



Clinical and radiographic outcomes of a transosseous suture technique for displaced lateral clavicle fractures

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Background: The purpose of this study was to evaluate the clinical and radiographic outcomes of a transosseous suture fixation technique for the treatment of unstable lateral clavicle fractures. The appropriate treatment for lateral clavicle fractures is controversial. Many authors have argued for nonsurgical treatment of these injuries; however, recent literature has shown a role for the surgical treatment of unstable fractures. The paucity of lateral clavicular bone and the unique anatomy of this area of the shoulder makes surgical treatment of these injuries challenging. This article reports a single-surgeon experience with a transosseous suture fixation technique for the treatment of unstable lateral clavicle fractures.

Materials and Methods: A retrospective review of all patients with unstable lateral clavicle fractures treated with a transosseous suture technique from 2015–2018 was performed. The indication for surgery was significant displacement between the main medial and lateral clavicle fragments. The surgical technique used was a modification of the technique as described by Levy. Patients were followed post-operatively with active and passive range of motion (ROM) measurements, strength testing, and American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score, visual analog scale score, and standard radiographs. Patients were followed to radiographic union.

Results: Twelve patients underwent surgical fixation of unstable lateral clavicle fractures from 2015–2018. All patients had excellent function, full ROM, minimal pain, and improved functional scores at final follow-up. Eleven patients achieved complete union of the fracture. One patient healed with a fibrous union; however, the fracture had maintained alignment and the patient was asymptomatic and satisfied with the result. No patient required a second surgery.

Conclusion: We found that the transosseous suture technique for fixation is an effective treatment for unstable lateral clavicle fracture. This technique is reproducible, cost effective, and limits the need for revision surgery often encountered with other techniques.

Level of evidence: Level IV; Case Series; Treatment Study

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Fractures of the distal or lateral third of the clavicle are relatively rare, and the appropriate treatment of these fractures is controversial. Distal clavicle fractures account for 12%–28% of all clavicle fractures.^{21,24,25,27} Neer initially classified these fractures into 3 types: Type I

fractures are those that occur lateral to coracoclavicular ligaments and spares the acromioclavicular joint. Type II occur medial to the coracoclavicular ligaments. Type III occurs lateral to the coracoclavicular ligaments and extends into the acromioclavicular joint.²⁰ Neer's classification system was later modified to include type IV, physeal fractures, and type V, a comminuted pattern.³

Historically, nonoperative treatment has been the preferred treatment for lateral clavicle fractures. Clinical experience suggested that most distal clavicle fractures healed; additionally, if a fracture were to proceed to nonunion, these patients are generally asymptomatic.^{6,22} However, more contemporary studies suggest that symptomatic nonunions are more prevalent than previously thought, particularly in unstable fractures.²⁶ This has led many authors to argue that unstable lateral clavicle fractures may benefit from surgery.^{9,19,20,23}

Multiple methods of fixation have been described, with each technique having its advantages and disadvantages.^{2,5,9,11-15,18,20,30} Levy and Duralde have reported a technique using transosseous suture fixation for unstable lateral clavicle fractures.^{7,15} This technique has the potential advantages of achieving high rates of union and excellent functional outcomes, while avoiding the complications and pitfalls that plague other methods. The purpose of this article is to describe our experience with transosseous suture fixation of unstable lateral clavicle fractures.

Materials and methods

Patient selection

A retrospective review of all patients with unstable lateral clavicle fractures treated with a transosseous suture technique from 2015-2018 was performed. Criteria for inclusion in the study were radiographic evidence of a displaced or unstable lateral clavicle fractures, Neer type II or V,⁴ with subsequent surgical treatment of that fracture with a transosseous suture technique. Unstable and displaced were classifications viewed synonymously, because a lack of attachment of the medial fragment to the coracoclavicular ligaments allowed for displacement and subsequent instability. We identified 12 patients (9 male, 3 female) who met inclusion criteria. Patients were excluded if there were incomplete radiographs, insufficient documentation to confirm date of injury, or insufficient follow-up.

Patients were followed postoperatively with active and passive range of motion (ROM) measurements, strength testing, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) and visual analog scale (VAS) scores, and standard radiographs. Patients were followed to radiographic union. All patients were followed at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months. Radiographs were obtained until radiographic union or until 12 months. If there was no union at 12 months, the fracture was classified as a nonunion per Neer's criteria.¹⁹

Time from initial injury to surgery, time to fracture union, and ASES and VAS scores were collected. Abduction, forward elevation, external rotation, and internal rotation ROM measurements



Figure 1 Initial fracture displacement, fracture reduction, and maintenance of fracture reduction was measured on standard anteroposterior radiographs by measuring the coracoclavicular distance. The distance from the inferior cortex of the clavicle to the superior cortex of the coracoid. This was measured on all radiographs in addition to observing fracture healing.

was collected. Motor strength was measured for abduction, external rotation, and internal rotation and rated on the standard 5/5 scale. The incidence of complications were recorded for each patient. Complications were defined as an event during the postoperative period that threatened the outcome and required additional and nonroutine intervention. Standard radiographs included an anteroposterior clavicle, anteroposterior up-tilt clavicle view, and a shoulder girdle view. Radiographs were evaluated for radiographic union as well as restoration and maintenance of the coracoclavicular distance. Coracoclavicular distance was measured on the initial shoulder girdle view. The contralateral shoulder was used as a baseline. Initial coracoclavicular distance was measured on the injury film from the inferior cortex of the clavicle to the superior cortex of the coracoid (Fig. 1). This was then measured again on the patient's final radiograph. Statistical analysis using the Fisher exact test and *t* test was performed to compare outcomes for each group treated based on the method of fixation, rate of complications, and their outcome scores. Values of $P < .05$ were considered significant.

Operative procedure

The surgical technique used was a modification of the technique as described by Levy.¹⁵ The operation was performed in a beach chair position with the arm draped free. A standard anterosuperior approach to the clavicle was performed. The main fracture fragments were exposed by elevating the deltotracheal fascial flaps with minimal soft tissue disruption. The fracture was provisionally reduced as much as possible under direct visualization. A 2-mm anterior-posterior tunnel was placed in the main medial and main lateral fragments, respectively. Both holes were placed perpendicular to the long axis of the clavicle. Three permanent no. 2 sutures were then passed through the transosseous tunnels in a cruciate fashion with a suture-shuttling device. Three permanent no. 2 sutures were then passed inferior to the main lateral fragment for later cerclage fixation. While holding the reduction, the cruciate sutures were tied first, followed by the cerclage sutures

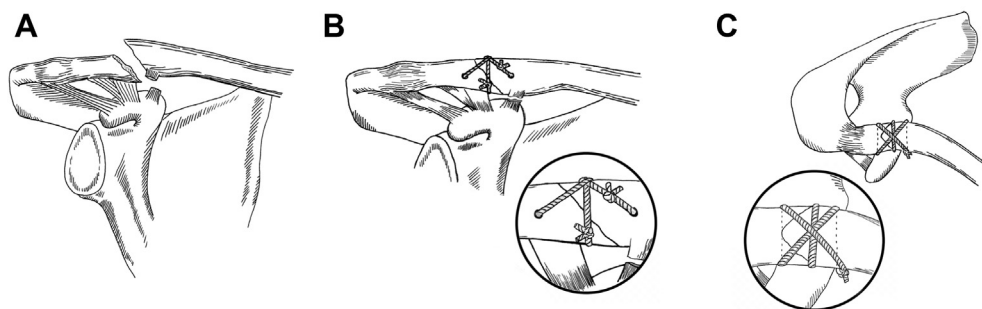


Figure 2 (A) Example of an unstable lateral clavicle fracture before reduction. (B and C) Example of the fixation. The fracture is provisionally reduced. A 2-mm drill hole is made on either side of the fracture. Two to three sutures (only 1 shown for simplicity) are passed through the holes in a cruciate or tension band fashion. Two to three cerclage sutures are passed around the fracture. The cerclage sutures are tied first followed by tying the cruciate or tension band sutures.

Table I Demographics

	Total	Type II fracture	Type V fracture
All patients	12	7	5
Male	9	6	3
Female	3	1	2
Age at surgery, yr, mean (range)	48 (26-77)	48 (26-77)	50 (27-75)

(Fig. 2). Fluoroscopic images were obtained to confirm reduction and stability of fixation. Coracoclavicular fixation was not performed in any of the cases (Fig. 2).

Postoperative protocol

Patients were immobilized in a sling for 6 weeks postoperatively. Pendulum exercises were allowed for activities of daily living. At week 6, the sling was discontinued, and the patients were given a home exercises program consisting of passive, active assist, and active ROM exercises. At week 12, the patients were given a progressive strengthening program.

Results

From 2013-2018, a total of 14 patients underwent an all-suture fixation of a lateral clavicle fracture. Twelve patients met inclusion criteria. Average age was 44.8 years (range 26-76). Nine male and 3 female patients underwent surgery. There were 7 type II and 5 type V fractures (Table I). No patient required a second surgery (Fig. 3).

The average duration of follow-up was 36.4 months (6-72 months). Eleven patients went on to full radiographic union and 1 patient went on to nonunion. Because of the small number of patients in our series and the fact that there was only 1 nonunion, a statistical analysis could not be performed comparing the 2 groups. The coracoclavicular distance could be restored to that of the contralateral side in

all 12 cases. The average initial preoperative coracoclavicular distance was 25.9 mm. The average postoperative coracoclavicular distance was 12.9 mm ($P \leq .001$). The nonunion was a comminuted fracture (type V) with a greater initial coracoclavicular distance than those that went on to union, 36.6 mm compared to 25.9 mm; nevertheless, despite the nonunion, the postoperative coracoclavicular distance was 13.3 mm (Table II).

All patients had a good clinical outcome and had significant improvement in pain levels. The average preoperative VAS score was 7.1 (3-10). The average postoperative VAS was 0.4 (0-1). The final average ASES score for all patients was 96.2. All patients regained full active and passive ROM and 5/5 motor strength in all planes. The average time to regain full ROM was 4.7 months (1.5-18). The united fractures regained full ROM at an average of 3.1 months (1.5-6), and the nonunion regained full ROM at 18 months. For patients in which the fracture united, the average ASES score was 98. For the patient with the nonunion, the ASES score was 87. There was a difference between the final ASES scores in patients younger than 40 years (98.3) compared with those older than 40 years (90.2), although this difference did not reach statistical significance ($P = .16$). There was also no significant difference when comparing type II and type V fractures, 91.4 compared to 94.8 ($P = .56$) (Table III).

Discussion

This article shows that transosseous suture fixation is a safe and effective treatment for unstable distal clavicle fractures. Fractures treated with this technique achieved a high rate of union, with patients achieving excellent functional outcomes and a low rate of complications.

The surgical treatment of lateral clavicle fractures is technically challenging, and a variety of fixation constructs have been used, with varying degrees of success. Given the nature of the injury, there is a paucity of bone on the lateral



Figure 3 Example of a unstable lateral clavicle fracture before and after the all-suture fixation.

Table II Radiographic results

	Total	Union	Nonunion
All patients	12	11	1
Male	9	8	1
Female	5	3	0
<40 yr	5	5	0
>40 yr	7	6	1
Type II	7	7	0
Type V	5	4	1
Acute injury	11	10	1
Chronic injury	1	1	0
Preoperative coracoclavicular distance, mm	25.9	24.9	36.6
Postoperative coracoclavicular distance, mm	12.9	12.9	13.1
Change in coracoclavicular distance, mm	12.0	12.0	23.5

fragment of the fracture. In what little bone is present in the lateral fragment, there is often varying degrees of comminution, presenting significant challenges in creating a secure fixation construct. These challenges have been reflected in the literature, with numerous studies citing complications related to failure of implants.

Neer initially described fixation with wires. This technique proved problematic because of wire migration endangering neurovascular structures, as well as elevated rates of infection.^{13,16,29} Plate and screw constructs have been described; however, the tenuous nature of the bone in the lateral fragment often precluded secure fixation, leading to screw pullout, plate migration, and ultimately the need for a second surgery to remove the plate.¹⁰ To address the shortcomings of traditional plates, a hook plate was designed with a lateral extension to stabilize under the acromion. In this case, the solution was sometimes worse than the problem, in that patients treated with this technique had persistent pain and acromial fractures and underwent a mandatory second surgery for plate removal.^{11,17,18}

Techniques using fixation to the coracoid have also been described. Techniques using transclavicular cannulated screw fixation to the coracoid has been reported. At best, this technique mandated a planned second surgery for intact screw removal. At worst, the second surgery was required to remove a fracture screw.⁹ In cases in which the lateral fragment was so diminutive that the injury was a de facto high-grade acromioclavicular separation, Weaver-Dunn and acromioclavicular joint reconstructions have been performed; although results have been reasonable, these are much more extensive reconstructions than fracture fixation, with significantly more extensive dissection and surgical morbidity.^{8,28}

Levy initially described a minimally invasive transosseous suture technique to treat lateral clavicle fractures.¹³ Duralde and colleagues reported their experience with a similar technique, with parallel outcomes.^{7,15} Similar to these 2 studies, in our study too the patients had excellent results. The vast majority of our patients achieved rapid union. In the only case in which the fracture did not unite, the nonunion nevertheless did not preclude an excellent functional and clinical outcome, although the duration to achieve this result was longer compared with the patients in whom the fracture united. Significantly, none of our patients suffered a hardware-related complication, none required a second surgery, and none required supplemental fixation to the coracoid, as some authors have reported.¹ Additionally, although we did not perform a cost analysis, it makes intuitive sense that 6 strands of suture are less expensive than a plate and a variable number of screws. In the era of value-based care, this advantage of the technique is self-evident.

This study suffers from the usual limitations of a retrospective case series on the treatment of a relatively rare injury. The study was limited to the clinical experience of a single surgeon, and the number of patients in the study was small. There was no nonoperative control group, and there was no randomized trial comparing this technique to a

Table III Clinical results

	ASES score	Preoperative VAS score	Postoperative VAS score	Length of follow-up, mo
All patients	92.9	7.1	0.9	36.4
Male	92.7	7.6	1.0	35.6
Female	93.5	7.0	0.5	39.1
<40 yr	98.3	7.6	0.3	45.4
>40 yr	90.2	6.7	1.2	31.9
Union	93.6	6.8	0.9	34.7
Nonunion	87.0	10.0	1.0	49.9
Type II	91.4	6.1	1.4	41.5
Type V	94.8	8.4	0.3	30.1

ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; VAS, visual analog scale.

different technique. Nevertheless, this article reports an often unrecognized technique that can be useful in the treatment of patients with this injury.

Conclusion

The transosseous suture technique is an effective treatment for unstable lateral clavicle fractures. It allowed for a high rate of union, excellent functional outcomes, and a low rate of complications. In addition, the technique is reproducible, cost effective, and limits the need for revision surgery often encountered with techniques involving metal implants.

Disclaimer

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