Original Article

Arthroscopic Lysis of Adhesions for Stiffness After Surgical Management of Proximal Humerus Fractures Leads to Satisfactory Outcomes in Most Patients

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Purpose: To report patient-reported outcomes (PROs), range of motion (ROM), and satisfaction, in patients who underwent arthroscopic lysis of adhesions for stiffness after open reduction with internal fixation (ORIF) or reverse shoulder arthroplasty (RSA) for fracture. **Methods:** A retrospective review was performed to identify patients with stiffness who underwent arthroscopic lysis of adhesions following ORIF or RSA for proximal humerus fracture at a single institution between 2012 and 2021 with minimum 1-year follow-up. PROs including visual analog scale for pain (VAS), American Shoulder and Elbow Surgeons (ASES), and Subjective Shoulder Value (SSV), as well as active ROM including forward flexion (FF), external rotation (ER), internal rotation (IR), were collected pre- and postoperatively. Attempted nonoperative treatment before arthroscopic lysis of adhesions was documented. Complications and satisfaction were also recorded. **Results:** A total of 21 patients met the study criteria (4 RSA, 17 ORIF), with an average age of 66.7 ± 8 years. The study sample comprised mostly of female patients (90%). The mean time from the index surgery to arthroscopy was 9 months, and mean follow-up post-lysis was 17 months. Patients with ORIF reported significant pain relief (VAS, Δ −3.2) and improvement in range of motion (FF, Δ 36°; ER, Δ 20°; IR Δ 3 spinal levels) and PROs (ASES, Δ 34.7; SSV Δ 44.8) ($P <$ .01) after lysis. Patients with RSA had significant improvement in ASES (Δ 21.8; $P = .04$), SSV (Δ 8.8; $P = .04$), and FF (Δ 38; $P = .02$) but did not have significant improvement in VAS (Δ −2; $P = .2$), ER (Δ 0°; $P = 1.0$), and IR (Δ 1 spinal level; $P = .2$). Satisfaction was 100% in the RSA cohort and 82% in the ORIF cohort. No complications were observed. **Conclusions:** Arthroscopic lysis of adhesions for stiffness after surgical management of proximal humerus fracture leads to satisfactory outcomes in most patients. Post-ORIF, patients may achieve improvement in PROs and global ROM, whereas post-RSA, patients may achieve improvement in PROs and FF but do not necessarily improve in rotational ROM. **Level of Evidence:** Level IV, therapeutic case series.

Common surgical treatment options for proximal humerus fractures include open reduction with internal fixation (ORIF) and reverse shoulder arthroplasty (RSA).[1] Although both procedures have yielded satisfactory patient-reported outcomes (PROs) and complication rates, RSA has demonstrated improved forward flexion (FF) compared with ORIF, and ORIF improved external rotation (ER) compared with RSA.[1-3] The decision between ORIF and RSA varies based on the fracture pattern and patient population. For instance, RSA has been associated with greater quality of life in elderly patients (age >70 years).[4] Regardless of which intervention is performed, the postoperative period follows a similar course with physical therapy (PT) routinely prescribed to expedite range of motion (ROM) recovery.[5,6] Nevertheless, stiffness continues to be a known complication that represents a source of patient dissatisfaction regardless of surgical treatment.[5-7]

Arthroscopy provides a minimally invasive treatment options to address complications following ORIF or RSA.[6,8-10] The utility of arthroscopic lysis of adhesions in adhesive capsulitis has been well-documented,

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Received July 11, 2023; accepted October 4, 2023.

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2666-061X/23965

https://doi.org/10.1016/j.asmr.2023.100821

and its use for stiffness following trauma also has been reported. Nevertheless, studies assessing outcomes in the latter patient cohorts remain limited, often characterized by short follow-up duration or a lack of specificity regarding prior attempts at conservative measures.[11,12]

The purpose of this study was to report PROs, ROM, and satisfaction in patients who underwent arthroscopic lysis of adhesions for stiffness after ORIF or RSA for fracture. The hypothesis was that patients undergoing lysis of adhesions would experience greater improvements in function in the post-ORIF setting compared to the post-RSA setting.

Methods

Study Design

A retrospective review from a prospectively collected database was performed on consecutive patients who underwent arthroscopic lysis of adhesions for persistent stiffness following ORIF or RSA for treatment of a proximal humerus fracture between January 2012 and December 2022 at a single institution. Institutional review board exemption was obtained before the study's inception. The inclusion criteria were (1) patients treated for 3- or 4-part proximal humerus fractures, (2) postoperative stiffness defined as patient-perceived lack of satisfaction with ROM, (3) failed conservative management for stiffness including at least 3 months of PT, and (4) minimum 1-year follow-up. Those with (1) revision to RSA from ORIF, (2) concomitant aseptic loosening or rotator cuff pathology, (3) history of trauma or fractures around the shoulder, (4) nerve injury, or (5) incomplete data were excluded.

Post-Fracture Management and Rehabilitation

Following either ORIF or RSA for proximal humerus fracture, all patients were placed in a sling for a duration of 4 weeks postoperatively. After this initial period, the sling was removed and patients commenced passive ROM exercises. After 4 weeks of ROM exercises alone, strengthening exercises were added to the protocol, which patients continued for 2 months while progressively increasing weight. Patients were followed at the 2-week, 3-month, 6-month, and 12-month time points postoperatively.

For patients with persistent stiffness beyond the 3-month mark, PT was re-prescribed focusing exclusively on ROM. In ORIF cases in which PT alone failed to restore adequate motion, patients were offered intra-articular steroid injections, with a maximum of 2 injections permitted. If PT and injections did not yield satisfactory improvements in motion, surgical release was offered.

Lysis of Adhesions Surgical Technique

All surgeries were performed in patients in the lateral decubitus position by the senior author (P.J.D.). Lysis of adhesions following RSA has distinct considerations and has been described previously in detail.[13] In these cases, the posterior portal was established at a slightly superior position to avoid implant contact. The subacromial space was re-established first followed the subcoracoid space. The subcoracoid space was cleared until the anterior glenosphere was visualized.

For patients with ORIF, lysis of adhesions was followed by open hardware removal. Through the posterior viewing portal, the glenohumeral joint was accessed and a shaver or electrocautery were introduced through an anterior portal to open the rotator interval and release the anterior capsule. The subcoracoid space was also cleared from the tip of the coracoid to the based. The arthroscope was then moved to the anterior portal and the electrocautery to the posterior portal as needed to release the posterior and inferior capsule. The subacromial space was then cleared of any adhesions. Finally, the deltopectoral incision was opened and the proximal humeral plate was removed. Postoperatively, all patients began immediate ROM with a physical therapist 3 times per week for 3 weeks, followed by advancement as tolerated.

Study Variables

All variables were collected for the overall cohort and separated for patients with RSA and patients with ORIF. Demographic variables including age, sex, tobacco use, and length of follow-up were collected. Comorbidities were standardized using the Charlson Comorbidity Index, a composite index encompassing 17 different comorbidities associated with mortality.[14] Conservative management, such as nonsteroidal anti-inflammatory drug intake and injections, before undergoing arthroscopic lysis of adhesions was documented. Active ROM and PROs were documented at baseline and postoperatively at a minimum 1-year follow-up. ROM measurements included FF, ER at the side, and internal rotation (IR) recorded by the treating surgeon (P.D.) or a physician assistant. IR was numerically scaled based on the nearest spinal level achieved with the thumb (i.e., T10 = 10, T12 = 12, L2 = 14, L4 = 16, S1 = 18, hip = 20). PROs included American Shoulder and Elbow Surgeons (ASES) score, visual analog scale for pain (VAS), and Subjective Shoulder Value (SSV). Complications and satisfaction were also recorded for analysis.

Statistical Analysis

Categorical and continuous variables were identified for bivariate analysis. Categorical variables were reported as fractions and percentages, whereas

Table 1. Baseline Demographics

	Overall (n = 21)		RSA (n = 4)		ORIF (n = 17)	
Age, y, mean, SD	66.7	8.0	73	1.4	65.2	9.6
Male						
Yes, %	2	10%	0	0%	2	12%
CCI						
Mean, SD	2	1.5	2	2	2	1.4
DM type 2						
Yes, %	4	19%	1	25%	3	18%
BMI						
Mean, SD	29.9	7.4	30.8	6.9	29.7	7.5
Osteopenia						
Yes, %	4	19%	1	25%	3	18%
Osteoporosis						
Yes, %	4	19%	1	25%	3	18%
Tobacco use						
Nonsmokers						
Yes, %	11	52%	2	50%	9	53%
Current						
Yes, %	1	5%	0	0%	1	6%
Former						
Yes, %	9	43%	2	50%	7	41%
Months from first surgery to arthroscopy						
Mean, SD	9.3	3.1	5.3	1.5	10.3	3.5
Follow-up post-arthroscopy, mo						
Mean, SD	17.2	6.5	19	8.1	16.8	6.1
Injection						
Yes, %	9	43%	0	0%	9	53%
Number of injections						
1 injection						
Yes, %	7	33%	0	0%	7	78%
2 injections						
Yes, %	2	10%	0	0%	2	22%
Physical therapy						
Yes, %	21	100%	4	100%	17	100%
Physical therapy duration, mo						
Mean, SD	4.2	2.2	4.3	1.5	4.2	2.4
NSAIDs						
Yes, %	19	90%	4	100%	15	88%

BMI, body mass index; CCI, Carlson Comorbidity Index; DM, diabetes mellitus; NSAIDs, nonsteroidal anti-inflammatory drugs; ORIF, open reduction with internal fixation; RSA, reverse shoulder arthroplasty; SD, standard deviation.

continuous variables were reported as means and standard deviations. Demographics and PROs were analyzed descriptively and inferentially, respectively. Paired *t* tests were used to assess clinical improvement for the entire cohort as well as patients with RSA and patients with ORIF independently. Statistical significance was denoted by a *P* value threshold of less than .05.

Results

Baseline Demographics

A total of 21 patients met the study criteria (4 RSA, 17 ORIF). Baseline demographics are summarized in Table 1. The average time from the index surgery to arthroscopy was 9.3 ± 3.1 months, 5.3 ± 1.5 months in the RSA cohort, and 10.3 ± 3.5 months in the ORIF cohort. The mean follow-up post-lysis was 17.2 ± 6.5 months. The average duration of PT before undergoing arthroscopic lysis was 4.2 months. Half of the patients with ORIF (n = 9) had at least one injection administered in contrast to none of the patients with RSA.

Clinical Outcomes

Clinical outcomes are shown in Tables 2, 3, and 4 for the entire cohort, patients with RSA, and patients with ORIF, respectively. Patients with ORIF showed significant pain relief (VAS, Δ −3.2) and improvement in ROM (FF, Δ 36°; ER, Δ 20°; IR Δ 3 spinal levels) and PROs (ASES, Δ 34.7; SSV, Δ 44.8) ($P < .01$). Conversely, patients with RSA had significant improvement in ASES (Δ 21.8; $P = .04$), SSV (Δ 8.8; $P = .04$), and FF (Δ 38; $P = .02$) but did not see significant improvement in VAS (Δ −2; $P = .2$), ER (Δ 0°; $P = 1.0$), and IR (Δ 1 spinal level; $P = 0.2$). Despite this, all patients with RSA reported being satisfied at the latest follow-up (Table 3). With respect to patients with ORIF, 82% were satisfied at least 1 year from surgery,

Table 2. Clinical Outcomes for the Overall Cohort

	Preoperative		Postoperative		Improvement		
	Mean	SD	Mean	SD	Mean	95% CI	*P* Value
Patient-reported outcomes							
VAS	4.7	1.9	1.8	1.6	−3.0	−2.1 to −4.4	<.01
ASES	47.0	14.0	79.1	14.4	32.2	22.2-42.2	<.01
SSV	44.7	18.0	82.7	7.7	37.9	27.7-48.1	<.01
Range of motion							
FF	99°	22°	135°	23°	36°	25°-47°	<.01
ER	24°	14°	41°	14°	16°	14°-29°	<.01
IR	S1	1*	L4	2*	2*	1-3*	<.01
Satisfaction							
Yes, %	18	86%					
Complications							
Yes, %	0	0%					

ASES, American Shoulder and Elbow Surgeons; CI, confidence interval; ER, external rotation; FF, forward flexion; IR, internal rotation; SD, standard deviation; SSV, Subjective Shoulder Value; VAS, visual analog scale.
*Spinal levels.

which amounted to 86% of the entire cohort (Tables 2 and 4). No complications were observed.

Discussion

Arthroscopic lysis of adhesions for stiffness after surgical management of proximal humerus fractures led to satisfactory outcomes in most patients. The overall cohort improved significantly in PROs and ROM with a high satisfaction rate. Furthermore, the data revealed notable improvements in both PROs and global ROM among patients with ORIF, whereas patients with RSA showed improvements in PROs and FF but failed to show significant changes in rotational ROM.

Postoperative immobilization is often recommended until the tuberosities have healed to prevent fragment displacement after proximal humerus treatment.[6,15-18] However, prioritizing bone healing over early motion may potentially lead to the development of arthrofibrosis. Conservative measures include PT in the early postoperative period, nonsteroidal anti-inflammatory drugs, and steroid injections.[15,16] Although limited ROM in RSA cases can be attributed to the mechanical properties of the implant, stiffness can also arise from excessive scar formation, particularly in fractures in which the healing process is more profound.[6,15,19,20] The ideal candidate for lysis of adhesions demonstrates both loss of active and passive ROM refractory to conservative measures, as well as confirmation of a healed fracture in patients with ORIF and well-positioned components without evidence of loosening in RSA cases.

Lysis of adhesions following ORIF has consistently yielded positive outcomes, particularly in addressing stiffness.[21,22] Chan et al.[12] conducted a retrospective case series of 88 patients who underwent arthroscopic hardware removal and lysis of adhesions after ORIF, resulting in significant ROM improvement: FF from 115° to 152° ($P < .001$), abduction from 71° to 139°

Table 3. Clinical Outcomes for RSA for Patients With Fracture

	Preoperative		Postoperative		Improvement		
	Mean	SD	Mean	SD	Mean	95% CI	*P* Value
Patient-reported outcomes							
VAS	4	1.4	2	2.2	−2	−1.4 to −5.4	.20
ASES	56.3	8.5	78	13.9	21.8	2.0-41.5	.04
SSV	72.5	10.4	81.3	6.3	8.8	1.1-16.4	.04
Range of motion							
FF	80°	34°	118°	21°	38°	14°-61°	.02
ER	13°	15°	13°	10°	0°	−29° to 29°	1.00
IR	Hip	2*	S1	2*	1*	0-2*	.20
Satisfaction							
Yes, %	4	100%					
Complications							
Yes, %	0	0%					

ASES, American Shoulder and Elbow Surgeons; CI, confidence interval; ER, external rotation; FF, forward flexion; IR, internal rotation; RSA, reverse shoulder arthroplasty; SD, standard deviation; SSV, Subjective Shoulder Value; VAS, visual analog scale.
*Spinal levels.

Table 4. Clinical Outcomes for Patients With ORIF

	Preoperative		Postoperative		Improvement		
	Mean	SD	Mean	SD	Mean	95% CI	*P* Value
Patient-reported outcomes							
VAS	4.9	2	1.7	1.5	−3.2	−2.3 to − 4.2	< .01
ASES	44.8	15.3	79.4	14.5	34.7	26.9-42.4	< .01
SSV	38.2	19.8	83	8	44.8	34.0-55.6	< .01
Range of motion							
FF	103°	19°	139°	24°	36°	28°-44°	<.01
ER	27°	14°	47°	15°	20°	11°-29°	<.01
IR	S1	2*	L3	4*	3*	2-4*	<.01
Satisfaction							
Yes, %	14	82%					
Complications							
Yes, %	0	0%					

ASES, American Shoulder and Elbow Surgeons; CI, confidence interval; ER, external rotation; FF, forward flexion; IR, internal rotation; ORIF, open reduction with internal fixation; SSV, Subjective Shoulder Value; VAS, visual analog scale.
*Spinal levels.

($P < .001$), ER at side from 44° to 59° ($P = .012$), and IR at 90° from 26° to 62° ($P < .001$), with a minimum 6-week follow-up. Our study aligns with these findings, although our mean follow-up was 17 months compared with 5 months in their study. The longer follow-up in the current study demonstrates sustained improvements in ROM at 1-year follow-up. PROs have also demonstrated lasting improvements in the literature.[9,11,22,23] Maqdes et al.[11] reported significant improvement in Constant−Murley score (43.4 vs 60.5, $P = .003$) and VAS (4.7 vs 2.8, $P = .012$) scores in an 18-month follow-up of 11 patients who underwent arthroscopic hardware removal and capsular release following ORIF. Similarly, Katthagen et al.[23] observed significant improvement in Simple Shoulder Test and Constant−Murley scores from the 3-month to 12-month follow-ups (Constant−Murley score 50.3 vs 58.9, $P = .02$; Simple Shoulder Test 7.2 vs 8.6, $P = .02$). However, PROs plateaued from the 12-month to 2-year mark (Constant−Murley score 58.9 vs 58.7, $P = .55$; Simple Shoulder Test 8.6 vs 8.9, $P = .75$). These findings, as our own, demonstrate immediate and sustained clinical improvement resulting from lysis of adhesions and hardware removal until 1 year postoperatively.

Shoulder stiffness following shoulder arthroplasty is a common cause of patient dissatisfaction and has been associated with poorer outcomes compared with other stiffness etiologies.[6-8,21] Although arthroscopy has traditionally been used to address infection, its application has expanded to other postarthroplasty pathologies.[6,8,24] Wagner et al.[25] found improved ROM in 19 patients post-arthroplasty who underwent open or arthroscopic capsular release, with significant increases in FF, abduction, and IR (77° to 117°, 49° to 98°, and sacrum to L1, respectively) at a mean follow-up of 2.3 years. Similarly, Tytherleigh-Strong et al.[26] analyzed PROs in 29 patients who underwent arthroscopy for persistent pain and limited motion after arthroplasty and showed significant improvement in preoperative Constant−Murley score (23 to 62 points) at follow-ups ranging from 5 to 37 months. However, these studies focused on anatomic total shoulder arthroplasty, as there is a dearth of literature on arthroscopy following RSA. Moreover, with fractures there is a notably greater degree of soft-tissue trauma, which may exacerbate stiffness due to a more robust healing response.[15] In the current study, there was enhanced PROs, improved FF, and high patient satisfaction in patients post-RSA. Although ER and IR did not show significant improvement, this may be attributed to prosthesis-related mechanical factors.[19,20] In light of this, patients should be counseled regarding these limitations in ROM even after undergoing lysis of adhesions.

Limitations

This study has several limitations. First, due to its retrospective design, there is potential for selection bias. Performing a retrospective review of electronic medical records provided us with accessible data in an area that is lacking in clinical insight, but future prospective studies in this arena could yield stronger recommendations, especially in the RSA setting. Second, the small sample size limited the ability to compare patients with ORIF to RSA inferentially rather than descriptively. Nonetheless, available literature on lysis of adhesions after ORIF or RSA is lacking, particularly in the RSA setting. Third, the influence of the patient's compliance with the postoperative rehabilitation protocol on the functional outcome remains unclear. Finally, the female predominance limited the exploration of outcomes in male patients. However, this may be explained by the higher incidence rate of proximal humerus fractures in female patients.

Conclusions

Arthroscopic lysis of adhesions for stiffness after surgical management of proximal humerus fracture leads to satisfactory outcomes in most patients. Patients post-ORIF may achieve improvement in PROs and global ROM, whereas patients post-RSA may achieve improvement in PROs and FF but do not necessarily improve in rotational ROM.

Disclosure

The authors report the following potential conflicts of interest or sources of funding: M.E.M. is a consultant for Arthrex. P.J.D is a consultant and receives royalties from Arthrex. All other authors (J.A., N.A.Z., A.Ī.K., T.P.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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