J Shoulder Elbow Surg (2019) 28, 244–251

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Comparative analysis of work-related outcomes in hemiarthroplasty with concentric glenoid reaming and total shoulder arthroplasty

Anirudh K. Gowd, BS[a], Grant H. Garcia, MD[b], Joseph N. Liu, MD[c], Marissa R. Malaret, BS[a], Brandon C. Cabarcas, BS[a], Anthony A. Romeo, MD[d,*]

[a]*Division of Sports Medicine, Department of Orthopedic Surgery, Rush University Medical Center, Chicago, IL, USA*
[b]*Division of Sports Medicine, Department of Orthopedic Surgery, Seattle Orthopedic Center, Seattle, WA, USA*
[c]*Division of Sports Medicine, Department of Orthopedic Surgery, Loma Linda University Medical Center, Loma Linda, CA, USA*
[d]*Division of Shoulder and Elbow Surgery, Department of Orthopedic Surgery, The Rothman Institute, New York, NY, USA*

Background: Anatomic total shoulder arthroplasty (aTSA) has demonstrated high levels of return to work, although there are fears of glenoid component loosening with higher work demand.
Methods: A retrospective query was performed of all patients who received hemiarthroplasty with ream-and-run resurfacing (Hemi RR) between 2005 and 2014. Included patients were matched to an aTSA cohort by age, body mass index, sex, and hand dominance. Preoperative and postoperative work status, by level of duty and occupation, was collected.
Results: Twenty-five patients receiving Hemi RR and 28 patients receiving TSA completed this questionnaire (82.8% compliance). Mean follow-up was 69.1 ± 24.8 months. In total, 100% of Hemi RR patients returned to work, and 89.3% of TSA patients returned to work ($P = .091$). The Hemi RR patients had higher rates of return to work for heavy-duty workers only (7 of 7 vs. 2 of 4, $P = .038$), although only 1 patient in the TSA group reported failure to work was due to shoulder reasons. Mean duration of return to work was 2.5 ± 4.8 months for patients receiving Hemi RR and 1.98 ± 2.6 months for those receiving TSA ($P = .653$).
Conclusions: Hemi RR had a high return to heavy-duty work, likely due to fewer surgeon-imposed restrictions. The results of this study may help manage return to work expectations after Hemi RR according to the level of duty and suggest Hemi RR is a viable option for heavy-duty laborers with end-stage glenohumeral arthritis.
Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: ream and run; glenohumeral arthritis; total shoulder arthroplasty; hemiarthroplasty; return to work; level of duty

The Rush University Medical Center Institutional Review Board approved this study.

*Reprint requests: Anthony A. Romeo, MD, Division of Shoulder and Elbow Surgery, Department of Orthopedic Surgery, Rothman Institute, 176 3rd Ave, New York, NY 10003, USA.
E-mail address: romeoortho@gmail.com (A.A. Romeo).

Patient demand for shoulder arthroplasty at younger ages is becoming exceedingly common. Demand in patients aged younger than 55 years is expected to increase by 333.3% by 2030 due to the world's aging population.[33] Age of retirement is also steadily increasing, drawing importance to the ability

1058-2746/$ - see front matter
https://doi.org/10.1016/j.jse.2018.07.026

to perform work-related tasks at older ages.[36] Returning to work after shoulder arthroplasty is becoming increasingly important to prospective patients. Establishing work-related outcomes is essential toward performing preoperative counseling and is relevant when determining the optimum treatment modality.

The anatomic total shoulder arthroplasty (aTSA) is the gold standard for the management of end-stage glenohumeral arthritis with an intact rotator cuff and generally has excellent functional outcomes.[40,41] The common criticism of the aTSA is that survivorship of the glenoid implant may not be suitable for younger or high-demand patients.[5,12,25,34,37] Survivorship for glenoid component loosening at 10 years is reported between 70% and 96%,[8,10,16,35,37,42] so there is some apprehension in performing an arthroplasty if there is an expectation that it will fail during a patient's life time. However, return to work in the short-term after aTSA is reported as excellent. The most recent study reports 92.3% return to work within 2.1 months after aTSA.[25] Still, there is concern for heavy-duty laborers, because a high duty of work will cause greater edge loading of the implant and subsequent component loosening.[7,25,34]

Hemiarthroplasty may also be used for management of arthritis; however, clinical outcomes are significantly inferior to that of aTSA.[9,11,20,24,46] Return to work outcomes have been previously established between 61.5% and 69.4%.[13,20] In addition, when the glenoid is not addressed, patients may experience persistent arthritic symptoms requiring subsequent conversion to TSA.[2,4,5] Patients with an additional conversion to TSA have also reported inferior outcomes compared with primary aTSA.[2,4] Hemiarthroplasty with the ream-and-run technique (Hemi RR) has recently been popularized as an alternative technique for glenoid resurfacing.[6,27,28,30,31,44,45] The lack of a glenoid component allows for fewer patient restrictions after rehabilitation, and reaming provides a fibrocartilaginous surface that facilitates glenohumeral articulation.[29] A growing body of evidence may suggest that the Hemi RR may be of significant value to younger populations with end-stage glenohumeral arthritis with a high demand of activity.[17,44]

By establishing return to work outcomes for the Hemi RR compared with aTSA, we may more appropriately set patient expectations and expand current treatment guidelines for indications of what the most appropriate treatment option is for this patient demographic. The hypothesis of this study was that patients receiving Hemi RR and aTSA would have equivalent return to work outcomes but that those with Hemi RR would find improved return to work in heavy-duty labor because this procedure does not restrict activity level.

Materials and methods

Study design

A prospectively maintained institutional registry was queried for all patients who underwent a primary Hemi RR procedure between 2004 and 2014 for end-stage glenohumeral osteoarthritis. Exclusion criteria included those receiving this surgery as a revision, those without working outcomes, and those receiving this procedure for alternative diagnoses. Minimum follow-up was 2 years. The resulting population cohort was matched 1:1 using the nearest neighbor method on the basis of age (±5 years), sex, body mass index (BMI), dominant extremity, and follow-up period (±6 months; Fig. 1).

Surgical technique and rehabilitation

The Hemi RR was performed similar to the technique of Matsen et al,[31] with some minor changes. Of note, the operating surgeon switched from performing a subscapularis tenotomy to a subscapularis peel in 2013. Attention was made to the glenoid surface after sizing of the humeral component. A guide pin was centered on the glenoid, and a reamer was used to remove articular cartilage down to cancellous bone, achieve appropriate concavity, and correct marginal retroversion. The diameter of the humeral implant was consistently 2 mm smaller than the diameter of concentric reaming.

The aTSA and Hemi RR cohorts were both rehabilitated on identical protocols. They wore a sling for 6 weeks and were restricted from active internal rotation and backward extension during this interval to protect the subscapularis. Passive to active range of motion was progressed from 6 weeks to 12 months. Strengthening was begun at 3 months. Patients undergoing aTSA were counseled that they should expect overhead lifting restrictions of 10 pounds (4.5 kg), whereas those undergoing Hemi RR did not have these restrictions.

Data collection

Included and matched patients were contacted via email and telephone. A previously established work-related questionnaire was administered to each patient (Appendix 1).[11-15,20,25,26] Patients were instructed to report duty of labor per the US Department of Labor classification according to pounds of lifting in their occupation.[47] Patient medical records were reviewed for latest BMI, sex, and comorbidities. Complications and revision surgery were questioned during patient contact but confirmed from review of the medical record.

Shoulder radiographs at the latest follow-up were compared with preoperative and initial postoperative images to evaluate humeral head decentering and medialization, respectively. Average follow-up of the latest radiograph was 38.3 ± 39.6 months in the Hemi RR group, and 37.4 ± 26.1 months in the aTSA group. All patients were monitored with radiographs, as standard of care, to check for signs of glenoid component loosening, subluxation, or dislocation. Two fellowship-trained orthopedic surgeons, who were blinded to patient name and outcomes, evaluated these radiographic measurements using previously described methodology.[19,39,45]

Outcomes

The primary outcome of interest was patient return to work with respect to duty of labor. Duty of labor was self-reported by the patient. Sedentary work was classified as up to 10 pounds (4.5 kg) of lifting. Light work involved exerting up to 20 pounds (9.1 kg) of force occasionally, and 10 pounds (4.5 kg) frequently. Medium work involved exerting 20 to 50 pounds (9.1 to 22.7 kg) occasionally, 10 to 25 pounds (9.1 to 11.3 kg) frequently, or 10 pounds (4.5 kg) constantly. Heavy work involved exerting 50 to 100 pounds (22.7 to 45.4 kg) occasionally, 25 to 50 pounds (11.3 to 27.7 kg)

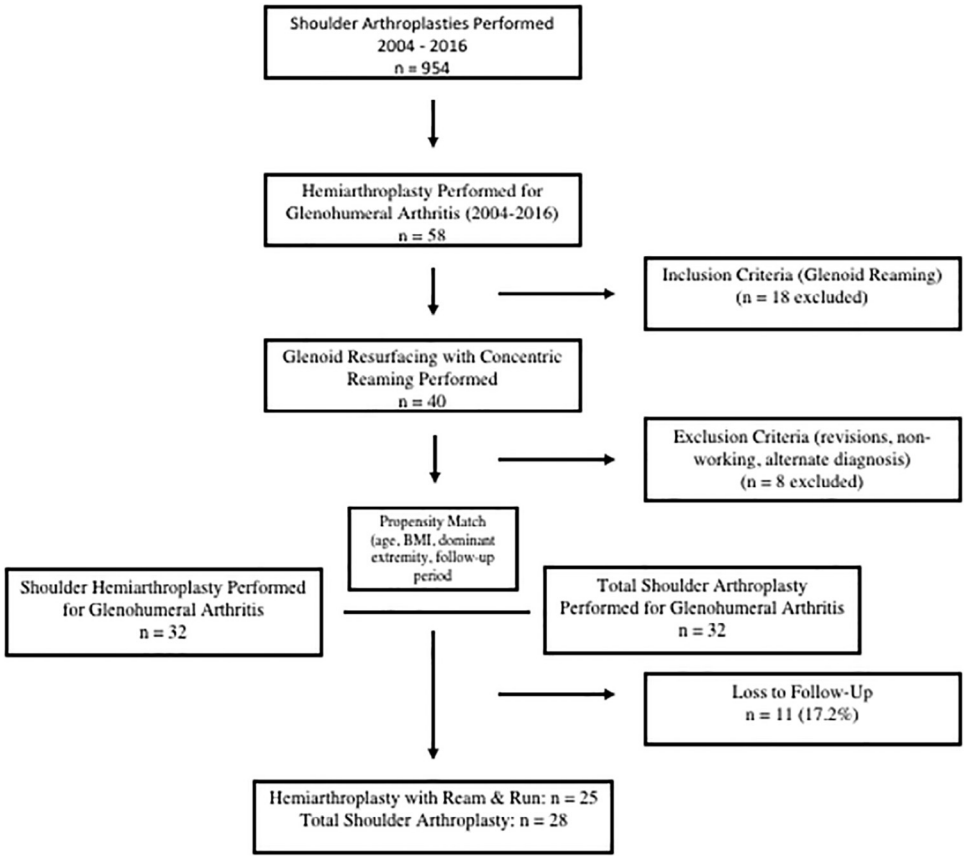

Figure 1 Selection criteria used to construct matched population cohorts undergoing hemiarthroplasty ream-and-run glenoid resurfacing and anatomic total shoulder arthroplasty.

frequently, or 10 to 20 pounds (4.5 to 9.1) constantly. Return to work at lower levels of duty was also noted.

Preoperative and postoperative clinical outcomes were evaluated using the American Shoulder and Elbow Surgeons (ASES) score. A distribution-based minimal clinically important difference (MCID) was calculated from these measures. A threshold value for substantial clinical benefit (SCB) was used from previous literature.[41] Previous literature was not used for MCID because the distribution-based calculation is specific to the patient population.[32] The calculated value for MCID was 11.9, which was within 1 standard deviation of previously established scores (13.6, 13.5).[40,49] Established SCB was 36.5.[41] The ratio of patients achieving these clinically significant outcomes was also evaluated.

Statistical analysis

RStudio 1.0.143 software (R Studio, Boston, MA, USA) was used for statistical computing. A Student *t* test was used to calculate differences between continuous variables, and a χ^2 goodness of fit test was used to compare categoric variables. Proportions were compared using a 2-sample *z* test. Significance was set to $P < .05$.

Results

After inclusion and exclusion criteria were applied, 32 consecutive Hemi RR patients were matched with 32 aTSA patients, and 53 patients (25 Hemi RR and 28 aTSA) were available for follow-up (82.8%). Demographic variables were re-evaluated to ensure that patient cohorts were still matched after loss to follow-up (Table I).

Patients were asked to name reasons for undergoing shoulder arthroplasty. For Hemi RR and aTSA, respectively, an equivalent number of patients wanted to continue to play sports/stay active (20% vs. 14.2%, $P = .582$), and return to work (16.0% vs. 3.6%, $P = .834$), Significantly more patients in the aTSA cohort reported that increased range of motion was the motivation for undergoing surgery (28.6% vs. 4.0%, $P = .017$).

After surgery, 17 of 25 Hemi RR and 21 of 28 aTSA patients reported no problems ($P = .575$). No patients reported dislocations or infections. Chronic pain was reported by 3 of 25 Hemi RR patients and 1 of 28 aTSA patients ($P = .246$). One patient in the Hemi RR cohort reported feeling unstable. This patient did not have any dislocations or subluxations but underwent conversion to an aTSA for persistent pain. The patient was very active and reported apprehension with regard to her surgical shoulder. Two patients in the aTSA cohort reported having weakness. There were 5 of 25 and 6 and 28 complaints of postoperative stiffness in Hemi RR and aTSA patients, respectively ($P = .897$). One patient in the Hemi RR complained of nagging

Table I Demographic characteristics of Hemi RR and aTSA cohorts

Variable	Hemi RR (n = 25)	aTSA (n = 28)	*P* value
Age at surgery, yr	52.8 ± 7.7	53.3 ± 9.2	.849
Body mass index, kg/m^2	28.5 ± 3.5	31.1 ± 5.7	.088
Follow-up, mo	68.6 ± 24.2	69.2 ± 26.9	.939
Previous procedures, No.	0.5 ± 0.6	0.4 ± 0.6	.862
Sex			.764
Male	23	25	
Female	2	3	
Right-hand dominant	15	13	.407
Preoperative ASES score	49.1 ± 12.1	44.3 ± 14.3	.120

Hemi RR, hemiarthroplasty with ream-and-run glenoid resurfacing; *aTSA*, anatomic total shoulder arthroplasty; *ASES*, American Shoulder and Elbow Surgeons.
Continuous data are presented as mean ± standard deviation and categoric data as number of patients.

Table II Clinical outcomes after Hemi RR and aTSA

Variable	Hemi RR	aTSA	*P* value
Satisfaction			
Good/excellent	17/18 (94.4)	20/20 (100.0)	.285
Patient-reported outcome measures			
Postoperative Short Form (12-Item)			
MCS	54.3 ± 8.4	56.2 ± 7.8	.401
PCS	48.8 ± 9.8	47.0 ± 10.0	.500
ΔASES score	35.9 ± 19.3	41.5 ± 22.7	.344
Achieved MCID	22/25 (88.0)	25/28 (89.3)	.881
Achieved SCB	10/25 (40.0)	18/28 (64.3)	.077

Hemi RR, hemiarthroplasty with ream-and-run glenoid resurfacing; *aTSA*, anatomic total shoulder arthroplasty; *MCS*, Mental Component Score; *PCS*, Physical Component Score; *ASES*, American Shoulder and Elbow Surgeons score; *MCID*, minimal clinically important difference; *SCB*, substantial clinical benefit.
Categoric data are presented as number of patients/total (%) and continuous data as mean ± standard deviation.

soreness, and another complained of acute pain. There were no other complaints in the aTSA cohort.

Three patients in the Hemi RR and 2 in the aTSA cohort returned to the operating room. In the Hemi RR cohort, 2 patients underwent conversion to aTSA at 123 months and 16 months postoperatively, and 1 patient received arthroscopic débridement. This patient had a bony overgrowth on the inferior aspect of the glenoid along with rotator cuff tendinitis that benefited from an arthroscopic débridement and reported dissatisfaction with the index surgery. The 2 patients who underwent conversion report they were fairly satisfied. In the aTSA cohort, 1 patient required a subscapularis repair and the other required revision aTSA with (isolated) glenoid explantation due to glenoid loosening at 86 months after the index surgery.

Eight patients in each cohort did not respond to satisfaction after surgery. In the Hemi RR and aTSA cohorts, respectively, there was 94.4% and 100% levels of good/excellent satisfaction of those who did respond ($P = .285$). There was no statistical difference in postoperative Mental Component ($P = .401$) or Physical Component ($P = .500$) scores on the 12-Item Short Form Health Survey. Both cohorts were equivalent with respect to change in ASES score ($P = .344$), achievement of MCID ($P = .881$), and achievement of SCB ($P = .077$). Both cohorts demonstrated equivalent measurements of medialization ($P = .660$), preoperative decentering ($P = .064$), and postoperative decentering ($P = .332$). Inter-rater reliability was measured as $\kappa = 0.873$, $\kappa = 0.715$, and $\kappa = 0.714$, respectively. Average medialization was –2.2 ± 5.0 mm in the Hemi RR and –1.5 ± 4.9 mm in the aTSA group. Average preoperative decentering was 3.7% ± 2.0% for Hemi RR and 5.7% ± 4.6% for aTSA, and postoperative decentering was 3.4 ± 2.5% for Hemi RR and 4.1 ± 2.9% for aTSA (Table II).

Two patients in both cohorts were covered by workers' compensation ($P = .904$). One of these patients, in the aTSA cohort, did not return to work, whereas the others were able to. Occupations of included patients are summarized in Table III. Some overlapping occupations were classified in differing level of duties because patients self-reported varying levels of lifting associated with their specific occupation. All patients in the Hemi RR cohort returned to work, whereas 25 of 28 returned to work in the aTSA cohort ($P = .091$). The average duration until return to work was 2.5 ± 4.8 months in the Hemi RR cohort and 2.0 ± 2.6 months in the aTSA cohort ($P = .653$). There was a statistically significant difference between Hemi RR and aTSA cohorts for return to heavy-duty work (7 of 7 vs. 2 of 4, $P = .038$; Table IV). In the aTSA group, 1 patient who was unable to return was 47 years old at time of surgery and employed as a firefighter. This patient was unable to return to work because of permanent restriction with overhead lifting above limited to 4.5 kg, which the patient was also counseled on before surgery. The other patient, 53 years old at time of surgery, was employed as a construction worker and unable to return to work for reasons unrelated to his shoulder. Of note, this patient underwent bilateral total knee arthroplasty approximately 18 and 24 months after his shoulder surgery.

Discussion

Work-related outcomes are becoming an increasingly important consideration in patients undergoing shoulder arthroplasty, and physicians are thus more often being required to counsel patients preoperatively with regard to these expectations. Furthermore, patient occupation is relevant to the clinical decision-making process of selecting which procedure to perform, because surgeons should take into account a patient's daily upper extremity use when selecting the appropriate treatment. A sedentary office secretary will not have identical glenohumeral joint forces at play as a coal miner, for instance.

Table III Summary of preoperative occupations in Hemi RR and aTSA

Duty level	No.	Hemi RR	No.	aTSA
Sedentary	7	Computer engineer ×2, financial executive ×3, quality assurance analyst, scientist	10	Accountant, attorney, manager, chemical engineer, computer engineer, financial trader ×2, logistic coordinator, physician, security professional
Light duty	7	Dentist, financial executive ×2, insurance agent, manager, police officer, salesman	5	Desk job (unspecified), elevator maintenance, engineer, professor, supermarket manager
Moderate duty	4	Deliveryman, electrician, police officer, waste plant operator	9	Electrician, engineer, manager ×4, retail, oil company maintenance
Heavy duty	7	Farming ×2, firefighter, funeral director, mason, physician, teacher/coach	4	Construction labor, firefighter, physical education teacher, truck driver

Hemi RR, Hemiarthroplasty with ream-and-run glenoid resurfacing ; *aTSA*, anatomic total shoulder arthroplasty.

Table IV Rate of return to work and mean duration of return to work stratified by level of duty

Variable	Hemi RR (n = 25)	aTSA (n = 28)	*P* value
Return to work			
Sedentary duty	7/7	9/10	.390
Light duty	7/7	5/5	>.99
Moderate duty	4/4	9/9	>.99
Heavy duty	7/7	2/4	**.038**
Overall	25/25	25/28	.091
Time to work, mo			
Sedentary duty	0.9 ± 1.1	2.1 ± 3.8	.433
Light duty	1.0 ± 1.7	1.3 ± 1.2	.743
Moderate duty	6.8 ± 11.5	2.1 ± 2.0	.236
Heavy duty	3.1 ± 2.3	3.0 ± 2.8	.950
Overall	2.5 ± 4.8	2.0 ± 2.6	.653

Hemi RR, Hemiarthroplasty with ream-and-run glenoid resurfacing; *aTSA*, Anatomic total shoulder arthroplasty.
Categoric data are shown as the proportion and continuous data as mean ± standard deviation.
The bold *P* value is statistically significant ($P < .05$).

Within our patient cohorts, we found excellent return to work in both Hemi RR and aTSA groups. Interestingly, heavy duty of labor patients had significantly greater return to work in the Hemi RR group than in the aTSA group, although this comparison was underpowered and likely limited by selection bias in which procedure was most appropriate for the patient. Regardless, the fact that all heavy-duty workers were able to return to work after Hemi RR, and remain working, is still significant because they did not have the same restrictions to overhead activity required by the aTSA cohort. The major findings of this study demonstrate nearly equivalent rates of return to work after Hemi RR and aTSA. Physicians should consider the Hemi RR as a viable option for younger patients with glenohumeral arthritis, particularly with higher levels of demand.

The aTSA has long been the gold standard for relief of symptomatic glenohumeral arthritis. Recent evidence suggests 75.6% of patients report feeling substantially better after this procedure, which is comparable to the proportion found in our cohort.[41] Previous measurements of return to work have varied considerably between 30.8% and 92.3% with respect to aTSA among 3 studies.[3,21,25] The 89.3% return to work reported in this study is most similar to the 92.3% reported by Liu et al,[25] most likely due to the similarities in age between the 2 cohorts (mean, 53.3 ± 9.2 vs. 48.4 ± 7.8 years). The Bulhoff et al[3] cohort was composed of significantly older mean age (71 years) that may confound return to work by proximity to retirement age.

Meanwhile, the series by Jawa et al[21] consisted of only workers' compensation patients involved in heavier duties of labor, of which, 7 of 13 reported not returning to work due to shoulder conditions. Previous reports have demonstrated consistently inferior results within the workers' compensation population,[1,18,22,48] which Jawa et al[21] corroborated when clinical outcomes were compared with the nonworkers' compensation population. Our series was not powered for this subanalysis because only 1 workers' compensation patient was unable to return to work.

Most importantly, Liu et al[25] found statistically lower return to work and longer time to return to work in heavy-duty labor populations. The present study further corroborates this finding, at least compared with Hemi RR. There likely exists some physician apprehension in recommending return to heavy-duty labor over fears of glenoid loosening and progressive wear, which is the most likely explanation for this finding. An electronic survey of ASES members demonstrated that physicians would restrict 25% of patients from any sport and 49% of patients from contact sports. This finding represents an analogous level of apprehension in shoulder surgeons restricting activity. Yet, Liu et al[25] and the present study both suggest some degree of durability of at least most of the aTSA in managing shoulder symptoms of patients involved in heavy-duty labor at 5 years of follow-up without work-related complications. The senior author (A.A.R.) shares this apprehension of glenoid loosening and consistently places overhead lifting restrictions of 10 pounds (4.5 kg) on patients receiving aTSA to prevent further need for revision. The Hemi RR provides an alternative solution in the heavy-duty laborer with glenohumeral arthritis because physicians would be less inclined to limit overhead lifting.

Work-related outcomes have only been established for hemiarthroplasty without glenoid resurfacing. Garcia et al[13] reported a 69.4% return, although there were no patients performing heavy-duty labor and only 4 patients involved in moderate-duty labor. Of note, the primary diagnosis for surgery was osteoarthritis in 50.6% of patients. In their cohort, 4 patients were converted to aTSA or reverse TSA.[13] Findings of the present study are substantially better; however, direct comparisons cannot be made because the present study only discussed the Hemi RR for glenohumeral arthritis in younger patients, whereas the cohort in the Garcia et al[13] study was an average age of 69 years with multiple included diagnoses. An additional cohort established by Hurwit et al,[20] analyzed return to work in patients after hemiarthroplasty for end-stage arthritis or cuff deficiency with glenoids that were not amenable to implant. Overall return to work was 70.7%, which is still considerably inferior to that of the present study. This difference suggests that the addition of concentric glenoid reaming significantly improves both patient satisfaction and functional outcomes.

Survivorship models for arthroplasty are relevant to work force populations to determine whether implants may last the entirety of a patient's life expectancy. Cumulative 10-year survivorship of aTSA have been reported between 70% and 96%, and most often failing due to glenoid component wear or loosening.[8,10,16,35,37,42] Comparatively, need for revision in hemiarthroplasty is reported to range from 7.5% to 25% over 10 years,[23,35,43] and persistent glenoid wear is most often cited as the reason for revision in 35% of cases.[35] Additional long-term survivorship data suggest that in patients aged younger than 55, cumulative implant survival rates for hemiarthroplasty and aTSA are 75% and 87%, respectively.[35] From this analysis, the need for conversion of hemiarthroplasty to aTSA is roughly double the rate at which aTSAs are revised for glenoid loosening. This may suggest that the hemiarthroplasty may not be as effective in younger populations as previously thought. In addition, long-term follow-up of hemiarthroplasties converted to aTSA have demonstrated inferior clinical outcomes, which may likely be due to continued progression of arthritic glenoid wear.[4,38]

Initial long-term series on the Hemi RR procedure suggest that 16% of patients required a subsequent procedure, of which only one-third required prosthetic revision.[44] Early clinical outcomes have demonstrated positive results with evidence of minimal medialization (2.3 ± 3.2 mm).[45] Similar findings were corroborated from the present study (−2.2 ± 5.0 mm). Furthermore, reaming invariably requires removal of bone stock, which may become an issue if future conversion is necessary. Medialization of the humeral component has also not been evidenced in previous studies nor in the present study with midterm follow-up.[45] Furthermore, clinical outcomes on patients with conversion to aTSA after reaming has not fully been evaluated, and additional long-term evaluation of this cohort may be valuable. In the present study, neither patient that required conversion to TSA reported any long-term issues, and both were able to return to work as a salesman and quality assurance analyst. Overall, the findings of this study add that patients can return to all levels of work. The Hemi RR is an important consideration in the young patient that desires high work load.

This study has some limitations. The primary limitation is the retrospective study design. As a consequence, the occupations between the cohorts were not identically matched. In addition, the sample size was limited by the infrequency of patients who were indicated for the Hemi RR.

Using a survey at long-term follow-up allows collection of specific and uniform information from all patients. However, patients may be subject to recall bias. This may particularly affect the time in months taken to return to work by the patient. To minimize this bias, patient medical records were cross-referenced to ensure accuracy of available information.

There were slight differences in patient selection for each procedure that limit the comparison between cohorts. Patients who received aTSA were counseled that they would have permanent overhead lifting restrictions, whereas those who underwent Hemi RR would not receive these restrictions. Therefore, there is significant selection bias in comparison between cohorts for heavy-duty workers. Still, the finding that heavy-duty workers had 100% return to work after Hemi RR is significant regardless of comparison to the return experienced by aTSA.

Lastly, no terminal radiographic analysis was performed, so medialization might have been present that was not discernible at the latest radiograph date.

Conclusion

Hemiarthroplasty with concentric glenoid reaming and aTSA both provided excellent rates of return to work. Hemi RR had a slightly higher return to heavy-duty work than aTSA, although the numbers were small, possibly due to fewer surgeon-imposed restrictions. The results of this study help manage return to work expectations after Hemi RR according to level of duty and suggest it as a viable option for heavy-duty laborers with end-stage glenohumeral arthritis.

Disclaimer

Anthony A. Romeo receives royalties from Arthrex Inc., is on the speakers bureau for Arthrex Inc., is a paid consultant for Arthrex Inc., receives research support from Arthrex Inc., DJO Surgical, Smith & Nephew, and Ossur; has received other financial support from Arthrex Inc. and DJO Surgical; receives publishing royalties from Saunders/Mosby-Elsevier; serves on the boards of *Journal of Shoulder and Elbow Surgery*, SLACK Inc., *Orthopedics Today*, *Orthopedics*, *Sports Health*, *Techniques in Shoulder and Elbow Surgery*, *Operative Techniques in Sports Medicine*, *Orthopaedic Journal of Sports Medicine*,

American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, and the Arthroscopy Association of North America. The remaining 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.

References

1. Balyk R, Luciak-Corea C, Otto D, Baysal D, Beaupre L. Do outcomes differ after rotator cuff repair for patients receiving workers' compensation? Clin Orthop Relat Res 2008;466:3025-33. http://dx.doi.org/10.1007/s11999-008-0475-1
2. Bryant D, Litchfield R, Sandow M, Gartsman GM, Guyatt G, Kirkley A. A comparison of pain, strength, range of motion, and functional outcomes after hemiarthroplasty and total shoulder arthroplasty in patients with osteoarthritis of the shoulder. A systematic review and meta-analysis. J Bone Joint Surg Am 2005;87:1947-56. http://dx.doi.org/10.2106/JBJS.D.02854
3. Bülhoff M, Sattler P, Bruckner T, Loew M, Zeifang F, Raiss P. Do patients return to sports and work after total shoulder replacement surgery? Am J Sports Med 2015;43:423-7. http://dx.doi.org/10.1177/0363546514557940
4. Carroll RM, Izquierdo R, Vazquez M, Blaine TA, Levine WN, Bigliani LU. Conversion of painful hemiarthroplasty to total shoulder arthroplasty: long-term results. J Shoulder Elbow Surg 2004;13:599-603. http://dx.doi.org/10.1016/j.jse.2004.03.016
5. Cheung EV, Sperling JW, Cofield RH. Revision shoulder arthroplasty for glenoid component loosening. J Shoulder Elbow Surg 2008;17:371-5. http://dx.doi.org/10.1016/j.jse.2007.09.003
6. Clinton J, Franta AK, Lenters TR, Mounce D, Matsen FA 3rd. Nonprosthetic glenoid arthroplasty with humeral hemiarthroplasty and total shoulder arthroplasty yield similar self-assessed outcomes in the management of comparable patients with glenohumeral arthritis. J Shoulder Elbow Surg 2007;16:534-8. http://dx.doi.org/10.1016/j.jse.2006.11.003
7. Collins D, Tencer A, Sidles J, Matsen F 3rd. Edge displacement and deformation of glenoid components in response to eccentric loading. The effect of preparation of the glenoid bone. J Bone Joint Surg Am 1992;74:501-7.
8. Dillon MT, Ake CF, Burke MF, Singh A, Yian EH, Paxton EW, et al. The Kaiser Permanente shoulder arthroplasty registry: results from 6,336 primary shoulder arthroplasties. Acta Orthop 2015;86:286-92. http://dx.doi.org/10.3109/17453674.2015.1024565
9. Edwards TB, Kadakia NR, Boulahia A, Kempf JF, Boileau P, Nemoz C, et al. A comparison of hemiarthroplasty and total shoulder arthroplasty in the treatment of primary glenohumeral osteoarthritis: results of a multicenter study. J Shoulder Elbow Surg 2003;12:207-13. http://dx.doi.org/10.1016/S1058-2746(02)86804-5
10. Fox TJ, Cil A, Sperling JW, Sanchez-Sotelo J, Schleck CD, Cofield RH. Survival of the glenoid component in shoulder arthroplasty. J Shoulder Elbow Surg 2009;18:859-63. http://dx.doi.org/10.1016/j.jse.2008.11.020
11. Garcia GH, Liu JN, Mahony GT, Sinatro A, Wu HH, Craig EV, et al. Hemiarthroplasty versus total shoulder arthroplasty for shoulder osteoarthritis: a matched comparison of return to sports. Am J Sports Med 2016;44:1417-22. http://dx.doi.org/10.1177/0363546516632527
12. Garcia GH, Liu JN, Sinatro A, Wu H-H, Dines JS, Warren RF, et al. High satisfaction and return to sports after total shoulder arthroplasty in patients aged 55 years and younger. Am J Sports Med 2017;45:1664-9. http://dx.doi.org/10.1177/0363546517695220
13. Garcia GH, Mahony GT, Fabricant PD, Wu HH, Dines DM, Warren RF, et al. Sports- and work-related outcomes after shoulder hemiarthroplasty. Am J Sports Med 2016;44:490-6. http://dx.doi.org/10.1177/0363546515613077
14. Garcia GH, Taylor SA, Mahony GT, DePalma BJ, Grawe BM, Nguyen J, et al. Reverse total shoulder arthroplasty and work-related outcomes. Orthopedics 2016;39:e230-5. http://dx.doi.org/10.3928/01477447-20160119-03
15. Garcia GH, Wu HH, Liu JN, Huffman GR, Kelly JD 4th. Outcomes of the remplissage procedure and its effects on return to sports. Am J Sports Med 2015;44:1124-30. http://dx.doi.org/10.1177/0363546515626199
16. Gauci MO, Bonnevialle N, Moineau G, Baba M, Walch G, Boileau P. Anatomical total shoulder arthroplasty in young patients with osteoarthritis. Bone Joint J 2018;100-B:485-92. http://dx.doi.org/10.1302/0301-620X.100B4.BJJ-2017-0495.R2
17. Getz CL, Kearns KA, Padegimas EM, Johnston PS, Lazarus MD, Williams GR. Survivorship of hemiarthroplasty with concentric glenoid reaming for glenohumeral arthritis in young, active patients with a biconcave glenoid. J Am Acad Orthop Surg 2017;25:715-23. http://dx.doi.org/10.5435/JAAOS-D-16-00019
18. Henn RF 3rd, Tashjian RZ, Kang L, Green A. Patients with workers' compensation claims have worse outcomes after rotator cuff repair. J Bone Joint Surg Am 2008;90:2105-13. http://dx.doi.org/10.2106/JBJS.F.00260
19. Hsu JE, Gee AO, Lucas RM, Somerson JS, Warme WJ, Matsen FA 3rd. Management of intraoperative posterior decentering in shoulder arthroplasty using anteriorly eccentric humeral head components. J Shoulder Elbow Surg 2016;25:1980-8. http://dx.doi.org/10.1016/j.jse.2016.02.027
20. Hurwit DJ, Liu JN, Garcia GH, Mahony G, Wu HH, Dines DM, et al. A comparative analysis of work-related outcomes after humeral hemiarthroplasty and reverse total shoulder arthroplasty. J Shoulder Elbow Surg 2017;26:954-9. http://dx.doi.org/10.1016/j.jse.2016.10.004
21. Jawa A, Dasti UR, Fasulo SM, Vaickus MH, Curtis AS, Miller SL. Anatomic total shoulder arthroplasty for patients receiving workers' compensation. J Shoulder Elbow Surg 2015;24:1694-7. http://dx.doi.org/10.1016/j.jse.2015.04.017
22. Lambers Heerspink FO, Dorrestijn O, van Raay JJ, Diercks RL. Specific patient-related prognostic factors for rotator cuff repair: a systematic review. J Shoulder Elbow Surg 2014;23:1073-80. http://dx.doi.org/10.1016/j.jse.2014.01.001
23. Levy O, Copeland SA. Cementless surface replacement arthroplasty (Copeland CSRA) for osteoarthritis of the shoulder. J Shoulder Elbow Surg 2004;13:266-71. http://dx.doi.org/10.1016/j.jse.2004.01.005
24. Liu JN, Garcia GH, Mahony G, Wu HH, Dines DM, Warren RF, et al. Sports after shoulder arthroplasty: a comparative analysis of hemiarthroplasty and reverse total shoulder replacement. J Shoulder Elbow Surg 2016;25:920-6. http://dx.doi.org/10.1016/j.jse.2015.11.003
25. Liu JN, Garcia GH, Wong AC, Sinatro A, Wu HH, Dines DM, et al. Return to work after anatomic total shoulder arthroplasty for patients 55 years and younger at average 5-year follow-up. Orthopedics 2018;41:e310-5. http://dx.doi.org/10.3928/01477447-20180213-08
26. Liu JN, Wu HH, Garcia GH, Kalbian IL, Strickland SM, Shubin Stein BE. Return to sports after tibial tubercle osteotomy for patellofemoral pain and osteoarthritis. Arthroscopy 2018;34:1022-9. http://dx.doi.org/10.1016/j.arthro.2017.09.021
27. Matsen FA 3rd. The ream and run: not for every patient, every surgeon or every problem. Int Orthop 2015;39:255-61. http://dx.doi.org/10.1007/s00264-014-2641-2
28. Matsen FA 3rd. Survivorship of hemiarthroplasty with concentric glenoid reaming for glenohumeral arthritis in young, active patients with a biconcave glenoid. J Am Acad Orthop Surg 2018;26:e164-6. http://dx.doi.org/10.5435/JAAOS-D-17-00788
29. Matsen FA 3rd, Clark JM, Titelman RM, Gibbs KM, Boorman RS, Deffenbaugh D, et al. Healing of reamed glenoid bone articulating with a metal humeral hemiarthroplasty: a canine model. J Orthop Res 2005;23:18-26. http://dx.doi.org/10.1016/j.orthres.2004.06.019

30. Matsen FA 3rd, Warme WJ, Jackins SE. Can the ream and run procedure improve glenohumeral relationships and function for shoulders with the arthritic triad? Clin Orthop Relat Res 2015;473:2088-96. http://dx.doi.org/10.1007/s11999-014-4095-7
31. Matsen FA 3rd, Lippitt SB. Current technique for the ream-and-run arthroplasty for glenohumeral osteoarthritis. JBJS Essent Surg Techn 2012;2:e20.
32. Nwachukwu BU, Runyon RS, Kahlenberg CA, Gausden EB, Schairer WW, Allen AA. How are we measuring clinically important outcome for operative treatments in sports medicine? Phys Sportsmed 2017;45:159-64. http://dx.doi.org/10.1080/00913847.2017.1292108
33. Padegimas EM, Maltenfort M, Lazarus MD, Ramsey ML, Williams GR, Namdari S. Future patient demand for shoulder arthroplasty by younger patients: national projections. Clin Orthop Relat Res 2015;473:1860-7. http://dx.doi.org/10.1007/s11999-015-4231-z
34. Pinkas D, Wiater B, Wiater JM. The glenoid component in anatomic shoulder arthroplasty. J Am Acad Orthop Surg 2015;23:317-26. http://dx.doi.org/10.5435/JAAOS-D-13-00208
35. Rasmussen J V, Hole R, Metlie T, Brorson S, Äärimaa V, Demir Y, et al. Anatomical total shoulder arthroplasty used for glenohumeral osteoarthritis has higher survival rates than hemiarthroplasty: a Nordic registry-based study. Osteoarthritis Cartilage. 2018;26:659-65. http://dx.doi.org/10.1016/j.joca.2018.02.896
36. Riffkin R. Americans settling on older retirement age. Gallup <https://news.gallup.com/poll/182939/americans-settling-older-retirement-age.aspx>; 2015, accessed April 16, 2018.
37. Roberson TA, Bentley JC, Griscom JT, Kissenberth MJ, Tolan SJ, Hawkins RJ, et al. Outcomes of total shoulder arthroplasty in patients younger than 65 years: a systematic review. J Shoulder Elbow Surg 2017;26:1298-306. http://dx.doi.org/10.1016/j.jse.2016.12.069
38. Sassoon AA, Rhee PC, Schleck CD, Harmsen WS, Sperling JW, Cofield RH. Revision total shoulder arthroplasty for painful glenoid arthrosis after humeral head replacement: the nontraumatic shoulder. J Shoulder Elbow Surg 2012;21:1484-91. http://dx.doi.org/10.1016/j.jse.2011.11.028
39. Service BC, Hsu JE, Somerson JS, Russ SM, Matsen FA 3rd. Does postoperative glenoid retroversion affect the 2-year clinical and radiographic outcomes for total shoulder arthroplasty? Clin Orthop Relat Res 2017;475:2726-39. http://dx.doi.org/10.1007/s11999-017-5433-3
40. Simovitch R, Flurin P-H, Wright T, Zuckerman JD, Roche CP. Quantifying success after total shoulder arthroplasty: the minimal clinically important difference. J Shoulder Elbow Surg 2018;27:298-305. http://dx.doi.org/10.1016/j.jse.2017.09.013
41. Simovitch R, Flurin PH, Wright T, Zuckerman JD, Roche CP. Quantifying success after total shoulder arthroplasty: the substantial clinical benefit. J Shoulder Elbow Surg 2018;27:903-11. http://dx.doi.org/10.1016/j.jse.2017.12.014
42. Singh JA, Sperling JW, Cofield RH. Revision surgery following total shoulder arthroplasty: analysis of 2588 shoulders over three decades (1976 to 2008). J Bone Joint Surg Br 2011;93:1513-7. http://dx.doi.org/10.1302/0301-620X.93B11.26938
43. Singh JA, Sperling JW, Cofield RH. Risk factors for revision surgery after humeral head replacement: 1,431 shoulders over 3 decades. J Shoulder Elbow Surg 2012;21:1039-44. http://dx.doi.org/10.1016/j.jse.2011.06.015
44. Somerson JS, Matsen FA 3rd. Functional outcomes of the ream-and-run shoulder arthroplasty: a concise follow-up of a previous report. J Bone Joint Surg Am 2017;99:1999-2003. http://dx.doi.org/10.2106/JBJS.17.00201
45. Somerson JS, Neradilek MB, Service BC, Hsu JE, Russ SM, Matsen FA 3rd. Clinical and radiographic outcomes of the ream-and-run procedure for primary glenohumeral arthritis. J Bone Joint Surg Am 2017;99:1291-304. http://dx.doi.org/10.2106/JBJS.16.01201
46. Sowa B, Thierjung H, Bülhoff M, Loew M, Zeifang F, Bruckner T, et al. Functional results of hemi- and total shoulder arthroplasty according to diagnosis and patient age at surgery. Acta Orthop 2017;88:310-4. http://dx.doi.org/10.1080/17453674.2017.1280656
47. United States Department of Labor. Dictionary of occupational titles (4th ed, rev 1991): appendix C. Washington, DC: U.S. Department of Labor.
48. Verma NN, Garretson R, Romeo AA. Outcome of arthroscopic repair of type II SLAP lesions in worker's compensation patients. HSS J 2007;3:58-62. http://dx.doi.org/10.1007/s11420-006-9023-2
49. Werner BC, Chang B, Nguyen JT, Dines DM, Gulotta LV. What change in American Shoulder and Elbow Surgeons Score represents a clinically important change after shoulder arthroplasty? Clin Orthop Relat Res 2016;474:2672-81. http://dx.doi.org/10.1007/s11999-016-4968-z