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Fractures of the Acromion Process: A Proposed Classification System

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Summary: A review of 27 fractures of the acromion process during a 15-year period revealed five distinct types that were classified into three groups. Stress fractures are rare, do not result from acute trauma, and gain little benefit from nonoperative treatment. Type I fractures are minimally displaced. Type IA fractures are avulsion fractures and heal rapidly. Type IB fractures result from direct trauma to the extremity, and are minimally displaced. Most heal with nonoperative treatment. Type II fractures are displaced laterally, superiorly or anteriorly and do not reduce the subacromial space. Most are pain free with full motion after 6 weeks of nonoperative treatment. Type III fractures reduce the subacromial space. This may occur by an inferiorly displaced acromion fracture, or an acromion fracture associated with an ipsilateral, superiorly displaced glenoid neck fracture. Patients in this group sustained significant trauma to the involved extremity. All type III fractures treated nonoperatively develop significant limited shoulder motion with pain, suggesting that early surgical intervention may be indicated. **Key Words:** Acromion—Fracture—Shoulder—Trauma.

Fractures of the acromion process are relatively rare, representing 9% of all fractures of the scapula (2), which represent 1% of all fractures (14). Despite this rarity, there are many case reports in the literature that associate fractures of the acromion process with complications such as nonunion (6,13,22, 31,33,34), nerve or brachial plexus injury (16,19,20, 30), rotator cuff tear (30), acromioclavicular joint separation (19), and humeral head subluxation (21). Because fractures of the acromion process occur infrequently, no accepted treatment method has been established. In the past, authors have recommended a variety of treatment options including slings (8,35), Velpeau's dressings (10,22), and immobilization in spica casts (3,37). Some advocate closed reduction of displaced fractures (22), whereas others recommend open reduction with internal fixation (8,26) or excision of the acromion fracture fragment (26,31). These recommendations are anecdotal, because no large series of fractures of the acromion process is available in the literature. The purpose of this study was to review a large series of acromion fractures to determine trends in the mechanism of injury, the fracture pattern, and treatment methods, and to propose a classification of these injuries.

MATERIALS AND METHODS

From January 1975 to January 1991, 27 patients with fractures of the acromion process were treated at our institution. These patients were identified using ICD-9 Diagnostic Codes from hospital discharge records. Of these 27 patients, 8 were female and 19

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were male. The average age of the patients was 35.7 years (range 14–78). Twelve patients sustained fractures of the left acromion, whereas 15 patients sustained fractures to the right side. None of the patients were found to have bilateral acromion fractures. A review of the charts and roengentograms of these patients was performed to provide information on this uncommon injury (Table 1). Follow-up data were derived from clinic notes and roengentograms. In all cases anteroposterior (AP) views of the shoulder were available from the time of injury and follow-up visits. For some patients, additional views including axillary and scapular "Y" views were also available. Computed tomography scans and 30° caudal tilt views generally were not available, and were not analyzed.

Patients were followed until they were nontender at the fracture site, had full pain-free shoulder motion, and had radiographic evidence of fracture union. Minimum follow-up was 4 weeks. If the fracture did not meet these criteria by 12 weeks, it was considered a nonunion. For the seven patients younger than age 25 years, in whom an os acromiale may obscure the diagnosis, independent confirmation of the presence of a fracture was made by a radiologist not involved in the study. Of the 27 patients in this series, 5 were lost to follow-up, and 2 died of their injuries within 4 weeks.

RESULTS

After reviewing the mechanism of injury, the fracture pattern, and the eventual outcome, five distinct types of acromion fractures were identified and were classified into three groups (Fig. 1). Type I fractures are minimally displaced, and can be subdivided into two types. Type IA fractures are avulsion fractures and developed as a result of muscle strain, with no direct trauma to the acromion process. Type IB fractures are associated with direct trauma to the involved acromion and are minimally displaced. Type II fractures are displaced superiorly, anteriorly, or laterally, and do not decrease the subacromial space. Type III fractures are displaced and cause a reduction in the subacromial space by an inferiorly displaced acromion, or by an associated superiorly displaced glenoid neck fracture. Stress fractures are found in patients with no history of acute trauma, are seen in patients with rheumatologic disorders and/or rotator cuff-tear arthropathy (7), and are considered separately.

Type I: Minimally Displaced Fractures of the Acromion Process

Fourteen of the 27 patients in this series sustained type I fractures of the acromion process. This group was subdivided into two subgroups based on the fracture pattern and the mechanism of injury. The type IA fractures are avulsion fractures and occur as a result of an acute injury, but without direct trauma to the acromion process. Similarly, the type IB fractures result from an acute injury, but with direct trauma to the acromion process.

Type IA, or avulsion fractures as described previously (15,22,29), are thought to occur as a result of deltoid muscle forces, or as a result of strain from the acromioclavicular ligament. In our series, three patients were found to have this type of fracture (Fig. 2A), sustained with no history of direct trauma to the shoulder. Radiographically, all three were found to have anterolateral or posterolateral avulsion fractures, characterized by fracture fragments that were peripheral and not transverse. Patients had tenderness over the acromion, and were painful with active shoulder motion.

Treatment consisted of sling immobilization for 2 weeks, after which complete healing was noted by full, pain-free shoulder motion, with callus seen radiographically in two patients. One patient continued to have significant pain with shoulder motion and developed a painful nonunion of her fracture. After 10 months this was treated by open reduction and internal fixation with a plate and screws, and at 4 months postsurgery she was pain free with a full range of motion and radiographs demonstrating union.

The type IB fracture is characterized by a history of direct trauma to the shoulder with displacement <2 mm. In this series, 11 patients were found to have this type of fracture (Fig. 2B). Seven occurred as a result of vehicular trauma, and four as a result of falls.

Of the 11 patients with type IB fractures, 4 were lost to follow- up, and another with metastatic lung cancer died 4 days after falling and sustaining a fracture of the acromion process. The fracture was not thought to be pathologic. Of the remaining six patients, one developed a nonunion that became pain free by 12 weeks, but showed no radiographic evidence of union. The other five patients all went on to full, painless shoulder motion, but varied in their recovery time, ranging from 4 weeks to 9 months. Factors associated with delayed recovery included crutch use for concomitant lower extremity trauma,

TABLE 1. *Twenty-seven cases of fractures of the acromion process, arranged by type*

Type	Data[a]	Mechanism	Radiographic findings	Treatment	Results/FU	Other injuries
Stress	50/F/L	None	Nondispl. + scan	Sling × 8 wks	Nonunion, with pain/18 mos	SLE
Stress	69/M/R	None	Displ. neck fx	Changed activity	Nonunion with pain/12 mos	Paraplegic relies on UE to ambulate
IA	24/M/R	Dodged baseball bat	Postlat. avulsion	Sling × 2 wks	FROM, pain-free/1 mos	None
IA	14/M/L	Fell off bike	Distal avulsion	Sling × 2 wks	FROM, pain-free/1 mos	None
IA	30/F/L	Lifting 300-lb patient	Distal fx	Sling × 4 wks after 10 mos ORIF	Nonunion–pain after ORIF-FROM, no pain/16 mos	None
IB	24/M/L	MCA	Acrom. neck	Sling prn	No follow-up	Severe CHI, ICB
IB	14/M/R	MVA	Min. displ. distal	Sling prn	No follow-up	R coracoid fx, HTX, L1–L3 fx, C6–C7 fx
IB	26/F/R	MVA	Nondispl at base	Sling prn	No follow-up	CHI, nondispl. R glenoid, R hand, rib fx
IB	78/M/L	Fell down stairs	Nondispl.	Sling prn	No follow-up	None
IB	66/F/R	Fell at home	Nondispl. + scan	None	Died of lung CA	None
IB	44/F/R	Fell at home	Nondispl.	Sling/injections × 4 wks	FROM-no pain/6 mos	None
IB	38/M/L	MVA	Min. displ.	Sling prn × 4 wks	FROM—no pain/1 mo	CHI
IB	29/M/R	MVA	Nondispl.	Sling prn × 8 wks	FROM—no pain/2 mos	R ankle fx
IB	56/M/R	Fell from tree	Inf. acrom., sup. scapular spine	Sling prn × 12 wks	Nonunion, FROM no pain/2.5 mos	None
IB	42/M/R	MVA	Min. displ.	Crutch walking × 12 wks	FROM—no pain/13 mos	CHI, R tibia, L ulna, R SC disloc. R finger, rib fx
IB	18/M/L	Bike vs. car	Min. displ.	Crutch walking	6 mos FROM min pain, 9 mos no pain/9 mos	CHI, nondispl. L glenoid, L ulna, L calcaneus, L cuboid, C2–C3 fx, rupt. spleen, type II AC separation
II	51/M/L	Two-story fall	Displ. laterally	Sling prn	No follow-up	L scapula fx, T5 fx, rib fx
II	18/F/L	MVA	Displ. superiorly and laterally	Figure 8 × 6 wks	Spasticity from CHI/2 mos	CHI, L femur, rib fx, type III AC separation
II	21/M/R	Bike vs. car	Displ. superiorly	Sling prn × 5 wks	FROM—no pain/1.5 mos	R scapula, R olecranon, type II AC separation
II	23/M/L	Snowmobile	Displ. superiorly and anteriorly	Figure 8 × 3 wks	FROM—no pain/1 mo	Rupt. spleen
II	42/M/R	MCA	Displ. laterally	Sling prn × 3 wks	FROM—no pain mild deformity/1 mo	R ankle, R tibia, R toe
II	42/F/R	Pedestrian MVA	Displ. laterally	Sling prn × 6 wks	FROM—no pain/12 mos	R clavicle, R tibia, L tibia, L humerus pelvis, L1 fx, rib fx, type II AC separation
II	54/M/L	Airplane	Displ. laterally	Sling prn	Nonunion FROM no pain/12 mos	C1 fx, facial fx
III	48/M/L	Felled tree	Displ. inferiorly, midacromion, superiorly displ. glenoid fx	I + D, ex-fix of open humerus fx	Nonunion abd. 50°, Flex. 50°, ext. 45°/11 mos	L glenoid fx, L scapula fx, L open humerus fx, flail chest, brachial plexus injury, radial nerve injury, L2 fx, R knee ACL, T5 fx, type II AC separation, rot. cuff injury
III	20/M/R	Boat propeller	Displ. inferiorly, midacromion with ipsilat. nondispl. glenoid fx	I + D, ORIF of glenoid	Abd. 95°, flex. 95°, ext. 50°/14 mos	Open R scapula fx, R humerus fx, R lat. epicondyle fx, R radius fx, R ulna fx, high radial nerve injury, inf. humeral head subluxation, rot. cuff injury
III	44/F/R	Pedestrian MVA	Displ. inferiorly, base of acromion fx	Sling prn	Died 4 days after injury	R clavicle, R humeral neck, rib fx, flail chest, PTX, R olecranon fx, B tibia fxs, pelvis fx, C2 fx, L forearm fx
III	49/M/R	MVA with train	Min. lat. displ. with ipsilat. sup. glenoid fx	Sling prn	Impingement sx, FROM/9 mos	T7 fx with paraplegia, pelvis fx, R rolando fx, R spinal access. nerve injury

F, female; M, male; R, right; L, left; MVA, motor vehicle accident; MCA, motorcycle accident; Fx, fracture; I + D, irrigation and debridment; ORIF, open reduction and internal fixation; ex-fix, external fixation; FROM, full range of motion; FU, follow-up; CA, cancer; CHI, closed head injury; SLE, systemic lupus erythematosus; ICB, intracranial bleed; PTX, pneumothorax; HTX, hemothorax; ACL, anterior cruciate ligament tear; UE, upper extremities; SC, sternoclavicular; AC, acromioclavicular; B, bilateral.

[a] Numbers represent ages (yrs) of patients.

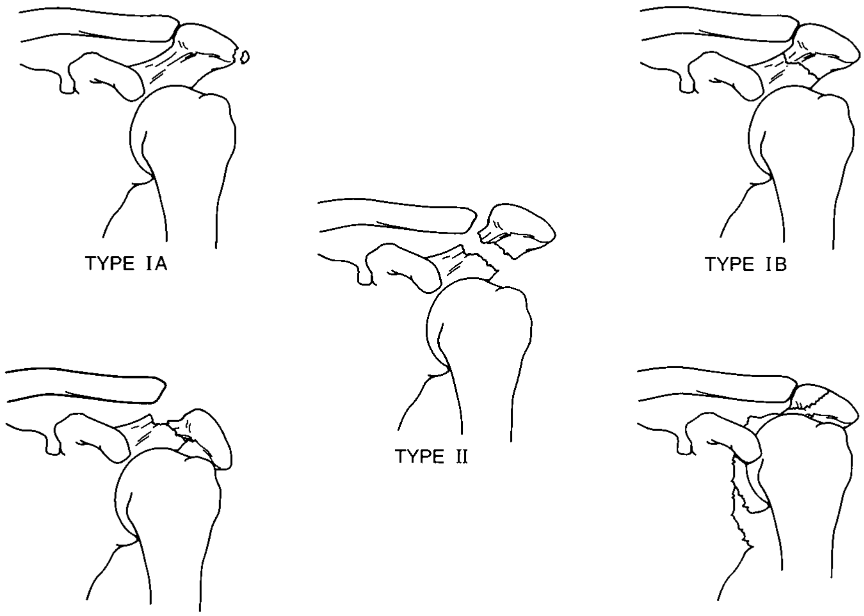

FIG. 1. Classification of fractures of the acromion process. Type I fractures are not displaced and include avulsion fractures (type IA) and true fractures (type IB). Type II fractures are displaced, but do not cause a reduction in the subacromial space. Type III fractures cause a reduction in the subacromial space, either by inferior displacement of an acromion fracture or by being associated with an ipsilateral superiorly displaced glenoid neck fracture.

and ipsilateral shoulder girdle trauma. One patient in this series had a delay in the diagnosis for 2 months, and was treated with cortisone injections. Once the diagnosis was made she was treated with a sling for four weeks, after which she had painless, full range of motion.

Type II: Displaced Fractures of the Acromion Process with No Reduction in the Subacromial Space

Seven patients sustained acromion fractures that were displaced superiorly (one), superiorly and anteriorly (one), superiorly and laterally (one), and laterally (four). These fractures did not decrease the subacromial space (Fig. 3). All patients were treated with a sling for comfort. One patient was lost to follow-up. One patient sustained a severe closed head injury with residual hypertonicity of the involved upper extremity. Although radiographically healed and pain free by 6 weeks, the increased muscle tone limited shoulder motion. The remaining five patients were all pain free with full shoulder motion by 6 weeks. Radiographically, four of these patients had evidence of union, whereas one patient developed a nonunion.

Type III: Displaced Fractures of the Acromion Process with a Reduction in the Subacromial Space

Four patients sustained fractures that reduced the subacromial space, either as a result of inferior dis-

A B

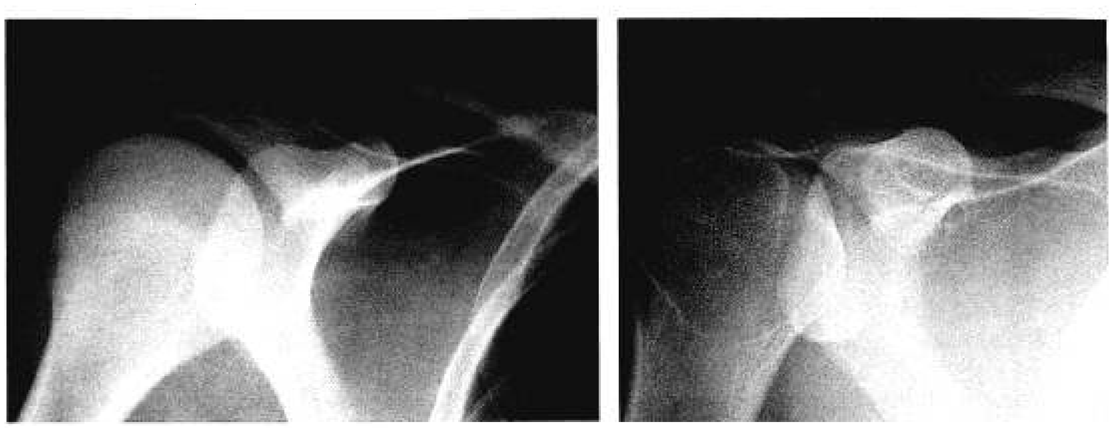

FIG. 2. A: Type IA, avulsion fracture of the acromion process. Note the avulsion fragment laterally (arrow). **B:** Type IB, nondisplaced fracture of the acromion process. The arrow designates the transverse fracture line.

FIG. 3. Type II, displaced fracture of the acromion process with no reduction in the subacromial space. Although this fracture is displaced superiorly, the patient did not have a rotator cuff tear.

placement of an acromion fracture (one), or by an ipsilateral superiorly displaced glenoid neck fracture (two), or both (one). All patients were treated with a sling. The patient with an inferiorly displaced fracture of the acromion died, leaving three patients available for follow-up. Two patients ultimately developed severely limited shoulder motion due to a decrease in the subacromial space, and rotator cuff injuries (Fig. 4A). The third patient sustained fractures of the acromion and glenoid neck that eventually united, but after 6 months he continued to have symptoms of subacromial impingement (Fig. 4B).

Stress Fractures of the Acromion Process

Stress fractures of the acromion process are distinguished from other types of acromion fractures by the mechanism of injury, because the stress fracture occurs in the absence of acute trauma. As others have previously reported (7), this fracture can be associated with rotator cuff-tear arthropathy, and/or rheumatologic conditions. Two patients of the 27 in our series were found to have this type of fracture. The first, a 50-year-old woman with systemic lupus erythematosus, was found to have left shoulder pain at rest, exacerbated by motion. Plain roengentograms of the shoulder revealed a nondisplaced fracture of the acromion (Fig. 5A). The diagnosis was confirmed by bone scan (Fig. 5B). Treatment consisted of sling use for 8 weeks. After 18 months she continued to have pain with no radiographic evidence of union.

The second patient was a paraplegic man who relied on his upper extremities for weight bearing for 42 years. While transferring, he noted a pop associated with weakness of the right shoulder. Roengentograms did not demonstrate a fracture, and a diagnosis of a rotator cuff tear was made. He responded to physical therapy. Four years later he developed the insidious onset of pain in the shoulder during upper extremity weight-bearing. Roengentograms revealed a fracture of the neck of the acromion (Fig. 6). After 1 year of follow-up, he continued to have discomfort with upper extremity weight-bearing. Radiographs did not demonstrate union of the fracture.

A

B

FIG. 4. A: Type III, displaced fracture of the acromion process with reduction in the subacromial space. This patient sustained an inferiorly displaced fracture of the acromion process as well as an ipsilateral displaced glenoid neck fracture. Both fractures contribute to the severe reduction in the subacromial space. **B:** Type III, minimally displaced fracture of the acromion process with an ipsilateral superiorly displaced glenoid neck fracture with reduction in the subacromial space. Arrows designate both fractures. After the fractures united, this patient developed symptoms of impingement.

A

B

FIG. 5. A: Stress fracture of the acromion process in a patient with systemic lupus erythematosus. Arrow designates the fracture. **B:** Bone scan of a stress fracture of the acromion process in a patient with systemic lupus erythematosus. Note the increased radioisotope tracer uptake in the acromion.

General Trends

Associated trauma to the ipsilateral shoulder girdle was common. Eleven patients sustained fractures, three patients sustained acromioclavicular separations, one patient sustained an inferior humeral head subluxation, and rotator cuff problems were seen in three patients.

Nine patients had injuries to other extremities and eight patients had fractures of the spine. Seven patients had rib fractures, frequently associated with a hemo- or pneumothorax. Six patients had closed head injuries. Six patients had fractures of the ipsilateral upper extremity. Other injuries included pelvis fractures in three patients, brachial plexus or nerve injuries in three patients, visceral injuries in two patients, and facial fractures in one patient.

FIG. 6. Stress fracture of the acromion process. The patient is paraplegic and uses his upper extremities for locomotion.

Nonunions were found in 6 of the 20 patients for whom follow-up was available and were seen in all types of acromion fractures, without a consistent pattern. Both stress fractures developed nonunions and continued to be painful after nonoperative treatment. Most nonunions that occurred with traumatic acromion fractures were not painful. One patient with a type IA fracture and a persistently painful nonunion was successfully treated by internal fixation.

DISCUSSION

Fractures of the acromion process are rare and may be associated with significant complications such as nonunions (6,13,22,31,33,34), nerve or brachial plexus injuries (16,19,20,30), rotator cuff tears (30,31), acromioclavicular joint separations (19), and humeral head subluxations (21). Nevertheless, the misdiagnosis of an acromion fracture can occur. In the 6-week-old embryo, the early acromion appears as a collection of mesenchyme attached to a precartilage scapular body, and by 8 weeks the first of four acromial ossific nuclei begin to form bone. The peripheral three ossific nuclei (metaacromion, mesoacromion, and preacromion) remain in a cartilaginous state, and then ossify at ~15 years of age. By 25 years these centers normally coalesce. Failures of coalescence result in a separate bone, the os acromiale. Failure of fusion usually occurs at the junction of the meso- and metaacromion (5,9,11,12, 18,27,28). This os acromiale is found in ~3% of the population and is bilateral in 62% of those (17). It is distinguished from a fracture by observing that the cleavage line is smooth in contour with rounded edges, as opposed to the sharp, ragged edges of a fracture (11,17).

The initial roengentographic evaluation for a suspected fracture of the acromion should include AP, lateral, and axillary views of the shoulder (16). In addition to these views, Rockwood and Matsen recommend adding a 30° caudal tilt and a supraspinatous outlet view (31). If the diagnosis of an acromion fracture is in doubt, it can be confirmed with a bone scan. This is especially important in patients who have no history of trauma and who are suspected of having a stress fracture. Two patients in this series had this type of acromion fracture. Three similar cases have previously been described in the literature in association with rotator cuff-tear arthopathy (7). Two of these three patients had preexisting rheumatoid arthritis, and one of these patients had bilateral stress fractures of the acromion.

Type IA or avulsion fractures of the acromion are rare but have been described in the literature (15, 21,29). In this type of fracture the acromial origin of the deltoid may avulse a small fragment of bone when under significant stress, or the fracture may be a result of stress at the acromioclavicular ligament. This type of fracture is identified by an episode of acute injury to the upper extremity, with no direct trauma to the acromion. Patients with type IA fractures usually recover quickly with nonoperative treatment; however, nonunions can occur.

Type IB fractures are minimally displaced acromion fractures and were the most common type of acromion fracture in this series. These fractures all developed as a result of direct trauma to the acromion and can be associated with polytrauma, or may occur as isolated acromion fractures. All patients in this series were treated with a sling, and this generally resulted in fracture union with full, pain-free shoulder motion. If ipsilateral shoulder girdle fractures occur, or the patient has lower extremity fractures and requires crutches, the recovery process may be delayed.

Types II and III fractures are displaced fractures of the acromion, suggesting high-energy trauma. All of the patients with types II and III fractures of the acromion process had associated injuries that included trauma to the shoulder girdle and chest, injury to the acromioclavicular joint, and nerve and brachial plexus injuries. These injuries may delay recovery. The use of crutches or a wheelchair for lower extremity injuries may delay healing of the fractured acromion.

Type II fractures were those displaced superiorly, anteriorly, or laterally and did not decrease the subacromial space. Patients in this group were all treated nonoperatively and did well. Superiorly displaced acromion fractures have been linked previously with rotator cuff tears (30,31); however, rotator cuff pathology was not seen in the two patients in this series with superiorly displaced acromion fractures. For the patient who sustains a superiorly displaced fracture of the acromion and develops symptoms suggestive of a rotator cuff tear, arthrograms are recommended (30). Posteriorly and medially displaced fractures were not found in this series, but should be included in this group, because they would not be expected to decrease the subacromial space, and would be expected to do well.

Type III fractures were those that caused a reduction in the subacromial space. This occurred as a result of inferior displacement of the acromion fracture fragment or as a result of an acromion fracture associated with an ipsilateral superiorly displaced glenoid neck fracture. All of the patients in this group did poorly, presumably as a result of fracture fragments causing a mechanical limitation of shoulder motion, or as a result of reduction of the subacromial space causing impingement. Additionally, all type III acromion fractures were accompanied by significant ipsilateral shoulder girdle trauma, including injuries to the rotator cuff that contributed to the poor outcome.

Stress fractures were discussed separately and were not included in the classification system for two reasons. First, the mechanism of injury is markedly different for stress fractures, occurring without acute trauma and instead arising from repetitive microtrauma with subsequent fatigue. Second, in patients with rheumatologic disorders, the stress fracture may represent disease affecting the unfused portion of an os acromiale. Bernardeau described a synovial-lined joint cavity in the nonossified zone of the os acromiale (4). In patients with rheumatologic disease and an os acromiale, it is possible that the synovial tissue in the nonossified zone could become involved in the disease process. For such patients, excising the fragment and performing a synovectomy may provide relief.

All patients with stress fractures failed a trial of nonoperative therapy and developed painful nonunions. Previous reports indicate eventual pain relief with the excision of the distal acromial fragment in addition to rotator cuff repair, or total shoulder arthroplasty (7). In this series, patients were treated conservatively and they remained symptomatic. If excision is contemplated, care must be taken to avoid excising excessively large portions of the acromion, as radical excision of the acromion has been associated with significant deltoid weakening, persistent pain, cosmetic deformity, and wound problems (24). O'Donoghue suggests resection of acromion fractures if the fragment is $<\frac{1}{2}$-in size (26). If the fragment is larger, open reduction and internal fixation should be considered.

Previously, no distinction has been made for the different types of displaced fractures of the acromion process, and authors have empirically recommended excision of the displaced fragment if the patient is elderly (32) or if the fracture fragment is small (26). Others have recommended closed reduction (27) or open reduction and internal fixation (8,26). Various methods for the fixation of acromion process fractures have been described in the literature including tension band wiring (1,14,23,31,36), the use of plates and screws (22,36), the use of isolated screws (30), suture (6), the use of smooth or threaded wires (3,26,30), and the use of staples (25). We recognize two types of displaced fractures of the acromion process, and would recommend open reduction and internal fixation only in those associated with a reduction in the subacromial space. Other indications for open reduction with internal fixation may include large, symptomatic stress fractures, and painful nonunions.

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