Total Shoulder Arthroplasty versus Reverse Total Shoulder Arthroplasty: Outcome Comparison in Osteoarthritis patients with or without Concurrent Rotator Cuff Deficiency

Zeling Long
Second Xiangya Hospital Department of Orthopedics
Tony Chieh-Ting Huang
Mayo Clinic Rochester
Hanzhong Yu
Mayo Clinic Rochester
Wanchun Wang (wanchun.wang@csu.edu.cn)
2nd Xiangya Hospital of Central South University
Yicun Wang
Nanjing University

Research article

Keywords: Total shoulder arthroplasty, reverse total shoulder arthroplasty, rotator cuff, osteoarthritis, arthroplasty

Posted Date: January 15th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-146668/v1

Abstract

Background

Osteoarthritis (OA) is a common shoulder disorder that impacts shoulder functions. Shoulder arthroplasty is often required to restore function and quality of life. Reverse total shoulder arthroplasty (RSA), which was originally designed mainly for irreparable rotator cuff damage, has gained popularity in recent years for the treatment of advanced shoulder OA instead of the clinically standard total shoulder arthroplasty (TSA). However, this RSA has some nonnegligible flaws such as higher complications rate and economic cost, not mention the following problems caused by irreversible physical structural damage. Therefore, the employment of RSA needs to be carefully considered.

Purpose

This study aimed to compare TSA and RSA in OA patients with or without rotator cuff damage to better guide clinical decision making. We believe the radical use of RSA in patients without rotator cuff deficiency may cause more harm than good.

Study design

Cross-sectional study

Methods

We queried the Nationwide Inpatient Sample (NIS) database from 2011 to 2014 to collect information on OA patients who received TSA and RSA. Patients were divided into 2 groups of comparison according to the presence of rotator cuff deficiency and matched with propensity score analysis.

Results

A total of 57,156 shoulder arthroplasties were identified. RSA patients in the rotator cuff deficiency group had significant higher transfusion rates and longer hospital stays. RSA patients without rotator cuff deficiency had a statistically significantly higher number of implant-related mechanical complications, acute upper respiratory infections and postoperative pain. Overall, RSA incurred higher costs in both groups.

Conclusion

For OA patients with rotator cuff deficiencies, RSA has its benefits as complication rates were comparable to TSA. For those patients without rotator cuff deficiencies, the use of RSA should be reconsidered as there were more complications with higher severity.

What Is Known About This Subject

Reverse total shoulder arthroplasty was firstly designed for the management of irreparable rotator cuff damage, it's unique reverse ball-and-socket design provides inherent stability and improve the shoulder elevation in these rotator cuff deficient patients. Notably, RSA has some disadvantages that limit its wide usage, these include higher complications rate and higher price of the reverse shoulder prosthesis. Nevertheless, the application of reverse shoulder replacement is increasing year by year, a large amount of patients who underwent reverse total shoulder replacement don't have rotator cuff deficiency. Whether the advantages outweigh the disadvantages in these patients is not clear.

What This Study Adds To Existing Knowledge

Our study compared the complications and cost of reverse total shoulder replacement and traditional total shoulder replacement with or without rotator cuff deficiency. Provided statistical evidence for surgical selections.

Background

Osteoarthritis (OA) of the glenohumeral joint often result in painful shoulders [13, 25]. In cases when surgical intervention is warranted, joint replacement has been recommended by the American Academy of Orthopedic Surgeons (AAOS) as it has been shown to result in significant improvement of pain, quality of life, function, and overall patient health [9, 16, 18, 24, 33, 34, 37, 44, 45]. Moreover, total shoulder arthroplasty (TSA) has been recommended by AAOS over hemiarthroplasty (HA) due to better outcomes and less chance of revision[30].

Reverse total shoulder arthroplasty (RSA) was first developed by Grammont in 1980s specifically for the management of irreparable rotator cuff damage, complex fractures as well as a salvage option for previously failed conventional TSA, in which the rotator cuff tendons are deficient [4, 8, 29, 39]. The congruent joint surfaces of the reverse ball-and-socket design provides inherent stability, due to its altered center of shoulder joint rotation that increases the deltoid moment arm thus enhance the torque produced by deltoid, as a result, it compensates for the deficiency of RC and improve the shoulder elevation in these patients [7, 8, 26, 38].

Notably, RSA has some disadvantages that limit its wide usage; first of all, the RSA prothesis is much more expensive than the other prothesis [35]. Secondly, RSA has high risk of shoulder dislocation[1, 11], which causes repeated pain and suffering to patients as well as additional healthcare cost for treatment. Moreover, previous studies reported higher surgical complications rates such as mechanical loosening, infection[41]. and hemorrhage[22] in patients who received RSA compared to TSA.

Traditionally, TSA has been the standard treatment for shoulder OA. However, in the recent years, the use of RSA has increased rapidly and became preferred over TSA even when rotator cuff deficiency is not present [32, 35].

The purpose of current study is to investigate the complication rates associated with RSA surgery when used for the treatment of different conditions, and more specifically, the postoperative outcome of OA patients with or without rotator cuff deficiency who were treated with either TSA or RSA, providing further evidence to guide surgical decision for the surgical management of OA.

Methods

Data Source

We queried the clinical information of patients from the Nationwide Inpatient Sample (NIS) from 2011 to 2014, a database released by the Healthcare Cost and Utilization Project. The NIS database contains all-payer data on hospital inpatient stays from States participating in the Healthcare Cost and Utilization Project (HCUP). Each year of the NIS includes over 7 million inpatient stay data. It gathered more than 100 features from each of the discharges, including demographical information, hospital information, comorbidities, diagnoses during the stay, types of procedures, etc. The tremendous size of the NIS data provides significant benefits for the understanding of clinical problems from a statistical perspective.

Data Extraction and Processing

Using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes, we identified patients who underwent primary procedures as TSA (81.80), RSA (81.88), HA (81.81) during the period from 2011 to 2014. There were totally 57,156 samples extracted, 25,554 for TSA, 22,337 for RSA, and 9,265 for HA. To further analyze the data, we categorized OA patients into two groups based on the presence of rotator cuff deficiencies (**Figure 1**). Postoperative complications, length of hospital stay, costs, were recorded. A list of procedure codes used are listed in **Supplemental Table 4**.

Data Analysis

In order to compare the differences between the outcomes of TSA and RSA in the patients with or without rotator cuff deficiencies, patients were matched using a propensity score analysis method. The baseline characteristics used for matching included age, gender, race, hospital location, bed-size, ownership of hospital, and twenty-nine comorbidities which have already been measured in the NIS data. Additionally, seven rotator cuff related diagnoses were added to the group with rotator cuff deficiencies. All the characteristics were then fit into a logistic regression model to calculate propensity scores which can be used to identify similar patients for each group. Patients in different groups with closest score were matched and each patient could only be match once. Wilcoxon rank-sum tests were used to evaluate differences for numerical variables, while Chi-squared tests were used for categorical variables. A p-value less than 0.05 was considered statistically significant. All statistical data analyses were performed using SAS 9.4 software and Python.

Result

Patient Demographic

A total of 57,156 shoulder arthroplasties were identified in the NIS database (44.7% TSAs, 16.21% HAs, and 39.08% RSAs) from 2011-2014 (**Table I**). For TSA, 50.70% and 49.21% of patients were female and male, respectively. The average age of TSA patients was 67.31±9.66 years of age. For HA, 62% and 38% of patients were female and male, respectively. The average age of HA patients was 66.18±13.5 years of age. For RSA, 63.79% and 36.21% of patients were female and male, respectively. The average age of RSA patients was 72.38±8.93 years of age. Other hospital related demographic data was displayed in **Supplementary Table 1.**

Primary diagnoses

A list of diagnoses for each procedure is presented in **Table II** as defined by ICD-9-CM (International Classification of Disease, Ninth Revision, Clinical Modification). Five most common diagnoses were listed: osteoarthrosis, arthropathy, aseptic necrosis, rotator cuff injuries, humeral fractures. Osteoarthritis was the most common diagnosis for all 3 procedures (90.55%, 39.47%, 45.20% for TSA, HA, RSA, respectively) with a total of 26,893 counts (64.55%).

Trend of different procedures

From 2011 to 2013, TSA was the most performed procedure compared to RSA and HA with a steady percentage of 45 (**Figure 2A**). The percentage of TSA experienced a decline in 2014 (43%) and was overtaken by RSA (46%) for the most performed surgery, which had been increasing steadily since 2011. On the other hand, the percentage of HA was the lowest in 2011 and has been gradually decreasing since 2011.

When examining specifically for patients with OA who underwent surgery, the most performed surgery was TSA at 60% with a slight decline started in 2013 (**Figure 2B**). RSA was the second most performed surgery started at 22.5% and increased to 32.8% in 2014. HA was the least performed and has been steadily decreasing since 2011 to 6%.

A breakdown of procedures for patients with OA and rotator cuff deficiency was examined. RSA was the most performed procedure started at 55% and gradually increased to 70% (**Figure 2C**). The second most performed surgery was TSA, started at 32% and progressively decreased to 25%. HA was the least performed, started at 11% and decreased to 5%.

For OA patients but without rotator cuff deficiency (**Figure 2D**), TSA was the most performed started at 70%, which slightly increased then fell back to 72%. HA experienced a steady decline and was overtaken by RSA in 2012. RSA increased from 15% to 19% and HA decreased to 8% in 2014.

Post-operative complications

Postoperative outcomes were compared between TSA and RSA, the main subjects of interest. Only patients with OA were analyzed. To minimize confounding factors and reduce sample variability, patients were matched by age, sex, race, geographic location, and comorbidities. Unmatched and matched patient demographic data can be found in **Supplementary Table 2** and **Supplementary Table 3**, respectively.

OA patients were grouped by the presence of rotator cuff deficiency. In the rotator cuff deficiency group (**Table III**, left side), significant higher number of transfusions was found for RSA patients (70 vs. 97, $p = 0.0399$). Length of hospital stay was significantly higher for RSA patients (1.93 vs. 2.01days, $p = 0.0021$). In OA patients without rotator cuff deficiency (**Table III**, right side), statistical significant was found for the number of implant-related mechanical complication (8 vs. 29, $p = 0.0007$), acute upper respiratory infections (0 vs. 6, $p = 0.0312$), acute postoperative pain (85 vs. 130, $p = 0.0023$). Length of hospital stay was higher in RSA patients (2.08 vs. 2.25 days, $p < 0.0001$). Regarding total cost of surgery, TSA had lower costs compared to RSA in both groups ($p < 0.0001$ in both groups).

Discussion

In this study, we queried the NIS database to investigate surgical outcomes of TSA and RSA for OA patients with and without rotator cuff deficiency. RSA was originally designed for repair of rotator cuff injury and shoulder pseudoparalysis [2, 8, 19], therefore, we wanted to evaluate if the use of RSA in place of the clinically standard TSA was justified for OA patients without rotator cuff deficiency.

Initially we had gathered data on HA, the focus was gradually shifted to focus on comparing TSA to RSA as HA has fallen out of favor over the years for the management of OA.

According to our data (**Figure 2**) and also results from previous studies, RSA has a trend of increasing popularity each year [35, 46]. It has even surpassed TSA and became the most performed shoulder arthroplasty procedure in 2014 (**Figure 2A**) due to its expanded indications for other shoulder arthropathies [6, 12, 14, 15, 17, 31, 36, 47].

Although TSA remains the most frequently performed arthroplasty for OA patients, RSA increased over 10% (**Figure 2B**) since 2011 from 22.5% to 32.8%. Upon further analysis of this data, in OA patients with rotator cuff deficiency (**Figure 2C**), there was a dramatic increase of RSA performed (55-70%), while TSA experienced a decline from 32% to 25%. In OA patients without rotator cuff deficiency (**Figure 2D**), TSA remained high with a slight decline in 2014 (72%), while RSA had a gradual increase (15% to 19%), although not as dramatic as in patients with rotator cuff deficiency. Among all OA patients who underwent RSA, only 54.17% (5469 out of 10096, **Supplementary 2**) of the study patients had rotator cuff or bursa deficiencies. For these patients, complication profiles are very similar between TSA and RSA (**Table III**), only the rate of blood transfusion in RSA patients was higher than TSA patients. Although the length of hospital stay and surgical cost are significantly higher than TSA patients, RSA is still a good option considering the surgical benefits of RSA for patients with rotator cuff deficiency. RSA restores balance to the shoulder as it is designed to restore tension to the deltoid and keeps the center of joint rotation within the glenoid fossa [20, 21], which is necessary when the rotator cuff is insufficient [3, 27, 40].

On the other hand, there were as high as 45.83% (4627 out of 10096, **Supplementary Table 2**) of OA patients without rotator cuff that received RSA. For these patients, the benefit of RSA was limited. Furthermore, there were greater incidence of postoperative complications in patients who received RSA. The number of patients who had mechanical complication (8 vs. 29), acute upper respiratory infection (6 vs. 0, RSA vs. TSA), acute pain (130 vs. 85, RSA vs. TSA), and blood transfusions (306 vs. 182, RSA vs. TSA) are significantly higher. Besides, after RSA, the stability and mobility of the glenohumeral joint become dependent on the deltoid [28]. As a result, there is a higher requirement for postoperative physiotherapy [10, 43], which results in higher costs. Moreover, given the higher rate of multiple complications, and especially when the surgical cost of RSA and length of hospital stay are significantly higher, the use of RSA instead of TSA in this group of patients may not be justified.

Although the indications for RSA have been expanded in the last few years [15, 42], RSA is still being applied outside of the indicated conditions. However, once RSA has been done, future revision will be very difficult due to severely altered anatomy [5, 23, 48]. Furthermore, considering the high rate of complication and cost, surgeons should carefully reconsider the use of RSA outside of its indications.

Conclusion

With the help National Inpatient Sample database, more impactful studies involving larger number of patients can be conducted to better understand and compare surgical outcomes between procedures. We found that the use of RSA in the management of OA patients without rotator cuff deficiency had significantly more complications compared to those managed with TSA. Surgeons may need to reconsider when attempting to perform RSA in these patients. Future studies may need to focus on identifying factors causing higher risk of postoperative complications for RSA compared to TSA in this patient population to further improve the safety of shoulder arthroplasties.

Abbreviations

TSA total shoulder arthroplasty, HA hemiarthroplasty, RSA reverse total shoulder arthroplasty, OA osteoarthritis, NIS Nationwide Inpatient Sample; ICD-9-CM, International Classification of Diseases-9th Revision-Clinical Modification

Declarations

Ethics approval and consent to participate:

The study examined regional cost differences for congestive heart failure admissions using discharge data from the National Inpatient Sample and the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. All subjects included signed an informed consent and the study protocol have been approved by Central South University Ethics Committee.

Consent for publication

All authors have read and approved the final submitted manuscript.

Availability of data and materials:

The National (Nationwide) Inpatient Sample (NIS) is the largest publicly available all-payer inpatient care database in the United States, containing data on more than seven million hospital stays. All data used in this study is available online.

Competing interests:

The authors declare that we have no competing interests.

Funding:

Not applicable.

Authors' contributions:

Zeling Long, Yicun Wang, and Wanchun Wang conceived the project idea. Zeling Long and Hanzhong Yu designed the project, collected data and performed data analysis. Zeling Long, Tony Chieh-Ting Huang and Hanzhong Yu wrote the manuscript. Wanchun Wang and Yicun Wang supported and supervised the findings of this work. All authors contributed to the final manuscript.

Acknowledgements

I would like to thank all authors and people who helped in this study. I would also like to thank the National Inpatient Sample and the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality for providing large amount of high-quality online data.

References

1. Barco R, Savvidou OD, Sperling JW, Sanchez-Sotelo J, Cofield RH. Complications in reverse shoulder arthroplasty. *EFORT Open Rev.* 2017;1:72-80.
2. Baulot E, Sirveaux F, Boileau P. Grammont's idea: The story of Paul Grammont's functional surgery concept and the development of the reverse principle. *Clin Orthop Relat Res.* 2011;469:2425-2431.
3. Bezer M, Yıldırım Y, Akgün U, Erol B, Güven O. Superior excursion of the humeral head: a diagnostic tool in rotator cuff tear surgery. *Journal of shoulder and elbow surgery.* 2005;14:375-379.
4. Boileau P, Gonzalez J-F, Chuinard C, Bicknell R, Walch G. Reverse total shoulder arthroplasty after failed rotator cuff surgery. *Journal of shoulder and elbow surgery.* 2009;18:600-606.
5. Boileau P, Melis B, Duperron D, Moineau G, Rumian AP, Han Y. Revision surgery of reverse shoulder arthroplasty. *Journal of shoulder and elbow surgery.* 2013;22:1359-1370.
6. Boileau P, Trojani C, Walch G, Krishnan SG, Romeo A, Sinnerton R. Shoulder arthroplasty for the treatment of the sequelae of fractures of the proximal humerus. *Journal of Shoulder and Elbow Surgery.* 2001;10:299-308.
7. Boileau P, Watkinson D, Hatzidakis AM, Hovorka I. Neer Award 2005: The Grammont reverse shoulder prosthesis: results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. *J Shoulder Elbow Surg.* 2006;15:527-540.
8. Boileau P, Watkinson DJ, Hatzidakis AM, Balg F. Grammont reverse prosthesis: design, rationale, and biomechanics. *J Shoulder Elbow Surg.* 2005;14:147s-161s.

9. Boorman RS, Kopjar B, Fehringer E, Churchill RS, Smith K, Matsen FA, 3rd. The effect of total shoulder arthroplasty on self-assessed health status is comparable to that of total hip arthroplasty and coronary artery bypass grafting. *J Shoulder Elbow Surg.* 2003;12:158-163.
10. Buchmann S, Schoch C, Grim C, Jung C, Beitzel K, Klose M, Mauch B, Pfalzer F, Tepohl L, Tholen R, Gottfried T, Ortmann H, Scheibel M, Mauch F. Rehabilitation following reverse shoulder arthroplasty. *Obere Extremität.* 2019;14:269-283.
11. Chalmers BP, Wagner ER, Sperling JW, Cofield RH, Sanchez-Sotelo J. Treatment and Outcomes of Reverse Shoulder Arthroplasty Dislocations. *Journal of Shoulder and Elbow Arthroplasty.* 2017;1:2471549217695260.
12. Chalmers PN, Slikker III W, Mall NA, Gupta AK, Rahman Z, Enriquez D, Nicholson GP. Reverse total shoulder arthroplasty for acute proximal humeral fracture: comparison to open reduction–internal fixation and hemiarthroplasty. *Journal of shoulder and elbow surgery.* 2014;23:197-204.
13. Chillemi C, Franceschini V. Shoulder osteoarthritis. *Arthritis.* 2013;2013:370231.
14. De Wilde L, Boileau P, Van der Bracht H. Does reverse shoulder arthroplasty for tumors of the proximal humerus reduce impairment? *Clinical Orthopaedics and Related Research®.* 2011;469:2489-2495.
15. Drake GN, O'Connor DP, Edwards TB. Indications for reverse total shoulder arthroplasty in rotator cuff disease. *Clinical Orthopaedics and Related Research®.* 2010;468:1526-1533.
16. Fehringer EV, Kopjar B, Boorman RS, Churchill RS, Smith KL, Matsen FA, III. Characterizing the Functional Improvement After Total Shoulder Arthroplasty for Osteoarthritis. *JBJS.* 2002;84.
17. Gallinet D, Adam A, Gasse N, Rochet S, Obert L. Improvement in shoulder rotation in complex shoulder fractures treated by reverse shoulder arthroplasty. *Journal of Shoulder and Elbow Surgery.* 2013;22:38-44.
18. Gartsman GM, Roddey TS, Hammerman SM. Shoulder arthroplasty with or without resurfacing of the glenoid in patients who have osteoarthritis. *J Bone Joint Surg Am.* 2000;82:26-34.
19. Gerber C, Pennington SD, Nyffeler RW. Reverse total shoulder arthroplasty. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons.* 2009;17:284-295.
20. Grammont P, Baulot E. Delta shoulder prosthesis for rotator cuff rupture. *Orthopedics.* 1993;16:65-68.
21. Grammont P, Trouilloud P, Laffay J, Deries X. Study and development of a new shoulder prosthesis [in French]. *Rhumatologie.* 1987;39:407-418.
22. Groh GI, Groh GM. Complications rates, reoperation rates, and the learning curve in reverse shoulder arthroplasty. *J Shoulder Elbow Surg.* 2014;23:388-394.
23. Holcomb JO, Cuff D, Petersen SA, Pupello DR, Frankle MA. Revision reverse shoulder arthroplasty for glenoid baseplate failure after primary reverse shoulder arthroplasty. *Journal of shoulder and elbow surgery.* 2009;18:717-723.
24. Iannotti JP, Norris TR. Influence of preoperative factors on outcome of shoulder arthroplasty for glenohumeral osteoarthritis. *J Bone Joint Surg Am.* 2003;85:251-258.
25. Izquierdo R, Voloshin I, Edwards S, Freehill MQ, Stanwood W, Wiater JM, Watters WC, III, Goldberg MJ, Keith M, Turkelson CM, Wies JL, Anderson S, Boyer K, Raymond L, Sluka P. Treatment of Glenohumeral Osteoarthritis. *JAAOS - Journal of the American Academy of Orthopaedic Surgeons.* 2010;18.
26. Jobin CM, Brown GD, Bahu MJ, Gardner TR, Bigliani LU, Levine WN, Ahmad CS. Reverse total shoulder arthroplasty for cuff tear arthropathy: the clinical effect of deltoid lengthening and center of rotation medialization. *J Shoulder Elbow Surg.* 2012;21:1269-1277.
27. Keener JD, Wei AS, Kim HM, Steger-May K, Yamaguchi K. Proximal humeral migration in shoulders with symptomatic and asymptomatic rotator cuff tears. *The Journal of Bone and Joint Surgery. American volume.* 2009;91:1405.

28. Langohr GDG, Willing R, Medley JB, Athwal GS, Johnson JA. Contact mechanics of reverse total shoulder arthroplasty during abduction: the effect of neck-shaft angle, humeral cup depth, and glenosphere diameter. *Journal of shoulder and elbow surgery.* 2016;25:589-597.
29. Levy J, Virani N, Pupello D, Frankle M. Use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty in patients with glenohumeral arthritis and rotator cuff deficiency. *The Journal of bone and joint surgery. British volume.* 2007;89:189-195.
30. Lo IK, Litchfield RB, Griffin S, Faber K, Patterson SD, Kirkley A. Quality-of-life outcome following hemiarthroplasty or total shoulder arthroplasty in patients with osteoarthritis. A prospective, randomized trial. *J Bone Joint Surg Am.* 2005;87:2178-2185.
31. Mizuno N, Denard PJ, Raiss P, Walch G. Reverse total shoulder arthroplasty for primary glenohumeral osteoarthritis in patients with a biconcave glenoid. *JBJS.* 2013;95:1297-1304.
32. Nam D, Kepler CK, Neviaser AS, Jones KJ, Wright TM, Craig EV, Warren RF. Reverse total shoulder arthroplasty: current concepts, results, and component wear analysis. *J Bone Joint Surg Am.* 2010;92 Suppl 2:23-35.
33. Norris TR, Iannotti JP. Functional outcome after shoulder arthroplasty for primary osteoarthritis: a multicenter study. *J Shoulder Elbow Surg.* 2002;11:130-135.
34. Orfaly RM, Rockwood CA, Jr., Esenyel CZ, Wirth MA. A prospective functional outcome study of shoulder arthroplasty for osteoarthritis with an intact rotator cuff. *J Shoulder Elbow Surg.* 2003;12:214-221.
35. Palsis JA, Simpson KN, Matthews JH, Traven S, Eichinger JK, Friedman RJ. Current Trends in the Use of Shoulder Arthroplasty in the United States. *Orthopedics.* 2018;41:e416-e423.
36. Patel DN, Young B, Onyekwelu I, Zuckerman JD, Kwon YW. Reverse total shoulder arthroplasty for failed shoulder arthroplasty. *Journal of shoulder and elbow surgery.* 2012;21:1478-1483.
37. Raiss P, Aldinger PR, Kasten P, Rickert M, Loew M. Total shoulder replacement in young and middle-aged patients with glenohumeral osteoarthritis. *The Journal of Bone and Joint Surgery. British volume.* 2008;90-B:764-769.
38. Ramirez MA, Ramirez J, Murthi AM. Reverse total shoulder arthroplasty for irreparable rotator cuff tears and cuff tear arthropathy. *Clin Sports Med.* 2012;31:749-759.
39. Randelli P, Randelli F, Compagnoni R, Cabitza P, Ragone V, Pulici L, Banfi G. Revision reverse shoulder arthroplasty in failed shoulder arthroplasties for rotator cuff deficiency. *Joints.* 2015;3:31.
40. Su W-R, Budoff JE, Luo Z-P. The effect of anterosuperior rotator cuff tears on glenohumeral translation. *Arthroscopy: The Journal of Arthroscopic & Related Surgery.* 2009;25:282-289.
41. Villacis D, Sivasundaram L, Pannell WC, Heckmann N, Omid R, Hatch GF, 3rd. Complication rate and implant survival for reverse shoulder arthroplasty versus total shoulder arthroplasty: results during the initial 2 years. *J Shoulder Elbow Surg.* 2016;25:927-935.
42. Wiater MJ, Fabing MH. Shoulder arthroplasty: prosthetic options and indications. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons.* 2009;17:415-425.
43. Wilcox RB, Arslanian LE, Millett PJ. Rehabilitation Following Total Shoulder Arthroplasty. *Journal of Orthopaedic & Sports Physical Therapy.* 2005;35:821-836.
44. Wirth MA, Tapscott RS, Southworth C, Rockwood CA, Jr. Treatment of glenohumeral arthritis with a hemiarthroplasty: a minimum five-year follow-up outcome study. *J Bone Joint Surg Am.* 2006;88:964-973.
45. Worland RL, Arredondo J. Bipolar shoulder arthroplasty for painful conditions of the shoulder. *J Arthroplasty.* 1998;13:631-637.
46. Wright MA, Keener JD, Chamberlain AM. Comparison of clinical outcomes after anatomic total shoulder arthroplasty and reverse shoulder arthroplasty in patients 70 years and older with glenohumeral osteoarthritis and an intact rotator cuff. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons.* 2020;28:e222-e229.

47. Young AA, Smith MM, Bacle G, Moraga C, Walch G. Early results of reverse shoulder arthroplasty in patients with rheumatoid arthritis. *JBJS*. 2011;93:1915-1923.
48. Zumstein MA, Pinedo M, Old J, Boileau P. Problems, complications, reoperations, and revisions in reverse total shoulder arthroplasty: a systematic review. *Journal of shoulder and elbow surgery.* 2011;20:146-157.

Tables

Table I. Demographic characteristics of all patients undergo shoulder arthroplasties.

	TSA	HA	RSA	Unprofiled	*P* value
Sex					
Female (%)	12972 (50.79)	5736 (62)	14244 (63.79)	38	<0.000
Male (%)	12566 (49.21)	3516 (38)	8084 (36.21)		
Age at surgery					
n	25546	9260	22332	18	<0.000
Mean (SD), yr	67.31 (9.66)	66.18 (13.5)	72.38 (8.93)		
Race					
White (%)	21150 (90.47)	7403 (87.1)	18171 (89.03)	4869	<0.000
Black (%)	1003 (4.29)	430 (5.06)	897 (4.39)		
Hispanic (%)	669 (2.86)	399 (4.69)	783 (3.84)		
Asian/Pacific islander (%)	95 (0.41)	56 (0.66)	91 (0.45)		
Native American (%)	78 (0.33)	34 (0.4)	77 (0.38)		
Others (%)	383 (1.64)	177 (2.08)	391 (1.92)		
TOTAL (%)	25554 (44.71)	9265 (16.21)	22337 (39.08)		

P value was calculated by chi-squared test for categorical variables and one-way anova test for numerical variables.TSA, total shoulder arthroplasty; HA, hemiarthroplasty; RSA, reverse total shoulder arthroplasty.

Table II. Primary diagnosis for patients with different shoulder arthroplasties.

Diagnosis	TSA n(%)	HA n(%)	RSA n(%)	overall
Osteoarthritis	23140 (90.55)	3657 (39.47)	10096 (45.2)	36893 (64.55)
Arthropathy	1044 (4.09)	341 (3.68)	3166 (14.17)	4551 (7.96)
Aseptic necrosis	424 (1.66)	616 (6.65)	168 (0.75)	1208 (2.11)
Rotator cuff injury	131 (0.51)	212 (2.29)	4235 (18.96)	4578 (8.01)
Humeral fracture	276 (1.08)	3629 (39.17)	3078 (13.78)	6983 (12.22)
others	539 (2.11)	810 (8.74)	1594 (7.14)	2943 (5.15)
Overall	25554 (44.71)	9265 (16.21)	22337 (39.08)	57156 (100)

TSA, total shoulder arthroplasty; HA, hemiarthroplasty; RSA, reverse total shoulder arthroplasty.

Table III. Complications, Length of stay, and Cost of osteoarthritis patients with or without rotator cuff deficiencies undergo TSA or RSA.

Variables	w/ rotator cuff deficiency				w/o rotator cuff deficiency			
	TSA	RSA	*P* value	OR (95% CI)	TSA	RSA	*P* value	OR (95% CI)
Mechanical complication of implant	6 (0.27)	4 (0.18)	0.7536	0.67(0.19-2.36)	8 (0.17)	29 (0.63)	0.0007	3.64(1.66-7.97)
Nervous system complications	1 (0.05)	1 (0.05)	1	1(0.06-16)	5 (0.11)	5 (0.11)	1	1(0.29-3.46)
Cardiac complications	10 (0.45)	9 (0.41)	1	0.9(0.36-2.22)	18 (0.39)	25 (0.54)	0.3593	1.39(0.76-2.55)
Peripheral vascular complications	2 (0.09)	1 (0.05)	1	0.5(0.05-5.52)	1 (0.02)	3 (0.06)	0.6249	3(0.31-28.86)
Respiratory complications	7 (0.32)	6 (0.27)	1	0.86(0.29-2.55)	23 (0.5)	11 (0.24)	0.0572	0.48(0.23-0.98)
Digestive system complications	3 (0.14)	3 (0.14)	1	1(0.2-4.96)	15 (0.32)	7 (0.15)	0.1333	0.47(0.19-1.14)
Urinary complications	6 (0.27)	11 (0.5)	0.3314	1.84(0.68-4.98)	29 (0.63)	29 (0.63)	1	1(0.6-1.68)
Postoperative shock	0 (0)	2 (0.09)	0.4999	-	0 (0)	4 (0.09)	0.1249	-
Hemorrhage or hematoma	4 (0.18)	6 (0.27)	0.7536	1.5(0.42-5.33)	12 (0.26)	17 (0.37)	0.4575	1.42(0.68-2.97)
Postoperative infection	1 (0.05)	1 (0.05)	1	1(0.06-16)	2 (0.04)	1 (0.02)	1	0.5(0.05-5.51)
Urinary tract infection	25 (1.14)	27 (1.23)	0.8892	1.08(0.63-1.87)	79 (1.71)	101 (2.18)	0.1137	1.28(0.95-1.73)
Acute upper respiratory infections	2 (0.09)	0 (0)	0.4999	0(0.01-5.54)	0 (0)	6 (0.13)	0.0312	-
Acute postoperative pain	68 (3.09)	67 (3.05)	1	0.98(0.7-1.39)	85 (1.84)	130 (2.81)	0.0023	1.54(1.17-2.04)
Chronic postoperative pain	1 (0.05)	0 (0)	1	0(0.02-14.9)	1 (0.02)	0 (0)	1	0(0.02-14.9)
Transfusion	70 (3.18)	97 (4.41)	0.0399	1.4(1.03-1.92)	182 (3.93)	306 (6.61)	<0.0001	1.73(1.43-2.09)
Length of stay								
Mean (SD)	1.93 (1.12)	2.01 (1.07)	0.0021	RSA-TSA 0.08	2.08 (1.33)	2.25 (1.52)	<0.0001	RSA-TSA 0.17
Median	2	2			2	2		
Cost								

Mean (SD)	16960.36 (6915.39)	19468.65 (7723.6)	<0.0001	RSA-TSA 2508.29	16860.74 (6800.91)	19816.6 (8362.91)	<0.0001	RSA-TSA 2955.86
Median	15694.5	18018.86			15536	18212.88		

P value was calculated by Chi-squared test or Fisher's exact test for categorical variables and t-test or Wilcoxon rank-sum test for numerical variables.

TSA, total shoulder arthroplasty; RSA, reverse total shoulder arthroplasty; OR, odds ratio; CI, confidence interval; SD, standard deviation.

Figures

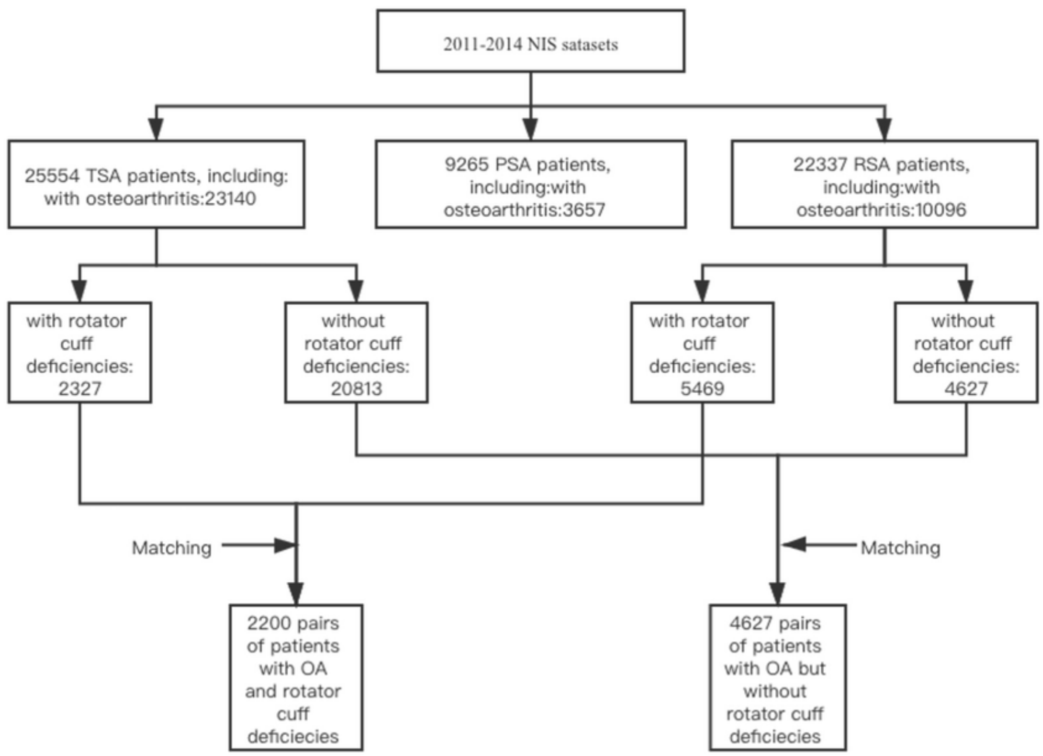

Figure 1

The sample selection and matching process.

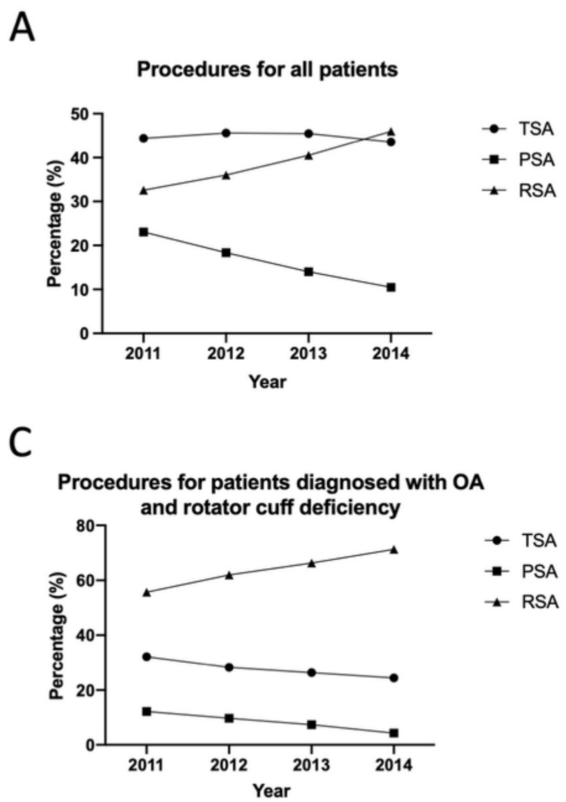

Figure 2

Trends of primary shoulder arthroplasties 2011-2014. A) All procedures combined. B) Procedures for patients diagnosed with OA. C) Patients with OA and rotator cuff deficiency. D) Patients with OA but not rotator cuff deficiency.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTables.docx