JSES International 6 (2022) 828–832

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

The shoulder function "tipping-point" for elective rotator cuff repair: demographic and longitudinal trends

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ARTICLE INFO

Keywords:
Tipping point
Rotator cuff repair
Elective surgery
Shoulder
Mental health
Demographics
Surgical history

Level of evidence: Basic Science Study; Validation of Outcome Instruments

Background: A patient's decision to undergo an elective orthopedic procedure is largely based on their symptoms and functional limitations. This point where patients choose to undergo surgery is known as the "tipping point." The primary aim of this study is to determine the relationship between demographic parameters and the tipping point for elective rotator cuff repair. The secondary aim is to investigate if the tipping point is associated with mental health. The tertiary aim is to determine if the tipping point changes over time.

Methods: Retrospective chart review was used to identify all patients who underwent primary arthroscopic rotator cuff repair between January 1, 2015, to January 1, 2020, with 1 of 3 board-certified orthopedic surgeons. Exclusion criteria included age <18 years, revision surgery, or incomplete datasets (American Shoulder and Elbow Surgeons [ASES], 12-item short form, demographic information, and surgical history). Preoperative ASES score was designated as the *tipping point* for an individual patient, with a lower score representing worse shoulder function and therefore a higher tipping point and vice versa. Demographic parameters (age, sex, body mass index [BMI], race, and insurance), hand dominance, and surgical history extracted from chart review were analyzed to determine associations with tipping point.

Results: A total of 2153 patients were identified from chart review, with 1731 included in the final analysis. The patients had a mean age of 58.6 ± 9.66 years and a mean BMI of 29.2 ± 6.02 kg/m^2. There was no significant difference in mean preoperative ASES score by year for the duration of this study (2015-2019, $P = .27$). Worker's compensation patients had a significantly lower mean preoperative ASES score than patients with commercial or government insurance ($P < .01$). Spearman's rank correlations showed no relationship between ASES score and patient demographics (age, sex, BMI, race, and hand dominance) or between ASES and previous orthopedic surgery. Preoperative ASES showed a weakly positive correlation ($\rho = 0.26$) with 12-item short form mental component score. Multivariate linear regression showed male sex is predictive of a lower tipping point ($P < .01$), whereas higher BMI, African American race, and history of arthroplasty are predictive of a higher tipping point ($P \leq .02$).

Conclusion: The tipping point was not demonstrated to change over time in our analysis. Male sex is predictive of a lower tipping point for arthroscopic rotator cuff repair, whereas elevated BMI, African American race, worker's compensation insurance, and prior arthroplasty are predictive of a higher tipping point. Also, better mental health function is associated with a lower tipping point.

A patient's decision to undergo an elective orthopedic procedure is largely based on their symptoms (including pain) and functional limitations.[27] As a person's ability to perform their daily tasks decline, a certain point is reached in which they would rather undergo surgery than continue living with their symptoms. This critical point has previously been referred to as the *tipping point*.[22] Previous studies have investigated the concept of a tipping point, primarily for arthroplasty procedures.[1,7,11,22,23] In particular, Somerson et al analyzed the tipping point for shoulder arthroplasty in terms of preoperative Simple Shoulder Test scores. They observed a significant relationship between higher tipping points and various demographic parameters, such as younger age, male sex, being married, commercial insurance, and mental well-being.[22]

This study was approved by Philadelphia + Thomas Jefferson University Office of Human Research Institutional Review Board.

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https://doi.org/10.1016/j.jseint.2022.05.004

Although there are considerable differences between indications for shoulder arthroplasty and rotator cuff repair (RCR), rotator cuff tears are often degenerative in nature, with patients generally attempting multiple nonoperative treatments before surgery.[6] Some patients with rotator cuff tears elect to undergo RCR, whereas others with analogous tears do not.[21] Furthermore, although the presence of a rotator cuff tear is needed as an indication for surgery, patients do not undergo surgical repair unless their symptoms are intolerable, or for some, unless conservative treatment has failed. In addition, decreasing complication rates and good clinical outcomes from RCRs may lead surgeons to offer surgical repair earlier in the disease course.[18]

Previous studies have investigated the factors that motivate patients to undergo RCR.[16,17,27] These qualitative studies give a snapshot into patients' thoughts as they decide to undergo RCR; however, they are limited by their study design. Quantitative investigation of the tipping point for undergoing RCR allows surgeons to understand differences in symptom tolerance between patient groups, as well as how this tolerance has changed over time. The primary aim of this study is to determine the relationship between demographic parameters and the tipping point for elective RCR. The secondary aim is to investigate if the tipping point is associated with mental health. The tertiary aim is to determine if the tipping point changes over time. The authors hypothesize that the shoulder function tipping point for elective arthroscopic RCR is influenced by patient demographics and has changed over time.

Methods

This was a retrospective study of patients who underwent primary arthroscopic RCR between January 1, 2015, and January 1, 2020, performed by 3 board-certified, fellowship-trained orthopedic surgeons at a single institution. The study protocol was approved by the corresponding institutional review board. Patients were excluded if they were aged <18 years at the time of surgery, if they were having a revision RCR, or if they did not complete the study questionnaires (American Shoulder and Elbow Surgeons [ASES] survey and 12-item short form [SF-12] survey). Electronic medical records were reviewed by research staff to obtain patient demographic information (age, sex, BMI, race, insurance payor type), hand dominance, and surgical history, with particular attention paid to prior contralateral RCR, prior upper extremity surgery, prior lower extremity surgery, prior spine surgery, prior arthroscopic surgery, prior arthroplasty, and any prior orthopedic surgery. Insurances were classified as commercial (Preferred Provider Organization or Health Maintenance Organization from a third-party seller), government (Medicare, Medicaid, federal- or state-provided Blue Cross/Blue Shield), or worker's compensation (WC).

Functional outcome scores of patients were recorded using the ASES score, which ranges from 0 to 100, with a higher score representing better functional capability. The preoperative ASES score was determined to be the patient's "tipping point," with a higher ASES score corresponding to better function and therefore a lower tipping point, and vice versa. The SF-12 survey was also administered to patients. Two scores are reported from the SF-12 survey: a mental component score (MCS) and a physical component score (PCS). The SF-12 survey is scored using a norm-based method, where the mean scores of the United States population for both MCS and PCS are 50, with a standard deviation of 10, and higher scores indicating better quality of life.[26]

Patient demographics, surgical history, and preoperative SF-12 scores were analyzed for relationships with preoperative ASES scores. Statistical analysis was performed on R (*R Core Team, 2017*). Statistical tests with $P < .05$ were deemed significant. Descriptive statistics are presented as mean ± standard deviation for continuous variables and as number (percentage) for categorical variables. Spearman's rank correlations were calculated to analyze associations between demographic factors, surgical history, and tipping point. Multivariate linear regression was also performed to determine if demographic factors or surgical history were predictive of changes in tipping point. A separate analysis was performed to determine if the date of surgery correlated with preoperative ASES scores. Chi-square or Fisher's exact tests were used to calculate *P* values for categorical data. Multiple comparison testing was computed on significant values for the insurance analysis to see which comparisons were significant between insurances and not just across insurances.

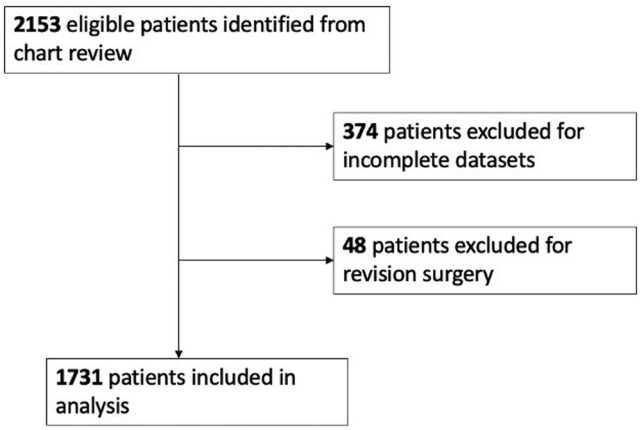

Figure 1 Flowchart of patient inclusion/exclusion.

Table I
Patient surgical history.

Type of surgery	Patients with procedure (%)	Patients without procedure (%)
Prior contralateral RCR	139 (8.0)	1592 (92.0)
Prior upper extremity surgery	322 (18.6)	1409 (81.4)
Prior lower extremity surgery	204 (11.8)	1527 (88.2)
Prior spine surgery	39 (2.3)	1692 (97.7)
Prior arthroscopy	307 (17.7)	1424 (82.3)
Prior arthroplasty	108 (6.2)	1623 (93.8)
Any prior orthopedic surgery	499 (28.8)	1232 (71.2)

RCR, rotator cuff repair.

Results

Of the 2153 patients identified from chart review, 374 were excluded for incomplete data sets and 48 were excluded for revision surgery, leaving 1731 included in the final analysis (80.4%; Fig. 1). These patients had a mean age of 58.6 ± 9.66 years and a mean BMI of 29.2 ± 6.02 kg/m^2. This cohort included 715 (41.3%) females and 1016 (58.7%) males. Seven hundred (40.4%) patients were left-hand dominant, and 1031 (59.6%) were right-hand dominant. A total of 1360 (78.6%) patients identified as White, 189 (10.9%) identified as Black or African American, and 182 (10.5%) identified as another race. Patient surgical history is shown in Table I. The mean preoperative ASES score was 43.6 ± 19.8. The mean preoperative SF-12 MCS score was 51.6 ± 12.1, and the mean preoperative SF-12 PCS score was 37.3 ± 9.13. There was no

Table II
Preoperative ASES by year (mean ± standard deviation).

	2015	2016	2017	2018	2019	*P* value
Variable	N = 255	N = 395	N = 490	N = 407	N = 184	
Preopertaive ASES	44.3 ± 21.5	43.4 ± 18.6	44.0 ± 19.2	44.2 ± 20.2	40.6 ± 20.2	.274

ASES, American Shoulder and Elbow Surgeons.

Table III
Association between demographics and preoperative ASES score.

Variable	Correlation coefficient (ρ)
Age	0.028
Sex	0.118
BMI	−0.147
Race	−0.053
Hand dominance	−0.018

ASES, American Shoulder and Elbow Surgeons; *BMI*, body mass index.

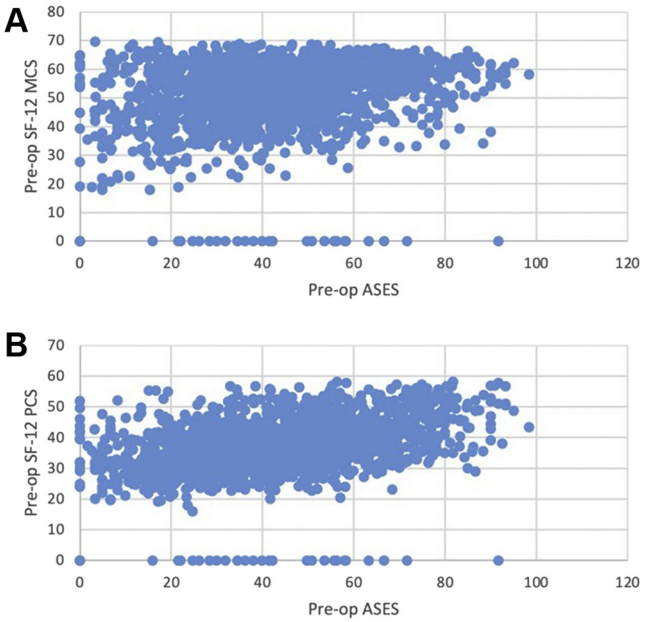

Figure 2 Correlation between SF-12 scores and preoperative ASES scores. (**A**) Preoperative SF-12 MCS showed a weakly positive correlation with preoperative ASES (ρ = 0.262). (**B**) Preoperative SF-12 PCS showed a moderately positive correlation with preoperative ASES (ρ = 0.409). *SF-12*, 12-item short form survey; *ASES*, American Shoulder and Elbow Surgeons; *MCS*, mental component score; *PCS*, physical component score.

statistically significant difference in mean preoperative ASES score by year for the duration of this study (2015-2019, $P = .27$; Table II).

The most common insurance type was commercial (967 patients [55.9%]), followed by government (530 patients [30.6%]), then WC (234 patients [13.5%]). Patients with WC insurance had significantly lower mean preoperative ASES scores (higher tipping point) than patients with commercial or government insurance (WC = 39.1 ± 18.5; commercial = 44.4 ± 19.7; government = 44.1 ± 20.2; $P < .01$). Caucasian patients had the largest proportion of government insurance (32.8% of Caucasian patients, compared with 21.2% of African American patients, and 24.2% of patients who identified as another race [$P < .01$]). African American patients had the largest proportion of WC insurance (22.8% of African American patients, compared with 12.0% of Caucasian patients, and 15.4% of patients who identified as another race [$P < .01$]). The distribution of patients with commercial insurance was not significantly different across races (55.2% of Caucasian patients, 56.1% of African American patients, and 60.4% of patients who identified as another race; $P = .13$).

Spearman's rank correlations were performed to find potential associations between mean preoperative ASES score and patient demographics and clinical history. No correlation was found between patient demographics and preoperative ASES score ($P > .05$); correlation coefficients are shown in Table III. Preoperative SF-12 MCS showed a weakly positive correlation with preoperative ASES (ρ = 0.26), and preoperative SF-12 PCS showed a moderately positive correlation with preoperative ASES (ρ = 0.41; Fig. 2). No correlation was found between prior surgical history and preoperative ASES ($P > .05$); correlation coefficients are shown in Table IV.

Multivariate linear regression was performed to analyze factors predictive of association with a patient's preoperative ASES score. Male sex is associated with a 5.14 times greater preoperative ASES score ($P < .01$). Factors associated with a lower preoperative ASES score include higher BMI ($\beta = -0.41$, $P < .01$), Black/African American race ($\beta = -4.49$, $P < .01$), and prior arthroplasty ($\beta = -5.45$, $P = .02$). Other race (non-Black and non-White), prior contralateral RCR, prior orthopedic surgery, and prior upper extremity surgery were not associated with differences in preoperative ASES scores ($P > .05$). Linear regression results are presented in Table V.

Discussion

This was a retrospective cohort study analyzing the effect of demographic and clinical factors on the preoperative ASES score, defined here as the “tipping point,” of patients undergoing primary arthroscopic RCR. There was no significant difference in preoperative ASES score by year, suggesting that the tipping point at which patients elect to undergo this procedure is not changing over time. This is in agreement with a 2020 study by Reams et al demonstrating that the tipping point for reverse shoulder arthroplasty did not change over the 10-year study period.[20] Also, the finding that patients with WC insurance have a higher tipping point is concordant with prior studies that have shown that patients with WC insurance have worse baseline functional status and outcomes after RCR.[2,15]

Patient demographic factors other than insurance (age, sex, BMI, race, and hand dominance) showed no correlation with tipping point. However, linear regression revealed that male sex was predictive of a higher preoperative ASES score, whereas higher BMI and African American race were predictive of lower preoperative ASES scores. This relationship suggests that males choose to undergo surgery at a higher functional capacity than women (ie, males have a lower tipping point) or may have greater functional/quality-of-life deficits than they reveal in the surveys. Previous studies also found that male patients have greater preoperative shoulder function before RCR and/or shoulder arthroplasty and attributed this to female patients attempting more conservative treatments such as corticosteroid injections.[12,13,24] Although the use of conservative therapies was not assessed in this study, it is possible that males may opt for surgery rather than conservative treatment because of work-related demands[2] or social stigma to

Table IV
Association between surgical history and preoperative ASES score.

Variable	Correlation coefficient (ρ)
Prior contralateral RCR	0.032
Prior upper extremity surgery	−0.003
Prior lower extremity surgery	−0.014
Prior arthroscopy	0.029
Prior arthroplasty	−0.054
Prior spine surgery	−0.006
Prior orthopaedic surgery	−0.0003

ASES, American Shoulder and Elbow Surgeons; *RCR*, rotator cuff repair.

Table V
Linear regression for preoperative ASES.

Variable	Estimate	Lower 95	Upper 95	*P* value
Sex: male*	5.14	3.28	6.99	<.001
Preoperative BMI*	−0.41	−0.56	−0.25	<.001
Race				
White	Reference			
Black*	−4.49	−7.46	−1.51	.003
Other	0.03	−2.97	3.03	.984
Prior contralateral RCR	3.63	−0.66	7.91	.097
Prior orthopedic surgery	2.68	−1.01	6.36	.155
Prior upper extremity surgery	−3.85	−8.16	0.45	.079
Prior arthroplasty*	−5.45	−10.02	−0.89	.019

ASES, American Shoulder and Elbow Surgeons; *BMI*, body mass index; *RCR*, rotator cuff repair.
*Statistically significant.

perform physically demanding tasks. Prior studies have described an association between higher BMI and worse outcomes after RCR;[5,14] however, no studies have yet analyzed obesity as a risk factor for worse preoperative function before RCR. It can be theorized that higher weight puts additional stress on the shoulder, leading to a lower state of baseline shoulder function for obese patients.

Furthermore, our finding that African American race is predictive of a higher tipping point (lower ASES score) is in agreement with a prior study by Figaro et al, which found that African Americans are significantly less likely to undergo knee arthroplasty than Caucasians despite having the same or greater levels of functional deficits.[6] This article highlighted several themes as reasons for surgery hesitancy among African Americans, including negative expectations and fear of surgery,[6] although another factor to consider with this trend is the "weathering" phenomenon. Weathering describes the negative health effects caused by the chronic stress of challenges faced by African American people.[6,8,9] Our belief is that the chronic effects of weathering lead to African Americans being at a worse baseline health state[24] and therefore at a lower functional capacity when electing to undergo RCR. Another likely contributing factor to the higher tipping point for African Americans is decreased access to health care in minority communities,[4,25] which could lead to these patients presenting later in their disease course. This is supported by the analysis of insurance payor types, which showed that African American patients had the highest proportion of WC insurance. The fact that African American race and WC insurance were both independently associated with a higher tipping point reinforces the challenges faced by this demographic after rotator cuff tears. Future studies could investigate the relationship between rotator cuff tear size, tipping point, race/ethnicity, and access to care.

In addition, there was no correlation between prior surgical history (prior contralateral RCR, prior upper or lower extremity surgery, prior shoulder arthroscopy, prior spine surgery, prior arthroplasty, or any prior orthopedic surgery) and tipping point. However, linear regression revealed that prior arthroplasty was associated with a higher tipping point (lower ASES score). This can likely be attributed to surgery fatigue, where patients who had prior arthroplasty were not fully satisfied,[3,10] are less interested in having another operation, and are willing to have a higher tipping point before wanting the next surgery. This could also be because of these patients being accustomed to some shoulder dysfunction in the context of rotator cuff tears being a degenerative condition, and their lack of preoperative function is not as problematic for them.

Preoperative ASES score had a weakly positive correlation with SF-12 MCS and a moderately positive correlation with SF-12 PCS. This association is logical, given that a higher ASES score reflects better shoulder function, and a higher SF-12 score reflects better quality of life. The fact that the PCS has a stronger correlation with tipping point than the MCS likely reflects the fact that the ASES survey is primarily focused on physical ability and has no questions about mental well-being. Greater mental well-being being associated with a lower tipping point (higher ASES score) is in accordance with published studies demonstrating that patients with psychiatric illness report worse functional status before shoulder surgery.[19]

A prior prospective study by Weekes et al investigated patient and physician decision-making factors for undergoing RCR and compared these factors to preoperative shoulder function as measured by ASES scores.[27] This study similarly identified that males have higher preoperative ASES scores than females but did not find the relationship that this present study found with higher BMI associated with lower preoperative ASES scores. The study by Weekes et al also identified other patient and surgeon factors that contributed to the decision to undergo RCR, including daily chronic pain, concern for tear enlargement, and sleep difficulties.[27] Although these results inform clinicians about patient priorities in the decision to undergo RCR, the present study is able to quantify the relationship between demographic factors, surgical history factors, and the degree of disability before the decision to undergo arthroscopic RCR.

The limitations of this study include the potential for bias and inaccuracy caused by the retrospective nature of this study. Also, this study focused on demographics and surgical history, so the relationship of factors such as rotator cuff tear size and concern for tear enlargement with preoperative shoulder function was not assessed. Patient activity level and use of conservative therapies (such as corticosteroid injections) were also not assessed in this study. Another potential limitation is the exclusion of patients with rotator cuff tears who were not scheduled to undergo RCR. There is additional variability because multiple surgeons were included in this study. The generalizability of our results to other orthopedic patient populations may be limited because patients were recruited from a limited geographic region at a private community orthopedic practice.

Conclusion

The tipping point was not demonstrated to change over time in our analysis. Male sex is predictive of a lower tipping point for arthroscopic RCR, whereas elevated BMI, African American race, WC insurance, and prior arthroplasty are predictive of a higher tipping point. Also, better mental health function is associated with a lower tipping point.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: B.T. has received consulting fees from DePuy Synthes (Raynham, MA, USA) and DePuy Orthopaedics (Warsaw, IN, USA) in payments or benefits in an amount of less than USD 10,000. However, this is not relevant to this study. F.T. has received

consulting fees from DePuy Synthes (Raynham, MA, USA) and DePuy Orthopaedics (Warsaw, IN, USA) in payments or benefits in an amount of less than USD 10,000. However, this is not relevant to this study. The other authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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