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The management of clavicle fractures

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The clavicle is one of the most commonly injured bones in the body.[1] Fractures of the middle third of the clavicle account for approximately 80% of all clavicle fractures, with 15% of fractures occurring in the lateral third and 5% in the medial end.[1] The traditional treatment of fractures of the clavicle rarely involves surgical intervention; most are treated with immobilization with a sling or figure-of-eight strap for comfort. Complications from conservative treatment are unusual, but when they do occur, they typically involve nonunion or malunion at the fracture site. Nonunion rates range from 0.03% to 15%.[1-3] Nonunion may be symptomatic, resulting in pain and decreased function of the involved shoulder. Treatment for symptomatic nonunion of a clavicle fracture is open reduction and internal fixation of the clavicle with plating, with or without the use of bone grafting.

Anatomy

The clavicle extends laterally from the sternum to the acromion of the scapula. It has two articulating surfaces: medially, it articulates the sternum at the sternoclavicular joint, and laterally, it articulates with the acromion at the acromioclavicular joint. The clavicle acts as a bridge connecting the upper limb to the trunk, transmitting forces placed on the upper limb to the axial skeleton.[1] The clavicle also functions as an attachment for numerous muscles.[4] These muscular attachments are responsible for the deformities frequently seen with displaced clavicle fractures.

Mechanism of injury

There are two mechanisms of injury that most typically result in clavicle fractures. A fall onto an outstretched arm or onto the lateral aspect of the shoulder is the most common. The force of the fall is transmitted through the upper extremity to the clavicle, producing the fracture. The other common mechanism of injury is direct trauma to the bone itself.

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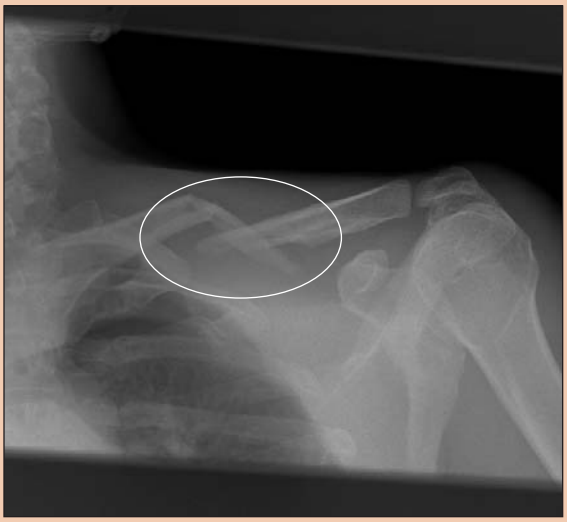
FIGURE 1

Displaced midshaft clavicle fracture with large butterfly fragment



Diagnosis

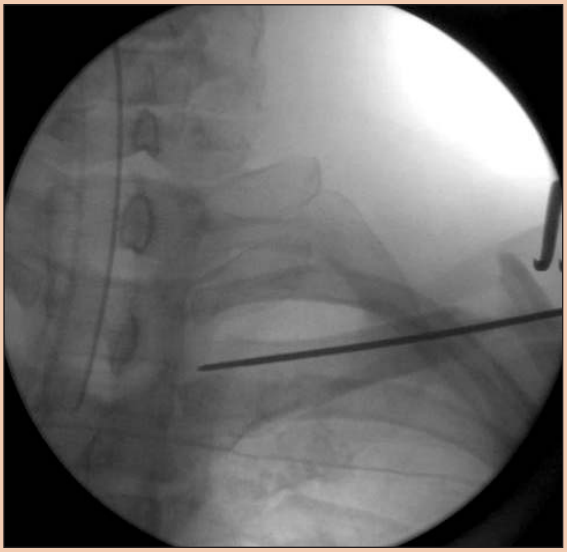
Pain and marked swelling at the site of fracture, decreased shoulder range of motion, brachial plexus nerve compression symptoms, and gross deformity of the clavicle are all indicators of clavicle fractures. Physical examination shows point tenderness at the fracture site, as well as edema and ecchymosis about the site of the fractured clavicle. If displacement of the fracture is severe, tenting and erythema of the skin over the fracture are visible, and in the most extreme cases the skin may become blanched, stretched, and compromised to the point of impending skin breakdown from pressure beneath.

The patient with a suspected clavicle fracture should undergo radiography, including an anteroposterior view and a 45-degree cephalic tilt view. Axillary radiographs may also be useful to determine displacement in the anteroposterior plane.

The most common displacement of these fractures is superior migration of the medial portion of the fracture over the lateral portion. This displacement pattern is due to the pull of the sternocleidomastoid and trapezius

FIGURE 2

Introducing a guide wire into the medial fragment



muscles on the proximal/medial fragment and to the counter-pull of the weight of the limb on the distal/lateral fragment.

Nonsurgical treatment

Immobilization for pain control and healing is the most common treatment of this fracture and is usually accomplished in one of two ways. A figure-of-eight clavicular splint holds the shoulders back and the scapulae together posteriorly, stabilizing the fracture and decreasing fracture displacement.[1,2] Figure-of-eight braces do have potential complications, including frequent discomfort, difficulty of use, and skin breakdown from tight straps. A simple sling is the treatment most orthopedists now use.

Results Nonsurgical treatment is usually adequate to decrease pain and allow the fracture to unite. Radiographic union is typically seen by 12 weeks, though symptomatic relief can occur in as little as 6 to 8 weeks and even sooner in patients with minimally displaced fractures and in children.[5] In a study comparing nonoperative treatment of clavicle fractures to surgically repaired fractures, Federico and colleagues found that patients treated conservatively returned to activities of daily living in 16.7 days and 87.5% eventually recovered range of motion equal to that in the uninvolved opposite shoulder.[3] Another investigation evaluating the conservative treatment of clavicle fractures showed that 55 of 56 nondisplaced fractures healed uneventfully and a good clinical outcome was achieved in 83% of displaced fractures and 73% of comminuted fractures.[3]

Complications The complications of nonsurgical treatment include nonunion and malunion of the fracture, persistent pain, possible neurologic damage, and shoulder deformity.[1-3,5] Of these, nonunion is the most common. Hill and colleagues reported nonunion in 8 of 52 patients.[6] Much research has gone into determining which fractures are at higher risk for nonunion. One study showed nonunion rates of 4.5% for diaphyseal fractures, 11.5% for lateral end fractures, and 8.3% for medial end fractures.[7] Robinson and colleagues also confirmed a high rate of nonunion for lateral clavicle fractures, finding nonunion in 14 of 101 (14%) patients.[8] Zlowodzki and colleagues showed a nonunion rate of 15.1% in displaced fractures treated conservatively.[2]

Risk factors for nonunion include severe (15-20 mm) vertical or horizontal displacement, excessive (15-20 mm) shortening, high-energy fracture, vertical intervening fragments (see Figure 1, page 50), and refracture of a previous fracture site. Patients with severely displaced fractures and those with fractures in the lateral one third should be informed that they may be at higher risk for nonunion.

Surgical treatment

Prevention and treatment of nonunion and malunion are the most common indications for surgical intervention in clavicle fractures. Open reduction and internal fixation are performed in two ways: using plate fixation or with an intramedullary device such as a screw, pin, or nail.

Plate fixation is the most widely used surgical method for treating nonunion of clavicle fractures, and a good deal of research has been performed evaluating its success. Four studies have shown a postoperative union in 87 of their combined 90 patients using plate fixation.[5,7-9] Wick and colleagues performed plate fixation on 60 fractures and reported that all patients were free of pain at rest and all but one patient enjoyed full range of motion.[10] McKee and colleagues found similar results when comparing symptomatology: in their study of symptomatic malunions, 12 of 12 patients noted a decrease in pain, 10 of 11 patients saw a decrease in neurologic symptoms, and 12 of 13 patients who had been unhappy with the appearance and asymmetry of their shoulder were satisfied with its appearance postoperatively.[11]

Indications for surgery include severe displacement, shortening, skin compromise, and delayed union.

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Intramedullary fixation is another common surgical approach. The usual techniques involve the insertion of rigid hardware within the medullary canal to align the fracture site and produce healing. A number of different materials have been used, including rigid screws, flexible nails, and Kirschner wires.[10-13] A biomechanical study showed that plating and intramedullary Herbert bone screws have the same mechanical strength to failure.[14] Ngarmukos and colleagues treated 99 acute fractures and 11 nonunions using 2-mm Kirschner wires; the results show radiographic union by 8 weeks in acute fractures and by 20 weeks in cases of nonunion.[15] One major drawback of this procedure is the risk of hardware migration. In Ngarmukos' study, the ends of the wires were bent to prevent migration; therefore, all required removal 6 to 12 months postoperatively.[15] Other investigators have looked at using more rigid hardware to eliminate the problem of having to have a second procedure. Hoe-Hansen and Norlin, and Proubasta and colleagues, used an intramedullary cancellous screw and a Herbert cannulated bone screw, respectively.[16,17] Both studies showed complete healing of nonunions in a combined 11 cases.[16,17] Hoe-Hansen and Norlin report that a second procedure to remove the cancellous screw was performed on one patient.[16] The advantages of intramedullary fixation over plate fixation include smaller incision size, less periosteal stripping, better compression at the fracture site (with variable-pitched intramedullary screws), and completely embedded hardware, which decreases both the risk of painful hardware and a second procedure for hardware removal.

Complications can occur with surgical intervention, as with conservative treatment. Any surgery carries an increased risk for infection, as well as for nerve and vessel damage. This is especially relevant for the clavicle, which sits in close proximity to the subclavian vessels and the brachial plexus. Great care is required to avoid subclavicular neurovascular structures in the approach to and dissection of clavicle fractures, particularly midshaft and proximal fractures, as well as in the approach to displaced nonunions. Paresthesiae and dysesthesiae may result from transection or neuroma formation of supraclavicular nerves, and it is important to identify and protect these commonly encountered structures.

Nonunion may also occur following clavicular fixation.[9,17] Hardware failure due to injury or falls is reported, as are nonunion and refracture following hardware removal.[9,18] Grassi and colleagues compared surgical fixation with conservative treatment and found a high rate of complications with open intramedullary fixation.[9] Their study showed a quicker return to activities of daily living (16.7 days) and to sports (2.6 months) in nonsurgical treatment of clavicle fractures.[9] Jubel and colleagues dispute these findings, showing a return to athletic training in 5.9 days and participation in competition in 16.8 days after intramedullary fixation.[19] *Continued on page 56*

FIGURE 3

Guide wire in the lateral fragment, introduced medially, exiting the clavicle and the skin

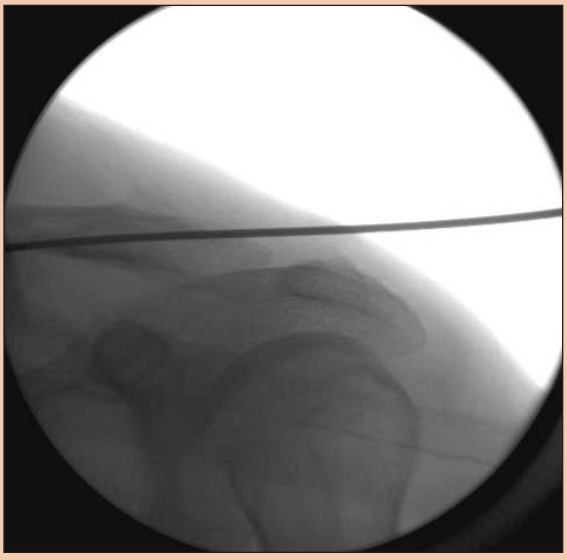

FIGURE 4

Cannulated intramedullary fixation screw, after guide wire has been removed

Intramedullary screw fixation

At our institution, we have been treating selected acute fractures and nonunions using the Herbert cannulated bone screw. Indications for surgery include severe displacement, shortening, skin compromise, and delayed union.

The patient is in the beach chair position with a radiolucent table or dropout section to allow intraoperative fluoroscopic evaluation. A straight incision is made over the fracture site. The fracture is exposed, enabling the removal of any clot or debris to allow reduction. A terminally threaded guide wire is then placed into the medullary canal of the medial fragment and advanced medially using c-arm visualization (see Figure 2, page 53). The guide wire is over reamed by hand using a cannulated drill bit and then removed. The guide wire is then driven into the intramedullary canal of the lateral fragment and through the posterolateral end of the clavicle, avoiding the acromioclavicular joint and tenting the skin posterolaterally. A small skin incision is made over the subcutaneous guide wire, and the wire is advanced completely into the lateral fragment, exiting the skin laterally (see Figure 3, page 54).

Intramedullary fixation may allow earlier return of function and decreased complications.

The fracture is then reduced, and the wire is driven in retrograde fashion into the medial fragment of the fracture. Fluoroscopy is used throughout the procedure to ensure that the guide wire remains in the medullary canal of the clavicle and does not protrude into the sternoclavicular joint and to ensure that the reduction is maintained. The posterior lateral cortex of the clavicle is then drilled over the guide wire with a cannulated drill bit using a soft-tissue protector. A cannulated Herbert screw of appropriate length and diameter is introduced from the posterolateral aspect of the lateral fragment of the clavicle. With the reduction maintained, the screw crosses the fracture site and enters the medial fragment of the fracture. The differential pitch of the Herbert screw allows for compression of the fracture site, thereby increasing the stability and rigidity of the construct (see Figure 4, page 54). Comminuted fragments, if present, are placed about the fracture or sewn to adjacent periosteum if soft-tissue attachments remain. Bone grafting is rarely necessary for acute fractures. The incision is thoroughly irrigated and closed.

Motion in the form of pendulum exercises, followed by unlimited active range of motion, is started as soon as pain allows. Strengthening is reserved until there is early radiographic evidence of impending union, usually at 6 weeks postoperatively.

Discussion

Clavicle fractures are common in primary care settings as well as in orthopedic and sports medicine clinics. Conservative treatment includes immobilization of the fracture site with a figure-of-eight brace or a simple sling. Complications that may arise include nonunion of the fracture site; persistent pain; dysfunction due to malunion, dysesthesiae or paresthesiae; and an unappealing cosmetic result. Of these, nonunion of the clavicle is the most common. Numerous studies have shown that open reduction and internal fixation of the clavicle is an excellent option to correct this complication. Intramedullary fixation of the acute displaced clavicular fracture may allow earlier return of function, earlier return to work and activities, and decreased complications compared to conservative management. Outcome studies are under way to examine the role of open reduction and internal fixation in the acute setting as the preferred mode of clavicular fracture management. □

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