Analysis of Operative versus Nonoperative Treatment of Displaced Scapular Fractures

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Abstract

Background Operative indications for displaced scapular fractures have been controversial and inconsistent. Surgeons have been dissuaded to operate on these uncommon fractures because of the complex anatomy, approaches, and fracture patterns. It is unclear whether return to work, pain, or complications differ in patients with scapular fractures treated nonoperatively or operatively.

Questions/Purposes We therefore assessed differences in rates of union, range of motion, ability to return to work, pain, and complications between operatively and nonoperatively treated scapular body and neck fractures.

Patients and Methods We retrospectively reviewed 182 patients with 182 scapular fractures treated between 2002 and 2005. Of the 182 fractures, 31 were treated with open reduction internal fixation and matched by age, occupation, and gender to 31 patients treated nonoperatively. The proportions of AO/OTA fracture types were similar in the two groups. The mean displacement, shortening, and angulation were greater in the operative group as compared with the nonoperative group. All patients were followed until healing or discharge from care (average, 1.5 years;

range, 14–32 months). We assessed complications, return to work, and radiographic healing.

Results All fractures healed. We found no differences in return to work, pain, or complications.

Conclusions Our observations suggest operative treatment of displaced scapula fractures results in similar healing, return to work, pain, and complications as nonoperative treatment. We do not recommend operating on any scapular neck or body fractures displaced less than 20 mm.

Level of Evidence Level III, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Scapular fractures occur uncommonly. The incidence is reportedly 1% of all fractures and 3% to 5% of upper extremity fractures [13, 14]. The scapular mobility and anatomic protection result in a low incidence of scapular fractures [13]. Substantially displaced fractures of the scapula may alter shoulder girdle function resulting from malalignment, arthrosis, dysfunction of the rotator cuff, scapulothoracic dyskinesis, and impingement-type pain [3–5, 17, 18, 23, 24]. Historically, nonoperative intervention and early ROM have resulted in predictable healing, return to activities of daily living, and reduction in pain [8, 13]. Because of the extensive muscular attachments and envelope, early and complete healing occurs. The large arc of scapular-thoracic and glenohumeral motion compensates for most deformities. Insufficient bone stock, complex three-dimensional anatomy, and difficult surgical exposures create problems with internal fixation [13].

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Each author certifies that his or her institution approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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The criteria for operative treatment of scapula fractures remain controversial and no universal parameters can be found in the existing literature [13, 14]. Displaced scapular body and glenoid neck fractures with and without intra-articular glenoid fractures can be reduced through a modified Judet approach and can be stabilized with minifragment fixation based laterally [16]. However, it is unclear whether return to work, pain, or complications differ in patients with scapular fractures treated nonoperatively or operatively.

We therefore compared: (1) rates of union; (2) ROM; (3) return to work; (4) pain; and (5) complications of matched pairs of patients treated nonoperatively and operatively.

Patients and Methods

We identified all patients with Current Procedural Terminology codes 23570, 23575, and 23585 for scapular and glenoid fracture who had initial treatment from January 2002 through December 2005. We identified 182 scapular fractures. For this study we included (1) patients equal to or older than 18 years; (2) radiographic and/or CT-diagnosed scapular or glenoid fracture; (3) treatment by open reduction and internal fixation; and (4) followup until radiographic union and functional outcome were established. Operative indications consisted of at least one of the following, but not limited to: (1) medial displacement of greater than 20 mm; (2) shortening of greater than 20 mm; (3) angular deformity greater than 45°; and (4) intra-articular step-off greater than 3 mm, double shoulder suspensory injuries (DSSI) [7, 11, 24] (including clavicle, coracoid, acromion), or intra-articular displaced glenoid fractures. Two or more combined DSSI lesions would constitute a potentially unstable shoulder injury pattern. No one measurement determined operative intervention. The contraindications for surgery were: (1) associated injuries such as severe traumatic brain injury with elevated intracranial pressures, unstable cervical spine injuries unable to be placed into a lateral decubitus position, or severe burn overlying the surgical approach; and (2) acute medical comorbidities precluding surgery such as insufficient cardiac output, chronic obstructive pulmonary disease, and severe dementia. We excluded patients with: (1) inadequate radiographic (18 patients) and/or functional analysis (48 patients); or (2) surgical approach other than the modified Judet for scapular or glenoid fracture (four patients). The remaining 31 patients comprised the operative cohort. Computer-generated randomization was used to match 31 patients with complete data treated nonoperatively based on age, occupation, and gender. The remaining unmatched nonoperative patients (50) were excluded. The minimum followup was 12 months

(mean, 1.5 years; range, 14–32 months). No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records and radiographs. This study was an Institutional Review Board-approved retrospective exploratory review of a matched cohort of nonoperatively and operatively treated scapular fractures.

A power analysis determined that a minimum sample size of 16 in each group (32 total) would have an 80% power to detect a difference in clinically relevant 15° ROM between groups. This assumed a common standard deviation of 15 using two independent group t-tests with a 0.05 two-sided significance level. All available patients who met inclusion criteria during the study period were included.

All patients had radiographs and some had CT imaging to diagnose, classify, and measure displacement patterns. The initial treating surgeon completed radiographic measurements and fracture classification. For purposes of this study, a blinded reviewer (JPC) who was unaware of the outcomes measured and confirmed the classification of the initial and followup fracture images. Fracture patterns were classified as per the AO/OTA [19], Goss [13], and Ada and Miller [1] fracture classification systems for each fracture. Radiographic displacements were measured with a ruler (in millimeters) and protractor (in degrees). Whenever possible, the PACS software was used for measurements. Measurements were recorded as displacement, shortening, and angulation (Table 1). Of the patients with glenoid fractures, the nonoperative group had 15 mm displacement and the operative group had 32 mm displacement (range, 15–43 mm).

Because this was a matched pair analysis, demographic variables were similar. Right-sided injuries were similar for the nonoperative and operative groups (Table 2). The primary source of payment was private insurance. Worker's compensation was received by four (12.9%) of the nonoperatively treated patients and two (6.5%) of the operatively treated patients (Table 2). The injuries resulted from blunt trauma. Concomitant injuries included clavicle fracture (eight of 31 [25.8%] operative group and three of 31 [9.7%] nonoperative group) and proximal humeral fracture (two of 31 [6.5%] operative group and three of

Table 1. Preoperative fracture parameters

Measurement	Nonoperative (n = 31)	Operative (n = 31)	p
Displacement (mm)	19.6 (5–35)	30.8 (15–45)	< 0.001
Shortening (mm)	18.5 (5–38)	39.0 (15–55)	< 0.001
Angulation (degrees)	15.3 (0–45)	27.8 (0–100)	0.004

Ranges shown in parentheses.

31 [9.7%] nonoperative group). Similar fracture classifications were present (Table 3).

The initial treating surgeon determined operative intervention based on patient age, injury pattern, fracture displacement, associated injuries (unstable intra-articular glenoid and/or clavicle fracture[s]), and comorbidities. Medial displacement was determined with Grashey views (true AP view of shoulder, 30° external rotation) [21].

Table 2. Patient demographics

Demographic	Nonoperative (n = 31)	Operative (n = 31)
Gender		
Male	27 (87.1%)	27 (87.1%)
Female	4 (12.9%)	4 (12.9%)
Age	43.4 (21–72)	42.6 (21–69)
Side		
Right	17 (54.8%)	18 (58.1%)
Left	14 (45.2%)	13 (41.9%)
Mechanism		
MVA	13 (41.8%)	15 (48.4%)
Fall	7 (22.6%)	7 (22.6%)
MCA	2 (6.5%)	5 (16.1%)
ATV/snowmobile	2 (6.5%)	2 (6.5%)
Sports	1 (3.2%)	1 (3.2%)
Other	6 (19.4%)	1 (3.2%)
Payer		
Self-pay	3 (9.7%)	3 (12.9%)
Medicaid	4 (12.9%)	1 (3.2%)
Medicare	3 (9.7%)	2 (6.5%)
Private Insurance	11 (35.5%)	16 (51.6%)
Auto	6 (19.4%)	6 (19.4%)
Worker's Compensation	4 (12.9%)	2 (6.5%)

MVA = motor vehicle accident; MCA = motorcycle accident; ATV = all-terrain vehicle.

Angular deformity and translation were best appreciated on the scapular Y view. Conventional CT imaging out of the plane of the scapula can be confusing but these images can be reformatted to provide information that can be extremely helpful. Three-dimensional CT imaging most clearly identifies displacement, angulation, and fracture pattern (Fig. 1A–B). Ipsilateral shoulder injuries were recorded.

Three orthopaedic surgeons (CBJ, JRR, TJE) with fellowship training in trauma treated all the fractures. All operatively treated scapular fractures were performed in the lateral position on a radiolucent table using the modified Judet approach [16]. The usual deformity of the proximal body fragment or glenoid component is shortening, relative medialization, and flexion to the medial border or body. The fracture fragments were reduced using 2.5-mm terminally threaded Schanz pins (Synthes, Paoli, PA)

Table 3. Fracture classifications

Classification	Nonoperative (n = 31)	Operative (n = 31)
AO/OTA		
A2	23 (74.2%)	20 (64.5%)
A3	7 (22.6%)	7 (22.6%)
B2	1 (1.6%)	1 (3.2%)
B3	0	3 (9.7%)
Goss		
Body	13 (41.9%)	12 (38.7%)
Anatomic neck	1 (3.2%)	0
Surgical neck	16 (51.6%)	18 (58.1%)
Acromion	0	1 (3.2%)
Coracoid	1 (3.2%)	0
Ada and Miller		
Anatomic neck	6 (19.4%)	0
Medial coracoid	24 (77.4%)	26 (83.9%)
Superomedial angle	1 (3.2%)	5 (16.1%)

Fig. 1A–B Three-dimensional reconstruction of AO/OTA B2 lateral column body fracture shows shortening, displacement, and angulation in a 35-year-old man who fell from a height onto his side. (A) AP view; (B) scapular Y view.

Fig. 2A–B Postoperative radiographs are shown after operative treatment through a Modified Judet approach and implantation of 2.7-mm screws and 2.7-mm DCP. (A) AP view; (B) scapular Y view.

inserted into the posterior aspect of the glenoid neck and the lateral border freely or in combination with a small external fixator (Synthes). The fixator attachment maintained the reduction. For isolated glenoid neck or scapular fractures, the plate was balanced on either side of the fracture line along the lateral border for balanced fixation and best quality bone for fixation. For glenoid fractures, the most proximal screw was inserted through the plate that was placed just under the glenoid lip (Fig. 2A–B). If fixation medially was required, the plate was placed along the medial border and under the surface of the scapular spine. If a clavicular fracture was associated with a simple scapular body or glenoid neck fracture, the clavicular fixation was performed initially. Subsequent scapular fixation was considered based on residual deformity and surgeon preference. With the arm placed alongside the patient in a semiextended position, the clinical shoulder morphology and radiographic clavicular length and shoulder stability were assessed. Closure was performed in a layered fashion. Nonabsorbable sutures (No. 2 Ethibond; Ethicon, Inc, Cincinnati, OH) were used to repair the cephalad deltoid to the scapular spine, through osseous suture holes, whereas medial and caudad deltoid was repaired to the inferior fascia. Muscular closure was performed over a 1/8-inch Hemovac drain. Suture repair with 0.0 or 2.0 Vicryl (Ethicon, Inc) tightly closed the thick subcutaneous fascia of the Judet flap. The subcutaneous fascial closure was paramount in relieving tension on the skin closure to reduce the incidence of a hypertrophic scar. An additional drain was inserted below the subcutaneous fascial layer. The skin was then closed with staples or nylon sutures. Drains were discontinued and dressings changed when drainage was less than 10 cc per 8-hour time period, which usually occurred on postoperative Day 2.

Patients with scapular body and neck fractures treated nonoperatively were immobilized with a sling or immobilizer until pain allowed motion and function. If associated lower extremity injuries were present, patients were not allowed load-bearing of the extremity until radiographic consolidation of the fracture and pain allowed. ROM, strengthening, and rotator cuff function were begun when pain allowed. Radiographic images (Grashey, axillary, and scapular Y) were obtained at 2, 6, and 12 weeks (Fig. 3A–B). When pain subsided and fracture lines and borders consolidated, imaging was discontinued.

In patients treated operatively, similar restrictions were placed on ROM, strengthening, and rotator cuff function. Unlimited passive forward flexion and abduction ROM were started before discharge and continued for 6 weeks. The 6-week period was chosen arbitrarily to allow for successful deltoid reattachment to the scapular spine, healing of soft tissues, and adequate pain management. Outpatient formal physical therapy was instituted within 1 to 2 weeks postoperatively for passive ROM only. Active full ROM and strengthening began at 6 weeks postoperatively. Therapy was discontinued when patient or therapist goals were achieved. Radiographs were obtained at the 2-, 6-, 12-, and 24-week intervals. Patients were allowed to return to light duty work at 6 weeks and heavy-duty work at 6 to 12 weeks.

Patients were followed at 2 weeks, 6 weeks, 12 weeks, 6 months, and one year minimum. ROM (forward flexion, abduction, external rotation, internal rotation) was determined by the surgeon at each postoperative interval visit and recorded for this study as the ROM outcome at the final office visit. Forward flexion was measured from a lateral view. With the shoulder in neutral abduction and 90° of forward flexion, internal and external rotation was

Fig. 3A–B Six-week radiographs are shown of nonoperative treatment in a 42-year-old man who was involved in a motor vehicle accident. (A) AP view; (B) scapular Y view.

Table 4. Range of motion

ROM (degrees)	Nonoperative (n = 31)	Operative (n = 31)	t	p
Forward flexion	144.9 ± 44.6 (70–180)	152.6 ± 40.1 (35–180)	−0.500	0.621
Abduction	129.1 ± 47 (70–180)	146.2 ± 41.6 (65–180)	−0.982	0.334
External rotation	67.0 ± 20 (45–90)	50.8 ± 26.7 (10–90)	1.371	0.182
Internal rotation	76.3 ± 15 (60–90)	57.8 ± 29.1 (15–95)	2.127	0.050

Values are mean ± SD; ranges provided in parentheses.

determined based on the arc of motion compared with the neutral point of reference. Because this was a retrospective study, each surgeon determined total shoulder ROM in a nonblinded nonstructured manner. The individual glenohumeral or scapulothoracic ROM was not distinguished. Presence of complications such as wound problems, deep and superficial infections, malunion, nonunion, nerve injury, rotator cuff weakness, shoulder stiffness, or cosmesis were identified. Incidence of secondary surgery was determined. Patients were followed until complete radiographic healing or return to baseline level of functioning at a minimum of 1 year.

Radiographs (Grashey, axillary, and scapular Y views) were obtained at 2 weeks, 6 weeks, 12 weeks, and 6 months. Further radiographs were obtained past 6 months if clinical examination revealed pain, nonsymmetric ROM, or mechanical symptoms. Nonunion was defined as a residual fracture line present greater than 6 months postoperatively and was judged by the operating surgeon. Fixation failure was defined as failure of surgical construct repair. Malunion was defined as any nonanatomic fracture alignment or angulation measured intraoperatively

or postoperatively with radiographs. Nonanatomic alignment was defined as more than 5 mm of medial displacement or shortening. Nonanatomic angulation was defined as more than 10° of angulation in the coronal or sagittal planes.

Initially, descriptive analyses were obtained for all variables required to address the questions. We compared categorical variables (eg, return to work, complications) between treatment groups with chi square analysis. T-tests were used to compare continuous variables (eg, fracture measurements, rates of union, ROM) between treatment groups. The data were analyzed using SPSS® Version 15.0 (Chicago, IL).

Results

All fractures healed and we observed no differences in return to work, pain, or complications in the two groups. The last recorded ROM was similar (Table 4). The operative group had more ($p = 0.043$) physical therapy visits (25 ± 20) than the nonoperative group (14 ± 8). Similar

numbers of patients returned to work at the same job as preinjury status with 28 of 31 (90.3%) patients in the nonoperative group and the operative group ($p = 0.332$). Of the patients changing jobs or not returning to work (three of 31 [9.7%] in each group), the change in employment was related to associated injuries and poly-trauma, not the scapular injury. In the nonoperative group, nine were unemployed initially, eight were performing light duty, four were performing heavy duty, four were performing moderate duty, four were sedentary, and two were retired. In the operative group, four were unemployed, eight were performing light duty, four were performing heavy duty, seven were performing moderate duty, six were sedentary, and two were retired. One patient in each group had persistent pain. No complications related to the scapular fracture treatment were noted in either group. No patients reported incisional numbness, pain, or scarring in the operative group. Documented complications to operative fixation were related to clavicular hardware irritation or removal in both groups. In comparison of the groups, the nonoperative group had one clavicle fracture plated without problems, whereas the operative group had three clavicular fracture platings with two of the three individuals reporting plate irritation and who underwent subsequent removal.

Discussion

Scapular fractures are uncommon, high-energy injuries usually with associated injuries [1, 6, 13, 20, 25–29]. Because the scapula is enveloped by thick muscle, fractures heal quickly and predictably [18]. The literature is replete with case series, retrospective reviews, and fracture classifications [1, 13, 29]. Because no guide to operative versus nonoperative indications exists [1, 6, 13], we compared: (1) rates of union; (2) ROM; (3) return to work; (4) pain; and (5) complications of matched pairs of patients treated nonoperatively and operatively.

We acknowledge limitations of our study. First, inherent issues related to the retrospective nature of data collection were present. We had complete data sets for 31 matched pairs of patients. The patient sample may have been larger with a prospective study. The retrospective nature of this study precluded the ability to obtain functional outcomes using validated functional outcome surveys. Second, patients were followed until complete radiographic healing or return to baseline level of functioning (pain-free, normal activities, radiographic fracture consolidation without fixation failure) for an average of 1.5 years rather than long term with an 18- to 24-month interval. Third, operative intervention was surgeon- and fracture-dependent instead of a randomized method of treatment determination.

Fourth, similar comparative data to prior published scapular research was not consistent, clear, or complete. Fifth, because no CT imaging was indicated or used, true radiographic healing is difficult at best to interpret from radiographs alone despite seeing callus formation on nonoperative management and resolution of fracture lines without disruption of internal fixation. Despite these limitations, the study had complete fracture imaging to determine fracture patterns, enough data sets to be statistically significant, and had followup of long enough duration to determine healing and return to work. The strengths of this study relate to data generated from one large trauma center. Patients were treated with similar operative and nonoperative indications and protocols. Furthermore, a matched pair cohort analysis allowed for comparison of the two treatment groups while minimizing confounding factors.

Because the scapula is encased in a rich vascular network and muscular attachments, union rates should be high [4, 20]. Operative treatment strips soft tissue blood supply but did not deter healing rates compared with nonoperative treatment. The timing of postoperative radiographic imaging can influence the reported time to healing, and arbitrary points of 2, 6, and 12 weeks may not be sufficient. Adiposity or ribs can obscure and interfere with visualization of fracture union. None of the nonoperatively treated fractures displaced or angulated with time despite beginning therapy. None of the nonoperatively treated “floating shoulders” [8] changed fracture displacement or angulation with time. The acuity of nonoperative fractures’ displacement and translation did not worsen with time, but they did remodel with time. Despite using 2.7-mm dynamic compression plates and no locking plate technology along the lateral and medial scapular borders, no cases of fixation failure or loosening were noticed. The lateral border, medial border, and scapular spine accept relatively short screw lengths but provide good-quality bone. Regardless, time to union or healing was not an impediment to functional return in the operative patients. One patient in each group reported persistent pain despite radiographic healing of the fracture.

Final shoulder ROM measurements were similar for both groups. However, the operative group had more physical therapy visits. Surgical dissection resulting in scarring and muscle elevation for plate attachment could have required additional organized therapy for improved function. Because the modified Judet approach requires reattachment of the posterior deltoid to the scapular spine through osseous sutures, active ROM and strengthening are usually delayed 6 weeks for proper muscle healing. This delay in rehabilitation could have resulted in the need for more therapy sessions. Despite literature demonstrating shoulder dyskinesia with scapular malalignment and

Table 5. Literature comparison of ROM, return to work, pain, and complication variables

Author	Number of scapula fractures studied (patient sample)	Mean followup (months)	Measurement	ROM	Return to work	Pain	Complications	Conclusion/recommendation
Ada et al. [1]	16 nonoperative 8 operative (113)	15	Pain Strength ROM Crepitance	Problems with non operative; 100% full ROM	N/A	Rest pain: 50–100% Exertional pain: 40–60% in nonoperative, 100% painless ROM with operative	Weakness and limited ROM with non operative displaced fractures; “popping” with nonoperative of displaced fractures	Operative for “displaced scapular spine and neck fractures” Medial 9 mm Angulated 40° Operative stabilization of displaced fractures returns shoulder to painless normalized strength and ROM
Armstrong and Van der Spuy [3]	64, 11 displaced neck fractures (62)	6	ROM	Full movement except 6/11 displaced fractures with residual stiffness and 3/6 glenoid 100°	No functional disability	3/6 glenoid had painful movement	N/A	Good results with non operative treatment, less favorable with neck and glenoid fractures, consider operative with young and fit patients
Bauer et al. [4]	20 operative, 2 scapular neck (25)	756	Pain ROM Constant 84.1	3/20 minor limitation	15/20 (75%)	13 very good 2 good 4 fair 1 poor N/A	2 posttraumatic arthrosis	Good results with operative treatment
Bozkurt et al. [5]	18 nonoperative	25	ROM Constant 78.8	145°	N/A	N/A	N/A	Associated injuries and glenopolar angle worse results
Edwards et al. [10]	20 nonoperative, 11 clavicle fractures displaced > 10 mm, 5 scapular displaced > 5 mm	28	Herscovici 17 excellent 3 good Rowe 95 Constant 96 SF-36	18 normal, 2 with 20° loss	N/A	10 none 5 mild 4 moderate 1 severe	1 nonunion 2 loss of ROM Pain Weakness Shoulder Depression	Nonoperative management of combined clavicular and scapular injuries Most injuries were minimally displaced

Table 5. continued

Author	Number of scapula fractures studied (patient sample)	Mean followup (months)	Measurement	ROM	Return to work	Pain	Complications	Conclusion/recommendation
Gosens et al. [12]	22 nonoperative	63	DASH 17.5 SST 9.9 SF-36	140°	18/22 (82%)	14/22 Satisfied	Weakness, pain, crepitation, bump	Isolated fractures equal general population and ROM equal to uninjured contralateral, polytrauma less favorable
Hardegger et al. [14]	37 operative 3 neck 2 body 5 combo	78	Pain ROM Strength	21 full 5 minimal 5 moderate 2 severe limit	N/A	25 none 3 minimal 4 moderate 1 severe	2 infections 2 hematoma 8 manipulations	Operative indications not dependent on fracture pattern; demands skilled experience, operate > 10 mm
Herrera et al. [15]	14 operative (22)	27	DASH SF-36	156°	11/14 (79%)	12/14 none 1/14 mild 1/14 moderate	None	Surgery is safe, effective, acceptable functional results
Jones et al. [16]	37 operative (227)	12	ROM, function	158°	N/A	N/A	3 shoulder manipulations	Modified Judet approach safe and effective for operative scapular approach
Jones and Sietsema (current study)	62, 31 operative, 31 nonoperative (182)	18	ROM Pain RTW	168°	56/62 (90%)	60/62 none, 2/62 moderate	Polytrauma with limited return to function, none related to operative	Displacement: Nonoperative < 20 mm, operative ≥ 20 mm Operative reduction and stabilization returns majority of displaced fractures to normalized function, work, activities

Table 5. continued

Author	Number of scapula fractures studied (patient sample)	Mean followup (months)	Measurement	ROM	Return to work	Pain	Complications	Conclusion/recommendation
Leung and Lam [19]	15 patients	14	Rowe 8 excellent 6 good 1 fair	8, 151–180° 7, 120–150°	N/A	9 none 5 slight 1 moderate	0 infection 1 pneumothorax intraoperative 1 prominent plate requiring removal	Operative fixation of combined scapular and clavicular fractures
McGinnis and Denton [21]	39	Adequate in 26 patients	Pain, strength, ROM	19/26 Normal 5/26 Limited to < 90° 2/26 Unable to assess	N/A	16/26 excellent 3/26 good 2/26 fair 3/26 poor 2/26 unable to measure	Heterotopic ossification Limited ROM	Assess associated injuries Begin early ROM
Nordqvist and Petersson [23]	68 nonoperative		Patient satisfaction and ROM	168°	N/A	51/68 good 15/68 fair 2/68 poor	Residual deformity for nonoperative	50% with residual deformity have shoulder symptoms, long-term course not uniformly favorable
Oh et al. [25]	13 patients 3 nonoperative 5 ORIF clavicle 5 ORIF clavicle and scapula		Rowe ORIF 88 Nonoperative 77				4/5 nonoperative scapula with malunion	ORIF both clavicle and scapula to achieve predictably good results

ORIF = open reduction and internal fixation; DASH = Disabilities of the Arm, Shoulder Hand; SST = Simple Shoulder Test; RTW = return to work; N/A = not available.

angulation, our study population did not demonstrate appreciable shoulder dysfunction [18].

From a meta-analysis of case series, results of treatment were recorded [29]. Ninety-nine percent of all isolated scapular body and 83% of all glenoid neck fractures were treated nonoperatively. Nonoperative treatment resulted in good or excellent results in 86% of scapular body and 77% of glenoid neck fractures. In another review of the literature, 85% of scapular fractures treated operatively or nonoperatively perform good to excellent at an average of 4 years [18]. Our patient population performed well with 90% returning to work within 6 months of injury. Polytrauma not associated with the scapular fracture determined final function and result.

A recent systematic review reported 520 scapular fractures from 22 published series [30]. Because of a high variability between studies, use of different outcome measurements, and associated injuries, validated comparison of nonoperative with operative treatment could not be accomplished for any fracture type. Furthermore, many of the studies group together scapular spine, avulsion, neck, body, and glenoid fractures. When evaluating each individual scapular study related to some measurable outcome, some generalizations are noted (Table 5) [1, 3–5, 9, 12, 14–16, 19, 22]. In terms of nonoperative treatment, all the studies recorded excellent results if the fractures are minimally displaced [9, 12]. With Edwards et al., approximately 25% of the fractures were displaced greater than 5 mm [9]. Also, nonoperative treatment consistently produced some component of weakness, shoulder depression, lateral bump, and crepitation. Therefore, when assessing certain outcome measurements in particular, nonoperative management of displaced scapular neck and body fractures does not consistently produce early, pain-free, return to preinjury function. In contrast, patients consistently regain preinjury strength, ROM, and function with operative treatment of displaced fractures. Ada et al. recorded painless ROM and function. They recommended operative treatment for scapular fractures displaced more than 9 mm and/or angulated more than 40°. Bauer et al. noted excellent results and no complications with operative treatment. Because this study only included two scapular body or neck fractures, the results do not alter treatment greatly. Hardegger et al. recommended operative fixation for scapular fractures displaced greater than 10 mm [14]. Despite this case series having two infections and two hematomas requiring operative intervention, 68% had no pain and 70% had normal ROM. The degree of displacement or angulation was not specifically addressed. Our matched cohort analysis of nonoperative and operative groups was statistically similar for all demographics except fracture displacement, shortening, and angulation. Using the different fracture classifications [2], our scapular fracture patterns were similar for both groups. Surgeon and patient decision-making along

with fracture displacement and associated injuries determined nonoperative versus operative treatment. Because no scapular fracture validated musculoskeletal functional outcomes surveys occurred at the time of treatment, the final results of operative treatment might have been similar in this same fracture group.

Complications of operative fixation such as infection, hematoma, scarring, incisional problems, hardware removal, shoulder manipulation, and compartmental syndrome have been recorded [6, 28]. Our documented complications were related to associated clavicular fracture fixation and hardware and not the scapular fracture. Despite not having any validated surgical indications for scapular fixation, surgeon decision and fracture personality were interpreted correctly to reduce the fracture without morbidity and return the patient to normative functioning.

Operative fixation realigned and stabilized the markedly displaced scapular body and neck fractures. Both operative and nonoperative scapular fracture treatment resulted in high union rates, high return to work rates, and minimal complications. Despite operative fixation resulting in no complications and restoration of anatomical function, we do not recommend surgery for scapula fractures with less than 20 mm displacement. Requiring cooperation and communication, further randomized prospective control studies with functional outcome data are required to further define indications for operative fixation.

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References

1. Ada JR, Miller ME. Scapular fractures. Analysis of 113 cases. *Clin Orthop Relat Res*. 1991;269:174–180.
2. Armitage BM, Wijdicks CA, Tarkin IS, Schroder LK, Marek DJ, Zlowodzki M, Cole PA. Mapping of scapular fractures with three-dimensional computed tomography. *J Bone Joint Surg Am*. 2009;91:2222–2228.
3. Armstrong CP, Van der Spuy J. The fractured scapula: importance and management based on a series of 62 patients. *Injury*. 1984;15:324–329.
4. Bauer G, Fleischmann W, Dussler E. Displaced scapular fractures: indication and long-term results of open reduction and internal fixation. *Arch Orthop Trauma Surg*. 1995;114:215–219.
5. Bozkurt M, Can F, Kirdemir V, Erden Z, Demirkale I, Basbozkurt M. Conservative treatment of scapular neck fracture: the effect of stability and glenopolar angle on clinical outcome. *Injury*. 2005;36:1176–1181.
6. Cole PA. Scapula fractures. *Orthop Clin North Am*. 2002;33:1–18, vii.
7. DeFranco MJ, Patterson BM. The floating shoulder. *J Am Acad Orthop Surg*. 2006;14:499–509.
8. DePalma A. *Fractures of the Scapula. Surgery of the Shoulder*. 3rd ed. Philadelphia: Lippincott; 1983:362–371.

9. Edwards SG, Whittle AP, Wood GW 2nd. Nonoperative treatment of ipsilateral fractures of the scapula and clavicle. *J Bone Joint Surg Am.* 2000;82:774–780.
10. Edwards SG, Wood GW 3rd, Whittle AP. Factors associated with Short Form-36 outcomes in nonoperative treatment for ipsilateral fractures of the clavicle and scapula. *Orthopedics.* 2002;25:733–738.
11. Egol KA, Connor PM, Karunakar MA, Sims SH, Bosse MJ, Kellam JF. The floating shoulder: clinical and functional results. *J Bone Joint Surg Am.* 2001;83:1188–1194.
12. Gosens T, Speigner B, Minekus J. Fracture of the scapular body: functional outcome after conservative treatment. *J Shoulder Elbow Surg.* 2009;18:443–448.
13. Goss TP. Scapular fractures and dislocations: diagnosis and treatment. *J Am Acad Orthop Surg.* 1995;3:22–33.
14. Hardegger FH, Simpson LA, Weber BG. The operative treatment of scapular fractures. *J Bone Joint Surg Br.* 1984;66:725–731.
15. Herrera DA, Anavian J, Tarkin IS, Armitage BA, Schroder LK, Cole PA. Delayed operative management of fractures of the scapula. *J Bone Joint Surg Br.* 2009;91:619–626.
16. Jones CB, Cornelius JP, Sietsema DL, Ringler JR, Endres TJ. Modified Judet approach and minifragment fixation of scapular body and glenoid neck fractures. *J Orthop Trauma.* 2009;23:558–564.
17. Kavanagh BF, Bradway JK, Cofield RH. Open reduction and internal fixation of displaced intra-articular fractures of the glenoid fossa. *J Bone Joint Surg Am.* 1993;75:479–484.
18. Lantry JM, Roberts CS, Giannoudis PV. Operative treatment of scapular fractures: a systematic review. *Injury.* 2008;39:271–283.
19. Leung KS, Lam TP. Open reduction and internal fixation of ipsilateral fractures of the scapular neck and clavicle. *J Bone Joint Surg Am.* 1993;75:1015–1018.
20. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audige L. Fracture and dislocation classification compendium—2007: Orthopaedic Trauma Association classification, database and outcomes committee. *J Orthop Trauma.* 2007;21(Suppl):S1–S133.
21. McGinnis M, Denton JR. Fractures of the scapula: a retrospective study of 40 fractured scapulae. *J Trauma.* 1989;29:1488–1493.
22. Neviaser RJ. Radiologic assessment of the shoulder. Plain and arthrographic. *Orthop Clin North Am.* 1987;18:343–349.
23. Nordqvist A, Petersson C. Fracture of the body, neck, or spine of the scapula. A long-term follow-up study. *Clin Orthop Relat Res.* 1992;283:139–144.
24. Obrebsky WT, Lyman JR. A modified Judet approach to the scapula. *J Orthop Trauma.* 2004;18:696–699.
25. Oh W, Jeon IH, Kyung S, Park C, Kim T, Ihn C. The treatment of double disruption of the superior shoulder suspensory complex. *Int Orthop.* 2002;26:145–149.
26. Salimi J, Khaji A, Karbakhsh M, Saadat S, Eftekhari B. Scapular fracture: lower severity and mortality. *Sao Paulo Med J.* 2008;126:186–189.
27. Stephens NG, Morgan AS, Corvo P, Bernstein BA. Significance of scapular fracture in the blunt-trauma patient. *Ann Emerg Med.* 1995;26:439–442.
28. Thompson DA, Flynn TC, Miller PW, Fischer RP. The significance of scapular fractures. *J Trauma.* 1985;25:974–977.
29. Zdravkovic D, Damholt VV. Comminuted and severely displaced fractures of the scapula. *Acta Orthop Scand.* 1974;45:60–65.
30. Zlowodzki M, Bhandari M, Zelle BA, Kregor PJ, Cole PA. Treatment of scapula fractures: systematic review of 520 fractures in 22 case series. *J Orthop Trauma.* 2006;20:230–233.