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ORIGINAL PAPER

Ream and run and total shoulder: patient and shoulder characteristics in five hundred forty-four concurrent cases

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Abstract

Purpose Total shoulder (TSA) is commonly used to treat arthritic shoulders with intact rotator cuffs; however, some patients choose a ream and run (RnR) to avoid the potential risks and limitations of a prosthetic glenoid component. Little is known about how patients selecting each of these two procedures compare and contrast.

Methods We analyzed the patient characteristics, shoulder characteristics, and two year clinical outcomes of 544 patients having RnR or TSA at the same institution during the same six year period.

Results Patients selecting the RnR were more likely to be male (92.0% vs. 47.0%), younger (58 ± 9 vs. 67 ± 10 years), married (83.2% vs. 66.8%), from outside of our state (51.7% vs. 21.7%), commercially insured (59.1% vs. 25.2%), and to have type B2 glenoids (46.0% vs. 27.8%) as well as greater glenoid retroversion (19 ± 11 vs. 15 ± 11 degrees) ($p < .001$). The average two year SST score for the RnRs was 10.0 ± 2.6 vs. 9.5 ± 2.7 for the TSAs. The percent of maximum possible improvement (%MPI) for the RnRs averaged 72 ± 39% vs. 73 ± 29% for the TSAs. Patients with work-related shoulder problems had lower two year SSTs and lower %MPIs. Younger patients having TSAs did less well than older patients. Female patients having RnRs did less well than those having TSAs ($p < 0.001$).

Conclusions This investigation highlights important characteristics of patients selecting the RnR and the TSA for glenohumeral arthritis. Excellent outcomes can be achieved for appropriately selected patients having either procedure.

Keywords Ream and run · Total shoulder · Clinical outcomes · Patient characteristics · Shoulder characteristics · Retroversion · Glenoid type

Level of Evidence III Cohort study

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Introduction

While anatomic total shoulder arthroplasty (TSA) is commonly used for the management of glenohumeral arthritis in shoulders with intact rotator cuff function, a substantial number of patients in our practice elect the ream and run arthroplasty after a discussion of the potential risks and benefits of both procedures [1–5]. We suspect that patients having a ream and run differ significantly from those having a TSA. Understanding these differences is essential to interpreting the outcomes for these two procedures and in refining their indications.

Materials and methods

This is a Level III Cohort study approved by our Institutional Review Board (IRB #38897).

Study design and participants

The shoulder arthroplasties in this study were performed at a single institution over a four year period by one of two high volume shoulder surgeons experienced in both the ream and run and TSA using a consistent surgical technique with the same prosthesis system (Global Advantage, Anchor Peg Glenoid; DePuy Synthes; Warsaw, IN) [6]. The decision to perform a ream and run or a TSA was made by each patient after a detailed discussion with the surgeon considering the two alternatives using standardized handouts [7–9].

The techniques for the ream and run and TSA procedures were identical except for the management of the glenoid. In the ream and run procedure, the glenoid was conservatively reamed to a single concavity with a diameter of curvature 2 mm greater than that of the humeral head prosthesis; no specific attempt was made to change glenoid version. In the TSA, the glenoid was conservatively reamed to a single concavity and a glenoid component with a fluted central peg was inserted; the central peg was uncemented while the three peripheral pegs were cemented; no specific attempt was made to change glenoid version [10–12].

Patients started active-assisted flexion on the day of surgery and gentle strengthening at six weeks after surgery. Activities were then progressed in a similar manner except that patients having TSA were advised to avoid high-level physical activities, such as those involving impact and large loads. Patients were offered a closed manipulation if they had refractory stiffness at six weeks after their arthroplasty.

In our database, patients are characterized by gender, age at surgery, race, marital status, height, weight, body mass index (BMI), location of residence, health insurance, use of narcotics, tobacco use, alcohol use, work relationship of the shoulder problem, presurgical optimism about the outcome, and the SF-36. The shoulder pathology is characterized by diagnosis, side, glenoid type, glenoid retroversion [13, 14], prior surgery on the shoulder, and the pre-operative Simple Shoulder Test [15, 16].

Glenohumeral pathoanatomy is characterized using standardized axillary views rather than using CT scans. This approach is well supported in the literature [1, 13, 14, 17, 18]: recent studies demonstrated that measurements of glenoid version on standardized axillary views were within 10 degrees of the values measured on CT scans [17], radiographs and computed tomography scans showed similar observer agreement when classifying glenoid morphology in glenohumeral arthritis [19], and the intra- and interobserver reproducibility for standardized axillary views was essentially identical as that for CT scans [20].

We identified 638 patients who had either a TSA or a ream and run arthroplasty between August 24, 2010, and August 9, 2016. Two-year clinical outcomes were available on 263 (89%) of the 295 ream and run procedures and 281 (82%) of the 343 TSAs enrolled during this study period. The clinical outcome was characterized as the final Simple Shoulder Test (SST) score and as the percent of maximal possible improvement (%MPI) in the SST [4, 5, 14, 16, 21] at 2 years (18–30 months) after surgery. The SST was selected because it has been extensively validated [15], because it is in widespread international use, and because outcomes measured with the SST closely parallel those obtained with the ASES, Constant and Penn scores [9]. The percent of maximum possible improvement was calculated by first determining the amount of improvement: the difference between the two year postoperative SST score and the pre-operative SST score. This number was then divided by the maximum possible improvement: the difference between a perfect score on the SST (12) and the pre-operative SST score; the quotient is expressed as a percent. A good clinical outcome has been defined as an improvement of at least 30% of the maximum possible improvement [5, 9, 14, 21–24].

Shoulders having a second procedure (either a manipulation or an open procedure) during the study period were characterized. At the discretion of the surgeon, deep tissue and prosthesis explant specimens were submitted for cultures specifically for Cutibacterium (Propionibacterium) [25, 26].

Continuous variables were described by mean and standard deviations and categorical variables by count and percentage. The ream and run and TSA procedures were compared using a two-sample t test for continuous and the chi-squared test for categorical variables (unadjusted analysis). Fisher's exact test was used when the chi-squared test was not valid. An adjusted comparison of the ream and run and total shoulder arthroplasty procedures utilized the doubly robust method [27] on multiply imputed data sets. All calculations were carried out in R (Austria, Vienna), version 3.5.0. $p < 0.05$ was used to denote statistical significance.

Table 1 Patient characteristics

	Ream and run		Total shoulder		*p*
	N	Mean ± SD (range) or *N* (%)	*N*	Mean ± SD (range) or *N* (%)	
Patient characteristics					
Age at surgery	263	58 ± 9 (32–81)	281	67 ± 10 (24–90)	< 0.001
Sex	263		281		< 0.001
Female		21 (8.0%)		149 (53.0%)	
Male		242 (92.0%)		132 (47.0%)	
Race	263		281		0.628*
White		252 (95.8%)		270 (96.1%)	
Asian		3 (1.1%)		1 (0.4%)	
Black or African American		3 (1.1%)		2 (0.7%)	
Native American Indian or Native Alaskan		2 (0.8%)		1 (0.4%)	
Native Hawaiian or other Pacific Islander		1 (0.4%)		1 (0.4%)	
Other or mixed		2 (0.8%)		6 (2.1%)	
Marital status	262		280		< 0.001
Married		218 (83.2%)		187 (66.8%)	
Domestic partner		4 (1.5%)		4 (1.4%)	
Single		29 (11.1%)		41 (14.6%)	
Divorced		5 (1.9%)		13 (4.6%)	
Widowed		4 (1.5%)		31 (11.1%)	
Other		2 (0.8%)		4 (1.4%)	
Patient height (in inches)	263	70 ± 3 (61–80)	281	67 ± 4 (51–78)	< 0.001
Patient weight (in pounds)	263	202 ± 37 (108–339)	281	191 ± 47 (101–364)	0.004
Body mass index (calculated)	263	28.9 ± 4.7 (18.4–47.3)	281	30.1 ± 6.4 (15.4–58.5)	0.008
Patient's residence	263		281		<0.001
In county of our medical center		42 (16.0%)		68 (24.2%)	
In the same half of state with our medical center		60 (22.8%)		91 (32.4%)	
In the opposite half of the state		25 (9.5%)		61 (21.7%)	
Outside our state		136 (51.7%)		61 (21.7%)	
Insurance primary	254		254		< 0.001*
Commercial		150 (59.1%)		64 (25.2%)	
Medicare		59 (23.2%)		154 (60.6%)	
Medicaid		9 (3.5%)		9 (3.5%)	
Medicare and Medicaid		0 (0.0%)		3 (1.2%)	
L&I		14 (5.5%)		16 (6.3%)	
Self-pay		2 (0.8%)		1 (0.4%)	
Other		20 (7.9%)		7 (2.8%)	
Narcotic medication use	259	43 (16.6%)	274	73 (26.6%)	0.005
Tobacco use	263		279		< 0.001
Never		163 (62.0%)		126 (45.2%)	
Quit		78 (29.7%)		138 (49.5%)	
Passive		8 (3.0%)		1 (0.4%)	
Yes		14 (5.3%)		14 (5.0%)	
Alcohol use	262	183 (69.8%)	280	172 (61.4%)	0.039
Work-related problem?	262	16 (6.1%)	281	22 (7.8%)	0.432
SF-36 physical functioning mean	245	73 ± 17 (0–100)	244	56 ± 23 (0–100)	< 0.001
SF-36 role physical mean	239	52 ± 30 (0–100)	243	41 ± 27 (0–100)	< 0.001
SF-36 role emotional mean	243	90 ± 20 (0–100)	245	79 ± 27 (0–100)	< 0.001
SF-36 mental health mean	242	81 ± 14 (20–100)	243	76 ± 17 (15–100)	< 0.001

Table 1 (continued)

	Ream and run		Total shoulder		*p*
	N	Mean ± SD (range) or *N* (%)	*N*	Mean ± SD (range) or *N* (%)	
SF-36 bodily pain mean	247	42 ± 20 (0–100)	252	35 ± 19 (0–90)	< 0.001
SF-36 vitality mean	241	65 ± 19 (6–100)	242	53 ± 21 (0–100)	< 0.001
SF-36 general health mean	244	78 ± 16 (25–100)	244	67 ± 20 (10–100)	< 0.001
SF-36 social functioning mean	242	80 ± 24 (0–100)	244	68 ± 27 (0–100)	< 0.001
SF-36 physical component summary	218	48 ± 18 (−3–95)	200	34 ± 20 (−18–84)	< 0.001
SF-36 mental component summary	218	87 ± 18 (22–118)	200	80 ± 21 (18–119)	< 0.001
Presurgical optimism	257	9.4 ± 0.9 (3.0–10.0)	276	9.2 ± 1.0 (5.0–10.0)	0.011

*Fisher's exact test

Table 2 Shoulder characteristics

	Ream and run		Total shoulder		*p*
	N	Mean ± SD (range) or *N* (%)	*N*	Mean ± SD (range) or *N* (%)	
Shoulder characteristics					
Primary diagnosis	263		281		0.053*
OA (DJD, osteoarthritis)		207 (78.7%)		235 (83.6%)	
Capsulorrhaphy arthropathy		28 (10.6%)		12 (4.3%)	
Secondary DJD		13 (4.9%)		14 (5.0%)	
PTA (post traumatic arthritis)		8 (3.0%)		9 (3.2%)	
Chondrolysis		6 (2.3%)		4 (1.4%)	
AVN (avascular necrosis)		1 (0.4%)		3 (1.1%)	
RA (rheumatoid arthritis)		0 (0.0%)		2 (0.7%)	
Other		0 (0.0%)		2 (0.7%)	
Which shoulder was operated on?	263		281		0.147
Left		111 (42.2%)		136 (48.4%)	
Right		152 (57.8%)		145 (51.6%)	
Glenoid type	261		277		< 0.001*
A1		6 (2.3%)		7 (2.5%)	
A2		93 (35.6%)		158 (57.0%)	
B1		40 (15.3%)		35 (12.6%)	
B2		120 (46.0%)		77 (27.8%)	
C		2 (0.8%)		0 (0.0%)	
Glenoid retroversion (degrees)	261	19 ± 11 (−7 to 55)	276	15 ± 11 (− 8 to 89)	< 0.001
Pre-operative surgical shoulder Simple Shoulder Test score	263	4.9 ± 2.4 (0.0–11.0)	281	2.9 ± 2.3 (0.0–10.0)	< 0.001
1. Is your shoulder comfortable with your arm at rest by your side?	263	155 (58.9%)**	281	151 (53.7%)	0.222
2. Does your shoulder allow you to sleep comfortably?	263	23 (8.7%)	281	22 (7.8%)	0.698
3. Can you reach the small of your back to tuck in your shirt with your hand?	263	76 (28.9%)	281	51 (18.1%)	0.003
4. Can you place your hand behind your head with the elbow straight out to the side?	263	86 (32.7%)	281	73 (26.0%)	0.085
5. Can you place a coin on a shelf at the level of your shoulder without bending your elbow?	263	170 (64.6%)	281	128 (45.6%)	< 0.001
6. Can you lift one pound (a full pint container) to the level of your shoulder without bending your elbow?	263	159 (60.5%)	281	99 (35.2%)	< 0.001
7. Can you lift eight pounds (a full gallon container) to the level of your shoulder without bending your elbow?	263	64 (24.3%)	281	26 (9.3%)	< 0.001
8. Can you carry twenty pounds at your side with this extremity?	263	214 (81.4%)	281	116 (41.3%)	< 0.001
9. Do you think you can toss a softball under-hand twenty yards with this extremity?	263	130 (49.4%)	281	50 (17.8%)	< 0.001
10. Do you think you can toss a softball over-hand twenty yards with this extremity?	263	16 (6.1%)	281	11 (3.9%)	0.244
11. Can you wash the back of your opposite shoulder with this extremity?	263	28 (10.6%)	281	17 (6.0%)	0.052
12. Would your shoulder allow you to work full-time at your regular job?	263	166 (63.1%)	281	80 (28.5%)	< 0.001
Difference between SST surgical vs. contralateral	261	1.1 ± 2.6 (− 5.0, 12.0)	278	0.2 ± 3.3 (− 12.0, 12.0)	< 0.001

*Fisher's exact test

**"Yes" responses, number (percent)

Table 3 Post-op outcomes

	Ream and run		Total shoulder		
	N	Mean ± SD (range)	*N*	Mean ± SD (range)	*p*
Post-op outcomes					
Surgical shoulder SST	263	10.0 ± 2.6 (0.0–12.0)	281	9.5 ± 2.7 (0.0–12.0)	0.021
%MPI	263	72 ± 39 (− 150, 100)	281	73 ± 29 (− 33, 100)	0.834

Source of funding

There was no extramural funding for this investigation.

Results

Patient characteristics

The 263 patients having the ream and run procedure were distinctly different from the 281 patients having TSA (Table 1). They were significantly more likely to be male (92.0% vs. 47.0%, $p < .001$), were younger (mean ± SD 58 ± 9 years vs. 67 ± 10 years, $p < .001$), were more likely to be married (83.2% vs. 66.8%, $p < .001$), had lower BMIs (mean ± SD 28.9 ± 4.7 vs. 30.1 ± 6.4, $p = 0.008$), were more likely to be from out of state (51.7% vs. 21.7%, $p < 0.001$), were more likely to have commercial insurance (59.1% vs. 25.2%, $p < 0.001$), were less likely to be taking narcotic pain medication (16.6% vs. 26.6%, $p = 0.005$), were more likely to have never smoked (62% vs. 45.2%, $p < 0.001$), more likely to use alcohol (70% vs. 61%, $p = 0.039$), had better SF-36 scores ($p = 0.001$), and higher presurgical optimism (mean ± SD 9.4 ± 0.9 vs. 9.2 ± 1.0, $p = 0.011$).

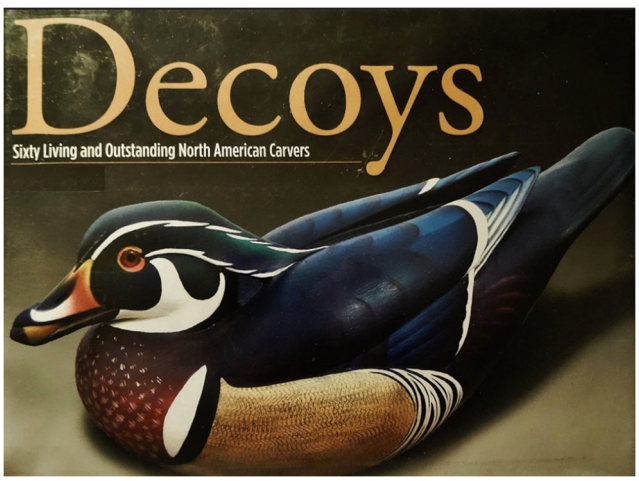

Fig. 1 Case 1. The patient is an internationally respected carver and collector of duck decoys

Shoulder characteristics

In comparison to the 281 patients having TSAs, the 263 patients having the ream and run were more likely to have type B2 glenoid pathoanatomy (46.0% vs. 27.8%), had greater average glenoid retroversion (mean ± SD 19 ± 11 vs. 15 ± 11 degrees), had higher pre-operative total SST scores (mean ± SD 4.9 ± 2.4 vs. 2.9 ± 2.3), and had a greater difference between the pre-operative SST scores of the surgical shoulder and the contralateral shoulder (mean ± SD 1.1 ± 2.6 vs. 0.2 ± 3.3) (Table 2).

Clinical outcomes

In spite of the marked differences in patient and shoulder characteristics, the clinical outcomes for the patients in the two different treatment groups were similar (Table 3). The mean ± SD of the final SST score for the ream and run procedures was 10.0 ± 2.6 vs. 9.5 ± 2.7 for the TSAs. The percent of maximum possible improvement averaged 72 ± 39 for the ream and run procedures and 73 ± 29 for the TSAs.

As examples, we present two patients having left shoulder arthroplasties 9 years ago, one having a total shoulder and one having a ream and run procedure.

The first patient (case 1) was 78 years of age at the time of his total shoulder arthroplasty (Fig. 1). His pre-operative radiographs show severe degenerative joint disease (Fig. 2). His post-operative radiographs are shown in Fig. 3. At 9 years after surgery he reports, “My left shoulder is now and has been in perfect condition with full 100% motion.”

The second patient (case 2) was a very active 50-year-old at the time of his ream and run arthroplasty. His pre-operative radiographs are shown in Fig. 4. His post-operative radiographs are shown in Fig. 5. At nine years after surgery he reports, “With my left shoulder I have no limitations and it feels like it did when I was in my 20s. The only problem I have right now is bruised ribs as I play flag football every weekend thanks to my surgery nine years ago. Today my shoulder is stronger than it was even three or four years ago. I am truly thankful for what the

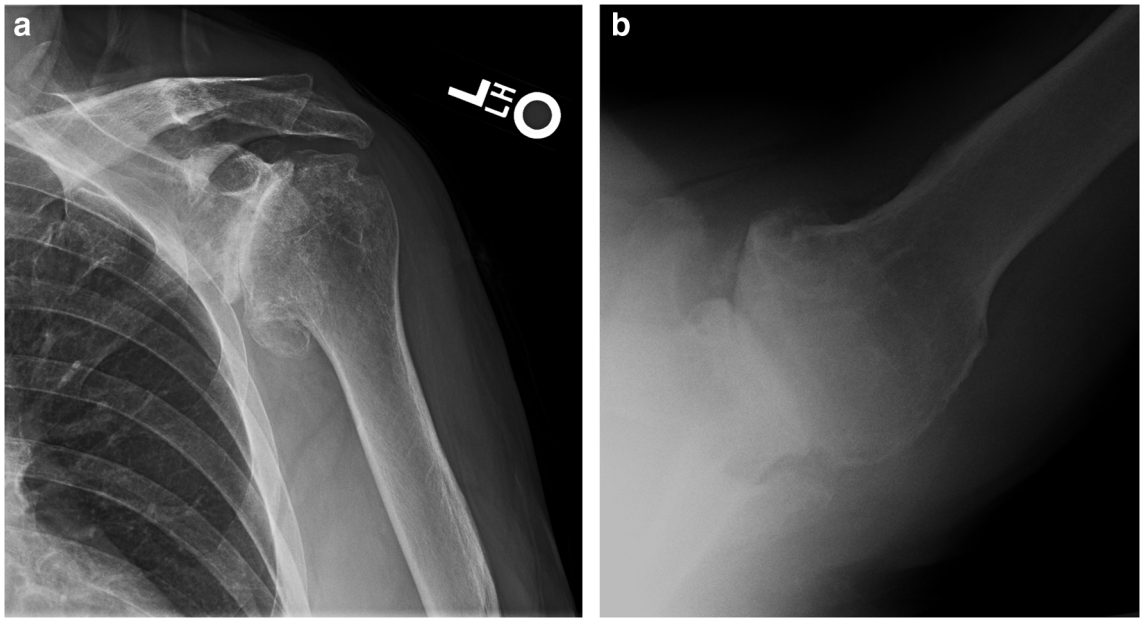

Fig. 2 Case 1. **a** Pre-operative AP and **b** axillary radiographs showing severe degenerative joint disease and a type A2 glenoid

surgery allows me to do that I could not before. I have retired from the corporate world and am now a high school teacher. I would not have been able to do this (writing on the board and beating my students in push-up contests) if it were not for my shoulder replacement." His physical activities are shown in the enclosed movie (Appendix Video in the Electronic Supplementary Material).

Factors associated with clinical outcomes

The multivariate regression demonstrated that gender, surgery type, gender by surgery type interaction, and work-related shoulder problems had statistically significant effects on both the final SST and %MPI. In comparison to female patients having the ream and run, female patients

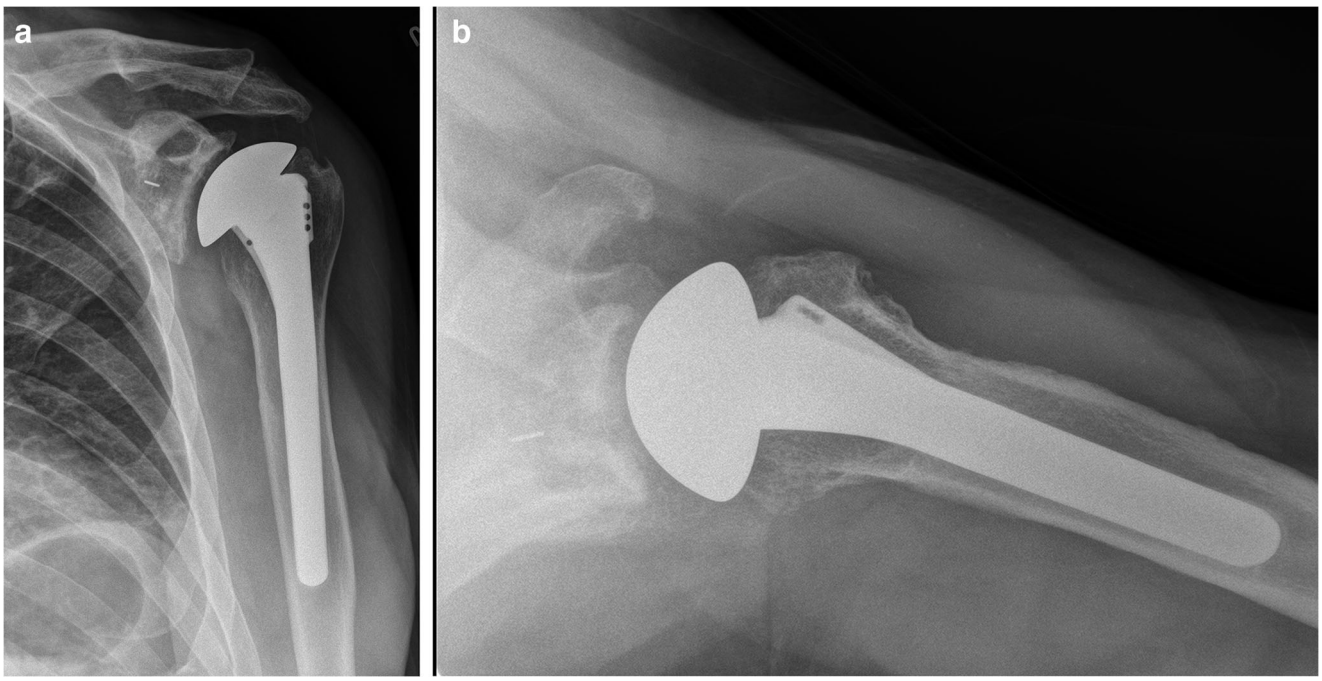

Fig. 3 Case 1. **a** Post-operative AP and **b** axillary radiographs showing secure fixation of the all-polyethylene glenoid component with bone ingrowth into the fluted central peg (arrow), and the fixation of a smooth stemmed humeral component with impaction autografting

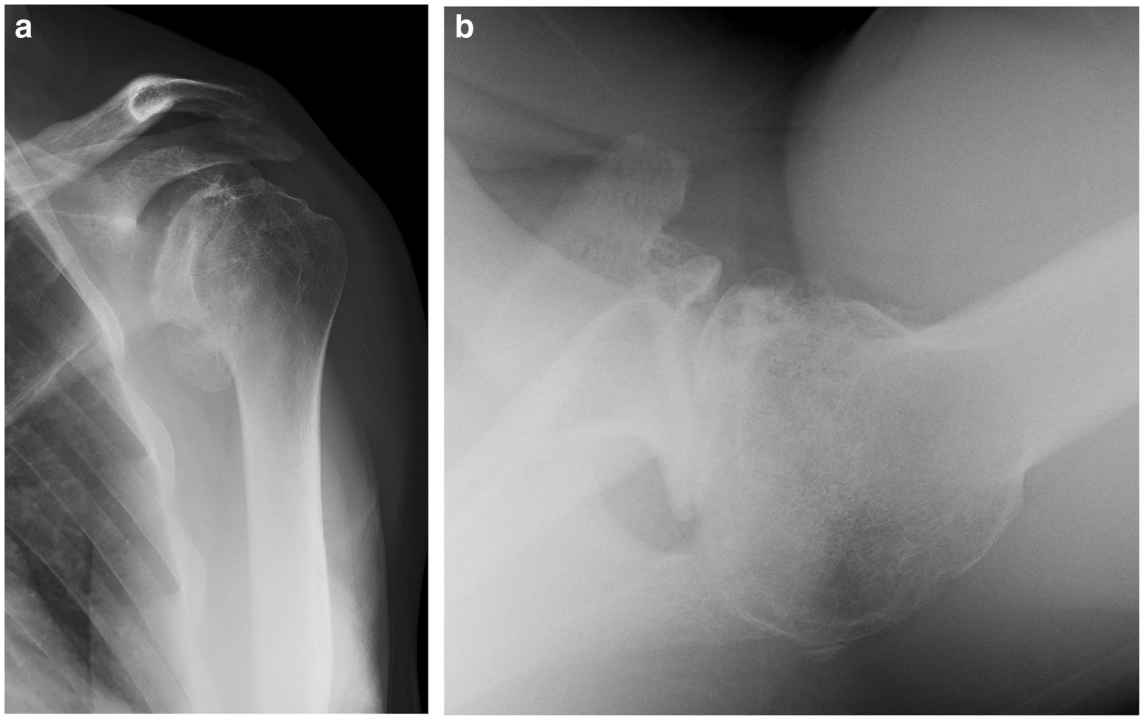

Fig. 4 Case 2. **a** Pre-operative AP and **b** axillary radiographs showing severe degenerative joint disease and a type B2 glenoid with biconcavity and posterior decentering of the head on the glenoid

having a TSA had significantly higher mean final SST scores (difference 2.4, 95% CI 1.0 to 3.8, $p < .001$) and higher mean %MPI (difference 30, 95% CI 14 to 46, $p < .001$) (Fig. 6) (Appendix Tables 1 and 2 in the Electronic Supplementary Material). By contrast, in comparison to those male patients having the ream and run, male patients having a TSA did not have significantly higher mean final SST scores (difference 0.3, 95% CI − 0.3 to 0.9, $p = 0.321$) or higher mean %MPI (difference 3, 95% CI − 4 to 10, $p = 0.421$). Patients with shoulder problems related to their work had lower mean final SST scores (difference − 2.3, 95% CI − 3.5 to − 1.1, $p < .001$) and lower mean %MPI (difference − 25, 95% CI − 39 to − 12, $p < .001$). While age did not have an effect on the ream

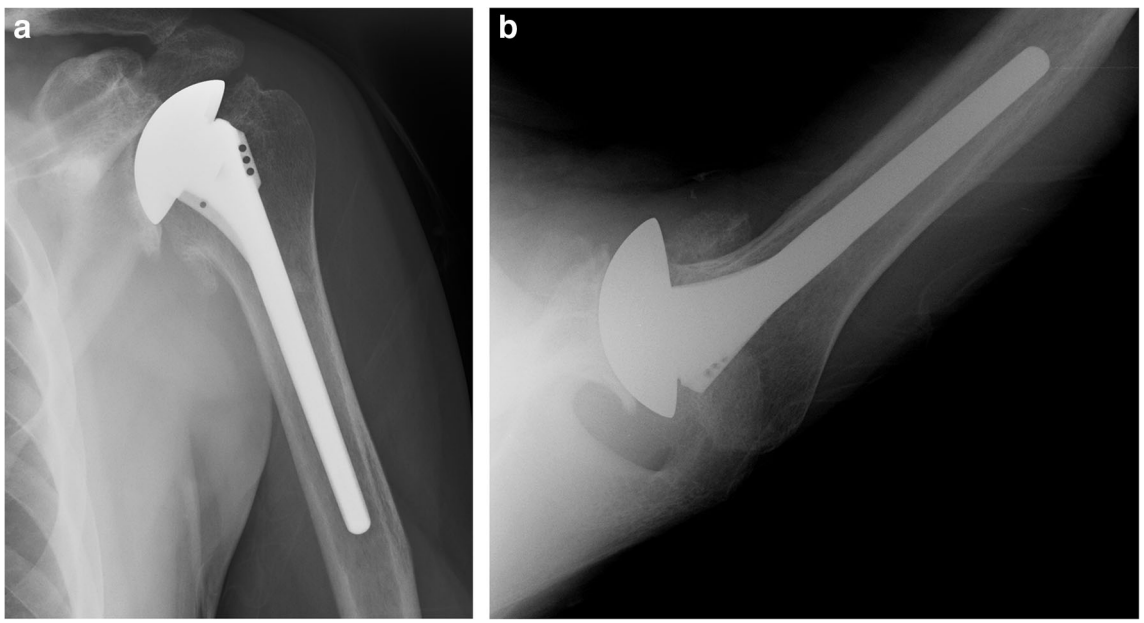

Fig. 5 Case 2. **a** Post-operative AP and **b** axillary radiographs showing centering of an anteriorly eccentric humeral head in the reamed glenoid, and the fixation of a smooth stemmed humeral component with impaction autografting

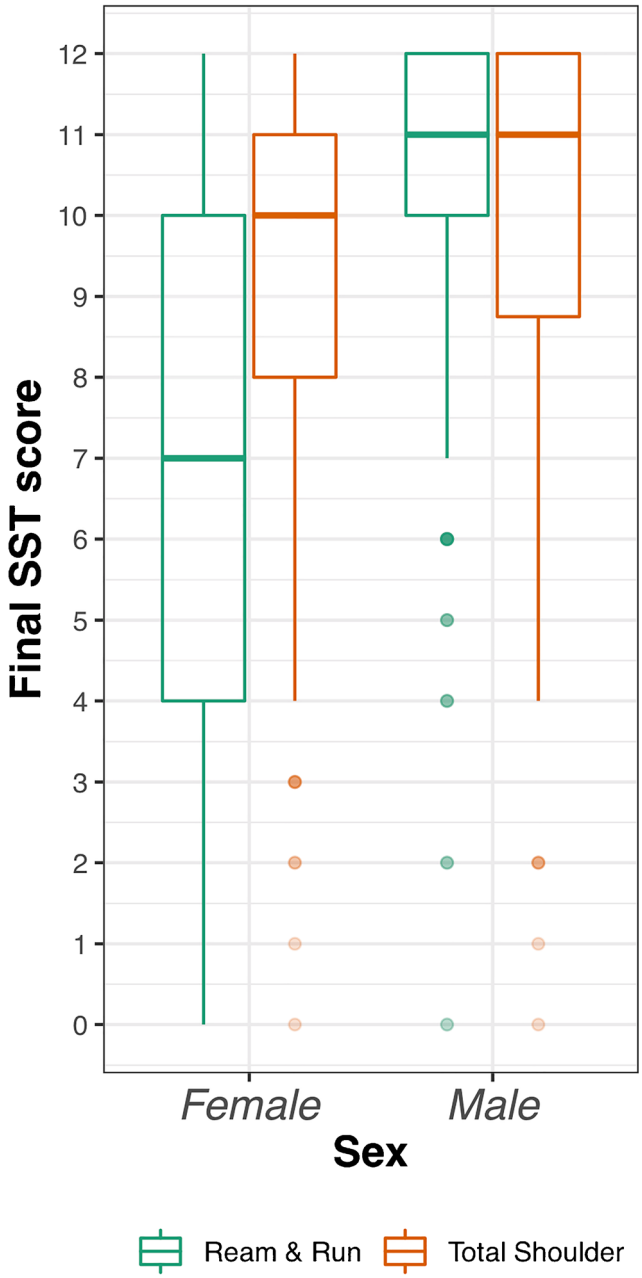

Fig. 6 The boxplot of the final SST by surgery type and gender

and run outcomes, younger patients tended to do significantly worse after TSA ($p < 0.001$) (Fig. 7).

Repeat procedures

Forty-seven patients (9%) had a second procedure within the study period; the two year outcomes for these patients were included in our analysis.

Among the 281 patients having a TSA, 13 (5%) had repeat procedures during the period of this study. The average age at the index total shoulder arthroplasty for the patients having a second procedure after a total shoulder was 57 ± 13 years, ten years younger that the average age of 67 ± ten years at the index TSA for those not having a second procedure ($p = 0.002$). Seven of the 13 (54%) patients having a second procedure after a TSA were female while 142 of the 268 (53%) not having a second procedure were female ($p = 0.954$). Six TSAs (2%) had a closed manipulation under anesthesia at an average of 15 weeks after their index arthroplasty. Two patients (1%) had arthroscopic procedures at other institutions—details of these arthroscopies were not available. Five patients (2%) had an open procedure at an average of six months after their index arthroplasty; these included two subscapularis repairs and three prosthetic revisions. Intra-operative cultures were obtained in three (60%) of these open revisions; none were positive.

Among the 263 patients having a ream and run procedure, 34 (13%) had a second procedure during the study period. The average age of the patients having a second procedure after a ream and run was 55 ± ten years in comparison to 58 ± nine years for the group not having a second procedure ($p = 0.018$). Seven (21%) of the 34 patients having a second procedure were female in comparison to 14 (6%) of the 229 ream and run patients not having a second procedure ($p = 0.004$). Twenty (8%) had a closed manipulation under anaesthesia at an average of 22 weeks after their index arthroplasty. Fourteen patients (5%) had an open procedure at an average of 15 months after their index arthroplasty; these included six exchanges of the humeral head component with soft tissue release, five complete single stage humeral component exchanges without additional glenoid surgery [28], and three conversions to a total shoulder. Intra-operative tissue and explant cultures were obtained in 12 (86%) of these open revisions; seven (58%) of these cultures were positive for Propionibacterium (Cutibacterium). All patients with positive cultures were males with the initial diagnosis of osteoarthritis; the average age (±SD) of these patients was 54 ± ten years.

Discussion

This study is unique in that it contrasts the patient characteristics and clinical outcomes between patients selected for one of two surgical techniques for managing the glenoid aspect of glenohumeral arthritis—the ream and run and the TSA—in a concurrent series of well-characterized cases performed by two surgeons experienced in both methods using consistent pre-operative and post-operative assessments and surgical technique. The final clinical outcomes for each of the two procedures were similar and were consistent with the Simple Shoulder Test scores for TSAs previously reported by other authors [9, 18, 29–38]. However, the characteristics of the patients and the characteristics of the shoulders having each of the two procedures were significantly different.

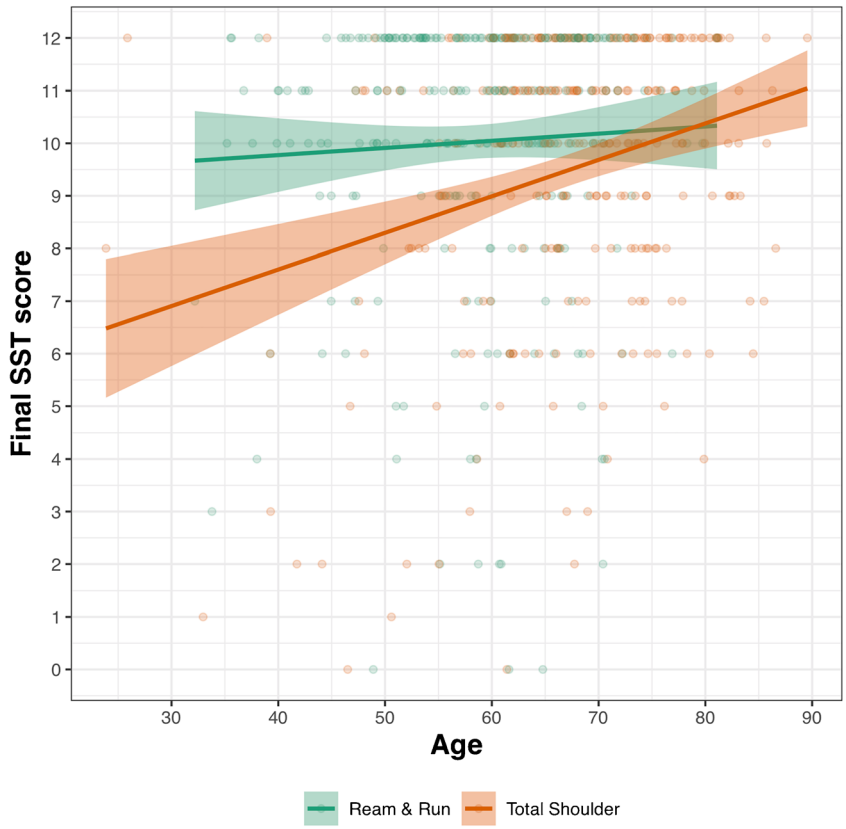

Fig. 7 Age vs. the final SST by surgery type. The lines are the linear regression fits and the shading represents the 95% confidence intervals around the means

Clinical outcomes were worse for younger patients having TSA, for female patients having the ream and run procedure, and for patients having work-related shoulder problems. Patients having a second procedure after either a TSA or a ream and run procedure were significantly younger than those not having a second procedure. Patients having a second procedure after a ream and run procedure were significantly more likely to be female than patients not having a second procedure. Half of the patients having a repeat open procedure after a ream and run procedure had positive deep tissue cultures for Propionibacterium (Cutibacterium), all were male patients with an average age of 54 ± ten years.

The results of this study should be viewed in light of certain limitations. First, this was not a randomized controlled trial, the procedure selection was determined by shared patient-surgeon decision making after a discussion of the relative risks and benefits. Second, of the 544 patients with glenohumeral arthritis and an intact rotator cuff who were enrolled in our longitudinal database between August 2010 and August 2016, 48% percent elected to have a ream and run procedure while 52% elected a total shoulder. This distribution of procedures is likely to be different than that for other centres. Third, the procedures were performed by one of two surgeons with a high level of experience in both the ream and run and the total shoulder arthroplasty; therefore, the results may not be generalizable to other settings. Fourth, while two year clinical outcomes were available for 89% of the ream and run procedures and 82% of the total shoulder arthroplasties, it is possible that the results would be different if data on those patients lost to follow-up were available. Fifth, longer-term studies may reveal different results.

This study demonstrates that excellent patient-reported clinical outcomes can be realized at two years after either a ream and run or a TSA in patients with glenohumeral arthritis and an intact rotator cuff. Patients with either procedure had an average two year SST score of 10 out of a possible score of 12 with an average improvement exceeding 70% of the maximal possible improvement. While the clinical outcomes were similar, the patients and the shoulders selected for the two different methods of managing the glenoid side of the glenohumeral joint were significantly different. Recognition of the importance of these differences in patient and shoulder characteristics may help inform surgical decision making with respect to these two surgical options.

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Compliance with ethical standards

Ethical review committee statement This study was approved by the Institutional Review Board (IRB) of the University of Washington (IRB Study #38897).

Conflict of interest The authors declare that they have no conflict of interest.

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