Five to Ten-Year Outcomes of Operatively Treated Scapular Fractures

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Background: The purpose of this study was to assess the 5 to 10-year clinical and patient-reported functional outcomes after open reduction and internal fixation (ORIF) of intra-articular and extra-articular scapular fractures.

Methods: We conducted a retrospective review of prospectively collected data on 106 patients who underwent ORIF of a scapular fracture at a single level-I trauma center between January 2005 and December 2010. Eight patients were excluded from the study because they had either severe neurologic injury or an isolated process fracture, and 66 patients (37 with an isolated extra-articular fracture and 29 with an intra-articular fracture) participated in the 5 to 10-year follow-up, yielding a follow-up rate of 67%. A physical examination including a strength assessment and range-of-motion measurements was performed on 89% of the follow-up cohort. Disabilities of the Arm, Shoulder and Hand (DASH) and Short Form-12 version 2 (SF-12v2) or SF-36v2 questionnaires were completed by all participating patients. Intra-articular and extra-articular fractures were analyzed in separate groups.

Results: The mean follow-up was 7.8 years in the extra-articular group and 7.3 years in the intra-articular group, with a range of 4.7 to 10.3 years. The mean DASH score was 8.9 in the extra-articular group and 9.1 in the intra-articular group (normal population = 10.1). Strength examination revealed no significant differences between the injured and uninjured shoulders for any movement ($p > 0.05$), while the range of external rotation was slightly decreased in both the extra-articular ($p = 0.01$) and the intra-articular ($p = 0.01$) group. The abduction range of motion was also slightly decreased in the intra-articular cohort ($p = 0.03$). Arthroplasty was indicated as a subsequent procedure for 2 patients in the intra-articular cohort. Sixty-one of the 66 patients returned to their original occupation or changed occupations for reasons unrelated to the shoulder injury.

Conclusions: At 5 to 10 years after ORIF of a scapular fracture, patients have excellent functional outcomes albeit with a small decrease in external rotation motion relative to the contralateral, normal shoulder. Interestingly, we found the outcomes after intra-articular and extra-articular fractures to be comparable.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Management of scapular fractures has become a topic of increasing interest among orthopaedic surgeons, as some studies have called into question the traditional benign-neglect approach of nonoperative treatment[1-8]. Scapular fractures account for 0.5% of all fractures[9], and extra-articular fractures account for between 62% and 98% of all scapular fractures[6,10-13]. The mechanism in many cases is high-energy trauma with multiple associated injuries; however, the incidence of fragility fractures as a result of low-energy trauma in the elderly is on the rise[9].

The indications for operative treatment of displaced fractures of the glenoid fossa[14-17] are well accepted, and 3 studies have documented good to excellent outcomes following open reduction and internal fixation (ORIF)[16,18,19]. However, the literature lacks validated assessments of strength, function, and motion, particularly at longer follow-up time points.

The operative indications for extra-articular scapular fractures remain controversial, and most fractures with minimal displacement heal without functional deficits. Several series detailing results of nonoperative management suggest that fractures with residual displacement lead to persistent symptoms and decreased function of the shoulder girdle[7,8,20-22]. One functional outcome study after operative management of extra-articular glenoid neck and scapular body fractures

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demonstrated good outcomes with validated functional outcomes assessment at a mean of 33 months after surgery[23]. Other studies, such as small case series and case reports, lacked appropriately validated assessments of strength, motion, and function[2,24-27].

This study is a retrospective review of a cohort of patients prospectively enrolled in a registry established in 2002 for the purpose of following the outcomes of operatively treated scapular fractures for 2 years. Other reports capturing 1 to 2-year outcomes from this registry have been published[1,19,23,24,28]. We believe that this study is the first to present clinical and patient-reported functional outcomes 5 to 10 years following ORIF of displaced intra-articular and extra-articular scapular fractures.

Materials and Methods

Operative data and functional outcomes were recorded in a prospective database, established with institutional review board approval. In 2015, additional institutional review board approval was received to call back all registry patients who had undergone the index procedure 5 to 10 years earlier. A total of 106 patients who had been treated with ORIF of a scapular fracture and who met the described operative indications between January 2005 and December 2010 were identified at a single level-I trauma center. Eight patients were excluded: 1 because of a severe brachial plexus injury that prohibited the patient from participating, 1 who had a traumatic brain injury that made it impossible to provide informed consent, 4 with an isolated acromion process fracture, and 2 with an isolated coracoid process fracture. This left 98 eligible patients.

Sixty-six patients (67%) consented to participate in this 5 to 10-year postoperative study. The 2 most common reasons why the other 32 did not participate was a change in geographical location that prevented the patient from visiting the clinic (7; 22%) and an inability to locate the patient (16; 50%) (Fig. 1). Extensive attempts had been made to reach the 16 patients who could not be located, with all documented telephone numbers as well as contact numbers called a minimum of 12 times over the course of 3 months, voicemail left when possible, e-mail and letters sent to the most recently known addresses, and finally an Internet search made in an attempt to find more current location information. Seven (19%) of the 37 extra-articular fractures and 11 (38%) of the 29 intra-articular fractures included in this study had not been previously reported on as the dates on which they were operated fell outside of the time periods studied in the original publications[1,19,23,24,28].

All patients were ≥18 years of age with ≥1 of the following operative indications: (1) intra-articular gap or step-off of >4 mm and involvement of >25% of the glenoid surface, (2) medial/lateral displacement (commonly referred to as "medialization") of ≥20 mm, (3) angular deformity of ≥45° in the semicoronal plane measured on the scapular Y view, (4) combined medial/lateral displacement of ≥15 mm and angulation of ≥30°, (5) a glenopolar angle of ≤22°, or (6) a double lesion of the superior shoulder suspensory complex as described by Goss[3] with ≥10 mm of displacement of both lesions (Table I). The standard preoperative assessment consisted of Grashey view (anteroposterior), transscapular Y, and axillary radiographs. If these initial radiographs suggested displacement that met the operative criteria, a computed tomography (CT) scan

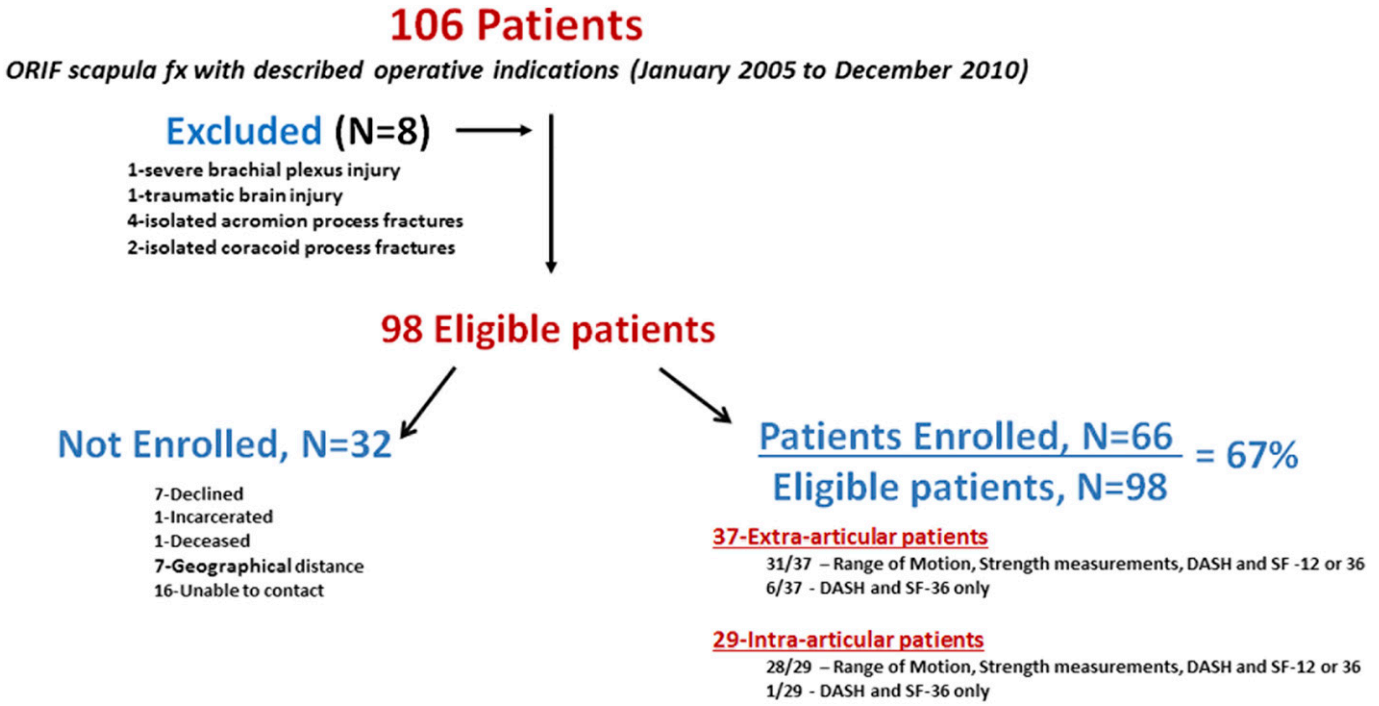

Fig. 1
Study enrollment of the eligible patient population. fx = fractures.

TABLE I Operative Indications, Mechanism of Injury, Fracture Classification, and Operative Data

	Extra-Articular (N = 37)	Intra-Articular (N = 29)
Operative indications*		
Intra-articular gap/step-off of >4 mm and >25% glenoid surface involvement	0 (0%)	8 (28%)
Medial/lateral displacement (medialization) of ≥20 mm	25 (68%)	6 (21%)
Angular deformity of ≥45° in semicoronal plane measured on scapular Y view	2 (5%)	3 (10%)
Combined medial/lateral displacement of ≥15 mm and angulation of ≥30°	6 (16%)	5 (17%)
Glenopolar angle of ≤22°	6 (16%)	8 (28%)
Double lesion of superior shoulder suspensory complex with ≥10 mm of displacement of both lesions	10 (27%)	2 (7%)
Mechanism of injury		
High fall (≥6 ft [1.8 m])	4 (11%)	4 (14%)
Low fall (<6 ft)	3 (8%)	3 (10%)
Motorcycle accident	12 (32%)	10 (34%)
Automobile accident	6 (16%)	2 (7%)
Pedestrian vs. motor vehicle	1 (3%)	0 (0%)
Fall from bicycle ("wipeout")	5 (14%)	2 (7%)
Bicycle vs. motor vehicle	0 (0%)	1 (4%)
Snowmobile	1 (3%)	3 (10%)
Fall from horse	1 (3%)	2 (7%)
Skiing accident	0 (0%)	1 (4%)
All-terrain vehicle accident	2 (5%)	0 (0%)
Other	2 (5%)	1 (4%)
Operative approach		
Anterior	Not applicable	7 (24%)
Posterior		
Judet flap[36]	29 (78%)	15 (52%)†
Judet intervals[37]	5 (14%)	4 (14%)
Straight	0 (0%)	4 (14%)†
2-incision[38]	3 (8%)	1 (3%)
Interval between fracture and surgery‡ *(days)*	14 (2-46)	15 (3-41)
Operative time‡ *(min)*	188 (92-503)	263 (100-487)
Estimated blood loss‡ *(mL)*	405 (150-1,850)	546 (200-2,000)
Fracture location (OTA/AO classification)§		
Acromion process (14.A1)	1 (3%)	
Coracoid process (14.A2)	2 (3%)	2 (7%)
Body (14.A3)	36 (97%)	
Isolated anterior glenoid (14.B1)		4 (14%)
Glenoid neck (14.C1)	9 (24%)	
Extension into the glenoid neck (14.C2)		7 (24%)
Extension into the scapular body (14.C3)		18 (62%)

*Twelve (32%) of the 37 patients in the extra-articular group and 3 (10%) of the 29 patients in the intra-articular group had ≥2 of the operative indications. †One patient also had an anterior approach. ‡The values are given as the mean with the range in parentheses. §Nine (24%) of the 37 patients in the extra-articular group and 2 (7%) of the 29 patients in the intra-articular group had ≥2 of the fracture classifications.

with 3-dimensional (3D) reconstruction was obtained to further assess displacement and for preoperative planning. The technique for measuring displacement using 3D CT has been previously described and validated[29]. Fractures were classified according to the revised (OTA/AO) classification system[30].

All patients were managed with a standardized rehabilitation protocol consisting of full passive and active-assisted shoulder motion with a full active range of motion beginning immediately after surgery, with 3 to 5 lb (1.4 to 2.3 kg) of resistance added between 1 and 2 months postsurgery. A strengthening program

TABLE II Patient-Reported Outcomes

	Extra-Articular (N = 37)	Intra-Articular (N = 29)
Follow-up* *(yr)*	7.8 (4.9-10.2)	7.3 (4.7-10.3)
DASH* (normal population: 10.1)	8.9 (0-55)	9.1 (0-32)
SF-36v2 or SF-12v2* (normal population: 50 ± 10)	49.9 (29-64)	52.6 (38-64)
Pain score* (0 = none, 10 = worst)	2 (0-9)	1.7 (0-5.5)
Return to work *(%)*	92	93

*The values are given as the mean with the range in parentheses.

was initiated in the third month, and the patient was advanced as tolerated. All restrictions, including on contact sports, were removed after 90 days. Preoperative data including patient demographics, laterality of the fracture, and mechanism of injury were recorded. Electronic medical records were reviewed to document operative data including time to surgery, operative time, operative approach, perioperative complications, and subsequent procedures pertaining to the operatively treated shoulder.

All study participants completed a Disabilities of the Arm, Shoulder and Hand questionnaire (DASH)[31] and Short Form-12 version 2 (SF-12v2) or SF-36v2 General Health Survey[32]. All patients were questioned regarding residual pain and work status. Comprehensive clinical motion and strength measurements of the injured shoulder and the contralateral shoulder, which was used as an internal control, were completed for 89% (59) of the 66 study participants. These measurements were obtained by 1 examiner with experience and training in performing both sets of measurements using a standardized protocol. Active range of motion in degrees of shoulder forward flexion, abduction, and external rotation was measured with a 14-in (36-cm) goniometer as previously described[23]. Strength in pounds of force of shoulder forward flexion, abduction, and external rotation was measured with a handheld dynamometer (microFET2; Hoggan Health Industries) as previously described[23]. Intra-articular and extra-articular fractures were analyzed separately with regard to motion, strength, and functional outcomes. A statistical analysis comparing the motion and strength of the injured shoulder with those of the uninjured shoulder was performed using a paired t test.

Results

There were 37 extra-articular fractures (isolated, no intra-articular involvement) and 29 intra-articular fractures (with or without extra-articular involvement). The mean follow-up was 7.8 years (range, 4.9 to 10.2 years) in the extra-articular group and 7.3 years (range, 4.7 to 10.3 years) in the intra-articular group, and the mean ages were 45.4 years (range, 22 to 68 years) and 52.7 years (range, 24 to 76 years), respectively. Most of the patients were male in both the extra-articular cohort (29 of 37; 78%) and the intra-articular cohort (25 of 29; 86%). The fractured scapula was located on the dominant side in 38% (14) of the patients with an extra-articular fracture and 45% (13) of those with an intra-articular fracture.

Motorcycle collisions were the most common mechanism of injury for both the extra-articular (12; 32%) and the intra-articular (10; 34%) fractures. Other common high-energy mechanisms are reported in Table I. Falls from low heights (<6 ft [1.8 m]) caused 8% (3) of the extra-articular fractures and 10% (3) of the intra-articular fractures, which were considered fragility fractures because of that mechanism of injury (Table I). The fracture classification, operative approach, time from injury to surgery, operative time, and estimated blood loss are listed for each cohort in Table I.

In the intra-articular group, there were 7 suprascapular and 3 axillary nerve lesions associated with these complex fractures. Five patients with an extra-articular fracture had an associated suprascapular nerve injury, and 2 had an axillary nerve injury. Of the 17 nerve lesions, 13 were diagnosed by an electromyographic (EMG) nerve conduction study or through intraoperative observation of the lesion.

Patient-reported outcomes, consisting of the DASH and SF-12v2 or SF-36v2 scores, return to work status, and the patient's pain perception, are presented in Table II. The mean DASH score was 8.9 (range, 0 to 55) in the extra-articular group and 9.1 (range, 0 to 32) in the intra-articular group (normal population = 10.1). A subanalysis of patients with nerve injury (n = 17) revealed a mean 5 to 10-year DASH score of 14.7 (range, 0 to 55). The DASH scores at the 5 to 10-year time point were also compared with the DASH scores obtained at 6 months and 12 months. Follow-up at these earlier time points was ≥73% for each cohort and showed increases in patient-reported function (decreases in the DASH scores) over time (Fig. 2).

In the extra-articular group, the mean active range of motion (and standard deviation) in degrees (injured/uninjured)

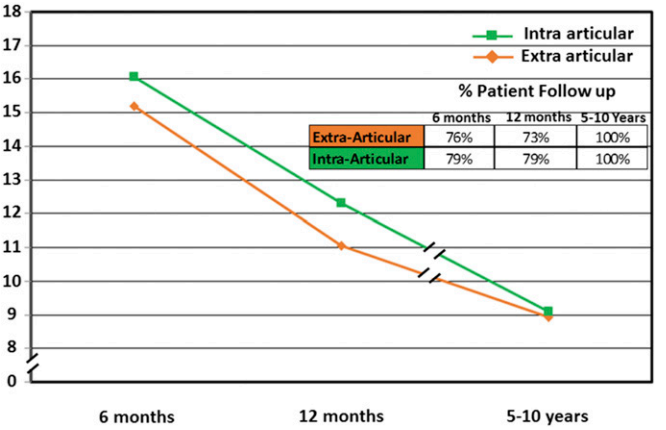

Fig. 2

Mean DASH scores for intra-articular (green) and extra-articular (orange) fracture cohorts at 6 months, 12 months, and 5 to 10 years after ORIF. The percentage of patient follow-up is reported for each time point and cohort.

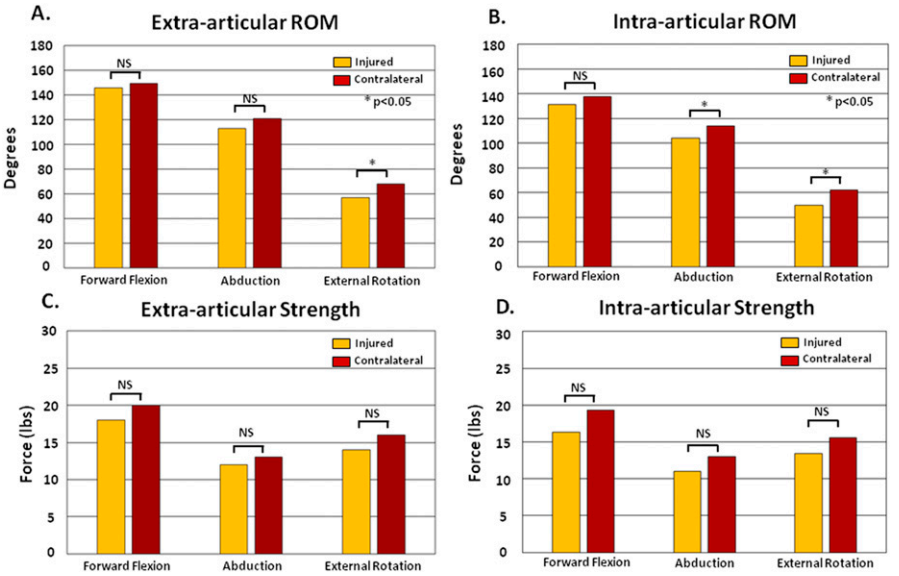

Fig. 3

Mean active range of motion (ROM) and strength. NS = not significant. 1 lb = 0.45 kg.

was 145.9 ± 18.1/150.2 ± 16.1 (97%) for forward flexion, 113.2 ± 17.2/121.5 ± 18.5 (93%) for abduction, and 57 ± 15.2/68.3 ± 17.2 (84%) for external rotation (Fig. 3-A). The respective values in the intra-articular group were 131.5 ± 16.7/137.8 ± 12.9 (95%), 104.2 ± 18.1/113.9 ± 13.4 (92%), and 49.7 ± 17.2/62.1 ± 17.3 (80%) (Fig. 3-B). A paired t test revealed a significant difference between the ranges of motion of the injured and uninjured shoulders in external rotation ($p = 0.01$) in both groups and in abduction in the patients with an intra-articular fracture ($p = 0.03$). The mean strength in pounds (1 lb = 0.45 kg) (injured/uninjured) was 17.8 ± 6.9/19.9 ± 6.5 (89%) in forward flexion, 11.9 ± 4.7/13.4 ± 4.3 (89%) in abduction, and 13.8 ± 4.5/15.6 ± 4.9 (89%) in external rotation in the extra-articular group (Fig. 3-C) and 16.3 ± 7.6/19.3 ± 8.3 (84%), 11 ± 4.8/13 ± 5.5 (85%), and 13.4 ± 8.3/15.5 ± 7.4 (86%), respectively, in the intra-articular group (Fig. 3-D).

The only perioperative complication occurred in the intra-articular group. A screw was placed intra-articularly and was exchanged 3 days postoperatively. Nine (31%) of the 29 patients with an intra-articular fracture had 1 of the following secondary procedures: shoulder arthroplasty (2), elective implant removal (3), and manipulation under anesthesia to address stiffness (4). There were no infections, and both cohorts had a fracture union rate of 100%. In the extra-articular group, 8 patients (26%) underwent a secondary procedure, either elective implant removal (5) or manipulation under anesthesia to address stiffness (3) (Table III).

Discussion

The literature provides support for ORIF of displaced intra-articular scapular fractures as several studies have documented good functional outcomes[16,18,19]. However, all but 1 lacked long-term follow-up with quantitative clinical outcome measures. The 1 series documenting >5 years of follow-up after ORIF of intra-articular fractures[18] consisted of 22 patients with a mean follow-up of 10 years (range, 5 to 23 years). Functional outcomes were assessed with the Constant and Murley score and on the basis of the range of motion. Although range-of-motion measurements indicated good outcomes, the results were not compared with the values on the uninjured side and strength was not evaluated.

In the current study, we assessed patient-reported outcomes at a mean of 7.5 years and found both the DASH and the general health (SF-12v2 or SF-36v2) scores to be within the range of the normal population. Similarly, 61 (92%) of the patients returned to their same field of employment as prior to their injury or changed occupations for reasons unrelated to the shoulder injury. Significant differences from the uninjured shoulder remained at the 5 to 10-year follow-up in only 3 areas: external rotation range of motion in both cohorts and abduction range of motion in the intra-articular cohort only. These differences seem unlikely to have clinical relevance, as reflected by the normal DASH scores. In addition, these results are better than what we found in our prior study at a mean of 2.75 years, at which time there were significant differences in external rotation range of motion and in all 3 strength measurements between the injured and contralateral arms[19], indicating that there is subtle and continued improvement over time.

The only patient in this series who had a perioperative complication (removal of an intra-articular screw 3 days postoperatively) had a DASH score of 3 at the time of final follow-up. Although there were multiple postoperative procedures in both groups (a total of 7 manipulations under anesthesia and 8 elective implant removals), only 2 patients in the intra-articular group (7%) underwent arthroplasty. There were no infections.

Only 1 patient had a complete brachial plexus palsy and was excluded from the study because of an inability to

TABLE III Clinical Outcomes*

	Extra-Articular (N = 31†)		Intra-Articular (N = 28†)	
	Injured/Uninjured	P Value (Paired Student T Test)	Injured/Uninjured	P Value (Paired Student T Test)
Active range of motion *(°)*				
Forward flexion		>0.05		>0.05
Mean	146/150		132/138	
95% CI	139-152/143-156		125-138/133-143	
%	97		95	
Abduction		>0.05		0.03
Mean	113/121		104/114	
95% CI	107-119/115-128		97-111/109-119	
%	93		92	
External rotation		0.01		0.01
Mean	57/68		50/62	
95% CI	52-63/62-74		43-56/55-69	
%	84		80	
Strength *(lb of force‡)*				
Forward flexion		>0.05		>0.05
Mean	18/20		16/19	
95% CI	15-20/18-22		13-19/16-23	
%	89		84	
Abduction		>0.05		>0.05
Mean	12/13		11/13	
95% CI	10-14/12-15		9-13/11-15	
%	89		85	
External rotation		>0.05		>0.05
Mean	14/16		13/16	
95% CI	12-15/14-17		10-17/13-18	
%	89		86	
Suprascapular nerve injury *(no.)*	5		7	
Axillary nerve injury *(no.)*	2		3	
Complications	0		Intra-artic. screw removed 3 days postop.	
Shoulder arthroplasty *(no.)*	0		2	
Implant removal (scapula) *(no.)*	5		3	
Manipulation under anesthesia *(no.)*	3		4	

*CI = confidence interval. †One patient from the intra-articular cohort and 6 patients from the extra-articular cohort were unable to return to the clinic for range-of-motion and strength testing. ‡1 lb = 0.45 kg.

participate. However, there was evidence on EMG testing of suprascapular and axillary nerve palsy in several patients. These nerve injuries often resolve; however, they do delay recovery of motion and most notably of strength within the first year[19]. It is for this reason that long-term follow-up studies such as this one are important in the understanding of the recovery of these patients. The origin of these nerve injuries is also unclear. Intraoperatively, it is not uncommon to find the suprascapular nerve entrapped within the fracture itself, or encased in immature callus, when the fracture pattern involves the spinoglenoid notch. Additionally, it is possible for the nerve to be injured with excessive traction either during the injury, which is most often high-energy, or during exposure of the lateral border of the scapula with surgical retraction. It is interesting, however, that, despite slight measurable differences in external rotation strength and even frank suprascapular nerve injury, we did not find cases of impingement

syndrome. It is thought that impingement syndrome results from a weak rotator cuff that allows the humeral head to migrate proximally and impinge on the acromion[33]. This was not a finding in our patient population. More research is needed to elucidate the origin of these injuries and their resolution.

ORIF of extra-articular scapular fractures still remains highly controversial despite many studies showing poor outcomes with nonoperative treatment of certain fracture patterns, particularly those with a glenopolar angle of <20° (normal glenopolar angle = 35° to 40°)[7,8,21,22,34]. In one 14-year follow-up study of 68 nonoperatively treated extra-articular scapular fractures, functional outcomes were assessed using a qualitative rating system of patient satisfaction, function, and shoulder motion in addition to radiographic evaluation[35]. Half of the patients had shoulder symptoms including pain, functional deficit, and decreased motion or strength. Twenty of the 68 participants declined radiographic evaluation, and residual scapular deformity was documented in 42% (20) of the 48 patients with radiographic follow-up.

In our previous study of 61 patients with ORIF of an extra-articular scapular fracture, we reported good outcomes using the same quantitative functional, strength, and motion measurements at a mean of 2.75 years postoperatively[23]. The current study was designed to provide long-term (5 to 10-year) follow-up of 2 fracture cohorts. It was our expectation that the results would be maintained in the extra-articular group, but we suspected that they would worsen in the intra-articular group given the insult to the glenoid at the time of injury. Despite the fact that 2 patients in the intra-articular group did require a shoulder arthroplasty, functional recovery was maintained or improved in both groups as reflected by the improvement in the mean DASH scores (Fig. 2).

The limitations of this study include its retrospective nature and the lack of a nonoperative control group. Another limitation is that the operations were performed by a single experienced surgeon with a career interest in such injuries in a practice in which well over 50% of the patients are referred. Therefore, the results of this study may not be generalizable; yet, they do provide outcomes against which future findings can be compared. Additionally, we recognize that including both intra-articular and extra-articular neck and body fracture patterns in the study may increase heterogeneity, and one must be cautious about applying the results of this study to every fracture pattern. We do, however, think that inclusion of both fracture types is warranted given the paucity of long-term results on the topic.

Furthermore, detailed information regarding recovery of nerve function was not part of the scope of this study. Nerve injuries were documented, but follow-up EMG studies were not obtained for patients with improved function. We believe that reviews of recovery from nerve lesions and functional outcomes should be pursued in the future.

A final weakness of the study is that 16 patients could not be reached for follow-up. It is possible that these patients had poor outcomes or experiences and sought additional treatment elsewhere.

In conclusion, in this study of the largest single-center series of which we are aware, we documented long-term quantitative clinical measurements and patient-reported outcomes following ORIF of glenoid fossa and scapular body and neck fractures. Restoration of length, alignment, and rotation are foundational concepts that are applied to most bones in the practice of internal fixation of fractures. The current study suggests that heeding this principle can yield nearly normal functional outcomes at 5 to 10 years following ORIF of both intra-articular and extra-articular scapular fractures as evidenced by normal DASH and SF-36 or SF-12 scores with only minimal deficits in motion and strength in the majority of patients. ■

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