J Shoulder Elbow Surg (2021) 30, S131–S139

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Anatomic total shoulder arthroplasty for primary glenohumeral osteoarthritis is associated with excellent outcomes and low revision rates in the elderly

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Background: The relative indications of anatomic total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RSA) continue to evolve. Some surgeons favor RSA over TSA for elderly patients with primary glenohumeral osteoarthritis (GHOA) and an intact rotator cuff due to fear of a postoperative (secondary) rotator cuff tear in this age group. However, RSA is associated with unique complications and a worse functional arc of motion compared with TSA. Therefore, it is important to understand the clinical outcomes and rates of revision surgery and secondary rotator cuff tears in elderly patients undergoing TSA.

Methods: Between January 1, 2010, and December 31, 2017, 377 consecutive TSAs were performed for primary GHOA in 340 patients 70 years of age or older. The mean age at surgery was 76.2 years (standard deviation [SD], 4.9). Clinical evaluation included pain, motion, and American Shoulder and Elbow Surgeons score. Radiographs were reviewed for preoperative morphology and postoperative complications. All complications and reoperations were recorded. The average clinical follow-up time was 3.3 years (SD, 2.0). Statistical analyses were performed, and Kaplan-Meier implant survival estimates were calculated. For all analyses, a P value $<.05$ was considered statistically significant.

Results: The mean pain visual analog scale and American Shoulder and Elbow Surgeons score at the final follow-up were 1.6 (SD, 2.2) and 78.0 (SD, 17.8), respectively. Forward elevation and external rotation increased from 96° (SD, 30°) and 26° (SD, 20°) preoperatively to 160° (SD, 32°) and 64° (SD, 26°) postoperatively ($P < .001$ for each). The percentage of patients who had internal rotation to L5 or greater increased from 24.8% preoperatively to 71.8% postoperatively ($P < .001$). Revision surgery was performed in 3 shoulders (0.8%), and the 5-year implant survival estimate was 98.9% (95% confidence interval: 97.3%-100%). There were 3 medical (0.8%), 10 minor surgical (2.7%), and 5 major surgical (1.3%) complications. No shoulder had radiographic evidence of humeral component loosening, whereas 7 (2%) had evidence of some degree of glenoid component loosening. In total, there were 5 secondary rotator cuff tears (1.3%), of which 2 (0.5%) required revision surgery.

Conclusion: Elderly patients with primary GHOA and an intact rotator cuff have excellent clinical and radiographic outcomes after

This study was reviewed and approved by our institutional review board (#12-007498).

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https://doi.org/10.1016/j.jse.2020.11.030

anatomic TSA, with high implant survival rates and a low incidence of secondary rotator cuff tears in the first 5 postoperative years. Age greater than 70 by itself should not be considered an indication for RSA over TSA.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Shoulder arthroplasty; reverse shoulder arthroplasty; elderly; osteoarthritis; secondary; rotator cuff tear

Shoulder arthroplasty has increased in incidence in recent decades due to technical improvements and clinical success.[9,15,23,35] This trend has been particularly true in the elderly, for whom the incidence has increased at the greatest rate.[25]

Historically, anatomic total shoulder arthroplasty (TSA) has been the standard surgical indication for patients with primary glenohumeral osteoarthritis (GHOA) and an intact and functioning rotator cuff.[7,18] Conversely, the more highly constrained reverse shoulder arthroplasty (RSA) has been reserved for those patients without a functioning rotator cuff.[5,32]

Because of the overall success of RSA in patients with defective rotator cuffs, however, the surgical indications for RSA have expanded to include other conditions, such as primary GHOA with severe bone loss or soft-tissue imbalance, complex fractures, tumor, and avascular necrosis, regardless of the presence of a functioning rotator cuff.[5,8] In fact, some centers have reported that more than 50% of their primary shoulder arthroplasties are now performed using RSA.[4]

Recently, some surgeons have recommended considering RSA over the historically indicated TSA for elderly patients with primary GHOA and an intact rotator cuff.[27,29,32,33] This choice seems mostly to be due to the fear of future rotator cuff dysfunction in these elderly patients, termed a secondary rotator cuff tear, which might lead to revision surgery after anatomic TSA.[10,34]

The choice of RSA over TSA in patients with intact rotator cuffs is not without potential adverse consequences, however, as RSA is associated with certain unique complications not seen in TSA. These complications include acromial and scapular spine fractures, inferior glenoid notching, and subcoracoid impingement.[11,20] Some authors have also found a higher rate of deep infection in patients undergoing RSA when compared with TSA.[16,21] In addition, restoration of motion seems to be superior with anatomic TSA, especially in terms of internal rotation.

When making the decision between TSA and RSA in elderly patients with primary GHOA and an intact rotator cuff, it would be important for the surgeon to understand the expected outcomes of the historically indicated TSA in this population. However, to date, few studies have reported these outcomes. Therefore, we conducted a study on elderly patients with primary GHOA and an intact rotator cuff who underwent TSA at our institution. The purpose of the study was to determine the clinical and radiographic outcomes in elderly patients with primary GHOA undergoing anatomic TSA as well as the rates of complications, secondary rotator cuff tears, and revision surgeries in this population.

Materials and methods

Patient selection

This was a retrospective cohort study of prospectively collected data from our Institutional Total Joint Registry database. All consenting patients 70 years or older who underwent a primary anatomic TSA for primary GHOA by 1 of 2 fellowship-trained shoulder and elbow surgeons between January 1, 2010, and December 31, 2017, were included in the study. The age of 70 was chosen for this study as this age is frequently cited in the literature as the cutoff beyond which RSA should be considered.[14,32,33] Rotator cuff integrity was confirmed on preoperative clinical assessment and at the time of surgery.

Surgical technique and postoperative protocol

All surgeries were performed at our tertiary care referral center. Patients underwent primary TSA via a deltopectoral approach with a subscapularis tenotomy. The subscapularis tendon was repaired with multiple interrupted heavy simple absorbable sutures. For patients with glenoid anteversion or retroversion of up to 15°, eccentric reaming was used to normalize the version; neither bone grafting nor augmented glenoid components were used. Postoperatively, a shoulder immobilizer was worn for 6 weeks. Patients were seen in clinic at 6 weeks and 1 year postoperatively. They were then invited to return for a physical evaluation and radiographs at 2 and 5 years postoperatively, and every 5 years thereafter. For patients unable to physically return to our institution, shoulder evaluations were completed using mailed or telephone questionnaires, and radiographs were also requested.

Complications and reoperations

All postoperative complications and reoperations were recorded. Complications were classified as medical or surgical, with surgical complications further categorized as minor if no change in management was required or major if a change in management was required. Complications listed in our Institutional Total Joint Registry database were confirmed with review of the electronic medical record. Revision surgeries were identified from the database and confirmed both through review of the electronic medical record and radiographically.

Radiographic analysis

Radiographs were reviewed to analyze preoperative glenohumeral morphology and postoperative implant changes. For each shoulder, 5 radiographs were collected: the preoperative, 6-week postoperative, and final postoperative axillary radiographs as well as the 6-week and final postoperative Grashey radiographs in external rotation. When preoperative axillary radiographs were not available or inadequate (18 shoulders), axial slices from preoperative computed tomography (CT) or magnetic resonance imaging scans were used if available (12 shoulders).

All imaging studies were reviewed by the 2 senior authors concurrently, and a consensus opinion on the radiographic findings was achieved. Preoperative radiographs were evaluated for glenohumeral morphology. Postoperative radiographs were evaluated for humeral head anterior, posterior, and/or superior subluxation, as well as dislocation, fracture, and glenoid or humeral component loosening.

Preoperative glenoid morphology was classified according to the modified Walch classification.[2,31] Pre- and postoperative humeral head subluxation was classified according to direction and graded mild, moderate, or severe according to Torchia et al.[28] Postoperative glenoid and humeral component radiolucencies were graded according to Lazarus et al[13] and Sperling et al,[26] respectively.

For determining the presence of a secondary rotator cuff tear, advanced imaging was obtained in postoperative patients who reported a new onset of shoulder pain or were found to have loss of motion, loss of strength, or glenohumeral instability on physical examination. For these patients, the rotator cuff was evaluated via an advanced imaging study (ultrasound or CT arthrogram) and intraoperatively at the time of revision surgery, when performed.

Range of motion and clinical scores

Preoperative range of motion values (forward elevation in the scapular plane and external and internal rotation with the shoulder adducted) were obtained from preoperative clinic notes and postoperatively either from the electronic medical record or from patient-completed questionnaires. Postoperative visual analog scale (VAS), defined as a patient's average daily pain, and American Shoulder and Elbow Surgeons (ASES) scores were calculated for each patient who had completed at least 1 questionnaire. When a given patient had completed multiple questionnaires, only the most recent responses were included.

Statistical analysis

Statistical analyses were performed using Student's *t*-test for numerical data, the χ^2 test for nonpaired categorical data, and McNemar's test for paired categorical data. Kaplan-Meier estimates of implant survival free from revision at 1, 2, and 5 years were calculated. Patients were also analyzed accordingly.

Results

Patient demographic information

There were 377 anatomic TSAs performed in 340 patients who met inclusion criteria. Demographic information is listed in Table I.

Preoperative radiology

There were 370 shoulders (98.1%) that had sufficient preoperative imaging to assess glenohumeral morphology (Table II). The majority of shoulders (288; 77.8%) had some degree of preoperative glenoid bone loss (Walch types A2, B2, or B3) apparent on preoperative radiographs. There were 145 shoulders (39.2%) with some degree of preoperative posterior humeral head subluxation and 12 shoulders (3.2%) with some degree of preoperative anterior humeral head subluxation. No shoulders had superior humeral head migration on preoperative radiographs.

Operative details and follow-up

Operative details are listed in Table III. Postoperatively, the average clinical follow-up was 3.3 years (standard deviation [SD], 2.0). No patients were lost to follow-up. There were 302 patients (88.8%) with ≥2-year follow-up and 51 (15.0%) who had died after their TSA. None of the deaths were related to the index surgery.

Complications and revisions

All patients had complete clinical information documented, including complications and revision surgeries when relevant. There were 18 total complications, of which 3 were medical (0.8%), 10 were minor surgical (2.7%), and 5 were major surgical (1.3%) complications (Table IV).

There were 3 intraoperative fractures (0.8%), 2 of which involved the greater tuberosity and 1 involved the anterior humeral cortex. All 3 fractures were nondisplaced and fixed at the time of the index procedure with a nonabsorbable suture. Postoperative management was not altered for these patients, and none of these 3 shoulders had radiographic evidence of component loosening or required a subsequent revision surgery.

The major surgical complications included 3 dislocations, 1 deep infection that was treated with long-term suppressive antibiotics, and 1 periprosthetic humeral shaft fracture due to a mechanical fall that was treated successfully in a fracture brace.

There were 3 revision surgeries (0.8%). Two revision surgeries were performed for anterosuperior escape (described below) and 1 revision surgery was performed for posterior instability at 7 days postoperatively. The patient who developed posterior instability had a B3 glenoid and severe posterior humeral head subluxation preoperatively. All revision surgeries were conversion to RSA. The 5-year Kaplan-Meier estimate of survival free from revision surgery was 98.9% (Table V).

In total, there were 5 secondary rotator cuff tears (1.3%). Two (0.5%) had subscapularis failure presenting with anterosuperior escape at 6 and 24 months postoperatively and were revised to RSA. The other 3 (0.8%) presented

Table I Preoperative demographic information

Variable	Mean (SD)/ Percentage (n)
Surgeries (n)	377
Patients (n)	340
Age (yr)	76.2 (4.9)
Sex	
Female	53.8% (203)
Male	46.2% (174)
Surgery laterality	
Right	50.1% (189)
Left	49.9% (188)
Height (cm)	167 (10.0)
Weight (kg)	85.3 (18.7)
BMI	30.6 (5.7)
Previous surgeries*	
1+	5.6% (21)
2+	1.3% (5)
3+	0.8% (3)

BMI, body mass index; *SD*, standard deviation.
* Nonarthroplasty surgeries on the ipsilateral shoulder.

Table II Preoperative radiographic glenohumeral morphology

Variable	Percentage (n)
Glenoid morphology	
A1	13.2 (49)
A2	37.3 (138)
B1	3.2 (12)
B2	23.0 (85)
B3	17.6 (65)
C	0.8 (3)
D	4.9 (18)
Humeral head subluxation	
None	55.7 (206)
Anterior	
Mild	2.4 (9)
Moderate	0.8 (3)
Severe	0.0
Posterior	
Mild	8.6 (32)
Moderate	21.1 (78)
Severe	9.5 (35)

with worsening clinical function at 5 months, 6 years, and 7 years postoperatively and were diagnosed with secondary rotator cuff tears on advanced imaging but deferred surgical intervention. Of these three patients, two completed postoperative questionnaires and reported an average VAS of 1.5 and average ASES score of 72.5.

Table III Operative details

Variable	Mean (SD)/ Percentage (n)
Anesthesia time (min)	149 (24.7)
Operative time (min)	75.1 (15.1)
Hospital LOS (d)	1.7 (1.8)
Hospital LOS >3 d	3.2% (12)
Implant	
Biomet Comprehensive	53.1% (200)
Stryker ReUnion	38.7% (146)
Smith & Nephew Cofield II	5.0% (19)
DePuy Global Advantage	3.2% (12)
Surgeon	
Surgeon 1	46.9% (177)
Surgeon 2	53.1% (200)

LOS, length of stay; *SD*, standard deviation.

Table IV Postoperative complications

Complications	Percentage (n)
Medical complications	
DVT/PE	0.3 (1)
Postoperative anemia	0.3 (1)
Postoperative ICU admission	0.3 (1)
Minor surgical complications	
Hematoma	0.8 (3)
Secondary rotator cuff tear	0.8 (3)
Intraoperative fracture	0.8 (3)
Transient ulnar neuropathy	0.3 (1)
Major surgical complications	
Instability	0.8 (3)
Periprosthetic fracture	0.3 (1)
Deep infection	0.3 (1)

DVT, deep vein thrombosis; *PE*, pulmonary embolism; *ICU*, intensive care unit.

Postoperative radiographic assessment

There were 268 shoulders (71.1%) with a complete postoperative Grashey film series, allowing for assessment of superior humeral head migration, and 259 shoulders (68.7%) with a complete postoperative axillary film series, allowing for assessment of anterior and posterior humeral head subluxation. Both sets of films were assessed for component loosening as well.

The rates of anterior and superior humeral head subluxation, but not posterior, were found to increase over time. The radiographic presence of any degree of anterior, posterior, or superior humeral head subluxation was 2.6%, 1.2%, and 2.0% on initial postoperative imaging and 8.9%,

Table V Kaplan-Meier implant survival estimates

Implant survival	1 year (95% CI)	2 years (95% CI)	5 years (95% CI)
Free of revision	99.4% (98.6, 100.0)	99.4% (98.6, 100.0)	98.9% (97.3, 100.0)

CI, confidence interval.

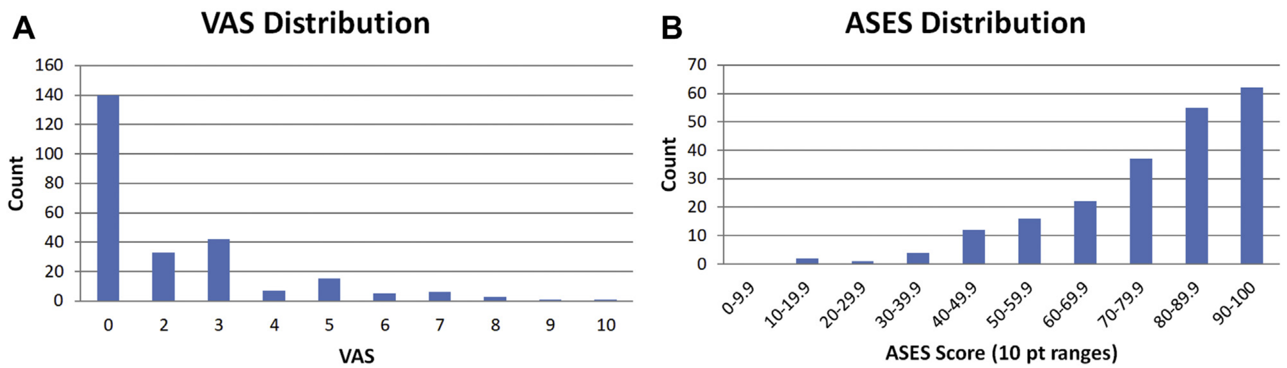

Figure 1 Distribution of postoperative visual analog scale (VAS) (**A**) and American Shoulder and Elbow Surgeons (ASES) scores (**B**) in elderly patients with primary glenohumeral osteoarthritis and an intact rotator cuff after anatomic total shoulder arthroplasty.

2.7%, and 7.8% on final postoperative imaging, respectively (anterior $P < .001$; posterior $P = .157$; superior $P < .001$).

In terms of component loosening, no shoulder was considered to have radiographic evidence of humeral component loosening and 7 (2.0%) had some evidence of glenoid component loosening at the final radiographic follow-up. There were no instances of complete implant failures. There was no correlation between shoulders with preoperative humeral head subluxation and those with postoperative humeral head subluxation or glenoid component loosening.

Range of motion

There were 227 shoulders (60.2%) with complete preoperative and postoperative range of motion data. Forward elevation and external rotation increased from a mean of 96° (SD, 30°) and 26° (SD, 20°) preoperatively to 160° (SD, 32°) and 64° (SD, 26°) postoperatively ($P < .001$ for each). The percentage of shoulders that had internal rotation to L5 or greater increased from 24.8% preoperatively to 71.8% postoperatively ($P < .001$).

Clinical scores

There were 253 shoulders (67.1%) that had at least 1 recorded postoperative VAS score and 211 (56.0%) that had reported at least 1 recorded postoperative ASES score. The mean VAS was 1.6 (SD, 2.2) and the mean ASES score was 78.0 (SD, 17.8). For VAS, 55% of respondents reported 0/10 pain and only 6.3% of respondents reported ≥5/10 pain (Fig. 1, *A*). For ASES scores, 55% of respondents reported ASES scores ≥80 and only 9.4% reported ASES scores ≤50 (Fig. 1, *B*). VAS and ASES scores were tightly correlated ($R^2 = 0.74$). There was no correlation between follow-up length and VAS or ASES score ($R^2 < 0.02$ for both).

Age-based analysis

When comparing patients in the cohort who were 70-79 years old at the time of their surgery with those who were 80 years or older, we found that the younger group had statistically significant shorter hospital lengths of stay and a lower rate of revision surgery. The rate of complications (medical, minor surgical, and major surgical) was higher in the older age group, but this difference was not statistically significant. There was no difference in VAS or ASES scores between the 2 groups (Table VI).

Discussion

The high rate of satisfactory reported outcomes after primary RSA for multiple indications, coupled with concerns regarding the possibility of late cuff failure after anatomic TSA, has prompted recommendations by some for universal implantation of RSA in patients older than 70 with primary GHOA and an intact rotator cuff.[27,29,32,33] The results of our study indicate that anatomic TSA performed with contemporary implants and surgical techniques is

Table VI Comparison of 70- to 79-year-old and 80+-year-old cohorts

Variable	70-79 years old	80+ years old	*P* value
Surgeries (n)	287	90	–
Patients (n)	261	82	–
Age (yr)	74.0 (2.8)	83.3 (2.9)	–
Follow-up (yr)	3.2 (2.0)	3.2 (2.1)	.913
Hospital LOS (d)	1.6 (2.0)	2.1 (1.1)	**.009**
Complications*	3.8%	7.8%	.126
Revisions	0%	3.3%	**.002**
VAS	1.6 (2.2)	1.8 (2.1)	.519
ASES	78.3 (17.8)	76.7 (17.1)	.610

LOS, length of stay; *VAS*, visual analog scale; *ASES*, American Shoulder and Elbow Surgeons.
Data represent mean (standard deviation) unless otherwise specified.
* Includes medical, minor surgical, and major surgical complications.
Bold values are statistically significant.

associated with excellent clinical and radiographic outcomes, low reoperation rates, and favorable implant survival free of revision at 5 years (Fig. 2). Secondary rotator cuff tears in this population are rare despite their age. As such, it provides data to support the value of anatomic TSA in this particular patient population.

Our study found that the incidence of symptomatic secondary rotator cuff tears in the elderly population after TSA was relatively low. In total, 5 shoulders were considered to have developed symptomatic secondary rotator cuff tears (1.3%) in our cohort, and only 2 shoulders (0.5%) required revision surgery, whereas the other 3 had acceptable function and deferred surgical management.

Although it is true that older patients in general have higher rates of rotator cuff tears than younger patients, it may not be true that older patients are at higher risk of a secondary rotator cuff tear than younger patients after anatomic TSA. For one, as rotator cuff tears and GHOA infrequently coexist despite both being common, the group of older patients with primary GHOA may not have the same high rate of a rotator cuff tears as similarly aged patients without GHOA. Also, the lower activity levels associated with older age may be protective of secondary rotator cuff tears after TSA, as some studies have demonstrated that younger, more active patients are actually at higher risk of requiring revision arthroplasty.[3,6,12,17,19,22,24,30]

We did find that there was a progression of anterior and superior humeral head subluxation rates between first postoperative radiographs and final radiographs. These radiographic findings may be indicative of anterosuperior rotator cuff thinning or dysfunction over time. However, no correlation could be identified between proximal or anterior humeral head migration and a decrease in VAS or ASES scores, indicating that, even if radiographic anterior and superior subluxation is considered to be a surrogate of progressive rotator cuff wear, this radiographic finding in isolation may have limited clinical impact.

Others have similarly reported excellent clinical outcomes in elderly patients who have undergone anatomic TSA for primary GHOA with intact rotator cuffs. Wright et al[33] retrospectively reviewed 102 patients over 70 years old with primary GHOA and an intact rotator cuff who had TSA. Of the 45% who reported clinical outcomes, the average postoperative VAS was 0.7 and the ASES score was 86.[33]

How one defines a secondary rotator cuff failure after TSA influences the reported cuff dysfunction rate. In our study, we evaluated for secondary rotator cuff tears in patients presenting with new symptoms with advanced imaging (ultrasound or CT arthrogram). We defined secondary rotator cuff tears this way such that our results would be clinically focused and meaningfully contribute to patient care. The clinical relevance of radiographic evidence of rotator cuff thinning in an otherwise well-functioning TSA, in our opinion, is limited and should not guide treatment recommendations or, by extension, the counseling of surgical candidates preoperatively.

Others have used superior humeral head migration on routine postoperative plain radiograph as the definition of a secondary rotator cuff tear, regardless of patient symptomatology. Unsurprisingly, higher rates of secondary rotator cuff tears have been found in these studies.[33,34] For instance, Young et al[34] reviewed TSAs with 5-year radiographic follow-up for secondary rotator dysfunction, which they defined as moderate or severe superior subluxation on radiographs. Of the 518 patients with complete radiographic follow-up, they reported a 16.8% rate of secondary rotator cuff dysfunction.[34] However, just one of these 87 shoulders required a revision to RSA due to the cuff dysfunction despite all of them being diagnosed with secondary rotator cuff failure, according to this criterion.[34] Although proximal migration on routine radiographs in an otherwise asymptomatic patient may indicate rotator cuff thinning, we do not believe that this isolated radiographic finding is indicative of cuff dysfunction or a surgical failure, as these patients maintain good clinical function.

When comparing patients in our cohort who were 80 years or older at the time of their surgery with those who were 70-79 years old, we found that patients in the older group had the same VAS and ASES scores despite a higher revision surgery rate (Table VI). Other studies that have evaluated the outcomes of anatomic TSA in patients over the age of 80 specifically have also found excellent clinical scores and low revision surgery rates. For instance, Iriberri et al[10] reviewed 32 TSAs in patients over 80 and found an average postoperative subjective shoulder value of 81% with no revision surgeries. Foruria et al[7] reviewed 50 TSAs in patients over 80 and found 80% excellent or satisfactory results and an average VAS of 1.8 with 3 revision surgeries for anterosuperior humeral head subluxation. Triplet et al[29] reviewed 18 TSAs in patients older than 80 and an average ASES of 91 and VAS of 0. Combined with our results, these data show that anatomic TSA in elderly patients with

A

B

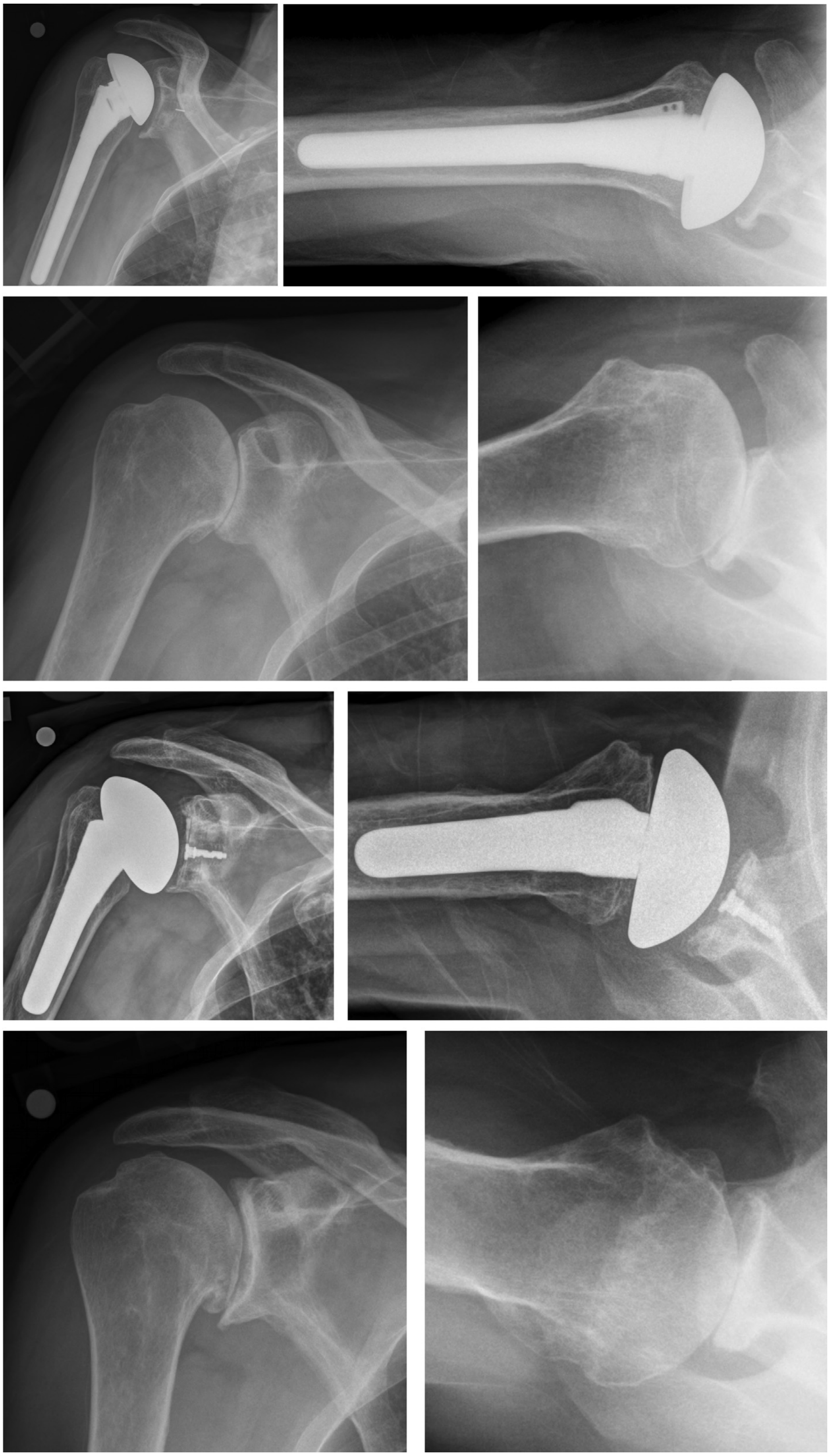

Figure 2 Case examples. An elderly patient (**A**) with a B2 glenoid deformity who underwent successful anatomic total shoulder arthroplasty (TSA). An elderly patient with severe preoperative posterior humeral head subluxation (**B**) who also underwent successful anatomic TSA. Pre- and postoperative (**A**: 3 years, **B**: 7 years) anteroposterior and axillary radiographs are shown.

GHOA, even for those over 80, results in excellent functional outcomes with low revision surgery rates.

In our practice, we do perform a large number of RSAs in elderly patients with primary GHOA, but we base the selection of RSA on the severity of glenoid bone loss, the degree of posterior humeral subluxation, and the occasional presence of associated cuff tears. However, in patients with an intact rotator cuff and lesser degrees of bone loss or subluxation, we do not consider age 70 or older an indication to perform RSA in primary GHOA.

Limitations

Readers of this study should be aware of several limitations when interpreting our results. First, there was no control group with which our patients were compared. It would have been better to compare these patients with a similar cohort that underwent RSA, but this is not standard practice at our institution. We used preoperative axillary view radiographs instead of CT scans to determine glenoid morphology. Although CT is considered a gold standard, a previous study did demonstrate that intraobserver agreement on the Walch classification based on plain radiographs is comparable to that based on CT.[1] Preoperative range of motion was determined by the surgeon in clinic, whereas postoperative range of motion was determined by a combination of surgeon assessment and patient questionnaires, meaning that this was not truly a direct comparison. Lastly, functional scores were not routinely obtained preoperatively, and so we were unable to calculate pre- to postoperative change in VAS and ASES scores.

Conclusions

Elderly patients with primary GHOA and an intact rotator cuff have excellent radiographic, functional, and clinical outcomes after anatomic TSA with low complication rates. Secondary rotator cuff failures and revision surgeries are both infrequent within the first 5 postoperative years. Despite recent trends, in our opinion, age greater than 70 should not be considered an indication in and of itself for RSA over TSA in patients with primary GHOA. To the contrary, older age may be associated with lower rates of implant failure and revision surgery compared with younger patients undergoing TSA.

Disclaimer

John W. Sperling receives royalties and is a paid consultant for Zimmer Biomet.

Joaquin Sanchez-Sotelo receives royalties from Stryker Corporation and is a paid speaker or consultant for Wright Medical Group Inc. and Exactech Inc.

The other authors, their immediate families, and any research foundations 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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