National Trends in the Surgical Treatment of Chronic Rotator Cuff Tear in Patients Without Arthritis

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abstract

Both rotator cuff repair (RCR) and reverse total shoulder arthroplasty (RTSA) are effective treatment options for chronic large degenerative rotator cuff tears (RCTs) in the elderly. The goal of this study was to evaluate national trends for surgical management of chronic RCT among patients without glenohumeral arthritis. The authors conducted a retrospective review from 2007 to 2015 using the PearlDiver database. The study included patients who had the *International Classification of Diseases, Ninth Revision,* diagnosis of chronic RCT without shoulder arthritis. Procedural codes from the *Current Procedural Terminology* and the *International Classification of Diseases, Ninth Revision,* were used to identify patients undergoing RCR or RTSA. Chi-square analysis assessed differences between the groups, and Cochran-Armitage trend tests were used to evaluate trends over time. Overall, 428,651 patients had chronic RCT without arthritis; 364,141 (84.9%) were treated nonoperatively, 53,566 (12.5%) underwent RCR, and 10,944 (2.6%) underwent RTSA. Patients who were 60 to 79 years old had the highest rate of surgical intervention (70.8% of all surgical patients), with 69.2% and 78.4% who underwent RCR and RTSA, respectively. A 3-fold increase in RTSA use was noted among patients 60 years and older vs patients younger than 60 years. Overall revision rates 2 years after RCR and RTSA among patients 60 to 79 years old were 13.0% and 3.7%, respectively. Revision rates after RCR remained constant over time (9.3% to 13.0%; *P*=.082), whereas revision rates after RTSA decreased significantly over time (12.1% to 2.2%; *P*=.016). Older patients were more likely to be treated nonoperatively compared with younger patients, but among those patients treated with RTSA, there was a 3-fold increase in the use of RTSA in patients older than 60 years as compared with patients younger than 60 years. Furthermore, the authors found the revision rates after RTSA decreased over time (12% to 2%), suggesting better implant design, improved knowledge on implant positioning, and increased surgical proficiency. Revision rates after RTSA decreased over time, suggesting better implant design and increased surgical proficiency. [*Orthopedics*. 2020;43(x):xx-xx.]

Shoulder pain and dysfunction have a significant effect on patient quality of life[1-3] and account for more than 4.5 million clinic visits annually. The diagnosis of rotator cuff tear (RCT) accounts for a large portion of shoulder pathology, with an estimated 250,000 rotator cuff repair (RCR) procedures performed annually.[1] In patients older than 80 years, RCT is even more prevalent, with rates as high as 80%.[4] As the aging population continues to become more active into the later decades,[5] it is increasingly important to optimize both conservative and surgical treatment of chronic RCT.

Originally, RCR was performed with an open approach, as described in 1911. However, with the advent of arthroscopic techniques in 1987,[6,7] most of these procedures are now performed arthroscopically. As an

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Table 1

Characteristics of Patients With Chronic Rotator Cuff Tears Without Arthritis Undergoing Surgical Treatment (2007 to 2015)

Characteristic	Rotator Cuff Repair (N=53,566)	Reverse Total Shoulder Arthroplasty (10,944)
Age, No. (%)		
<40 y	879 (1.6)	21 (0.2)
40-59 y	6856 (12.7)	547 (5.0)
60-79 y	37,062 (69.2)	8579 (78.4)
80+ y	2086 (3.9)	1635 (14.9)
Sex, No. (%)		
Male	25,668 (47.9)	6680 (61.0)
Female	27,898 (52.1)	4264 (39.0)
Region, No. (%)		
Midwest	13,842 (25.8)	3254 (29.7)
Northeast	998 (1.9)	286 (2.6)
South	32,847 (61.3)	6140 (56.1)
West	5879 (11.0)	1264 (11.5)
Charlson Comorbidity Index,[a] mean (SD)	1.42 (2.05)	2.09 (2.49)

[a]*Ten-year survival rates.*

alternative, reverse total shoulder arthroplasty (RTSA) was approved by the U.S. Food and Drug Administration in 2003 to treat massive irreparable RCT with arthritis in elderly patients.[8,9] When RCR is not viable, RTSA has become a first-line treatment option in elderly patients with RCT, with or without arthropathy and pseudoparalysis on clinical examination.[10] Within a specific patient population,[11] RTSA can result in major improvements in pain, motion, function, and patient satisfaction. An increasing number of studies support the effectiveness of RTSA in treating older patients who have chronic irreparable RCT without arthritis, as measured by a wide number of outcomes, including pain, active forward flexion, and to a lesser extent, external rotation motion.[9] The goal of this study is to describe national trends in the use of RCR and RTSA during an 8-year period as well as to compare revision rates in patients with chronic degenerative RCT without arthritis.

Materials and Methods

Data were obtained through a retrospective review using the PearlDiver Patient Record Database (PearlDiver Inc, Fort Wayne, Indiana) from 2007 to 2015. PearlDiver is a national orthopedic database of insurance billing records that is used to identify patients with an *International Classification of Diseases, Ninth Revision* (*ICD-9*) or *Current Procedural Terminology* (*CPT*) code. Within PearlDiver, the authors specifically used the Humana database, which contains 16 million patient records and information from both private and public payer insurance plans.

Patients with chronic RCT were identified with *ICD-9* codes 726.10, 727.61, and 726.13. The *CPT* codes 23410, 23412, and 29827 were used to categorize patients undergoing either open or arthroscopic RCR. In addition, the *ICD-9* procedure code 81.88, for reverse total shoulder arthroplasty, and the *CPT* code 23472, for total arthroplasty with glenoid and proximal humeral replacement, were used to identify patients undergoing RTSA. Patients with either primary or secondary shoulder arthritis, rotator cuff tear arthropathy (*ICD-9* diagnosis codes 71511, 71691, or 71591), and previous shoulder procedures were excluded from the study. Patients were categorized into 4 age cohorts: younger than 40 years, 40 to 59 years, 60 to 79 years, and 80 years or older. Patients who were 60 to 84 years old also were analyzed in 5-year age increments to assess differences in age-related treatment. The Charlson Comorbidity Index (CCI) was calculated for each cohort to estimate the overall health of each respective population.

All patients who had at least 2 years of follow-up were analyzed between 2007 and 2013 to assess the rate of secondary surgery within 2 years with the following *CPT* codes for revision shoulder arthroplasty: 23473, 23474, 23331, 23332, 23333, 23334, and 23335. Three subgroups were evaluated: (1) patients who underwent primary RCR and subsequent revision RCR; (2) patients who underwent RCR and subsequent revision to RTSA; and (3) patients who underwent RTSA and subsequent revision shoulder arthroplasty.

Student's *t* test and chi-square analysis were used to assess differences between continuous and categorical variables. Cochran-Armitage trend testing was used to assess for trend differences over time. All statistical analyses were performed with R software (version 3.0.2; R-Foundation, Vienna, Austria) and Excel (Microsoft, Mountain View, California).

Results

Of the 428,651 patients who were diagnosed with chronic RCT without arthritis, 364,141 (84.9%) were treated nonoperatively, 53,566 (12.5%) underwent RCR, and 10,944 (2.6%) underwent RTSA. Overall, 79% of the patients who underwent surgery were 60 to 79 years old. In addition, 48% of patients who un-

derwent RCR and 61% who underwent RTSA were men (**Table 1**). Surgical use was consistent within geographical regions, and the average CCI values for the RCR and RTSA groups were 1.42 and 2.09, respectively, with elderly patients having a higher average CCI in both surgical groups (**Figure 1**; *P*<.001).

Of all patients who had chronic RCT without arthritis, those who were 40 to 59 years old and those who were 60 to 79 years old had the highest overall rates of surgical intervention (11.5% and 70.8% of surgical patients, respectively). Among those 60 to 79 years old, 14.6% and 3.4% underwent RCR and RTSA, respectively. Patients who were 60 to 79 years old underwent 80% of all surgical procedures; however, in the group of patients who were treated with RTSA, there was an approximately 3-fold increase in RTSA use among patients 60 to 79 years old and those 80 years and older compared with patients who were 40 to 59 years old (**Figure 2**). Among operative candidates, the rate of RTSA use was similar between patients 60 to 79 years old and those 80 years and older (4.0% and 3.2%, respectively). However, 1 of every 4.5 patients 60 to 79 years old compared with 1 of every 1.4 patients 80 years and older underwent RTSA, with the rest of the patients undergoing RCR. The ratio of RTSA to RCR rates remained fairly constant among patients 40 to 59 years old and those 60 to 79 years old (1:13.4 and 1:4.5, respectively) between 2007 and 2015 (**Figure 3**). In patients who were 80 years and older, an increase from 1:2.2 to 1.4 occurred during the 8-year period.

Subgroup analysis for patients who underwent surgery and had at least 2 years of follow-up between 2007 and 2015 showed that the rate of revision RCR was 1.8 times greater in patients 80 to 84 years old compared with those 60 to 64 years old. The rate of revision to RTSA after initial RCR or RTSA was 1.9- and 1.2-fold greater, respectively, in patients 80 to 84 years. Groups younger than 60 years and older than 84 years were not analyzed because of an insufficient number of patients within the respective cohorts (**Figure 4**). For those 60 to 79 years old, between 2007 and 2013, the overall rate of secondary surgery was 14.0% after RCR and 7.7% after RTSA. The revision rate after RCR remained constant over time, ranging from 9.3% to 13.0% in 2007 to 2013 (*P*= .082). On the contrary, revision rates for revision shoulder arthroplasty after initial RTSA within 2 years decreased significantly over time (12.1% to 2.2%; *P*=.016; **Figure 5**). Among patients who underwent RCR, 2.3% subsequently underwent RTSA within 2 years. This trend increased over time from 0.9% in 2007 to 3.7% in 2013, representing a 4-fold increase (*P*=.056).

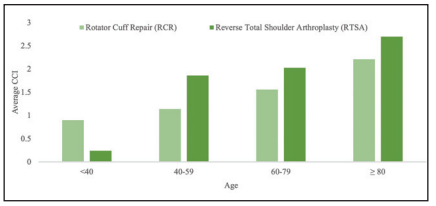

Figure 1: Charlson Comorbidity Index (CCI), a measure representing overall comorbidity burden, increased for both the rotator cuff repair and reverse total shoulder arthroplasty groups across the 4 age cohorts.

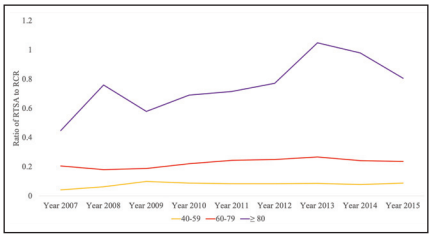

Figure 3: Ratio of reverse total shoulder arthroplasty (RTSA) to rotator cuff repair (RCR) procedures performed by age group between 2007 and 2015. The ratio in patients 40 to 59 years old and patients 60 to 79 years old remained relatively constant throughout the 7 years. In patients who were 80 years old and older, RTSA was increasingly favored over time. The group of patients younger than 40 years old is not shown because the sample size for RTSA was too small.

Discussion

This study found that elderly patients (80 years and older) who were diagnosed with chronic RCT without arthritis were most likely to be treated nonoperatively. However, a greater proportion of patients older than 60 years who had surgical intervention for chronic RCT without arthritis underwent RTSA rather than RCR compared with younger patients. Of all patients undergoing surgery, 79% were

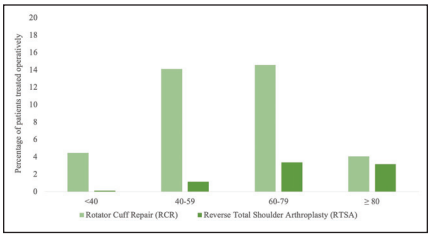

Figure 2: Percentage of patients who underwent either rotator cuff repair or reverse total shoulder arthroplasty after being diagnosed with a chronic rotator cuff tear. Patients who were 40 to 59 years old and those who were 60 to 79 years old had the highest rates of operative treatment.

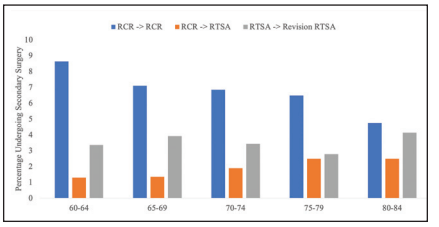

Figure 4: Rate of subsequent surgery within 2 years between 2007 and 2013. The rate of revision for rotator cuff repair (RCR) was 1.8-fold lower in patients 80 to 84 years old compared with those 60 to 64 years old. However, the rate of revision for reverse total shoulder arthroplasty (RTSA) after initial RCR or RTSA was 1.9 and 1.2-fold greater, respectively, in patients 80 to 84 years old.

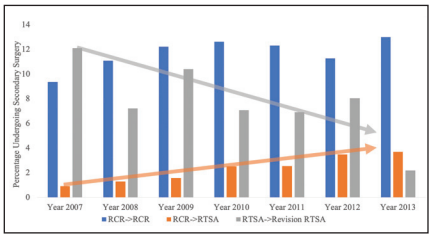

Figure 5: Rate of subsequent surgery within 2 years in patients 60 to 80 years old. There was a 5.5-fold decrease in the revision rate for reverse total shoulder arthroplasty (RTSA) between 2007 and 2013. There was a 4-fold increase in patients undergoing RTSA after rotator cuff repair (RCR) during the 7 years. The rate of second RCR remained relatively constant (11.7%).

60 to 79 years old. Although 2-year revision rates after RCR, with initial surgery occurring between 2007 to 2013, were unchanged over time (12%), revision RTSA rates trended downward over time from 12% (2007) to 2% (2013). Further, 2-year revision rates were significantly higher among 60- to 79-year-old patients after RCR (13.0%) compared with RTSA (3.7%).

Since the approval of RTSA in 2003, surgical technique continues to improve for the management of irreparable RCT with or without arthritis. Initially, RTSA had substantial drawbacks, including prosthetic design that may have led to early implant failure and high rates of neurologic injury because of technical difficulty with surgical exposure.[12,13] However, over time, surgeons have adjusted to the learning curve, as reflected by improving outcomes with RTSA.[14] The primary population for RTSA includes patients 65 years and older with RCT arthropathy,[15] but indications have been expanding and studies show that patients who can benefit from RTSA are not restricted to the elderly.[16-18] Other expanded indications include proximal humerus fracture, chronic instability, massive irreparable RCT without arthritis, tumor, and revision of failed shoulder arthroplasty.[19] Especially in patients with deficient rotator cuff, RTSA offers the advantage of using deltoid tensioning as a lever arm to restore shoulder function and the center of rotation for the shoulder while addressing arthritic glenohumeral pain.[11,20]

In the current study, 60- to 79-year-old patients were the most common age group undergoing RTSA. However, RCR remains the treatment of choice for patients with chronic RCT without arthritis that is deemed reparable as indicated by tear size, retraction, and fatty infiltration on preoperative magnetic resonance images. In this subset of patients, RCR is likely to lead to favorable outcomes and provides a more cost-effective approach than RTSA.[21,22] Makhni et al[23] showed that RCR may be a more cost-effective initial treatment than RTSA for patients with massive RCT. Other potential explanations for the higher rates of RCR in this population are that surgeons are more comfortable and familiar with RCR as an established procedure and that they have not been trained to perform RTSA. In contrast, RTSA has longer operative time, increased risk of wound or perioperative complications, and increased risk of infections; because this procedure is more significant, the risk of complications may be increased for patients with greater preoperative baseline comorbidities.[24] Interestingly, the current authors did not find that patients who were 60 to 79 years old and underwent RCR vs RTSA had significantly different severity of comorbidities (CCI, 1.56 vs 2.03, respectively; **Figure 1**), suggesting that preoperative comorbidities did not influence the choice of surgical intervention.

Among patients with RCT arthropathy, several studies confirmed that RTSA results in substantial improvement in range of motion, with a decreased rate of complications over time.[16,25-28] Nolan et al[16] showed substantial improvements in mean American Shoulder and Elbow Surgeons Shoulder Score, Subjective Shoulder Value, Constant-Murley score, forward elevation, and visual analog scale score after RTSA in a cohort of 71 patients with an average age of 74.2 years (range, 54-92 years). Most of the literature supports the use of RTSA in chronic RCT arthropathy in patients 60 to 79 years old, and the current study suggests that surgeons are more likely to consider RTSA rather than RCR in patients older than 80 years who have chronic RCT, even in the setting of no arthritis, compared with any other age group (**Figure 4**). This finding may have several explanations. For example, for these patients, chronic RCT may not be reparable because of the level of retraction, or the surgeon may consider RTSA a more predictable procedure than RCR if imaging shows evidence of poor tissue quality. As baby boomers continue to age and life expectancy increases,[29] the use of RTSA is likely to increase among those 80 years and older compared with patients 60 to 80 years old and 40 to 60 years old.

In addition, Sershon et al[15] reported evidence supporting the use of RTSA in patients younger than 60 years. The current study showed that surgeons treat this younger age group with RTSA less frequently (5.2% for patients 60 years and younger; **Table 1**) and that several factors play a role in the decision to treat a younger patient with RTSA, including the severity of RCT, its chronicity, the amount of fatty infiltration, and the surgical history. Especially in patients with chronic RCT that is irreparable or unlikely to be repaired successfully, RTSA may be a more appropriate first option, with a predictable outcome. Identifying preoperative factors that predict success or failure after RCR in patients with chronic RCT is essential because the current study showed much higher 2-year revision rates among 60- to 79-year-old patients in the RCR repair group (13.0%) compared with the RTSA group (3.7%). Mahure et al[30] described patients who underwent RTSA after failed RCR and reported worse outcomes compared with those who underwent primary RTSA instead. Revision rates in the current study show an age-dependent trend of conversion to RTSA within 2 years after primary RCR, with the likelihood of requiring subsequent RTSA after RCR increasing with age (2.5% of patients 80 to 84 years old compared with 1.3% of patients 60 to 64 years old; **Figure 4**). Although the age cutoff for RCR vs RTSA may vary based on surgeon preference or the tear pattern or tissue quality of the rotator cuff, RTSA is increasingly becoming the first-line treatment in patients with chronic irreparable RCT with or without arthritis. More data are needed to identify specific patient factors that are associated with a higher risk of RCR failure compared with RTSA.

In addition, the rate of conversion to RTSA within 2 years of RCR increased

during the study period, from 0.9% in 2007 to 3.7% in 2013. In contrast, the rate of revision shoulder arthroplasty after RTSA decreased from 12.1% to 2.2%, amounting to a 6-fold reduction from 2007 to 2013. This change may be attributed to recent improvements in the design of reverse shoulder implants and improved knowledge of glenosphere positioning that may have minimized early failure from scapular notching and impingement, along with improved surgical technique or surgeon experience, leading to improved patient outcomes and lower revision rates.[31] Recent studies have shown that increased surgeon experience with RTSA has led to better patient outcomes of decreased pain and improved function, with an overall decrease in both major and minor complications.[32-34] Further, in 2007, many surgeons may have been reluctant to revise a failed RCR to RTSA because the technology was relatively new in the United States (3 years).[11] These factors may have contributed to the increase in revision rates from 2007 to 2013 that was seen in the current study of failed RCR to RTSA as surgeons became more proficient with RTSA. Failure after rotator cuff surgery in patients without arthritis is particularly challenging because patients have persistent pain and/or pseudoparalysis of the shoulder along with impairment in activities of daily living, with limited surgical options.[29,35-37] The current study showed that surgeons are increasingly performing RTSA for older patients who have chronic RCT without arthritis and that the rate of revision for primary RTSA is decreasing over time.

Limitations of this study included those inherent to using large administrative databases. Increasing use during the study period also likely reflected the relatively recent introduction of RTSA in the United States, which occurred in 2004. Without clinical data or radiographs, the severity or reparability of RCT or the amount of fatty infiltration could not be evaluated as a risk factor for failure or revision surgery. Without patient-level data, multivariable models and more robust statistical methods could not be used. In addition, the treating physicians were not tracked, and the results may have been biased if some surgeons were comfortable performing only RCR and not shoulder arthroplasty. Further, the data were obtained from a private payer patient population captured in a single large database, making the results less generalizable to a greater patient population encompassing both government-sponsored and private insurance. Despite these limitations, this study represents the first nationwide report on the trends of treatment for RCR and RTSA and revision rates specifically tracking patients with chronic RCT without arthritis during a 7-year period.

Conclusion

The authors found that most patients who presented with chronic RCT without arthritis were treated without surgery, and the highest rate of surgical intervention was seen in patients 60 to 79 years old. Additionally, elderly patients with chronic cuff tear were more likely to be treated nonoperatively compared with younger patients. However, among all patients who were treated with RTSA, there was a 3-fold use of RTSA in patients older than 60 years compared with patients younger than 60 years. Furthermore, in patients between 60 and 79 years old, revision rates were higher after RCR (13%) than after RTSA (3.7%). Finally, the rate of revision shoulder arthroplasty after RTSA decreased from 12.1% to 2.2%, amounting to a 6-fold reduction from 2007 to 2013, which may be attributed to improved implant design, increased surgeon experience, or the surgical technique of implant positioning.

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