

Chapter 6

Open Reduction and Internal Fixation of Clavicle Fractures

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Introduction

Clavicle fractures are common, accounting for 2.6% to 5.0% of adult fractures.¹⁻³ Historically, clavicle fractures were thought to heal with predictability while being managed almost exclusively nonsurgically. This treatment was based largely on two retrospective studies performed in the 1960s by Neer⁴ and Rowe⁵ that suggested that surgical treatment actually resulted in an increased number of nonunions and complications compared with nonsurgical treatment.

Today, with improved surgical techniques, growing evidence indicates that early surgical treatment may be beneficial in appropriately selected patients. In fact, in a recent prospective multicenter randomized clinical trial by the Canadian Orthopaedic Trauma Society, a comparison of nonsurgical treatment and plate fixation of midshaft clavicle fractures revealed that plate fixation resulted in significantly better radiographic outcomes; Constant scores; Disability of the Arm, Shoulder, and Hand (DASH) scores; functional outcomes; and cosmetic scores.⁶

Classification

Clavicle fractures are generally classified based on the location of the fracture within the clavicle as well as the degree of comminution and angulation. The classification devised by Allman⁷ is commonly used; it categorizes clavicle fractures as proximal, midshaft, or distal. The location of the fracture within the clavicle and the degree of displacement, angulation, and comminution all play a role in determining treatment recommendations.^{3,8,9}

Overall, fractures of the midshaft make up about 70% to 80% of all clavicle fractures, whereas those of the lateral or distal portion make up approximately 21% and medial-end fractures approximately

2% to 3%.^{1,8-10} Midshaft fractures occur more commonly as a result of high energy and in a younger patient population and are more commonly displaced, whereas lateral and medial-end fractures occur more commonly in the elderly and are nondisplaced.^{2,8,9}

Patient Selection Indications

Overall surgical indications include open fractures, “floating shoulder,” impending skin necrosis, associated neurovascular injuries, and multiply injured trauma patients.^{3,8} More recently, studies have suggested that improved outcomes are associated with surgical fixation of fractures with shortening greater than 15 to 20 mm, with 100% displacement, or with comminution.⁶

Contraindications

Nonsurgical treatment is generally recommended for nondisplaced or minimally displaced fractures and in older, sicker patients who are either low demand or are medically unfit to undergo surgery. If nonsurgical treatment is pursued, a sling and a course of non-weight bearing is sufficient.^{3,8}

Preoperative Imaging

Orthogonal views of the clavicle are the best means of evaluating the fracture. The fracture should be evaluated for location within the clavicle, displacement, comminution, angulation, and associated fractures to the scapula and the proximal humerus. Evaluation of an AP radiograph of the chest should include not only the clavicle fracture itself but also associated chest injury, including rib fractures, pneumothorax, or hemothorax.

Other views that can supplement the initial views include the apical oblique view (affected shoulder tilted 45° anterior and x-ray beam 20° cephalad), which may

help diagnose minimally displaced fractures.¹¹ This view also can help in judging the adequacy of reduction in the operating room. The abduction lordotic view (x-ray beam angled 25° cephalad with shoulder abducted above 135°) is useful to evaluate healing after internal fixation.¹² Other radiographs that may be obtained include a stress view for a lateral clavicle fracture to evaluate for acromioclavicular joint separation and the integrity of the coracoclavicular ligaments.

In addition to radiographs, preoperative CT scans of the clavicle are being increasingly used. They are used particularly for evaluation of nonunions as well as medial-end fractures extending into the sternoclavicular joint.

Procedure

Room Setup/Patient Positioning

The surgical technique for midshaft clavicle fractures is described here. Many surgical procedures are available for clavicle fracture fixation, depending on surgeon preference and fracture characteristics.

Initially, the patient is placed supine or in a modified beach-chair position on a radiolucent operating table. Intraoperative fluoroscopy should be available. A bump can be placed under the medial portion of the scapula of the surgical shoulder. A pneumatically controlled arm positioner can be used to negate the weight of the arm and facilitate surgery (**Figure 1**). Before marking out the skin incision, palpation of the bony landmarks should be performed, including the soft triangle in the superolateral shoulder area bounded by the acromion laterally and the scapular spine posteriorly. Just anterior to this soft triangle is the acromioclavicular joint, and just anteromedial to this is the coracoid process. The clavicle should be palpated along its S-shaped curve medially to where it articulates with the sternum at the sternoclavicular joint. The location of the incision depends on the fixation technique used.

Surgical Technique

Plate Fixation

Plate fixation is the most commonly used technique for management of clavicle fractures. Contoured clavicle plates are

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Figure 1 Photograph shows a patient with a pneumatically controlled arm positioner in place for left shoulder surgery.

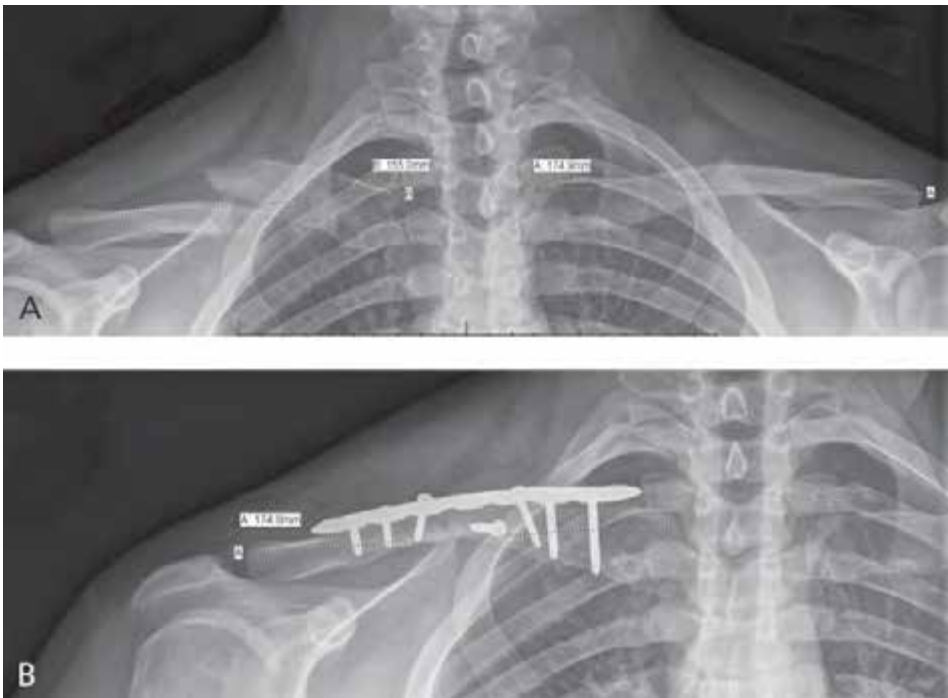


Figure 2 AP radiographs of a patient with a right midshaft clavicle fracture. **A**, Preoperative radiograph demonstrates 2 cm of shortening. **B**, Postoperative radiograph shows that clavicle length symmetric to the uninjured left side is restored with plate fixation. An interfragmentary screw and a contoured clavicle fracture plate were used.

available for superior plating of the midshaft (**Figure 2**); a different set of contoured plates is available for the lateral portion of the clavicle. Options for better contouring include trying a plate that is meant for the contralateral side or flipping the plates to use the medial side on the lateral side (for midshaft fractures only) and vice versa. Alternatively, a standard plate, such as a 3.5-mm limited-contact dynamic compression plate, can

be bent to fit the clavicle of each individual patient.

The main ways of positioning the plate are superiorly or anteroinferiorly. The approaches are nearly identical, except that with anterior placement of the plate, the deltoid and pectoralis major must be extraperiosteally elevated. Advantages of the anteriorly placed plate include decreased hardware prominence and screws directed posteriorly instead of in-

feriorly, toward the traversing neurovascular structures.

We prefer a longitudinal incision made just inferior to and in line with the clavicle (**Figure 3**). The supraclavicular nerves are preserved as they cross perpendicular to the clavicle just deep to the level of the platysma (**Figure 4**). A 3.5-mm limited-contact dynamic compression plate or precontoured locking plate is applied to the clavicle with a minimum of three bicortical screws placed on either side of the fracture. A lag screw can be applied perpendicularly across the fracture fragment to generate compression and increase stability in a simple fracture pattern. For a comminuted fracture, a bridge plating technique can be used without fracture exposure, placing the plate over the top of the periosteum.^{3,8,13}

Intramedullary Nailing

Intramedullary (IM) nailing is ideal for simple fractures of the middle third of the shaft that will have good cortical contact after fixation. IM nailing is not ideal for comminuted fractures, and this type of fixation does not resist torsional forces as well as plating does.³ Proposed advantages are smaller skin incisions, less soft-tissue stripping compared to plate fixation, easier removal of hardware, and fewer potentially weak areas after hardware removal.³

The most commonly used technique uses a 2- to 3-cm incision over the fracture fragment. The platysma is dissected through, and the middle branches of the supraclavicular nerve are protected. The medial fracture fragment is elevated with a bone-reducing clamp and the canal is prepared, with care taken not to disrupt the medial cortex. The lateral fragment is then elevated, which can be aided by externally rotating the arm. The drill is advanced through the posterolateral cortex of the lateral fragment, with care taken to ensure that the exit point is not too superior, to avoid pin prominence). The clavicle pin is passed from the fracture site out the posterolateral cortex, and a small incision is made over the palpable tip.

After fracture reduction, the pin is driven in the opposite direction, into the medial fragment toward the anterior cortex. Two nuts are used on the lateral portion of the pin, both to provide compression against the lateral cortex of the clavicle and to provide a means to advance and remove the clavicle pin construct throughout fixation. Furthermore, the laterally placed nuts prevent medial



Figure 3 Intraoperative photograph shows the typical incision for a left midshaft clavicle fracture. A contoured clavicle plate and screws are used to maintain reduction.

pin migration. The clavicle pin can be removed under general or local anesthetic in 10 to 12 weeks, after the fracture site has healed.^{3,14}

Additional Considerations for Lateral Clavicle Fractures

Fixation of lateral clavicle fractures depends largely on patient selection as well as fracture characteristics. Often, lateral clavicle fractures are nondisplaced and occur in low-demand, elderly patients with poor bone quality. Lateral clavicle fractures can be managed nonsurgically; although the risk of nonunion is increased, this has been shown to have little effect on quality of life and is even associated with high patient satisfaction.⁸ Fixation options include coracoclavicular screws, plate and hook-plate fixation, and the suture and sling technique.⁸ Late intervention for acromioclavicular arthritis may include either arthroscopic or open distal clavicle resection.

Additional Considerations for Medial Clavicle Fractures

The mainstay of treatment for medial clavicle fractures is also largely nonsurgical because most are extra-articular and minimally displaced. Fracture displacement posteriorly and compression on the superior mediastinal structure clearly indicate a need for treatment. First, closed reduction is attempted; if this fails, open reduction and internal fixation is performed. Fixation with either suture or nonabsorbable wide fiber suture obviates the need to return to the operating room for removal of hardware and avoids the risk of metal hardware migration.

Complications

Complications of the surgical management of clavicle fractures include infection, nonunion, malunion, the need for

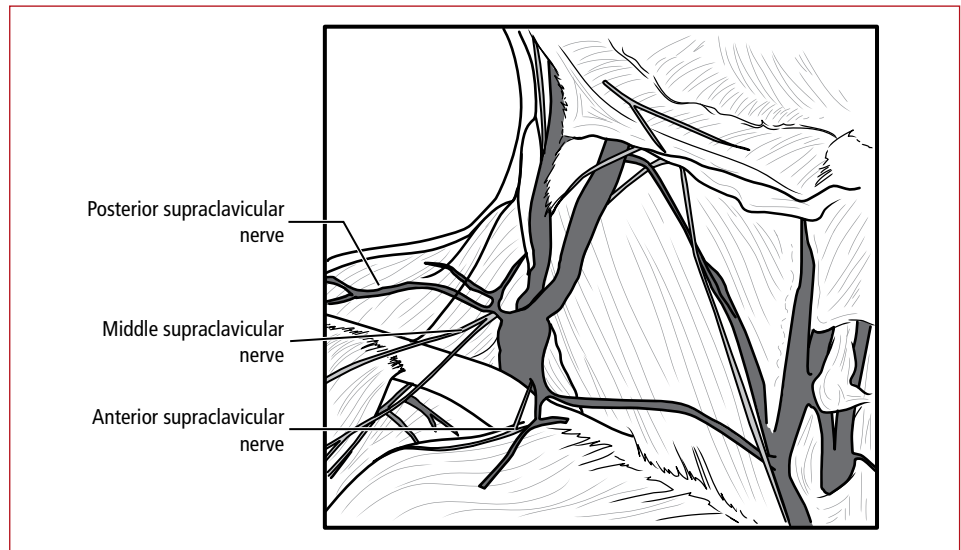


Figure 4 Illustration shows the anatomy of the supraclavicular nerves.

hardware removal, neurologic complications, refracture, and osteoarthritis of the acromioclavicular joint.

Infection has been reported to occur in 0% to 18% of surgically treated clavicle fractures, with decreasing rates in more recent studies.^{3,15}

Nonunions are often symptomatic in young patients, causing pain, decreased shoulder function, weakness, and a clicking sensation. At one time, nonunions were thought to occur with a frequency of less than 1% after nonsurgical management of clavicular fractures. A recent meta-analysis, however, reported that the nonunion rate for displaced midshaft clavicle fractures treated with plate fixation was 2.2% (10 of 460 patients) and with IM nail fixation was 2.0% (3 of 152 patients), whereas nonsurgical treatment resulted in a 15.1% (24 of 159 patients) nonunion rate.¹⁶ Many of the included studies, though, were level III and IV evidence. Risk factors for nonunion include increasing age, female sex, fracture displacement, and comminution.¹⁷

Malunion occurs in almost every fracture that is treated nonsurgically; this is due to angulation (particularly anterior-posterior) and shortening.³ Most malunions are asymptomatic, although some recent studies suggest that comminution, initial displacement greater than 15 to 20 mm, and increasing age are predictive of symptomatic malunions.⁶

Neurologic complications, with a prevalence ranging from 0.3% to greater than 20%, can occur as a result of the initial injury, with fracture compression of nerves; or as a late complication, such as if the brachial plexus or the subclavian vessels become encased within a hypertrophic

callus.^{5,6} This has been referred to as thoracic outlet syndrome and often is associated with ulnar nerve symptoms.^{3,8}

Patients run the risk of refracturing the clavicle if they return to sports too soon or have risk factors such as alcohol abuse or epilepsy. Refracture is also a possibility after the removal of hardware. Refracture rates have been cited as ranging from 0% to 8%.^{8,15}

Another late complication is posttraumatic osteoarthritis of the acromioclavicular joint, which often manifests as activity-related pain located anteriorly over the acromioclavicular joint; the pain can be reproduced with palpation or with cross-arm adduction. Posttraumatic osteoarthritis of the acromioclavicular joint is most commonly associated with intra-articular lateral clavicle fractures, although it can also occur with extra-articular fractures. Treatment includes distal clavicle excision (arthroscopic or open technique).⁸

The most dangerous intraoperative complication is injury to the subclavian artery or vein by drill penetration or during fracture immobilization.^{3,8} If this rare complication occurs, repair by vascular or cardiothoracic surgeons may be indicated.

Postoperative Care and Rehabilitation

Postoperatively, patients remain in a sling for comfort for approximately 4 weeks. Range of motion at the wrist and elbow and active-assisted range of motion to 90° of forward flexion with the sling removed should be performed at least five times a day. Once radiographic and clinical healing has been achieved at approximately

6 weeks, resisted activity at the shoulder can be initiated. Often, return to sport is not suggested until 3 months postoperatively.

Pearls

- Landmarks should be drawn out, including the superior/inferior clavicle margins, the sternoclavicular joint, the acromioclavicular joint, and the planned incision.
- The patient should be in a modified beach-chair position.
- A bump placed under the medial portion of the scapula to be operated on helps with reduction.
- A pneumatically controlled arm positioner allows precise positioning of the arm, negates the weight of the arm, facilitates the surgery, and frees fellows and residents to assist with the operation rather than holding the limb during the case.
- Placing the incision inferior to the clavicle avoids hardware that lies directly under the skin.
- Fracture reduction is aided by reduction clamps.
- We prefer anterior-inferior plating, because it avoids hardware prominence, for patients who will carry heavy loads over their shoulders, such as firefighters.
- In addition to standard radiographs, an apical oblique view is helpful to evaluate fracture reduction.

- Nonabsorbable suture can be looped around small segmental fragments to bring them into apposition with the main fracture lines.

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