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Open reduction and tunneled suspensory fixation for lateral end of clavicle fractures: surgical technique

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A R T I C L E I N F O

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Unstable distal end clavicle fractures are associated with significant rates of nonunion and poor functional outcomes. Surgical treatment is paramount for unstable fracture patterns; however, treatment options are various, with each having its advantages and drawbacks. Recently, suture-based coracoclavicular fixation techniques using suture buttons have been implemented with high union rates, satisfactory shoulder function, and low rates of complications. In this report, we demonstrate a modified fixation of unstable lateral clavicle fractures. Our technique entails open reduction and suspensory coracoclavicular fixation using suture anchors and suture button devices with supplemental acromioclavicular suspensory fixation.

Lateral clavicle fractures consist of 28% of all clavicle fractures.[20] Most of these injuries are nondisplaced and typically treated nonoperatively with good outcomes.[18,22,17] However, nonoperative treatment of unstable lateral end clavicle fractures (Neer types II and V) yielded relatively higher nonunion rates and poorer functional outcomes.[16,18] Hence, operative treatment in young and medically fit patients is highly recommended to avoid fracture healing consequences.[6]

A wide range of operative techniques has been described for the treatment of displaced lateral clavicle fractures. Open reduction and internal fixation using hook plate lateral locking plate, coracoclavicular (CC) fixation with sutures or screws, and tension band wire fixation are the most used techniques with satisfactory reported functional outcomes and fracture union.[8,9] In a recent meta-analysis by Uittenbogaard et al.,[25] the union rates were not significantly different among various fixation constructs, with union rates of 94% for suture-based CC fixation, 100% for CC fixation with a screw, 98% for hook plate fixation, and 99% for other types of plate fixation. The lowest union rate was 92% for tension band wire fixation. Despite the acceptable union rates, postoperative complications such as prominent hardware and shoulder impingement are not uncommon, and routine hardware removal is frequently performed.[9] Hook plates are reported to have a 12%-37.5% complication rate due to acromioclavicular (AC) joint arthritis and osteolysis, and routine plate removal within 3-6 months to prevent pain due to impingement and facilitate shoulder range of motion.[13,14] Compared with hook plates, locking clavicular plates have a lower hardware removal of 16%-37% and a reported complication rate of up to 30%.[4,24,27] Tension band wire fixation is associated with notably higher complication rates, with a reported hardware failure rate of 62% and wound complication rate of 9%.[25]

The ideal implant for lateral clavicle fractures should provide enough stability for fracture union with minimal complication rates and elective plate removals. CC fixation can be achieved with several constructs such as screws or sutures. Despite that, suture-based CC fixation has been recently popularized with high rates of union (94.1%-95.4%), satisfactory functional outcomes, and no need for implant removal.[1,11,23] However, there is still the concern of hardware failure leading to loss of reduction. Unstable lateral clavicle fractures often demonstrate biplanar medial fragment instability in both the superior-inferior and anterior-posterior directions, with the latter often being unaddressed in suture-based CC fixations. In a recent cross-sectional study of 35 patients with unstable lateral clavicle fractures, computed tomography scans revealed that posterior displacement was found in 94.6%.[5] Therefore, the purpose of this report was to provide a detailed surgical technique for a modified fixation of unstable lateral clavicle

Institutional review board approval was not required for this article.
The patient agreed to share his clinical information and photographs, and an informed consent was obtained.

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fractures. Our technique entailed open reduction and suspensory CC fixation using suture anchors and suture button devices with supplemental AC suspensory fixation to restore superior-inferior and anterior-posterior fracture stability (Video 1). The patient was informed that data concerning his case would be submitted for publication, and he provided verbal and written consent.

Technique

This technique was demonstrated on a 24-year-old male who sustained a left lateral end clavicle fracture following a direct fall on his left shoulder from a motorcycle. Left shoulder radiographs demonstrated a Neer type IIB fracture (Fig. 1). We prefer a modified beach chair position where the patient is in the supine position and the head elevated by 30°. The head is supported on a smaller cushion rather than a pillow to allow for ease of access to the shoulder. The left arm was then disinfected with chlorhexidine solution and sterile drapes were applied to isolate the right shoulder (Fig. 2).

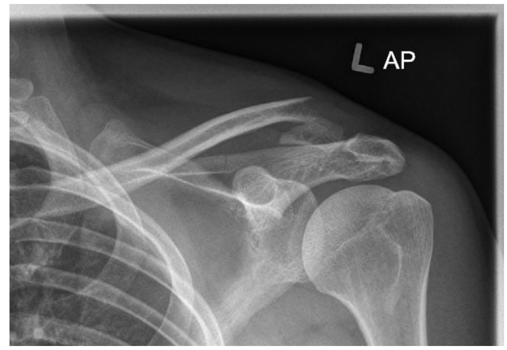

Figure 1 Anteroposterior left shoulder radiograph demonstrating displaced lateral end clavicle fracture.

Figure 2 Patient position is preferred in the supine position with the head elevated 30°.

Figure 3 Important anatomical landmarks are identified. C: coracoid; A: Lateral part of the acromion; Arrows: projected line of the medial clavicular fragment; Segmented line: planned saber-cut incision.

1-Surgical approach

Important surface landmarks are marked, such as the coracoid, acromion, and the planned incision (Fig. 3). A saber-cut approach is preferred as it is extensile and parallel to Langer's lines. A 6-8 cm vertical incision centered over the lateral clavicle is made, extending from the posterior acromion toward the coracoid. Subcutaneous flaps are created laterally and medially to ensure adequate visualization of the deltotrapezial fascia. For exposing the fracture site and medial clavicular fragment, partial detachment of the trapezius and deltoid attachment is often required. Thereafter, the fracture site is cleared from debris and blood clots to allow for subsequent fracture reduction.

2-Creation of clavicular tunnels and suture anchors insertion

Two bone tunnels, 1 cm apart, are created with a 2.5mm drill bit in the medial clavicular fragment. The most medial bone tunnel is on the anterior part of the medial clavicular fragment, whereas the lateral tunnel is posteriorly on the medial clavicle (Fig. 4, A).

Blunt dissection at the coracoid base is performed. First, a drill hole is made with a 4.5 mm drill-bit under radiographic guidance through the coracoid in preparation for the suture anchor insertion into the coracoid (Fig. 4, B). A bone tap is generally advised to reduce suture anchor insertional torque. A suture anchor is placed into the coracoid (Fig. 4, D); we prefer to use a Bio-Corkscrew FT 5.5 mm × 15 mm Corkscrew FT anchor with FiberWire suture strands (Arthrex). The senior author prefers to add an additional fixation point by providing suspensory fixation from the acromion to the medial end of the clavicle for added construct stability. This is performed by creating a drill hole into the lateral part of the acromion with a 3.5mm drill bit, followed by a bone tap (Fig. 4, B). Another Bio-Corkscrew FT 5.5 mm × 15 mm Corkscrew FT anchor (Arthrex) is then placed into the lateral acromion (Fig. 4, D).

3-Suspensory fixation

FiberWire suture strands from the coracoid anchor are passed through the medial bone tunnel from the medial clavicle fragment's undersurface to the superior surface by using a shuttling suture (Fig. 5, A). For the acromial anchor's sutures, one FiberWire suture is passed through the soft-tissue envelope posterior to the clavicle, whereas the other FiberWire suture is passed through the anterior soft-tissue envelope. This step ensures that sutures are not interposed at the fracture site. Both acromial FiberWires are then passed through the lateral bone tunnel of the medial clavicular fragment from the undersurface of the clavicle by using a shuttling suture (Fig. 5, A).

Fracture reduction is achieved by applying downward force by a bone tamp (Fig. 5, B). Fixation is achieved by using two suture buttons, one each for the sutures passed through clavicular tunnels. The coracoid FiberWire suture strands are passed through an Endobutton CL device (Smith & Nephew). The Endobutton is pushed down to the superior surface of the medial clavicle. The two coracoid FiberWire sutures are tensioned and then tied to secure the suture button fixation, thus achieving coracoclavicular fixation (Fig. 5, C). Thereafter, the acromial FiberWire suture strands are then passed through another Endobutton CL device, which is tied to achieve AC fixation (Fig. 5, C). The coracoclavicular suspensory

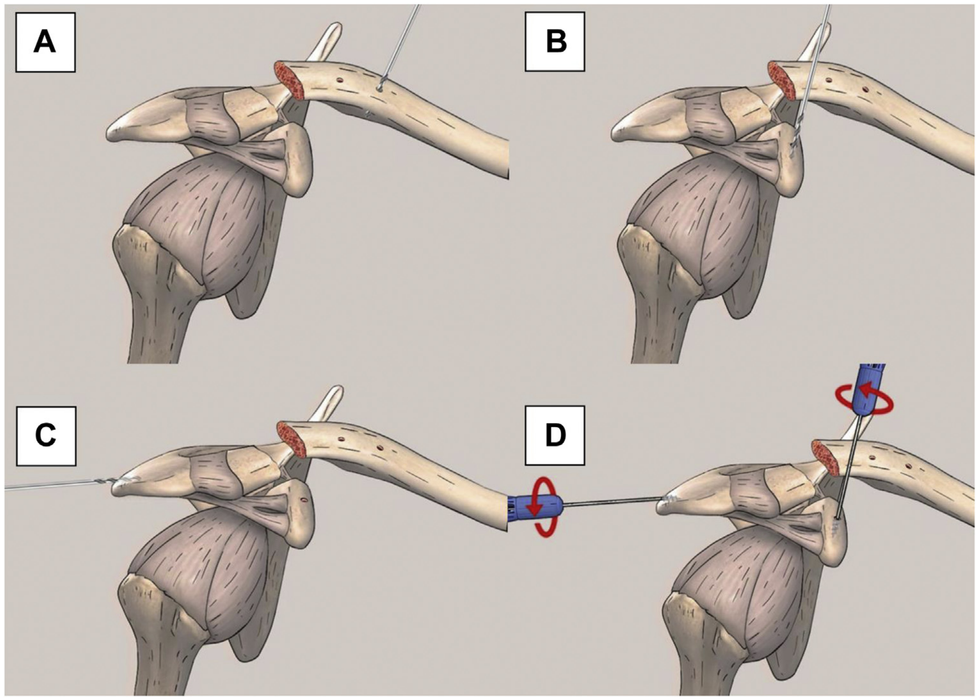

Figure 4 (A) Drilling two tunnels within the medial clavicular fragment; (B) Drilling of the coracoid in preparation for a suture anchor; (C) Drilling of the lateral acromion in preparation for a suture anchor; (D) Insertion of coracoid and acromion suture anchors.

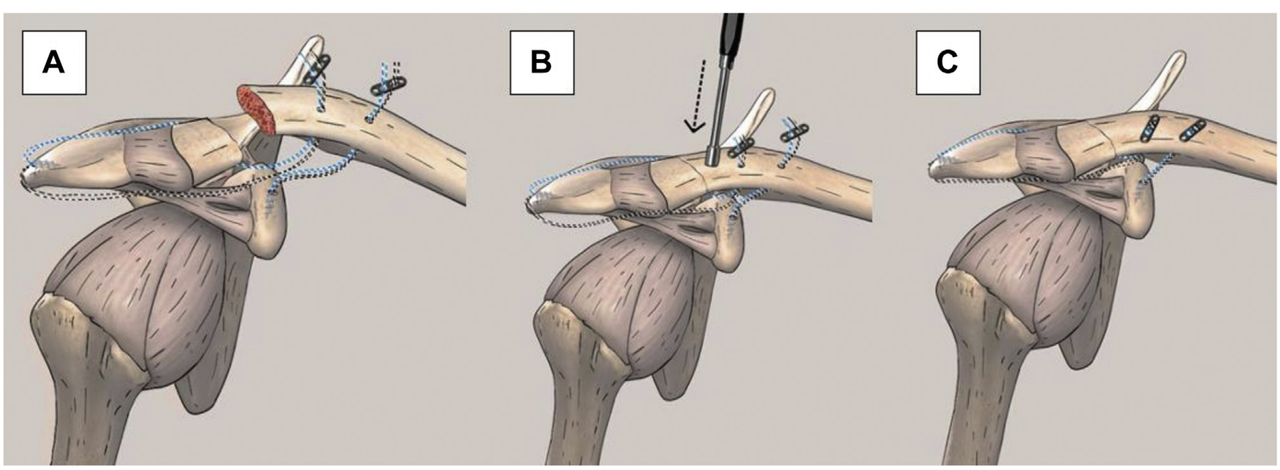

Figure 5 (A) The coracoid and acromion sutures are passed through the medial and the lateral clavicular tunnels, respectively; (B) Each suture is passed through a suture button fixation device, and fracture reduction is achieved; (C) Each suture is tightened thereby securing fracture fixation.

fixation is the main fixation point in the construct. Additionally, the construct is supplemented with an AC suspensory fixation to off-load stresses from the coracoclavicular component, given the high rates of anteroposterior instability. The final intraoperative radiograph is obtained for confirmation of successful open reduction and internal fixation (Fig. 6). It is paramount to repair the partially detached muscular attachment. Subsequently, the subcutaneous planes and skin are closed, followed by the application of a sterile compressive dressing.

Postoperative care and rehabilitation

The patient is typically provided with a sling for comfort for 4 weeks. The patient is encouraged to maintain full mobility of the unaffected joints by proceeding with elbow and wrist range of motion. The shoulder range of motion is restricted to pendular exercises up to approximately 6 weeks postoperatively with gradual active-assisted up to 90° of forward flexion. At 6 weeks, resisted activity exercises are only permitted once clinical and radiological fracture healing is achieved.

Results

We have performed a retrospective review on the patients who underwent the modified open reduction and tunneled suspensory fixation at our institution. A total of 16 patients with acute unstable lateral clavicle fractures were identified, of which 14 were males. The most common mechanism of injury was a motor vehicle

Figure 6 A postoperative radiograph demonstrating open reduction and tunneled suspensory fixation of lateral end clavicle fracture.

accident in 10 patients, fall from a significant height in 4 patients, and sport-related injury in 2 patients. The lateral clavicle fracture type was Neer type II in 15 patients and type V in 1 patient. The mean total operative time was 92.4 minutes (range 75-120 minutes).

In this retrospective review, all 16 patients were evaluated radiographically at 2 weeks, 6 weeks, 3, 6, and 12 months. Fifteen out of the 16 patients had confirmed radiographic union at the 12-month visit (Fig. 7). The patient that did not have confirmed union sustained a refracture after a fall on his shoulder at the 4-month follow-up interval. The patient ultimately underwent revision tunneled suspensory fixation; however, no radiographic evaluation was available 12 months after the revision surgery. Another patient sustained a refracture after a fall at 2 months; however, the fracture was not displaced, and fixation construct was not compromised. She was managed with continued observation, and fracture union was evident at the 12-month follow-up. In terms of functional outcomes, the 6-month follow-up was available on four patients only with a mean ASES score of 91.6 (83.33 to 93.3). Unfortunately, functional outcomes were not available to all patients at different time points due to the retrospective nature of this series.

Regarding complications, one patient had significant shoulder stiffness in the form of a secondary frozen shoulder at 6 weeks postoperatively. The patient eventually regained near full range of motion with a home-exercise program during the 6 months postoperative follow-up. Aside from the two refractures reported earlier, there were no reported complications such as neurovascular injury, intraoperative fractures, wound infections, loss of initial reduction without trauma, nonunion, or hardware failure at 12 months.

Discussion

Fixation of a lateral clavicle fracture is challenging with multiple techniques and constructs described in the literature.[2] Moreover, the paucity of the bone stock, the small size of the fractured fragment, and the deforming forces around the implants hinder the ability to achieve robust internal fixation. Among all fixation techniques, plate fixation offers robust and stable fixation. In a biomechanical study, plate fixation resulted in superior fracture stability under cyclic loading.[19] However, not all lateral clavicle fractures are amenable to plate fixation, and several drawbacks hinder their use. Hook plates are often associated with discomfort and may result in AC joint arthritis with a reported rate between 12% and 37.5%.[13,14] Hence, hook plates mandate removal once fracture healing occurs.[10] Precontoured lateral clavicular plates require sufficient bone stock in the lateral end clavicle fracture to allow for fixation of multiple screws.[12] Moreover, plate prominence is a common cause of subsequent surgery and implant removal

Figure 7 A 12-month postoperative follow-up radiograph demonstrating united lateral clavicle fracture.

with a reported rate of 16-37%.[4,24,27] Moreover, tension band wire fixation constructs are associated with significant complication rates of 62%.[25]

An alternative option to achieve fixation of lateral end clavicle fracture is CC fixation. Bosworth[3] initially described CC fixation with screws, which subsequently were reported to attain a 100% union rate.[7] However, the procedure was limited due to the need for subsequent implant removal in all patients and frequent complications such as screw loosening. Therefore, suture-based CC fixation has been recently implemented, which does not need implant removal if used alone.[26] Suture-based fixation is advantageous in fractures with a comminuted lateral clavicle fracture or insufficient bone stock of the lateral fragment. Several suture options can be utilized to achieve suspensory CC fixation, such as suture only, suture anchors, and suture buttons. The suture devices can be wrapped around the coracoid and clavicle without bone tunnels or by creating bone tunnels within the clavicle and coracoid.

Recently, tunneled suspensory CC fixation with suture buttons has been reported with satisfactory outcomes. In a case series on 19 patients with lateral end clavicle fractures, Shin et al.[23] reported successful results following suspensory fixation with two suture anchors and interfragmentary compression with suture tension bands. Fracture union was achieved in 18 out of 19 patients at a mean follow-up of 4.8 months, and one patient had fracture nonunion. Moreover, two patients had mild forward flexion limitation, and another two patients had mild discomfort when performing demanding activities. Al-Tawil et al.[1] have reported at a mean follow-up of 21 months that standalone TightRope device fixation achieved high union rates (22 out of 23 patients). Three complications were encountered in this series consisting of shoulder stiffness, prominence of the TightRope implant, and coracoid button migration. In the largest series thus far, Robinson et al.[21] performed standalone CC fixation in 67 patients with either the TightRope device or customized tunneled suspensory fixation. At a mean follow-up of 69 months, 94% of all cases achieved fracture union with satisfactory shoulder function. Four developed fracture nonunion, of which two were symptomatic and underwent revision surgical fixation. Three patients developed shoulder stiffness, and two patients underwent elective removal of the superior suture button due to prominence.

Suture-based CC fixation is not without limitations. Techniques that involve drilling at the coracoid are associated with a potential coracoid fracture or injury to a nearby neurovascular bundle.[15] Moreover, suture-based CC fixation might be biomechanically inferior compared to plate fixation. In a biomechanical study on lateral end clavicle fractures, fixation with a TightRope had a significantly higher failure rate compared to plate fixation after cyclic loading.[19] Suspensory fixation devices for unstable lateral clavicle fractures are aimed at restoring superior-inferior instability of the fracture through CC fixation. However, posterior instability of the medial clavicular fragment is often underestimated, which has been reported to occur in 94.6% of unstable lateral clavicle fractures.[5] In our experience, the medial clavicle fracture fragment is almost always displaced posteriorly due to the pull of the trapezius. Therefore, we routinely supplement our fixation construct with suspensory fixation from the acromion to the medial clavicle fragment to restore anteroposterior stability.

We acknowledge that this report has several limitations. This report is mainly to demonstrate a detailed surgical technique on how to achieve tunneled suspensory fixation of unstable lateral clavicle fracture. However, whether our modification of adding AC suspensory fixation translates into clinically meaningful results is unknown and has not been tested in a biomechanical study. Moreover, our results are limited to a retrospective case series of 16 patients with radiographic follow-up at 12 months. Another limitation is the lack of functional outcomes for all patients at several time points.

Conclusion

Tunneled suspensory CC fixation with supplementary AC suspensory fixation for unstable lateral clavicle fracture represents a valid surgical option for lateral end clavicle fractures with a high fracture union rate, low complications, and no need for elective implant removal.

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Supplementary data

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