945 (2.9%)	40 of 1097 (3.6%)	25 of 754 (3.3%)	14 of 236 (5.9%)	25 of 624 (4.0%)	23 of 769 (3.0%)	3 of 225 (1.3%)	25 of 839 (3.0%)	26 of 763 (3.4%)	14 of 243 (5.8%)
Unchanged	57 of 911 (6.3%)	56 of 945 (5.9%)	59 of 1097 (5.4%)	52 of 754 (6.9%)	26 of 236 (11.0%)	35 of 624 (5.6%)	44 of 769 (5.7%)	8 of 225 (3.6%)	45 of 839 (5.4%)	45 of 763 (5.9%)	22 of 243 (9.1%)
Better	127 of 911 (13.9%)	161 of 945 (17.0%)	185 of 1097 (16.9%)	102 of 754 (13.5%)	48 of 236 (20.3%)	88 of 624 (14.1%)	122 of 769 (15.9%)	29 of 225 (12.9%)	113 of 839 (13.5%)	121 of 763 (15.9%)	53 of 243 (21.8%)
Much Better	689 of 911 (75.6%)	701 of 945 (74.2%)	813 of 1097 (74.1%)	575 of 754 (76.3%)	148 of 236 (62.7%)	476 of 624 (76.3%)	580 of 769 (75.4%)	185 of 225 (82.2%)	656 of 839 (78.2%)	571 of 763 (74.8%)	154 of 243 (63.4%)

Table 1. Distribution of the anchor question response for each cohort

Improvement	ASES	Constant	UCLA	SST	SPADI	VAS	Shoulder Function	Active Abduction	Active Forward Flexion	Active External Rotation
Worse	3.3 ± 21.0	4.9 ± 19.5	0.2 ± 5.1	2.2 ± 2.7	14.0 ± 27.1	0.2 ± 3.1	0.7 ± 2.2	5.3 ± 42.3	-1.0 ± 48.5	12.1 ± 23.4
Unchanged	28.2 ± 22.3	18.5 ± 17.5	5.7 ± 5.6	4.3 ± 3.5	34.1 ± 23.6	-3.4 ± 2.9	1.5 ± 3.2	18.7 ± 36.7	15.6 ± 36.9	17.7 ± 22.9
Better	34.7 ± 21.6	25.9 ± 17.5	14.0 ± 5.7	5.3 ± 3.1	46.5 ± 24.1	-3.6 ± 3.0	2.9 ± 2.7	26.8 ± 37.9	31.4 ± 42.7	29.7 ± 24.5
Much Better	55.3 ± 17.5	38.5 ± 12.6	18.6 ± 4.4	7.2 ± 2.8	73.4 ± 23.8	-5.7 ± 2.3	5.0 ± 2.2	49.0 ± 36.3	53.8 ± 33.2	35.3 ± 21.7
All aTSA Patients	49.0 ± 22.6	34.5 ± 16.2	16.7 ± 6.4	6.7 ± 3.2	65.0 ± 29.0	-5.1 ± 2.8	4.4 ± 2.7	41.9 ± 39.0	45.6 ± 39.0	32.2 ± 23.1

Table 2. Average pre-to-post outcome improvement for the aTSA cohort at latest follow-up, stratified by the anchor question response (n=911)

Improvement	ASES	Constant	UCLA	SST	SPADI	VAS	Shoulder Function	Active Abduction	Active Forward Flexion	Active External Rotation
Worse	16.2 ± 23.9	14.0 ± 18.7	5.8 ± 6.0	2.3 ± 2.8	15.3 ± 28.9	-1.6 ± 3.7	1.6 ± 2.2	22.7 ± 39.9	20.0 ± 47.4	10.6 ± 25.0
Unchanged	30.5 ± 25.7	31.3 ± 23.5	8.7 ± 6.1	4.9 ± 4.4	31.0 ± 28.9	-3.2 ± 2.8	2.8 ± 3.2	31.9 ± 34.8	42.6 ± 35.5	20.5 ± 21.9
Better	35.9 ± 20.2	25.4 ± 15.1	14.8 ± 5.2	5.3 ± 3.5	45.4 ± 27.0	-4.0 ± 2.8	3.4 ± 2.7	27.0 ± 36.0	32.4 ± 40.2	11.9 ± 21.9
Much Better	51.5 ± 17.2	39.3 ± 14.6	18.2 ± 4.5	7.2 ± 2.8	68.1 ± 23.9	-5.2 ± 2.3	4.8 ± 2.4	48.5 ± 38.1	57.6 ± 43.0	20.8 ± 24.9
All rTSA Patients	46.5 ± 20.6	35.8 ± 16.7	16.7 ± 5.7	6.6 ± 3.3	61.2 ± 28.0	-4.8 ± 2.6	4.4 ± 2.6	43.0 ± 38.7	51.3 ± 43.6	18.9 ± 24.5

Table 3. Average pre-to-post outcome improvement for the rTSA cohort at latest follow-up, stratified by the anchor question response (n=945)

Outcome Metric	**SCB rTSA [95% CI]**	**SCB aTSA [95% CI]**
ASES	25.9 ± 2.9 [25.7 to 26.1]	37.6 ± 2.6 [37.4 to 37.8]
Constant	13.6 ± 2.6 [13.4 to 13.8]	25.4 ± 2.0 [25.3 to 25.5]
UCLA	10.4 ± 0.7 [10.3 to 10.5]	15.0 ± 0.6 [14.96 to 15.04]
SST	3.2 ± 0.5 [3.17 to 3.24]	3.7 ± 0.4 [3.67 to 3.73]
SPADI	42.7 ± 3.4 [42.5 to 42.9]	48.3 ± 2.9 [48.1 to 48.5]
VAS	2.6 ± 0.4 [2.57 to 2.63]	3.8 ± 0.4 [3.77 to 3.83]
Shoulder Function	2.4 ± 0.3 [2.38 to 2.42]	3.9 ± 0.3 [3.88 to 3.92]
Active Abduction	19.6 ± 4.3 [19.3 to 19.9]	36.1 ± 4.3 [35.8 to 36.4]
Active Forward Flexion	22.3 ± 4.8 [22.0 to 22.6]	45.5 ± 4.6 [45.2 to 45.8]
Active External Rotation	3.6 ± 2.7 [3.4 to 3.8]	20.1 ± 2.5 [19.9 to 20.3]

Table 4. SCB stratified according to prosthesis type

Outcome Metric	SCB < 60 yo [95% CI]	SCB 60-70 yo [95% CI]	SCB 70-80 yo [95% CI]	SCB > 80 yo [95% CI]
ASES	31.0 ± 4.0 [30.4 to 31.6]	37.5 ± 2.9 [37.3 to 37.8]	28.3 ± 3.4 [28.0 to 28.6]	25.3 ± 9.1 [24.0 to 26.6]
Constant	20.2 ± 3.5 [19.7 to 20.7]	24.2 ± 2.5 [24.0 to 24.4]	15.5 ± 3.0 [15.3 to 15.7]	6.8 ± 6.6 [5.9 to 7.7]
UCLA	12.9 ± 1.0 [12.8 to 13.0]	14.5 ± 0.8 [14.4 to 14.6]	11.0 ± 0.8 [10.9 to 11.1]	10.4 ± 2.2 [10.1 to 10.7]
SST	4.4 ± 0.6 [4.3 to 4.5]	3.7 ± 0.5 [3.66 to 3.74]	2.9 ± 0.5 [2.86 to 2.94]	2.5 ± 1.3 [2.3 to 2.7]
SPADI	40.6 ± 4.6 [39.9 to 41.3]	51.3 ± 3.4 [51.0 to 51.6]	43.0 ± 3.7 [42.7 to 43.3]	52.7 ± 6.6 [51.8 to 53.6]
VAS	2.9 ± 0.5 [2.8 to 3.0]	4.0 ± 0.4 [3.97 to 4.03]	2.9 ± 0.4 [2.87 to 2.93]	2.0 ± 1.2 [1.8 to 2.2]
Shoulder Function	3.7 ± 0.5 [3.6 to 3.8]	3.3 ± 0.3 [3.28 to 3.33]	2.7 ± 0.4 [2.67 to 2.73]	3.1 ± 1.0 [3.0 to 3.2]
Active Abduction	23.0 ± 7.1 [22.0 to 24.0]	29.8 ± 4.9 [29.4 to 30.2]	30.8 ± 5.1 [30.4 to 31.2]	23.7 ± 10.0 [22.3 to 25.1]
Active Forward Flexion	28.2 ± 7.0 [27.2 to 29.2]	42.9 ± 5.5 [42.4 to 43.4]	33.7 ± 6.0 [33.2 to 34.2]	25.4 ± 8.8 [24.2 to 26.6]
Active External Rotation	19.1 ± 4.5 [18.5 to 19.7]	12.2 ± 3.0 [12.0 to 12.5]	12.1 ± 2.9 [11.9 to 12.3]	-1.4 ± 6.8 [-2.4 to -0.5]

Table 5. SCB stratified according to age at time of surgery.

Outcome Metric	SCB Female [95% CI]	SCB Male [95% CI]
ASES	30.4 ± 2.7 [30.2 to 30.6]	32.9 ± 3.0 [32.7 to 33.1]
Constant	16.0 ± 2.2 [15.9 to 16.1]	21.9 ± 2.7 [21.7 to 22.1]
UCLA	11.8 ± 0.6 [11.76 to 11.84]	13.3 ± 0.8 [13.2 to 13.4]
SST	3.4 ± 0.4 [3.37 to 3.43]	3.4 ± 0.4 [3.37 to 3.43]
SPADI	51.7 ± 2.8 [51.5 to 51.9]	37.8 ± 3.6 [37.5 to 38.1]
VAS	3.0 ± 0.4 [2.97 to 3.03]	3.4 ± 0.4 [3.37 to 3.43]
Shoulder Function	2.9 ± 0.3 [2.88 to 2.92]	3.1 ± 0.3 [3.08 to 3.12]
Active Abduction	27.5 ± 4.1 [27.2 to 27.8]	28.8 ± 4.7 [28.4 to 29.2]
Active Forward Flexion	34.1 ± 4.5 [33.8 to 34.4]	35.9 ± 5.4 [35.5 to 36.3]
Active External Rotation	9.5 ± 2.7 [9.3 to 9.7]	14.1 ± 2.5 [13.9 to 14.3]

Table 6. SCB stratified according to gender.

Outcome Metric	SCB <36 months [95% CI]	SCB 36-72 months [95% CI]	SCB >72 months [95% CI]
ASES	26.6 ± 3.5 [26.4 to 26.9]	34.0 ± 2.6 [33.8 to 34.2]	39.8 ± 4.7 [39.1 to 40.5]
Constant	14.3 ± 3.2 [14.1 to 14.5]	22.2 ± 2.1 [22.0 to 22.4]	27.3 ± 3.0 [26.9 to 27.7]
UCLA	11.7 ± 0.9 [11.6 to 11.8]	12.8 ± 0.7 [12.75 to 12.85]	15.2 ± 1.1 [15.0 to 15.4]
SST	3.0 ± 0.6 [2.96 to 3.04]	3.4 ± 0.4 [3.37 to 3.43]	5.7 ± 0.5 [5.6 to 5.8]
SPADI	46.2 ± 3.8 [45.9 to 46.5]	41.2 ± 3.2 [41.0 to 41.5]	56.5 ± 4.9 [55.8 to 57.2]
VAS	2.7 ± 0.4 [2.67 to 2.73]	3.3 ± 0.4 [3.27 to 3.33]	4.4 ± 0.7 [4.3 to 4.5]
Shoulder Function	2.8 ± 0.4 [2.77 to 2.83]	3.2 ± 0.3 [3.18 to 3.22]	3.8 ± 0.4 [3.7 to 3.9]
Active Abduction	27.2 ± 5.8 [26.8 to 27.6]	25.0 ± 4.2 [24.7 to 25.3]	36.5 ± 5.7 [35.7 to 37.3]
Active Forward Flexion	32.1 ± 6.0 [31.7 to 32.5]	34.1 ± 5.2 [33.7 to 34.5]	42.8 ± 6.2 [41.9 to 43.7]
Active External Rotation	10.9 ± 3.0 [10.7 to 11.1]	11.7 ± 2.7 [11.5 to 11.9]	12.5 ± 5.0 [11.8 to 13.2]

Table 7. SCB stratified according to length of follow-up.

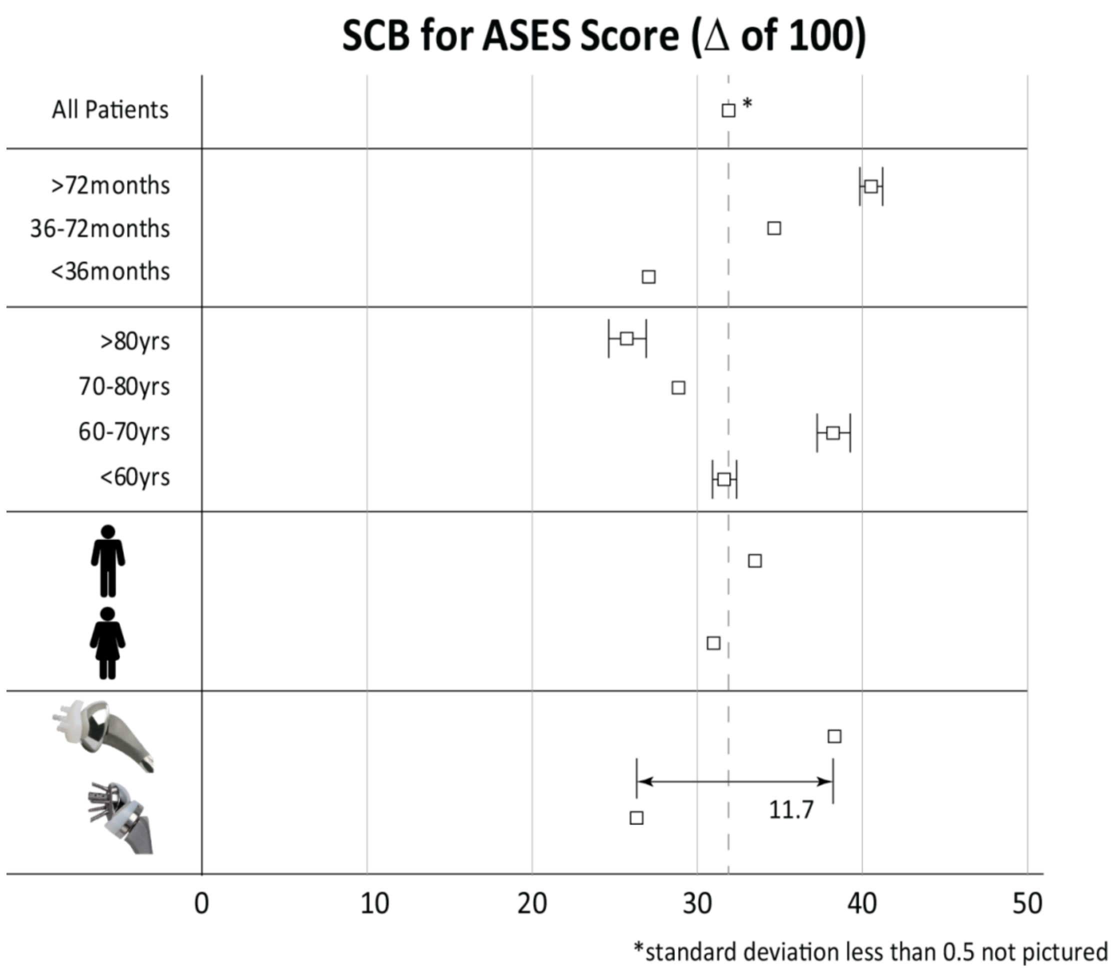

Figure 1. Graphical demonstration of SCB stratified according to time of follow-up, age, gender, and prosthesis type for ASES score.