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# Results of surgical treatment for unstable distal clavicular fractures

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**Hypothesis:** Delayed surgical treatment of unstable distal clavicle fractures is associated with a higher complication rate.

**Materials and methods:** Between 1998 and 2008, a retrospective study of 38 patients (average age, 42.9 year) with Neer type II clavicular fractures was performed. Fractures were treated with a hook-plate (22 patients) or with superior locked plate with suture augmentation (16 patients). Patients were divided into acute (27 patients) or delayed (11 patients) treatment groups based on the timing of surgical intervention before or after 4 weeks. All had clinical and radiographic follow-up for 1 year or until fracture union.

**Results:** Union was achieved in 36 of 38 patients (94.7%). The acute treatment group had an average American Shoulder and Elbow Surgeons score of 77.9 compared with 65.0 in the delayed group. Six complications occurred (15.8%) including 2 infections (5.3%), 1 hardware failure (2.6%), and 3 peri-implant fractures (7.9%). The complication rate was 36.4% in the delayed group vs 7.4% in the acutely treated group ($P = .047$).

**Discussion:** A high rate of union was observed in all cases regardless of timing or method of fixation. Despite a high rate of union, the results of treatment in the delayed group were more problematic. Patients treated with a hook-plate in a delayed fashion had more complications than those treated in an acute fashion ($P = .039$). Peri-implant fractures occurred only in patients treated with hook-plates.

**Conclusion:** Surgical timing played a critical role in the outcome and complication rate in treatment of unstable distal third clavicle fractures.

**Level of evidence:** Level III, Retrospective Cohort Comparison, Treatment Study.


**Keywords:** Distal clavicular fracture; clavicle; locked plate; hook-plate; complication

Fractures of the distal clavicle have remained a controversial and challenging problem in orthopedic practice. These injuries are not uncommon, making up approximately 21% of clavicular fractures.[25] Surgical and nonoperative management have both been advocated by numerous authors,

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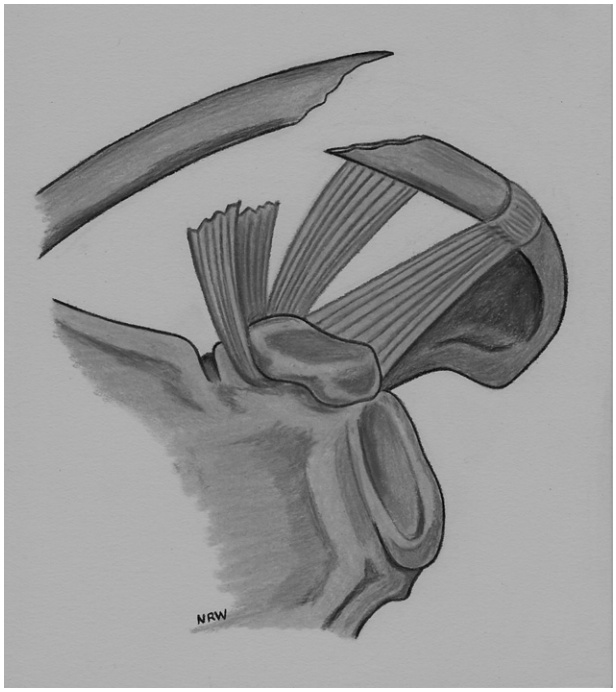


**Figure 1** This is an illustration of a Neer IIb distal clavicular fracture. This unstable fracture occurs because of disruption of the trapezoid ligament with inferior displacement of the medial fragment.

and treatment remains a topic of debate. The unique difficulties imposed by this specific fracture pattern were first described by Neer.[23] He classified distal clavicular fractures into 3 types. Type I was a fracture lateral to the coracoclavicular ligaments with typically minimal displacement. Type II fractures occurred more medial to the coracoclavicular ligaments and often resulted in significant displacement (Fig. 1). Type III fractures extended intra-articularly to the acromioclavicular joint. Neer recognized that type II distal clavicular fractures carry a higher risk of nonunion compared with other clavicular fracture types. Several subsequent studies have further supported this observation, with rates reported as high as 22% to 50% for nonoperatively managed fractures.[26,29,30] Fortunately, many nonunions appear to be asymptomatic, resulting in some authors to advocate closed treatment.[29]

Symptomatic nonunions of the lateral clavicle, although less common, do arise with an incidence reported as high as 14%.[29] A prolonged nonoperative course can result in bone resorption, prominent scar, and an altered surgical field that further complicates any subsequent surgical intervention. Owing to the success with acute operative stabilization and the high inherent risk of nonunion, several authors have proposed primary operative treatment for these injuries to avoid the inherent problems with delayed surgery. Although various techniques have been described, including Kirschner wires, tension band fixation, and coracoclavicular fixation with sutures or screws, poor fixation has remained a challenge and no definitive solution has been identified.[1,5,8-10,12-14,16-18,20,21,23,31-33]

Recently, standard plating using a hook-plate design (Synthes West Chester, PA), where additional fixation is provided by a ''hook'' that articulates with the inferior acromion, has shown good results.[8,9,12,14,18,21,31] Despite improved union rates, complications reported with this design have also been relatively frequent, including fracture, dislocation, and the subsequent need for plate removal due to subacromial pain and impingement.[4,22] With the advent of locked plating, several site-specific distal clavicle locking plates are now available that may provide improved fixation in compromised bone and a lower profile that may eliminate the need for hardware removal. Despite the theoretic advantages, clinical outcome data for these newer designs is currently lacking. The present study retrospectively reviewed the clinical outcomes of 2 surgical techniques, either a hook-plate or superior locked plate with coracoclavicular suture augmentation in an acute or delayed manner, to evaluate any differences with regard to method of fixation, timing of surgery, or relative complications.

## Materials and methods

This study was approved by the University of South Florida Investigational Review Board (IRB No. 107363).

### Patient selection

A retrospective medical record review was performed to identify distal clavicular fractures treated operatively between 1998 and 2008. Criteria for inclusion in the study were radiographic evidence of a Neer type II distal clavicular fracture (Fig. 2), adequate documentation to establish date of injury, no previous surgical treatment, and follow-up of at least 12 months or until radiographically documented fracture union.

We identified 38 patients (23 males, 15 females) who met the inclusion criteria. Patients were excluded if there was insufficient documentation to establish an injury date, incomplete radiographs to confirm the diagnosis, insufficient follow-up, or the inability to comply with the postoperative protocol. The patients were divided into acute ($\leq$4 weeks) and delayed (>4 weeks) treatment groups according to the time interval between injury and surgical treatment. This distinction was made based on the known changes in the characteristics of the fracture milieu by the 4-week mark from injury. Bone healing during closed treatment of an unstable distal clavicular fracture includes the formation of a soft callous, which occurs by approximately 3 weeks after the fracture.[27] Once this soft callous is formed, it must be appropriately addressed if any surgical intervention is then undertaken. Acute repair of the fracture occurred in 27 patients and delayed repair occurred in 11. Surgeries were performed by 1 of 3 shoulder and elbow fellowship-trained surgeons (D.D., M.F., M.M.). The treating surgeon determined the fixation method. Hook-plates were routinely removed at a planned second surgery, whereas the superior locked plates were not removed unless they became symptomatic after fracture union.

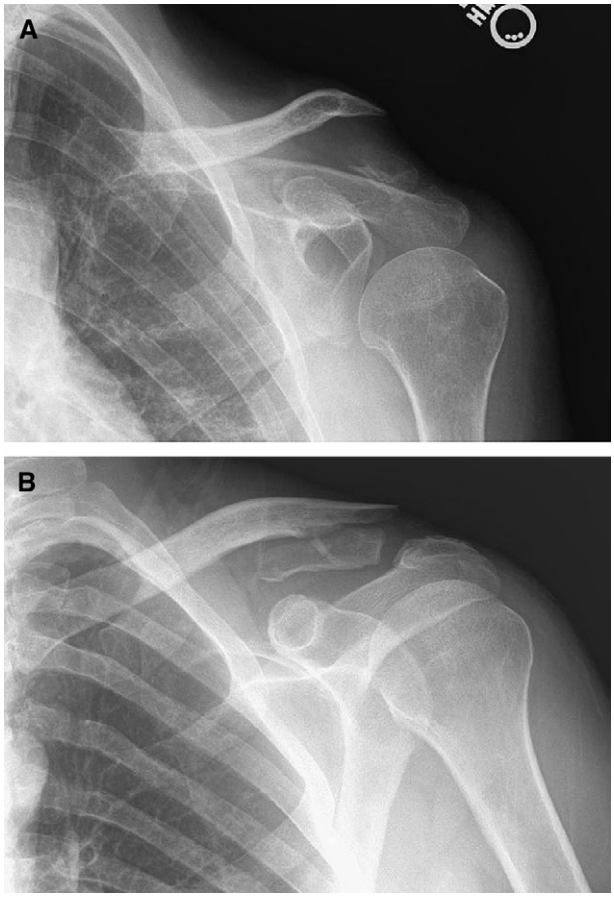


**Figure 2** (A and B) Radiographic examples show a displaced Neer type II distal clavicular fracture.

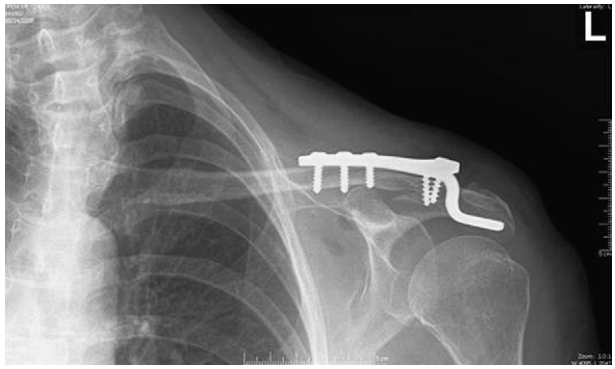


**Figure 3** Postoperative radiographs show hook-plate fixation for a Neer type II distal clavicle fracture.

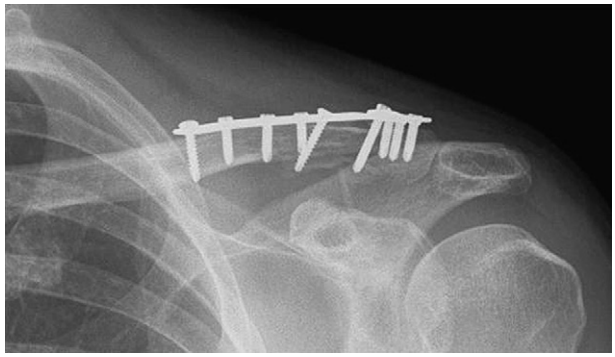

**Figure 4** Postoperative radiographs show superior locked plate fixation for a Neer type II distal clavicular fracture.

## Operative technique

Operative treatment was performed with the patient placed in the beach chair position. The head of the bed was elevated 60° and rotated 90° to the anesthesiologist. Fluoroscopy was positioned at the head of the bed to avoid hindrance with the operative field and the anesthesiologist. A standard anterior approach to the clavicle was performed regardless of fixation method. The fracture was exposed and reduced under direct visualization. In cases of delayed union or nonunion, the fracture site was débrided of all fibrous tissue, and the medullary canal was opened by intramedullary reaming with a burr or drill bit.

The initial reduction was held with Kirschner wires while the plate was applied. Hook-plates were used in 22 patients according to standard technique (Fig. 3) similar to that described by Hachenbruch et al.[11] Superior locked plates were placed in 16 patients on the reduced clavicular fracture with the maximum number of locking screws incorporated into the distal fragment (Fig. 4). In 13 patients, a Synthes 3.5-mm locking T-plate was applied in a manner similar to that described by Kalamaras et al.[13] The remaining 3 patients were treated with an Acumed (Hillsboro, OR) precontoured distal clavicle locking plate. In all circumstances, care was taken not to violate or span the acromioclavicular joint during superior locked plate fixation.

Coracoclavicular suture fixation was performed to augment superior locked plating in all cases. This was achieved by either passing sutures around the base of the coracoid or by using suture anchors placed into the coracoid base.

## Postoperative protocol

Patients were treated for 6 weeks postoperatively in a shoulder immobilizer. Pendulum exercises were allowed for hygiene purposes. Between 6 and 12 weeks, patients were allowed unrestricted range of motion with avoidance of lifting until after 12 weeks. Physical therapy was not routine.. All patients were monitored for 1 year or until radiographic union was achieved.

## Outcome analysis

Time to fixation, fracture union, American Shoulder and Elbow Surgeons (ASES) scores at the latest follow-up, and 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 operative or nonoperative treatment. Statistical analysis using the Fisher exact test was performed to compare outcomes for each group treated based on method of fixation, time to surgical intervention, rate of complications, and their ASES scores. Values of $P < .05$ were considered significant.

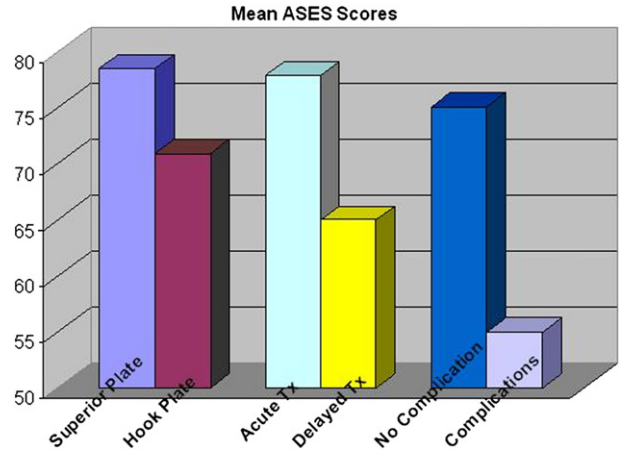


**Figure 5** Mean American Shoulder and Elbow Surgeons *(ASES)* scores were used to compare each subgroup of patients based on the method of fixation, the timing of surgery, and the effect of complications on final scores. Based on a maximum score of 100.

## Results

Union was achieved in 36 of the 38 patients (94.7%) after the index procedure. Patients were a mean age of 42 years (range, 14-77 years) at surgery. Average clinical follow-up was 12.2 months (range, 1.5-46.5 months). The acute treatment group consisted of 13 superior locked plates and 14 hook-plates, and the delayed group included 3 superior locked plates and 8 hook-plates. ASES scores were collected on 21 patients, including 9 patients treated with a superior locked plate and 12 with a hook-plate. Scores averaged 72.4 for those treated with hook-plates compared with 77.1 for those treated with superior locked plates. The average ASES score was 77.9 in the acute treatment group compared with 65.0 in the delayed group. The average ASES score was 77.4 in those without complications compared with 55.0 in the patients with complications (Fig. 5).

Complications occurred in 6 patients overall and included 2 infections requiring surgical incision and drainage, 3 peri-implant fractures, and 1 hardware failure. There were 2 nonunions after surgical treatment (Table I). Overall, 83% of complications occurred in the hook-plate treatment group compared with 17% in the superior locked plate group. Fractures treated in a delayed fashion had a higher incidence of complications compared with those treated acutely (36.4% vs 7.4%, respectively; $P = .047$). Significant complications occurred in 50% of the patients treated with a hook-plate in a delayed fashion vs 7% in the acute group ($P = .039$; Table II). One infection occurred in each of the hook-plate and superior locked plate groups and both were treated with an extensive irrigation and débridement. The hook-plate was removed after fracture union. The superior locked plate was removed during the incision and drainage and a distal clavicle excision was performed.

Peri-implant fractures occurred only in those patients treated with a hook-plate. In each case, the fracture involved the most medial screw of the hook-plate, resulting in a minimally displaced midshaft clavicular fracture (Fig. 6). Two of the fractures were the result of high-energy trauma (one from a direct blow during an altercation and another from a cycling accident). The third was a low-energy trauma from a simple fall. These fractures were treated nonoperatively, and all went on to fracture union. The hardware failure was in a patient originally treated in a delayed fashion with a hook-plate. The most proximal screws began to pull out 6 weeks after surgery, and revision surgery was performed with a superior locked plate. The fracture went on to a painless nonunion.

Routine removal of hook-plates was performed in 13 patients, and 9 declined further surgery for removal. Superior locked plates were removed in 5 patients, with 4 due to symptomatic hardware and 1 secondary to infection.

## Discussion

Since its first description by Neer in 1963, the ideal management of the fracture of the distal third of the clavicle remains a topic of debate. Nonoperative management continues to be well supported in the literature. Despite reported nonunion rates ranging from 22% to 44%, less than 15% of patients have required surgical management for treatment of a symptomatic nonunion.[6,26,29,30] The functional results demonstrated in the nonoperatively treated groups have also been comparable to those treated operatively. These outcomes have led many authors to advocate an initial nonoperative approach to this injury.[6,15,26,29,30]

Although good outcomes have been reported with nonoperative management, other authors recommend immediate operative intervention due to concerns for the high nonunion rate and the inherent difficulties with delayed management. Neer's original report recommended operative fixation based on a 67% rate of delayed union and a 33% incidence of nonunion with nonoperative management compared with 100% union within 6 weeks after operative treatment.[24] Several authors have subsequently arrived at the same conclusion, noting high rates of union and low rates of complications using various fixation techniques. Edwards et al[7] reported 43 patients with type II fractures in which 23 were treated operatively. Union occurred in all operatively treated patients, whereas the nonoperative group incurred a 30% nonunion rate and a 45% delayed union rate. The results of the current series compare favorably with previous reports, with fracture union achieved in 94.7% of cases.

Several techniques have been described to treat these difficult fractures, including Kirschner wires, tension band fixation, coracoclavicular fixation with sutures or screws, and plate fixation. Despite the numerous techniques available, no

**Table I** Details regarding patients who sustained complications

| Patient | Fixation method | Time to fixation | Complications | Clinical result |
|---|---|---|---|---|
| 3 | Hook-plate | Delayed | Peri-implant fracture | Conservative treatment; fracture union; declined plate removal. |
| 8 | Superior locked plate | Acute | Infection | Incision and drainage, antibiotics and immediate plate removal; painful nonunion treated with distal clavicle excision. |
| 25 | Hook-plate | Delayed | Peri-implant fracture | Conservative treatment, fracture union; plate removal. |
| 30 | Hook-plate | Acute | Peri-implant fracture | Conservative treatment, fracture union; plate removal. |
| 31 | Hook-plate | Delayed | Medial screw fixation failure | Revision to superior plate; painless nonunion |
| 35 | Hook-plate | Delayed | Infection | Incision and drainage; antibiotic treatment until fracture union and plate removal. |

**Table II** Patients in each subgroup and the number of complications per patient subgroup

| Fixation | Treatment subgroup | | Complications |
|---|---|---|---|
| | Acute | Delayed | |
| Hook-plate, No. | 14 | 8 | 5 |
| Superior locked plate, No. | 13 | 3 | 1 |
| Complications, No. | 2 | 4 | |

clear solution has been identified and poor fixation in the lateral clavicular fragment remains a concern. Newer implant designs have been developed in effort to reduce many of the poor outcomes related to previous fixation techniques that have mainly been related to fixation failure. Two newer implant designs were used in the current series, including the hook-plate and precontoured locking plates. The hook-plate allows for improved fixation by providing a hook that articulates with the undersurface of the acromion, which serves to reduce the distraction forces on the lateral fracture segment. Reports of successful fracture union with this plate design are prevalent.[8,9,12,14,18,20,21,28,31]

Flinkkila et al[9] retrospectively reviewed the outcomes of 63 patients treated with the clavicular hook-plate and noted a 94% union rate. Although the fixation is improved, the hook-plate is not without its complications, which have included peri-implant fracture, acromial wear, and persistent nonunion.[4,9,21,22] The Flinkkila series reported persistent nonunion in 5% of patients and peri-implant fracture medial to the plate in 5%. In addition to these complications, it is also recommended that this plate be removed after fracture union due to concern for persistent pain caused by acromial abrasion, thereby obligating the patient to a second surgical procedure.

In the current series, use of the hook-plates resulted in a union rate of 95% and an overall complication rate of 22.7%. Similar to the findings in the Flinkkila series, we also noted 3 fractures that occurred at the most medial hole in the plate. We hypothesize that a rigid construct that spans the acromioclavicular joint limits the ability of the clavicle to rotate as a load is applied or the arm is raised. The limited rotation at the acromioclavicular joint is thereby translated into increased torsional forces at the most medial screw of the plate. This results in a stress riser and may explain the peri-implant fractures observed in this location. Limited rotation could also account for the common observation of wear or notching on the undersurface of the acromion in patients with a retained hook-plate.

The second mode of fixation was a precontoured superior locked plate. Limited literature exists on outcomes with superior locking plates for unstable distal clavicular fractures. Fixation failure in the distal fragment with the use of locking plates for clavicular fractures has been reported.[3] Concern regarding this mode of failure prompted the use of additional fixation with suture augmentation in or around the coracoid. Suture or screw fixation of the clavicle to the coracoid has been previously described as a treatment for an unstable distal clavicle.[1,2,17,33] These results have been encouraging despite the small study groups. Using this technique as a supplement to the locking plate appears to reduce the risk of fixation failure. We observed a low complication rate (6.25%) and high rate of union (93.8%) using this treatment strategy. No fixation failures occurred in the subset of patients treated with a superior locked plate and suture augmentation. Functional outcomes appear to be equal when comparing this method with the hook-plate, with average ASES scores of 77 and 72, respectively, in our study.

Previous studies comparing patients treated in an acute or delayed fashion have shown essentially equivalent outcomes.[18,29,32] Many of these studies, however, combined both Neer type II and III fractures; therefore, the significance of the timing of surgery for the more unstable type II variant has remained largely unknown. Our current study is unique in that it consists only of Neer type II fractures. The current results indicate that the timing of treatment in this select group appears to be an important factor. A clinically significant decrease in available ASES scores of 12.8 points (77.8 for acute vs 65.0 for delayed) was seen in patients whose surgery was delayed for at least 4 weeks.[19] In addition, a significantly higher rate of complications was noted in patients with delayed (36.4%) vs acute treatment (7.4%; $P = .047$). These results highlight the importance of properly selecting those patients who may benefit from

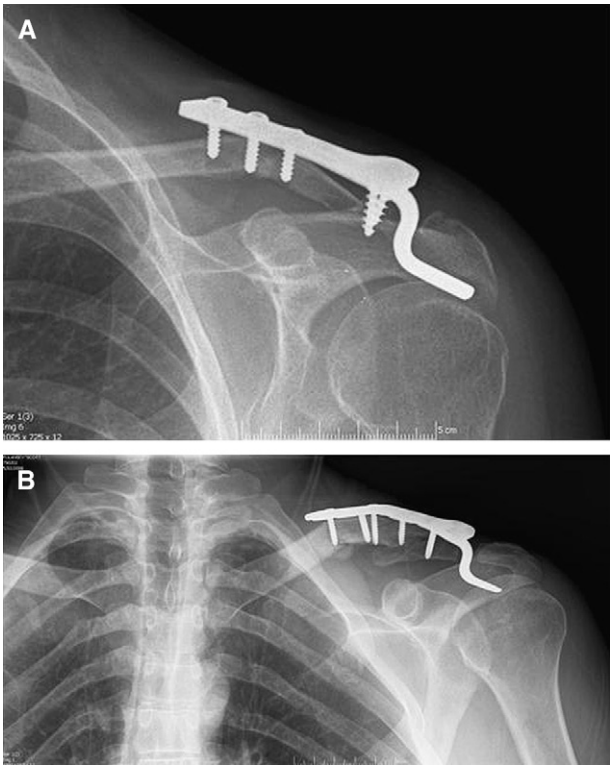


**Figure 6** (A and B) Radiographic examples show peri-implant fractures medial to the hook-plate fixation.

early operative intervention to avoid the potential pitfalls present with delayed surgical management.

The timing and method of fixation also appeared to affect outcome. We found that those treated with a hook-plate in a delayed fashion had the highest complication rate (4 of 8, 50%) of any subgroup of patients. We believe that the direct, fragment-specific fixation offered by the superior locking plate in comparison with the hook-plate, which acts as more of an indirect reduction aid, allows for more rigid fixation in the revision or delayed surgery setting. From the present findings, we advocate use of a superior locked plate with suture augmentation for delayed treatment of these fracture types.

The weaknesses of this study include its retrospective nature and the lack of a nonoperative control group. In addition, our sample size was small due to the low overall incidence of this particular fracture pattern, and our follow-up was relatively short and based on a population consisting of mainly trauma patients. Despite its weaknesses, the retrospective nature of the study provided ample information to compare 2 surgical techniques and the effect of surgical delay.

The current study is not designed as an implant comparison, but rather a technique comparison. Technique differences inherent to device implantation and the addition of coracoclavicular suture augmentation in the superior locked plating group but not in the hook-plate group makes direct comparison of the 2 implants unreliable. Although the results of the current study are improved with acute treatment compared with delayed, the purpose of the current report is also not intended to convey that immediate operative management is the treatment of choice. It does, however, indicate that surgical intervention can result in predictably high union rates regardless of timing of surgery. Proper patient selection and communication remain the keys to a successful operative or nonoperative treatment course.

## Conclusions

Surgical treatment of distal clavicular fractures results in high rates of union regardless of the timing or method of fixation. Superior locked plating with suture augmentation provides reliable results with few complications and the advantage of a lower rate of subsequent surgery for hardware removal. Peri-implant fractures with hook-plates are not uncommon and can occur with minimal additional trauma. Caution should be exercised when using hook-plates in a delayed fashion for distal clavicular fractures due to the high complication rate. Early plate fixation may decrease surgical complications and improve functional results.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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