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Treatment of clavicle fractures: current concepts review

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Clavicle fractures are common in adults and children. Most commonly, these fractures occur within the middle third of the clavicle and exhibit some degree of displacement. Whereas many midshaft clavicle fractures can be treated nonsurgically, recent evidence suggests that more severe fracture types exhibit higher rates of symptomatic nonunion or malunion. Although the indications for surgical fixation of midshaft clavicle fractures remain controversial, they appear to be broadening. Most fractures of the medial or lateral end of the clavicle can be treated nonsurgically if fracture fragments remain stable. Surgical intervention may be required in cases of neurovascular compromise or significant fracture displacement. In children and adolescents, these injuries mostly consist of physeal separations, which have a large healing potential and can therefore be managed conservatively. Current concepts of clavicle fracture management are discussed including surgical indications, techniques, and results.

Level of evidence: Review Article.

Keywords: Clavicle fractures; treatment; current concepts

Approximately 2% to 5% of all fractures in adults and 10% to 15% in children involve the clavicle.[40,44,49] The incidence of this type of fracture in the adolescent and adult population is reportedly 29 to 64 per 100,000 persons annually.[43,49,52] Fractures of the clavicle also show a bimodal age distribution. Young male patients who are aged less than 30 years and elderly patients aged over 70 years appear to be two distinct age groups at higher risk for clavicle fractures.[56]

In adults, more than two-thirds of these injuries occur at the diaphysis of the clavicle, and these injuries are more likely to be displaced as compared with medial- and lateral-third fractures. In children, up to 90% of clavicle fractures are midshaft fractures.[31,43] Lateral-third fractures are less common, accounting for approximately 25% of all clavicle fractures, and are less likely to be displaced than those occurring in the midshaft. Medial-third fractures comprise the remaining 2% to 3% of these injuries.[1,43,47,49,52,56]

Traditionally, nonsurgical management has been favored as the initial treatment modality for most clavicle fractures because of the high nonunion rates reported after operative treatment.[42,54] Although nonsurgical management may be optimal for many clavicle fractures, good outcomes of non−surgically treated fractures are not universal.[25,45,46,53] Recent evidence suggests that specific subsets of patients may be at high risk for nonunion, shoulder dysfunction, or residual pain after nonsurgical management.[62] In this subset of patients, acute surgical intervention may minimize suboptimal outcomes. Therefore, specific treatment of clavicle fractures should not be broadly applied but rather should be individualized based on fracture characteristics and patient expectations.

The purpose of this review is to provide an overview of the current treatment strategies for clavicle fractures based

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on their anatomic location and stability. In addition, a necessary distinction is made between fractures in adults and fractures in skeletally immature patients.

Classification of clavicle fractures

A number of classification systems have been proposed to aid in the description of clavicle fracture patterns for clinical and research purposes.[1,12,40,43,52] To date, most modern clavicle fracture classification systems are primarily descriptive and not predictive of outcome. The first widely accepted classification system for clavicle fractures was described by Allman[1] in 1967. Fractures were classified based on their anatomic location in descending order of fracture incidence. Type I fractures occur within the middle third of the clavicle, whereas type II and type III fractures represent involvement of the lateral and medial thirds, respectively.

Fractures of the lateral third of the clavicle were further subclassified by Neer,[40] recognizing the importance of the coracoclavicular (CC) ligaments to the stability of the medial fracture segment. A type I lateral clavicle fracture occurs distal to the CC ligaments, resulting in a minimally displaced fracture that is typically stable. Type II injuries are characterized by a medial fragment that is discontinuous with the CC ligaments. In these cases, the medial fragment often exhibits vertical instability after loss of the ligamentous stability provided by the CC ligaments. Type III injuries are characterized by an intra-articular fracture of the acromioclavicular joint with intact CC ligaments. Although these fractures are typically stable injuries, they may ultimately result in traumatic arthrosis of the acromioclavicular joint. A more subtle fracture may require special radiographic views for identification and may be mistaken for a first-degree acromioclavicular joint injury.

A more detailed classification system (Edinburgh classification) was proposed by Robinson.[52] Similar to earlier descriptions, the primary classification is anatomically divided into medial (type I), middle (type II), and lateral (type III) thirds. Each of these types is then subdivided based on the magnitude of fracture fragment displacement. Fracture displacement of less than 100% characterizes subgroup A, whereas fractures displaced by more than 100% account for subgroup B. Type I (medial) and type III (lateral) fractures are further subdivided based on articular involvement. Subgroup 1 represents no articular involvement, and subgroup 2 is characterized by interarticular extension. Similarly, type II (middle) fractures are subcategorized by the degree of fracture comminution. Simple or wedge-type fracture patterns make up subgroup 1, and comminuted or segmental fracture patterns represent subgroup 2.

Craig[12] further modified Neer type II lateral clavicle fractures by stressing the importance of the conoid ligament and separately classifying intra-articular and pediatric clavicle fractures. A recent comparison of these classification systems showed that Craig's classification was most prognostic when predicting delayed union or nonunion of lateral-third fractures and Robinson's classification had the greatest prognostic value for middle-third fractures.[12,47]

Medial-third fractures

Nonoperative management

Fractures of the medial third of the clavicle (Edinburgh type I) are nearly always treated nonoperatively. These clavicle fractures are uncommon, are frequently nondisplaced or minimally displaced, and rarely involve the sternoclavicular joint.[43,52,53] In general, a sling or figure-of-8 brace is provided for comfort, and as pain allows, early range of motion is encouraged. Patient comfort plays a key role in the total duration of immobilization, but the immobilization period generally varies between 2 and 6 weeks. A structured rehabilitation ensures a satisfactory outcome for most patients. To protect the healing clavicle, it is important to avoid contact sports for a minimum of 4 to 5 months.

Surgical management

Surgical treatment of medial-end clavicle fractures is indicated if mediastinal structures are placed at risk because of fracture displacement, in case of soft-tissue compromise, or when multiple trauma and/or ''floating shoulder'' injuries are present. Closed or open reduction should be performed to reduce the displaced fragment in an emergent fashion.[23,33]

When open reduction is necessary, several techniques have been described for internal fixation of fracture fragments. These include wire or plate fixation and interosseous sutures.[17,23,33] In general, Kirschner wire fixation has proven unsafe because of breakage and migration. By contrast, use of interosseous wires or suture and modified hooked Balser plate fixation appears more successful but requires a second operation for hardware removal.[17,23,33]

Children/adolescents

Most injuries in children and adolescents involving the medial end of the clavicle consist of physeal separations. This is because the medial epiphysis of the clavicle does not ossify until age 20 years and ossification centers rarely fuse before age 25 years.[22] It is important, however, to differentiate physeal separations from true sternoclavicular joint dislocations because of the remodeling potential and because the treatment of these 2 diagnoses can differ greatly. A computed tomography scan can be helpful to distinguish these entities.[22,33]

Results

The results of nonsurgical treatment of fractures of the medial end of the clavicle are in general satisfactory, although the low prevalence of these fractures precludes detailed analysis.[52] Nonunion rates between 4% and 8% are reported; however, an increased risk of nonunion accompanies cases of complete fracture fragment displacement.[52,53] Reports detailing the surgical treatment of medial clavicle fractures are also small, providing only anecdotal experiences with surgical management.[14,17,23,33]

Our preferred treatment

Nonsurgical treatment should be the first treatment of choice in the vast majority of patients. However, considering the increased risk for fracture nonunion in case of complete fracture displacement, open reduction and internal plate fixation should be considered in these cases.

Middle-third fractures

Nonoperative management

The goal of clavicle fracture treatment is to achieve bony union while minimizing dysfunction, morbidity, and cosmetic deformity. Historically, the vast majority of clavicle fractures have been treated nonoperatively in the acute setting. This is largely because of reported nonunion rates of less than 1% and separate reports by Neer[40] and Rowe[54] in the 1960s suggesting that operative intervention resulted in an increase in nonunion rate by more than 3-fold. In addition, several studies reported high rates of patient satisfaction after nonoperative treatment.[3,14,43]

Nonoperative management remains the treatment of choice for nondisplaced midshaft clavicle fractures (Edinburgh type 2A). Meta-analyses of 1,145 nonoperatively treated midshaft fractures, 986 of which were nondisplaced, showed a nonunion rate of only 5.9%.[62] The nonunion rate for displaced fractures, however, was 15.1% when treated nonoperatively. Management is identical to that of fractures of the medial third.

Surgical management

Definitive indications for acute surgical intervention include skin tenting, open fractures, the presence of neurovascular compromise, multiple trauma, or floating shoulder. Outside of these indications, the management of displaced fractures of the midshaft (Edinburgh type 2B) remains somewhat controversial. Recent literature is challenging the traditional belief that midshaft clavicle fractures uniformly heal without functional deficit. This paradigm shift is supported by several prospective studies by members of the Canadian Orthopaedic Trauma Society, who reported higher nonunion rates and functional deficits after nonsurgical treatment of midshaft clavicle fractures when compared with internal fixation.[10,36,37]

Other authors suggest that specific clavicle fracture types are at higher risk for poor patient-reported outcomes.[62] To this end, a retrospective series of 52 nonoperatively treated patients showed that displaced fractures with shortening of 2 cm or more are predictive of higher nonunion or symptomatic malunion rates.[25] Other studies have shown that nonunion rates may be as high as 20% in displaced and comminuted fractures after nonsurgical treatment and that strength and endurance deficits are more common in these cases.[36,52] These reports, in combination with a more prognostic classification system, have led many authors to recommend acute surgical fixation for these fracture subtypes.[53]

Therefore, relative indications for acute surgical treatment may include younger, active patients with clavicle shortening greater than 1.5 to 2 cm, significant cosmetic deformity, or multiple-trauma situations. Under these auspices, surgical fixation may provide more optimal outcomes and earlier return to sport. Adequate counseling regarding the risks, benefits, and likely results of treatment should occur in these circumstances. Late intervention should be considered for persistently symptomatic nonunions or malunions or if acromioclavicular arthritic changes occur.

Open reduction and internal fixation of clavicle fractures can be performed with either plate or intramedullary pin fixation. Plate fixation can provide immediate rigid fixation, helping to facilitate early mobilization.[25,27,39,40] However, it is thought that superior clavicle plating may result in a greater risk to underlying neurovascular structures and may be more prominent than anterior plating or intramedullary pin fixation.[11,62] A study by Bostman et al[6] reported that complication and reoperation rates may be as high as 43% and 14%, respectively, if hardware removal is considered. Other reported complications include infection, hardware failure, and hypertrophic scarring.[6,8] The recent introduction of anatomically contoured clavicle plates may reduce the need for hardware removal.[10,26]

Antegrade or retrograde intramedullary pin fixation is typically a more cosmetic technique, requiring a smaller incision and less stripping of the clavicle compared with plate fixation. Intramedullary pins frequently cannot be statically locked, thereby providing less rotational and length stability compared with other fixation techniques.[2,21,54,58] The intramedullary pin also requires routine removal after clinical and radiographic evidence of healing. Reported complications of this specific technique include implant breakage, skin breakdown, and temporary brachial plexus palsy.[38,51,57] A recent study reported major complications requiring revision surgery in 5 of 58 analyzed patients.[38] All revisions were performed for fracture nonunion.

Children/adolescents

The treatment of choice in children and adolescents with midshaft clavicle fractures is less controversial than that in adults. Because of the remodeling capabilities of clavicle fractures in children and adolescents, almost all fractures can be treated nonoperatively with a very low incidence of complications.[9,48,55] Those patients exhibiting skin perforation or neurovascular compromise may still benefit from operative intervention.[5] In addition, as in adults, the degrees of fracture shortening and displacement have recently been reported to predispose to malunion of clavicle fractures in adolescents. For these types of fractures, plate fixation proved a relatively safe and successful treatment to restore anatomy and shorten time to union.[59]

Supportive treatment with a sling or figure-of-8 brace is used for comfort. Sports participation should be avoided until radiographic evidence of healing is noted, which is typically after a minimum of 6 to 8 weeks. Andersen et al[3] evaluated sling and figure-of-8 brace immobilization and reported no differences in overall alignment or union rates between the immobilization techniques. In this series, however, the sling was better tolerated by patients than the figure-of-8 brace. Fracture healing is usually accompanied by a bump that will undergo remodeling over a number of months.[5,13]

Results

Reported outcomes of surgical treatment of midshaft clavicle fractures have become more favorable over the past 2 decades. A meta-analysis of current data on nondisplaced fractures suggested a relative risk reduction of 72% and 57% for nonunion as compared with nonoperative treatment by use of intramedullary pin fixation and plate fixation, respectively.[62] For displaced fractures, the relative risk reduction increased to 87% and 86%, respectively.

Patient-reported satisfaction scores may also be superior with early surgical management in some circumstances. A multicenter trial reported better functional outcomes, lower malunion and nonunion rates, and a shorter overall time to union in operatively treated clavicle fractures after plate fixation.[10] A significant improvement in functional outcome scores was also reported when operatively and nonoperatively treated fractures were compared. The authors note, however, that functional benefits are less clear when healed nonoperatively treated fractures and surgically treated injuries are evaluated. The most recently published trials comparing intramedullary pin and plate fixation reported high union rates and good functional outcome scores in both groups.[16,34] In addition, no significant difference in complication rates were found between the 2 techniques.

Our preferred treatment

The management of midshaft clavicle fractures should be individualized to the patient's goals and activity level. We generally recommend acute intervention in active patients where displacement of the fracture fragments is greater than 100%, greater than 1.5 to 2 cm of shortening exists, or significant comminution is present. For most midshaft fractures that do not have excessive comminution or obliquity to the fracture planes, it is our preference to use intramedullary pin fixation to minimize fragment stripping, avoid the supraclavicular nerves, achieve relative stability, and improve cosmesis (Fig. 1). In more comminuted fracture patterns, segmental fractures, or fractures with a large amount of obliquity, plate fixation is used. In the case of nonunions, the treatment of choice is usually open reduction and plate fixation (Fig. 2) with autogenous bone grafting. We use local bone graft in hypertrophic nonunions and iliac crest bone graft in atrophic nonunions.

Lateral-third fractures

Nonoperative management

Because the majority of fractures of the lateral third of the clavicle are nondisplaced or minimally displaced and extra-articular, nonoperative treatment is typically the treatment of choice.[45,52] The rehabilitation and treatment modalities available are similar to those for nonoperative management of midshaft and medial-end fractures.

Surgical management

The indication for surgical treatment of lateral-third clavicle fractures is based on the stability of the fracture segments, displacement, and patient age. The integrity of the CC ligaments plays a key role in providing stability to the medial fracture fragment. Displacement of the medial clavicle is seen when the CC ligaments are disrupted (Edinburgh type 3B). It is established that this fracture configuration leads to nonunion rates as high as 28%.[40,52] Other authors have reported that the risk of nonunion increases with advancing age and displacement.[28,29,53] Again, the presence of soft-tissue compromise, multiple trauma, and floating shoulder are also indications for operative treatment.

Many surgical techniques have been proposed for fixation of lateral-end fractures. These include Kirschner wire fixation,[41] CC screws,[7] plate or hook-plate fixation,[15,24] and suture and sling techniques.[20,24,32,60] However, reported complication rates limit their utility. For example, migration rates of up to 50% and failure of Kirschner wire fixation have led several authors to recommend that it not be used as a primary fixation technique.[18,29,35]

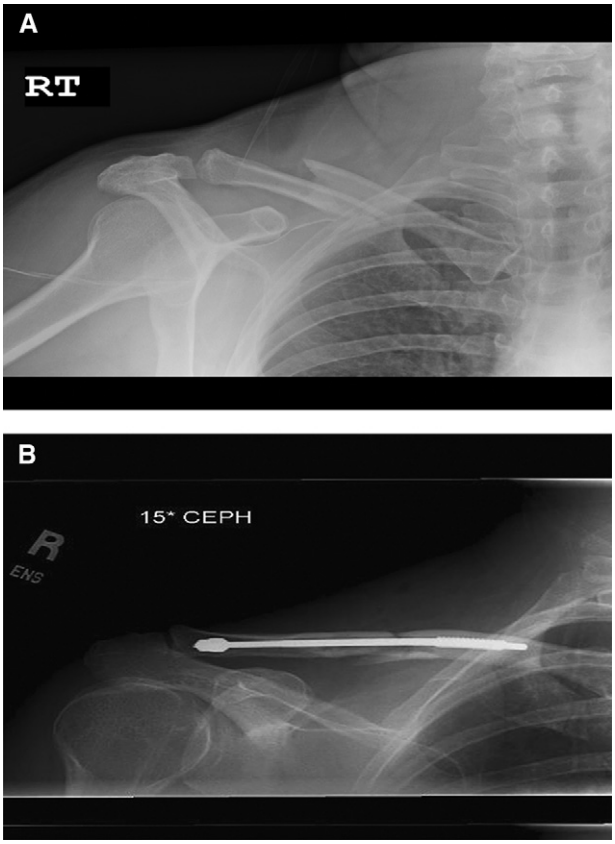

Figure 1 Preoperative radiograph of right-sided, acute, displaced, midshaft clavicle fracture **(A)** and corresponding postoperative radiograph after intramedullary pin fixation **(B)**.

Furthermore, the use of CC screw fixation is limited by the fracture location and extent of comminution. In addition, screws must be routinely removed because they can limit shoulder girdle motion. Some failures noted in patients treated with CC screw fixation are likely due to the combination of rigid (screw) fixation and the motion normally present at this location.

Plate fixation can also be used in circumstances where the distal fragment allows sufficient fixation.[28] A hook plate might be indicated if the distal fragment is inadequate for screw placement. This is performed in a fashion similar to standard plate fixation with the exception that distal fixation is achieved by placing the ''hooked'' end of the implant under the acromion to maintain a satisfactory reduction.

Finally, suture and graft sling techniques can be used to reconstruct CC ligaments in a manner similar to anatomic acromioclavicular joint reconstruction. These techniques can be used to reinforce other fixation techniques or as the primary mode of reconstruction.[20,24,32,60]

Children/adolescents

The physis of the lateral clavicle fuses around the age of 25 years. Therefore, most injuries to the lateral end of the clavicle result in physeal separation rather than fracture,

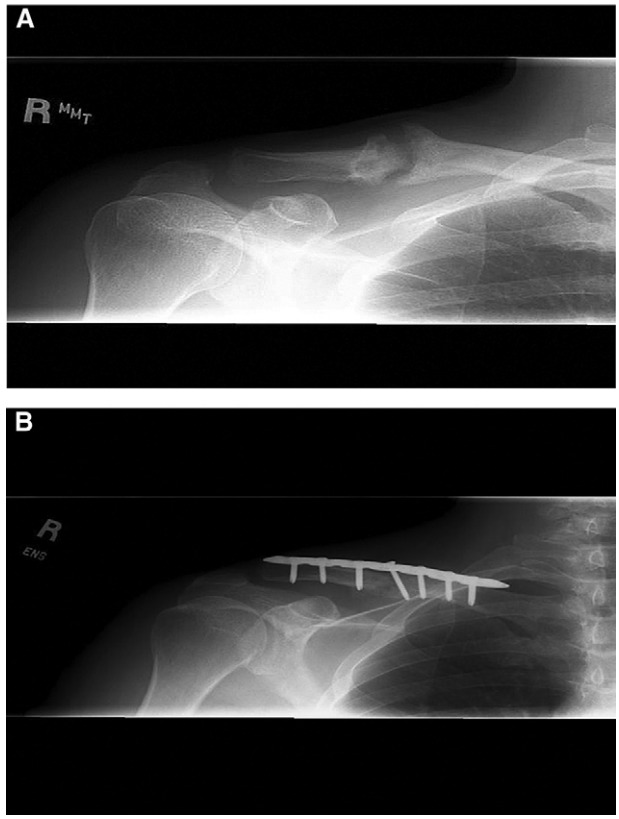

Figure 2 Nonunion of midshaft clavicle fracture **(A)** requiring open reduction and internal plate fixation **(B)**.

because the acromioclavicular and CC ligaments are biomechanically more robust than the physis. Because of the physeal injury, a large potential for healing and remodeling exists.[5] The majority of these injuries can therefore be treated with a period of immobilization. Indications for surgical intervention are infrequent but include considerable displacement, soft-tissue interposition, open injuries, or risk to soft-tissue structures in older adolescents.[30]

Results

Nonoperative management of lateral clavicle fractures results in a good outcome in up to 98% of minimally displaced or nondisplaced fractures.[53] Nonunion rates, however, are much greater for displaced fractures (Neer type II and Edinburgh type 3B) and are reported to be as high as 33% if treated nonsurgically.[40,44,52]

The timing of surgery for lateral-end fractures seems more important for patient outcome when compared with medial-third fractures.[28,50] Although the union rate does not seem to be influenced by acute or delayed treatment, the complication rate may be higher when the surgical treatment is delayed (7% vs 36%).[28] Lateral clavicle fractures that exhibit intra-articular extension may result in an increased risk of acromioclavicular joint degeneration. If acromioclavicular arthrosis occurs, the patient may require a late distal clavicle excision.

Despite the limitations of CC screw fixation, the results of fracture healing and restoration of shoulder function are mostly favorable, although only small cohorts have been reported.[4,61] Plates have also been used successfully, but complications such as peri-implant fracture, nonunion, stiffness, and arthritic progression are of concern in up to 15% of patients.[18,19,28] Finally, acceptable functional results and high union rates have been reported with the use of suture or graft sling techniques to reconstruct CC ligaments.[20,24,32,60]

Our preferred treatment

Nonoperative treatment is typically successful in cases where minimal to no displacement of the fracture fragments exists. However, when CC ligament injury is present and fracture displacement exists, surgical fixation is typically recommended. If sufficient bone is available laterally for screw purchase, our preference is plate fixation. In cases where this is not possible, we prefer to perform CC ligament fixation to hold the fracture fragments in place while healing occurs. This is typically performed with a CC fixation device with cortical buttons (Tightrope; Arthrex, Naples, FL, USA) or suture fixation device. Alternatively, a hook plate can be used, but this requires removal and may increase the risk of traumatic arthrosis of the acromioclavicular joint.

Conclusion

Most medial- and lateral-end fractures can be treated nonsurgically if fracture fragments remain stable. Surgical intervention may be required in cases of neurovascular compromise or significant fracture displacement. In children and adolescents, these injuries mostly consist of physeal separations, which have a large healing potential and can therefore be managed conservatively.

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