Original Article

Clin Shoulder Elbow 2022;25(1):42-48
https://doi.org/10.5397/cise.2021.00458

CiSE
Clinics in Shoulder and Elbow

eISSN 2288-8721

Primary versus revision total shoulder arthroplasty: comparing relative value and reimbursement trends

John Joseph Carney, Erik Gerlach, Mark Plantz, Peter Raymond Swiatek, Jeremy Marx, Matthew Saltzman, Guido Marra

Department of Orthopaedic Surgery, Northwestern University, Evanston, IL, USA

Background: Total shoulder arthroplasty (TSA) has been demonstrated to be an effective treatment for multiple shoulder pathologies. The purpose of our study was to compare the relative value units (RVUs) per minute of surgical time for primary and revision TSA.
Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried to identify patients that underwent primary TSA, one-component revision TSA, and two-component revision TSA between January 1, 2015 and December 31, 2017 using current procedure terminology codes. RVUs were divided by mean operative time for each procedure to determine the amount of revenue generated per minute. Rates were compared between the groups using a one-way analysis of variance with post-hoc Tukey test. Statistical significance was set at $p<0.05$.
Results: When dividing compensation by surgical time, we found that two-component revision generated more compensation per minute compared to primary TSA (0.284±0.114 vs. 0.239±0.278 RVU per minute or $10.25±$4.11 vs. $8.64±$10.05 per minute, respectively; p=0.001).
Conclusions: The relative value of revision TSA procedures is weighted to account for the increased technical challenges and time associated with these procedures. This study confirms that reimbursement is higher for revision TSA compared to primary TSA.

Keywords: Arthroplasty; Reimbursement mechanisms; Compensation and redress; Revision, joint

INTRODUCTION

Total shoulder arthroplasty (TSA) is an effective treatment for multiple shoulder pathologies [1-7]. Studies have shown that the use of TSA is increasing every year in the United Stated at a rate higher than that of total hip arthroplasty (THA) or total knee arthroplasty (TKA) [8-11]. Wagner et al. [10] found that between 2011 and 2017 the incidence of primary TSA performed per year increased 103.7%, while the incidence of primary THA and TKA increased by 29.1% and 17.8%, respectively. As the number of

Received: August 25, 2021 Revised: September 25, 2021 Accepted: October 4, 2021
Correspondence to: John Joseph Carney
Department of Orthopaedic Surgery, Northwestern University, 633 Clark St, Evanston, IL 60208, USA
Tel: +1-949-293-7211, Fax: +1-312-926-4643, E-mail: john.carney@northwestern.edu, ORCID: https://orcid.org/0000-0002-0865-0548

Financial support: None.
Conflict of interest: Dr. Saltzman receives intellectual property royalties from and is a paid consultant for Medacta. He also receives intellectual property royalties for Wright Medical Technology, Inc. Dr. Marra is a Board or Committee member for the American Academy of Orthopedic Surgeons, American Shoulder and Elbow Surgeons, and Association of Bone and Joint Surgeons. He is on the Editorial or Governing Board of Clinical Orthopedics and Related Research. He receives intellectual property royalties from Zimmer-Biomet. However, they were not involved in peer reviewer selection evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article was reported.

TSAs increases, the number of revision surgeries will likely increase as well.

Although arthroplasty provides patients with excellent outcomes for various glenohumeral disorders, the procedure is not without risk [12-14]. Implant failure (most commonly of the glenoid component), periprosthetic fracture, and infection are all complications of TSA that can necessitate a revision surgery, which can be more technically difficult than primary TSA with a significantly higher complication rate [15-20].

Although revision surgery is technically more challenging than primary surgery, the relative value of revision surgery does not necessarily reflect these differences. In the United States (US), the value and reimbursement for many procedures is estimated by the relative value unit (RVU) model. In this model, compensation is determined by a government agency known as the Centers for Medicare and Medicaid Services (CMS), which assigns a certain number of RVUs to a surgical procedure based on the agency's evaluation of the procedure's operative time, complexity, and workload. One RVU is equivalent to a certain amount of US dollars of compensation [21]. In the field of upper extremity surgery, the literature demonstrates that the CMS estimates of complexity, operative time, and workload used to determine procedures' RVUs poorly correlate with reported values [22]. In the total hip and knee arthroplasty literature, several studies have demonstrated that revision procedures may be undervalued [23-25].

The relative valuation of different arthroplasty procedures is further complicated by the fact that revision arthroplasty procedures are weighted differently depending on the joint of interest, which has been shown to yield significant differences in the relative value of primary and revision procedures [23,25,26]. Although these differences have been reported in the total hip and knee arthroplasty literature, it has not been reported for TSA. A further consideration is that one-component and two-component revision procedures for TSA are valued differently. Thus, the purpose of our study was to determine if the relative value and reimbursement in the current RVU model properly account for the increased complexity of different revision TSA procedures.

METHODS

Institutional Review Board approval and informed consent were not required for this study.

Data Extraction and Inclusion Criteria

Data was obtained through the American College of Surgeons National Surgical Quality Improvement Program database (ACS NSQIP). These data were collected by a group of trained surgical clinical reviewers who record perioperative data at over 700 hospitals across the United States, including International Classification of Disease 9th and/or 10th revisions (ICD-9, ICD-10) codes, current procedural terminology (CPT) codes, and data related to operations, discharge disposition, reoperations, readmissions, and mortality through 30 days postoperatively [27]. This database is among the most precise and accurate databases available for measuring patient outcomes after surgery given its high rate of complete data sets, operative data points, validation, and inter-rater reliability [28,29]. The database was queried to identify patients that underwent primary TSA, one-component revision TSA, and two-component revision TSA between January 1, 2015 and December 31, 2017 using the CPT codes 23472, 23473, and 23474, respectively. Any surgical cases with concurrent procedures performed were excluded from final analysis.

Variables of Interest

Patient variables were extracted and compared between treatment groups, including sex, age, body mass index (BMI), American Society of Anesthesiologists (ASA) class, and medical comorbidities—diabetes, smoking, chronic obstructive pulmonary disease (COPD), ascites, congestive heart failure, hypertension, renal failure, dialysis, and chronic steroid use. The total operative time in minutes and RVUs for each case were collected. The RVU per minute was calculated for each case by dividing the work RVU by the total operative time. Cases with concurrent procedures ($n = 2{,}898$) and their RVU values were excluded from the analysis. Within the 3-year period from which data were extracted, there were no changes in the work RVUs for primary TSA, one-component revision TSA, or two-component revision TSA. A Medicare conversion factor of 36.0896 dollars per RVU was used to determine the dollar reimbursement for each case [21]. The average reimbursement per case was determined by dividing the reimbursement for each case by the operative time.

Statistical Analysis

A Kruskal-Wallis test with post-hoc Bonferroni correction was used to compare differences in demographic and patient-specific variables between the primary TSA, one-component revision TSA, and two-component revision TSA groups. Variables of interest included sex, age, BMI, ASA class, and a variety of medical comorbidities—diabetes, smoking, COPD, ascites, congestive heart failure, hypertension, renal failure, dialysis, and chronic steroid use.

One-way analysis of variance with post-hoc Tukey test was used to compare differences in RVU, case length, RVU per minute, reimbursement per case, and reimbursement per minute between the primary TSA, one-component revision TSA, and two-component revision TSA groups. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 9,855 procedures were included in the study. Of these, 9,251 patients underwent a primary TSA, 229 underwent a one-component revision TSA, and 375 underwent a two-component revision TSA. The primary TSA group was older compared to the one- and two-component revision groups (under age 60, 15% vs. 21.8% and 17.1%, respectively; $p = 0.01$), had lower rates of class 1 obesity compared to one-component, though higher than two-component (26% vs. 33.2% and 22.9%, respectively; $p = 0.019$), and lower rates of diabetes compared to both one- and two-component revision (17.9% vs. 22.7% and 21.3%, respectively; $p = 0.049$). There were otherwise no statistically significant differences in demographic variables between the groups. The findings are summarized in Table 1.

During the study period, primary TSA generated 22.1 RVUs or $798.66, one-component revision TSA generated 25.0 RVUs or $902.24, and two-component revision generated 27.2 RVUs or $982.00. There was no statistically significant difference in surgical time between the three groups. When dividing compensation

Table 1. Summary of patient demographics

Variable	Primary TSA (n = 9,251)	One-component revision TSA (n = 229)	Two-component revision TSA (n = 375)	p-value
Sex				
Male	4,094 (44.3)	101 (44.1)	172 (45.9)	0.825
Female	5,157 (54.7)	128 (55.9)	203 (54.1)	NA
Age (yr)				
< 60	1,388 (15.0)	50 (21.8)	64 (17.1)	0.011
60–69	3,168 (34.2)	76 (33.2)	145 (38.7)	0.195
70–79	3,444 (37.2)	78 (34.1)	120 (32.0)	0.079
80–89	1,190 (12.9)	25 (10.9)	45 (12.0)	0.614
≥ 90	61 (0.7)	0	1 (0.3)	0.305
Body mass index (kg/m^2)				
Underweight	126 (1.4)	3 (1.3)	6 (1.6)	0.924
Normal	1,487 (16.1)	36 (15.7)	59 (15.7)	0.975
Overweight	2,964 (32.0)	68 (29.7)	140 (37.3)	0.071
Obese class I	2,403 (26.0)	76 (33.2)	86 (22.9)	0.019
Obese class II	1,299 (14.0)	30 (13.1)	46 (12.3)	0.581
Obese class III	972 (10.5)	16 (7.0)	38 (10.1)	0.223
Comorbidity				
Diabetes	1,660 (17.9)	52 (22.7)	80 (21.3)	0.049
Smoking	1,041 (11.3)	33 (14.4)	43 (11.5)	0.329
COPD	672 (7.3)	20 (8.7)	19 (5.1)	0.182
Ascites	2 (0.0)	0	0	0.937
Congestive heart failure	60 (0.6)	1 (0.4)	1 (0.3)	0.613
Hypertension	6,202 (67.0)	168 (73.4)	256 (68.3)	0.120
Renal failure	5 (0.1)	0	1 (0.3)	0.244
Dialysis	33 (0.4)	0	0	0.339
Chronic steroid use	452 (4.9)	13 (5.7)	24 (6.4)	0.367
ASA class				
Class 1 (no disturbance)	133 (1.4)	1 (0.4)	5 (1.3)	0.443
Class 2 (mild disturbance)	3,778 (40.8)	97 (42.4)	147 (39.2)	0.729
Class 3 (severe disturbance)	5,079 (54.9)	123 (53.7)	212 (56.5)	0.767
Class 4+ (life threatening)	248 (2.7)	7 (3.1)	10 (2.7)	0.941

Values are presented as number (%).
TSA: total shoulder arthroplasty, NA: not available, COPD: chronic obstructive pulmonary disease, ASA: American Society of Anesthesiologists.

https://doi.org/10.5397/cise.2021.00458

by surgical time, we found that two-component revision generated significantly more compensation per minute compared to primary TSA (0.284±0.114 vs. 0.239±0.278 RVU per minute or $10.25±$4.11 vs. $8.64±$10.05 per minute, respectively; p=0.001). The findings are summarized in Tables 2-5.

DISCUSSION

Our study demonstrates that when accounting for operative time, two-component revision TSA generates significantly more revenue compared to primary TSA. One-component revision does not generate any more or less revenue than primary TSA or two-component revision TSA.

Our findings are in contrast to similar studies that compared compensation for primary versus revision total hip and knee arthroplasty. Sodhi et al. [23] found that revision THA generated significantly less RVUs per minute compared to primary arthroplasty. This finding was confirmed in a more recent study by Feng et al. [30] which assessed both one- and two-component revision hip arthroplasty and found that both forms of revision arthroplasty generated significantly less revenue compared to primary arthroplasty. A study by Peterson et al. [25] also found that revision TKA had a lower reimbursement rate per minute when compared to primary TKA. One possible explanation for the difference in results between our study and the aforementioned studies may be that in our study there was no statistically significant difference in operative time between primary and revision procedures. In contrast, studies in both hip and knee arthroplasty found that revision cases took significantly longer to perform than primary cases. Operative time may not have been significantly different between the three groups in our study due to the fact that the revision arthroplasty group in our study was

Table 2. Comparisons of average RVU, case length, and RVU per minute for each procedure

Variable	Primary TSA	One-component revision TSA	Two-component revision TSA	p-value
RVU	22.1±0.0	25.0±0.0	27.2±0.0	-
Case length (min)	109.4±44.7	105.3±41.6	108.8±38.0	0.388
RVU per minute	0.239±0.278	0.278±0.116	0.284±0.114	0.001

Values are presented as mean±standard deviation.
RVU: relative value unit, TSA: total shoulder arthroplasty.

Table 3. Comparisons of average reimbursement for each procedure

Variable	Primary TSA	One-component revision TSA	Two-component revision TSA	p-value
Reimbursement per case ($)	798.66±0.00	902.24±0.00	982.00±0.00	-
Reimbursement per minute ($/min)	8.64±10.05	10.02±4.19	10.25±4.11	0.001

Values are presented as mean±standard deviation.
TSA: total shoulder arthroplasty.

Table 4. Comparisons of average RVU, case length, and RVU per minute for each procedure

Variable	p-value		
	Primary vs. one-component revision TSA	Primary vs. two-component revision TSA	One-component vs. two-component revision TSA
RVU	<0.001	<0.001	<0.001
Case length	0.361	0.970	0.615
RVU per minute	0.087	0.005	0.958

RVU: relative value unit, TSA: total shoulder arthroplasty.

Table 5. Comparisons of average reimbursement for each procedure

Variable	p-value		
	Primary vs. one-component revision TSA	Primary vs. two-component revision TSA	One-component vs. two-component revision TSA
Reimbursement per case	<0.001	<0.001	<0.001
Reimbursement per minute	0.087	0.005	0.958

TSA: total shoulder arthroplasty.

significantly younger than the primary group. This was a surprising finding given it would be expected that older patients would be more likely to undergo revision surgery. Regardless, our younger revision group likely had better bone and soft tissue quality, which could allow for a quicker revision surgery.

Outside of the arthroplasty literature, a study by Orr et al. [24] compared the RVUs per minute generated in spinal surgery based on the number of levels operated on, and they found that as more segments were fused, the revenue generated per minute decreased, concluding that shorter cases with fewer levels of fusion had a higher value. Lastly, a study by Schwartz et al. [31] comparing elective versus emergent general surgery procedures found that the two types of procedures were assigned the same RVUs, despite emergent procedures having higher rates of complication and longer length of stay.

In agreement with our findings, a different study by Sodhi et al. [26] comparing primary to revision total ankle arthroplasty found no differences in operative time between the two procedures, but a higher RVU assignment for revision cases. Our study similarly found no difference in operating time between primary and revision cases, but more RVUs generated in revision cases. Another study in agreement with ours was a general surgery study by Doval et al. [32] which found that although operating room times were longer for revision hernia repair cases, they generated both higher total RVUs as well as higher RVUs per minute compared to primary inguinal hernia repair. The differences in results between our findings as well as those of the two aforementioned studies with the rest of the literature may be explained by the poor correlation of CMS estimates of operative time compared to other reported values [22]. When the CMS estimated times are consistent with or longer than that of actual times, which may be the case with revision ankle and shoulder arthroplasty, surgeons are reimbursed for an equal or greater amount than primary arthroplasty. Conversely, revision estimate times below that of actual times will generate less than primary arthroplasty cases, which may be the case for hip and knee arthroplasty.

This study has several weaknesses that should be considered when interpreting our findings. First, this study utilized a database which can be subject to input errors and can only provide a limited number of metrics regarding a patient's medical care. Furthermore, the NSQIP database does not provide specific information regarding severity of comorbidities or specific outcomes related to a given procedure. Access to the database is limited to contributing institutions, and the high cost of participation has led to a disproportionate contribution from large teaching hospitals [28,33]. Second, there are not separate CPT codes for anatomic TSA or reverse TSA, so we were not able to identify if a difference in reimbursement exists between the two procedures. Lastly, the database does not contain long-term follow-up information, and thus the effect of factors that may further impact the overall revenue from a procedure, such as management of complications, was not included in our study.

This study is the first to compare reimbursement rates between primary and revision TSA as it relates to operative time. This data improves the understanding of weighted differences in the relative value of primary versus revision TSA, with revision surgery being worth more RVUs, and it adds to the general body of literature regarding the relative value of primary and revision procedures. Our findings can assist providers in understanding reimbursement trends for revision TSA cases.

The relative value of revision TSA procedures is reasonably weighted to account for the increased technical challenges and time associated with these procedures. Surgeons need not be deterred from performing revision TSAs on the historical basis that revision arthroplasty cases in general receive lower compensation than primary cases.

ORCID

John Joseph Carney https://orcid.org/0000-0002-0865-0548
Erik Gerlach https://orcid.org/0000-0002-5992-9119
Mark Plantz https://orcid.org/0000-0002-1837-4639
Peter Raymond Swiatek https://orcid.org/0000-0002-0247-1768
Jeremy Marx https://orcid.org/0000-0001-6729-7150
Matthew Saltzman https://orcid.org/0000-0001-8052-1399

REFERENCES

1. Roberson TA, Bentley JC, Griscom JT, et al. Outcomes of total shoulder arthroplasty in patients younger than 65 years: a systematic review. J Shoulder Elbow Surg 2017;26:1298-306.
2. Cuff DJ, Pupello DR. Comparison of hemiarthroplasty and reverse shoulder arthroplasty for the treatment of proximal humeral fractures in elderly patients. J Bone Joint Surg Am 2013;95:2050-5.
3. Osterhoff G, O'Hara NN, D'Cruz J, et al. A cost-effectiveness analysis of reverse total shoulder arthroplasty versus hemiarthroplasty for the management of complex proximal humeral fractures in the elderly. Value Health 2017;20:404-11.
4. Austin DC, Torchia MT, Cozzolino NH, Jacobowitz LE, Bell JE. Decreased reoperations and improved outcomes with reverse total shoulder arthroplasty in comparison to hemiarthroplasty for geriatric proximal humerus fractures: a systematic review

https://doi.org/10.5397/cise.2021.00458

and meta-analysis. J Orthop Trauma 2019;33:49-57.
5. Stanbury SJ, Voloshin I. Reverse shoulder arthroplasty for acute proximal humeral fractures in the geriatric patient: a review of the literature. Geriatr Orthop Surg Rehabil 2011;2:181-6.
6. Craig RS, Goodier H, Singh JA, Hopewell S, Rees JL. Shoulder replacement surgery for osteoarthritis and rotator cuff tear arthropathy. Cochrane Database Syst Rev 2020;4:CD012879.
7. Hyun YS, Huri G, Garbis NG, McFarland EG. Uncommon indications for reverse total shoulder arthroplasty. Clin Orthop Surg 2013;5:243-55.
8. Dillon MT, Chan PH, Inacio MC, Singh A, Yian EH, Navarro RA. Yearly trends in elective shoulder arthroplasty, 2005-2013. Arthritis Care Res (Hoboken) 2017;69:1574-81.
9. Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. J Bone Joint Surg Am 2011;93:2249-54.
10. Wagner ER, Farley KX, Higgins I, Wilson JM, Daly CA, Gottschalk MB. The incidence of shoulder arthroplasty: rise and future projections compared with hip and knee arthroplasty. J Shoulder Elbow Surg 2020;29:2601-9.
11. Best MJ, Aziz KT, Wilckens JH, McFarland EG, Srikumaran U. Increasing incidence of primary reverse and anatomic total shoulder arthroplasty in the United States. J Shoulder Elbow Surg 2021;30:1159-66.
12. Charles MD, Cvetanovich G, Sumner-Parilla S, Nicholson GP, Verma N, Romeo AA. Outpatient shoulder arthroplasty: outcomes, complications, and readmissions in 2 outpatient settings. J Shoulder Elbow Surg 2019;28(6S):S118-23.
13. Bedeir YH, Gawish HM, Grawe BM. Outcomes of reverse total shoulder arthroplasty in patients 60 years of age or younger: a systematic review. J Hand Surg Am 2020;45:254.e1-254.e8.
14. Savin DD, Frank RM, Sumner S, Richardson C, Nicholson GP, Romeo AA. Good functional outcomes expected after shoulder arthroplasty irrespective of body mass index. J Shoulder Elbow Surg 2018;27:S43-9.
15. Somerson JS, Hsu JE, Neradilek MB, Matsen FA 3rd. Analysis of 4063 complications of shoulder arthroplasty reported to the US Food and Drug Administration from 2012 to 2016. J Shoulder Elbow Surg 2018;27:1978-86.
16. Cheung E, Willis M, Walker M, Clark R, Frankle MA. Complications in reverse total shoulder arthroplasty. J Am Acad Orthop Surg 2011;19:439-49.
17. Newman JM, Stroud SG, Yang A, et al. Total shoulder arthroplasty in octogenarians: is there a higher risk of adverse outcomes. J Orthop 2018;15:671-5.
18. Franklin JL, Barrett WP, Jackins SE, Matsen FA 3rd. Glenoid loosening in total shoulder arthroplasty: association with rotator cuff deficiency. J Arthroplasty 1988;3:39-46.
19. Valenti P, Kilinc AS, Sauzières P, Katz D. Results of 30 reverse shoulder prostheses for revision of failed hemi- or total shoulder arthroplasty. Eur J Orthop Surg Traumatol 2014;24:1375-82.
20. Papadonikolakis A, Neradilek MB, Matsen FA 3rd. Failure of the glenoid component in anatomic total shoulder arthroplasty: a systematic review of the English-language literature between 2006 and 2012. J Bone Joint Surg Am 2013;95:2205-12.
21. Centers for Medicare & Medicaid Services. Final policy, payment, and quality provisions changes to the medicare physician fee schedule for calendar year 2021 [Internet]. Baltimore, MD: Centers for Medicare & Medicaid Services; 2020 [cited 2021 Mar 9]. Available from: https://www.cms.gov/newsroom/fact-sheets/final-policy-payment-and-quality-provisions-changes-medicare-physician-fee-schedule-calendar-year-1.
22. Nayar SK, Aziz KT, Zimmerman RM, Srikumaran U, LaPorte DM, Giladi AM. Misvaluation of hospital-based upper extremity surgery across payment, relative value units, and operative time. Iowa Orthop J 2020;40:173-83.
23. Sodhi N, Piuzzi NS, Khlopas A, et al. Are we appropriately compensated by relative value units for primary vs revision total hip arthroplasty. J Arthroplasty 2018;33:340-4.
24. Orr RD, Sodhi N, Dalton SE, et al. What provides a better value for your time? The use of relative value units to compare posterior segmental instrumentation of vertebral segments. Spine J 2018;18:1727-32.
25. Peterson J, Sodhi N, Khlopas A, et al. A comparison of relative value units in primary versus revision total knee arthroplasty. J Arthroplasty 2018;33:S39-42.
26. Sodhi N, Yao B, Newman JM, et al. A comparison of relative value units in primary versus revision total ankle arthroplasty. Surg Technol Int 2017;31:322-6.
27. Chow WB, Rosenthal RA, Merkow RP, et al. Optimal preoperative assessment of the geriatric surgical patient: a best practices guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. J Am Coll Surg 2012;215:453-66.
28. Alluri RK, Leland H, Heckmann N. Surgical research using national databases. Ann Transl Med 2016;4:393.
29. Kim L, Mabry C, Klimberg VS. Quality of benchmarks for assessment of care will influence outcome. Ann Surg 2007;245:672-3.
30. Feng JE, Anoushiravani AA, Schoof LH, et al. Barriers to revision total hip service lines: a surgeon's perspective through a deterministic financial model. Clin Orthop Relat Res 2020;478:1657-66.

31. Schwartz DA, Hui X, Velopulos CG, et al. Does relative value unit-based compensation shortchange the acute care surgeon. J Trauma Acute Care Surg 2014;76:84-92.
32. Doval AF, Nguyen-Lee JJ, Beal LL, Zheng F, Echo A. Does complexity relate to compensation? A comparison of relative value units in initial versus recurrent inguinal hernia repair. Hernia 2020;24:245-50.
33. Sheils CR, Dahlke AR, Kreutzer L, Bilimoria KY, Yang AD. Evaluation of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program. Surgery 2016;160:1182-8.

https://doi.org/10.5397/cise.2021.00458