Nonoperative Treatment Compared with Plate Fixation of Displaced Midshaft Clavicular Fractures. Surgical Technique

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Nonoperative Treatment Compared with Plate Fixation of Displaced Midshaft Clavicular Fractures

Surgical Technique

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ABSTRACT FROM THE ORIGINAL ARTICLE

BACKGROUND: Recent studies have shown a high prevalence of symptomatic malunion and nonunion after nonoperative treatment of displaced midshaft clavicular fractures. We sought to compare patient-oriented outcome and complication rates following nonoperative treatment and those after plate fixation of displaced midshaft clavicular fractures.

METHODS: In a multicenter, prospective clinical trial, 132 patients with a displaced midshaft fracture of the clavicle were randomized (by sealed envelope) to either operative treatment with plate fixation (sixty-seven patients) or nonoperative treatment with a sling (sixty-five patients). Outcome analysis included standard clinical follow-up and the Constant shoulder score, the Disabilities of the Arm, Shoulder and Hand (DASH) score, and plain radiographs. One hundred and eleven patients (sixty-two managed operatively and forty-nine managed nonoperatively) completed one year of follow-up. There were no differences between the two groups with respect to patient demographics, mechanism of injury, associated injuries, Injury Severity Score, or fracture pattern.

RESULTS: Constant shoulder scores and DASH scores were significantly improved in the operative fixation group at all time-points ($p = 0.001$ and $p < 0.01$, respectively). The mean time to radiographic union was 28.4 weeks in the nonoperative group compared with 16.4 weeks in the operative group ($p = 0.001$). There were two nonunions in the operative group compared with seven in the nonoperative group ($p = 0.042$). Symptomatic malunion developed in nine patients in the nonoperative group and in none in the operative group ($p = 0.001$). Most complications in the operative group were hardware-related (five patients had local irritation and/or prominence of the hardware, three had a wound infection, and one had mechanical failure). At one year after the injury, the patients in the operative group were more likely to be satisfied with the appearance of the shoulder ($p = 0.001$) and with the shoulder in general ($p = 0.002$) than were those in the nonoperative group.

CONCLUSIONS: Operative fixation of a displaced fracture of the clavicular shaft results in improved functional outcome and a lower rate of malunion and nonunion compared with nonoperative treatment at one year of follow-up. Hardware removal remains the most common reason for repeat intervention in the operative group. This study supports primary plate fixation of completely displaced midshaft clavicular fractures in active adult patients.

LEVEL OF EVIDENCE: Therapeutic Level I. See Instructions to Authors for a complete description of levels of evidence.

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INTRODUCTION

Traditionally clavicular fractures have been treated nonoperatively, even when substantial displacement has been present (Fig. 1). However, displaced midshaft clavicular fractures have been shown to be problematic in certain cases[1,2]. Recent studies have demonstrated that the union rate after midshaft clavicular fractures is not as favorable as once thought[3-5]. A meta-analysis of recent studies showed that the rate of nonunion of displaced midshaft clavicular fractures was 15.1% after nonoperative care compared with 2.2% after plate fixation[6]. Moreover, malunion of the clavicle has been found to be a definite clinical entity[7]. In a recent prospective randomized trial, functional outcomes and patient satisfaction following plate fixation of displaced midshaft clavicular frac-

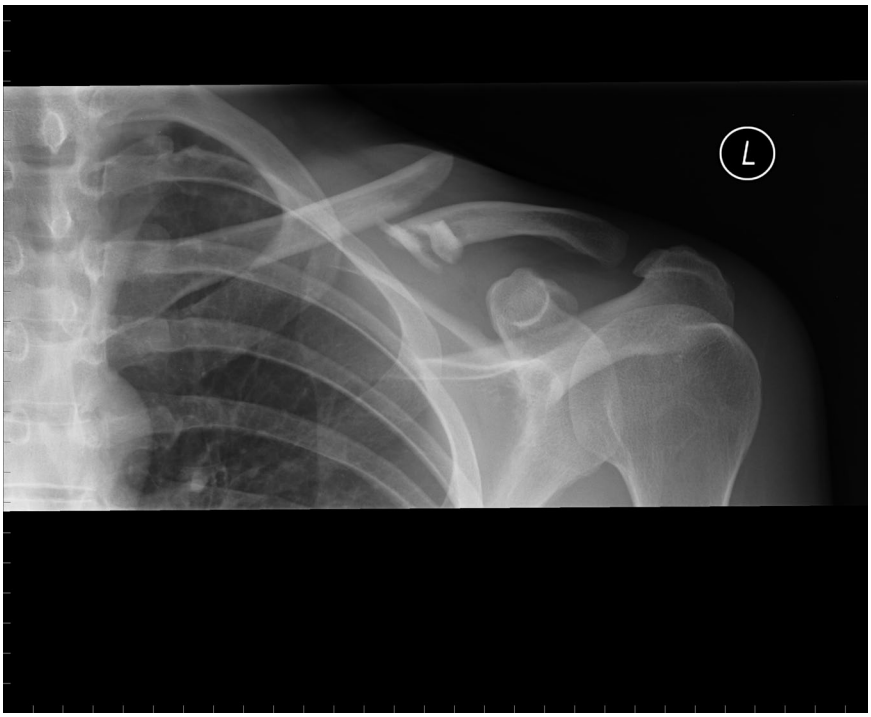

FIG. 1

Anteroposterior radiograph of the clavicle, demonstrating the typical deformity. The proximal fragment is displaced superiorly, while the distal fragment is displaced inferiorly, translated medially, and rotated anteriorly.

FIG. 2

The patient is placed in the beach-chair position with the head slightly tilted to the opposite side and taped in place.

FIG. 3

FIG. 4

Fig. 3 The operative site is draped from the sternum to the acromion. The proximal and distal fragment ends are identified and marked. A horizontal skin incision is made between the two fragment ends and centered over the fracture site. Yellow arrow = sternum, and red arrow = lateral border of the acromion. **Fig. 4** The skin, platysma, and subcutaneous tissue are raised as a single thick flap, exposing the underlying myofascial layer.

ture were superior to those following nonoperative treatment of such fractures[8]. In the present report, we describe the technique for open reduction and plate fixation of midshaft clavicular fractures.

SURGICAL TECHNIQUE

The patient is placed in the beach-chair position with a small pad behind the shoulder blade and the involved upper extremity tucked into the side with a bed sheet (Fig. 2). It is not routinely necessary to drape the arm free. The head of the patient is supported with a headrest and is slightly tilted to the opposite side to provide easy access to the clavicle with operative instruments. The operative site is prepared in standard sterile fashion and is draped from the lateral border of the acromion to the sternum (Fig. 3).

A horizontal skin incision is made along the superior surface of the clavicle and centered over the fracture site. The skin, platysma, and subcutaneous tissue are raised as a single flap (Fig. 4). Care is taken to avoid injury to any identifiable supraclavicular nerves. Some denervation is inevitable; however, this is usually not a long-term clinical problem because of gradual reinnervation of the skin from the medial and lateral sides of the incision. The underlying myofascial layer is identified and is sharply dissected down to bone so that a single continuous thick flap is raised for later closure over the plate. Thereby, a two-

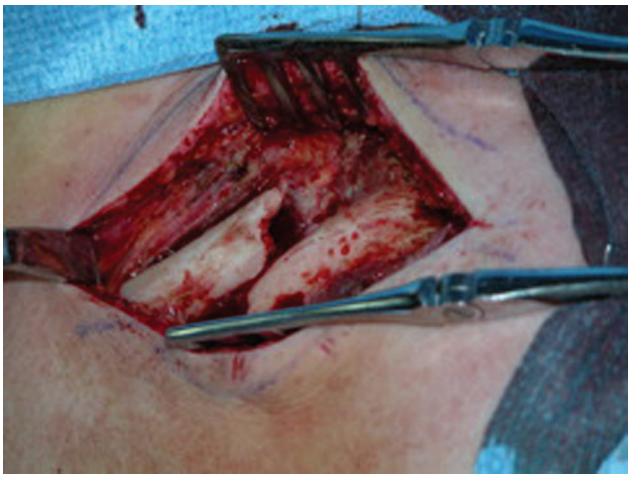

FIG. 5

The myofascial layer is sharply incised down to bone and raised as a thick flap. The fracture site is exposed and carefully assessed.

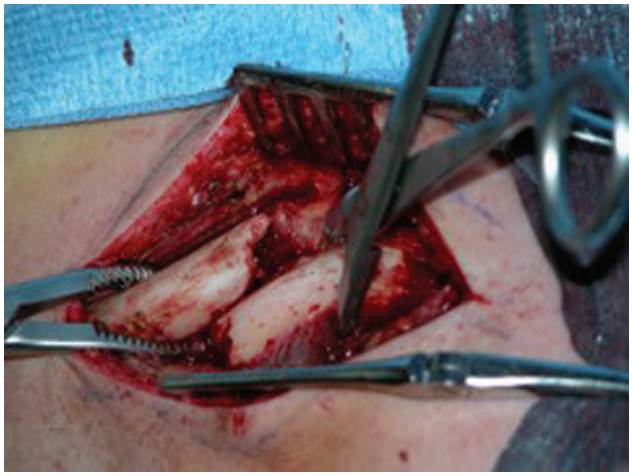

FIG. 6-A

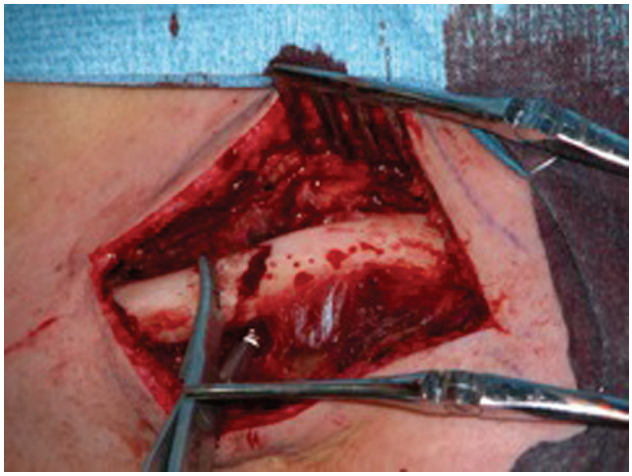

FIG. 6-B

Fig. 6-A Two reduction clamps are placed on the proximal and distal fragments. Then, the distal fragment is distracted, elevated, and derotated to obtain the reduction. **Fig. 6-B** The fracture is anatomically reduced and is held in place with a reduction clamp.

layer soft-tissue closure will be achieved at the conclusion of the procedure.

Next, the fracture is exposed and carefully assessed (Fig. 5). Typically, the proximal fragment is displaced superiorly, while the distal fragment is displaced inferiorly, translated medially, and rotated anteriorly; the flat superior surface of the distal fragment thereby faces more anteriorly rather than directly superiorly as a result of the action of the deforming muscles. After removal of the interposing soft tissue and clearing of the fragment ends, the fracture is anatomically reduced and is held in place with a reduction clamp (Figs. 6-A and 6-B). A 3.5-mm dynamic compression plate is centered accurately over the fracture site so that at least three screws can be placed in each of the proximal and distal fragments[9]. We usually position the plate over the superior surface of the clavicle (Figs. 7 and 8). The plate is then clamped to the proximal and distal fragments with two bone-holding forceps. It is not routinely necessary to use a blunt retractor under the clavicle, but care must be taken to avoid overdrilling deep to the clavicle. If inadvertent plunging does occur, then a chest radiograph is necessary postoperatively to rule out pneumothorax. Bleeding from injury to the subclavian vessels will typically stop with manual pressure. If the

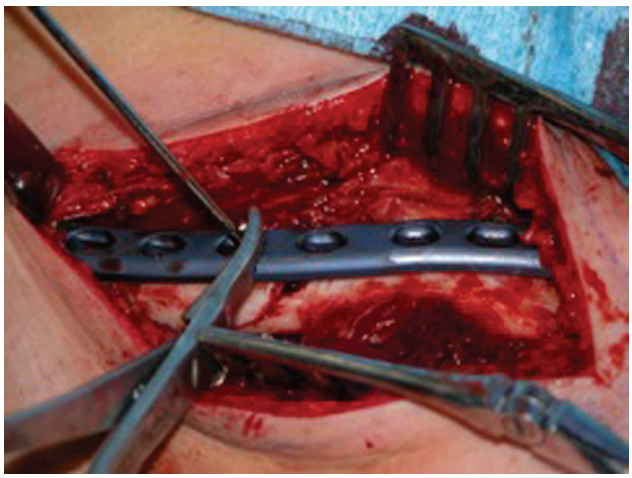

FIG. 7

A 3.5-mm precontoured dynamic compression plate is placed on the superior surface of the clavicle and centered over the fracture site.

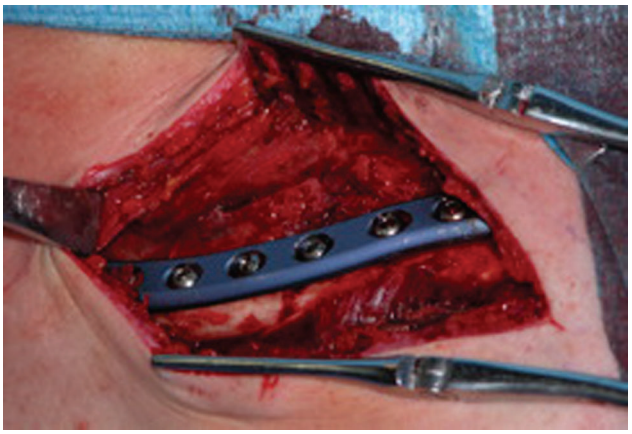

FIG. 8

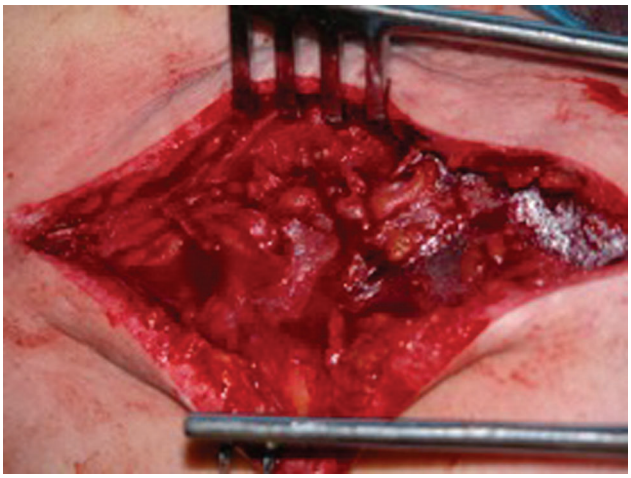

FIG. 9

Fig. 8 Three bicortical screws are inserted into both the proximal and the distal fragment. **Fig. 9** After thorough irrigation, the myofascial layer is closed with interrupted absorbable sutures.

fracture is oblique, a 3.5-mm lag screw is placed across the fracture site. Butterfly fragments, if present, are reduced and fixed to a major fragment with an interfragmentary compression screw if possible. It is important not to strip these fragments of their soft tissues. In approximately 20% of cases, the fracture is very comminuted, and in such situations the plate is applied in the neutral mode without compression. However, in the majority of cases, compression is applied through the plate.

It is important to correctly restore length and rotation. Preoperatively, the distance between the acromioclavicular joint and the sternoclavicular joint on the contralateral side is measured both clinically and radiographically in order to estimate the amount of clavicular length to restore.

Following wound irrigation, meticulous closure is performed in two layers. The myofascial layer is closed with number-1 absorbable sutures in an interrupted fashion (Fig. 9). Then the subcutaneous tissues are closed with number-2.0 absorbable sutures, and the skin is closed with a subcuticular stitch or staples. The incision is infiltrated with 0.5% bupivacaine (Fig. 10), and the arm is placed in a standard sling. An anteroposterior radiograph of the clavicle is made in the recovery room (Fig. 11). A chest radiograph is not routinely made unless a

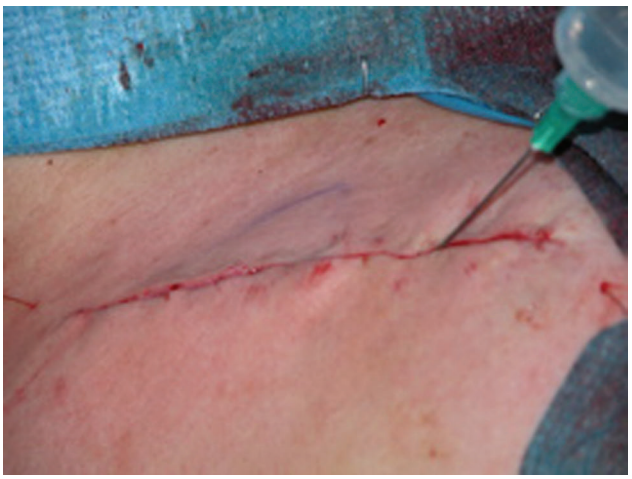

FIG. 10

Two-layer soft-tissue closure is achieved, and the skin is closed with a subcuticular suture and infiltrated with local anesthetic (0.5% bupivacaine).

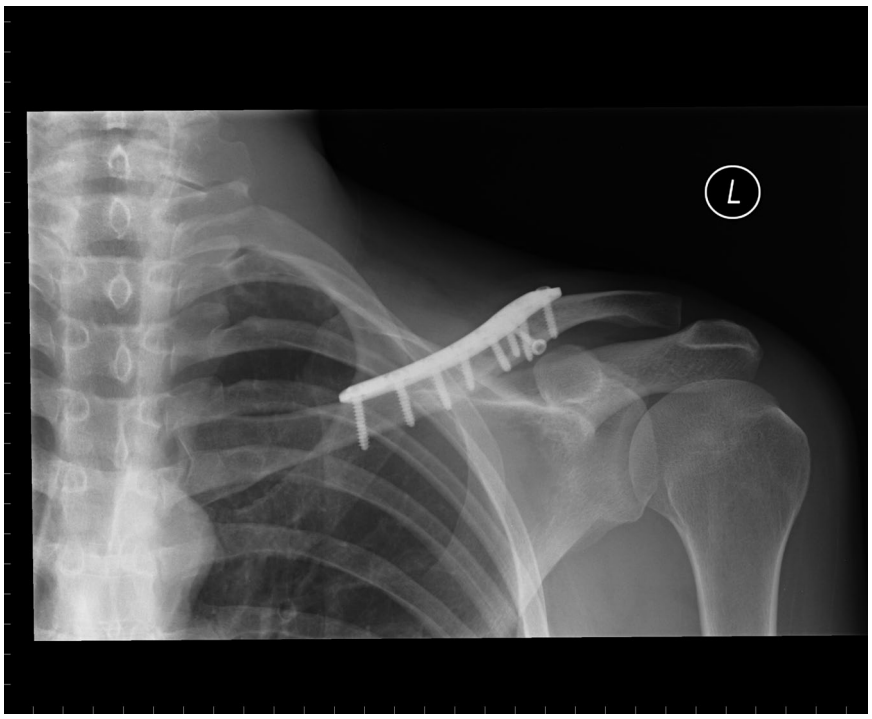

FIG. 11

Postoperative anteroposterior radiograph of the clavicle, showing anatomic reduction of the fracture and secure plate fixation.

specific injury to the pleura is suspected.

POSTOPERATIVE CARE

The arm is maintained in a sling on a full-time basis for two weeks, after which use of the sling is discontinued and active assisted range-of-motion exercises of the shoulder in the scapular plane are begun. Full active motion is initiated at four weeks. When clinical and radiographic signs of union are present, strengthening and resistive exercises of the rotator cuff, deltoid, and trapezius are begun, usually at six to eight weeks. By three to four months, most patients are allowed to participate in all sports activities.

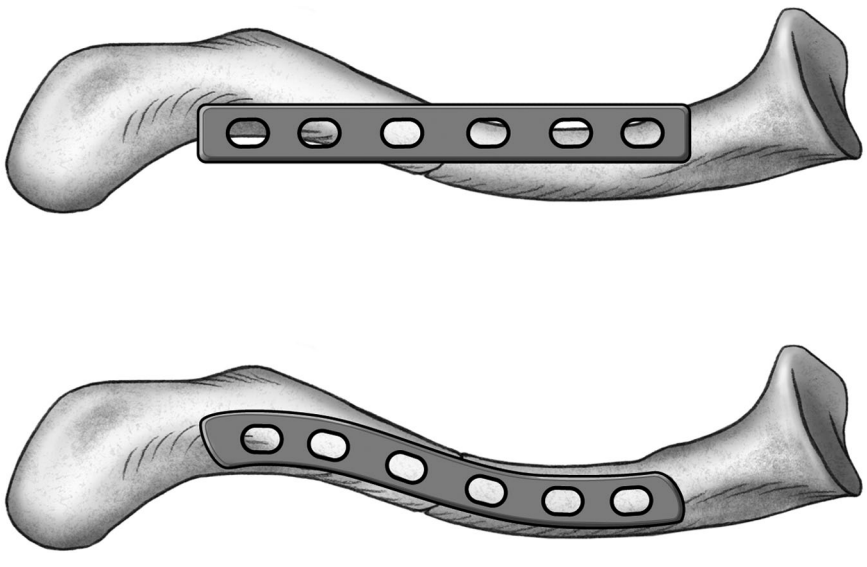

FIG. 12

Schematic demonstrating the difference between the precontoured anatomic plate and a standard compression plate, which tends to project from the bone medially and laterally and produces soft-tissue irritation.

CRITICAL CONCEPTS

INDICATIONS:

The majority of clavicular fractures can be treated effectively with nonoperative means. Operative fixation is indicated in healthy, physically active individuals between the ages of sixteen and sixty years with any of the following:

- A completely displaced midshaft fracture with shortening of >2 cm
- Superior displacement with skin tenting and/or an impending open fracture
- An associated neurovascular injury
- An open clavicular fracture
- A floating shoulder with a completely displaced clavicular fracture
- An obvious clinical deformity with shoulder asymmetry (a combination of shortening, rotation, and displacement)
- Multiple injuries with any of the above indications

CONTRAINDICATIONS:

- Active infection in the operative area
- Prior soft-tissue irradiation in the operative area
- Burns over the clavicular area
- Debilitating medical conditions
- A high risk of poor patient compliance, especially due to substance abuse (drugs and/or alcohol)
- An elderly patient with a sedentary lifestyle

PITFALLS:

- Preoperative planning and patient selection are crucial. Patients at high risk for multiple falls, alcohol abuse, or noncompliance may have early mechanical failure of the fixation and are not candidates for this procedure.
- Failure to carefully contour the plate to accommodate the s-shape of the clavicle can lead to implant prominence and soft-tissue irritation at the ends of the plate. The use of a precontoured anatomic plate helps to decrease soft-tissue irritation.
- A minimum of three 3.5-mm screws should be placed in each of the proximal and distal fragments, and ideally the plate should be applied in compression mode to reduce the risk of delayed union or nonunion.
- Cautious drilling, especially when sharp drills and taps are used, is of paramount importance in this procedure. A blunt retractor placed under the clavicle, which adds undesired soft-tissue dissection, can be used if necessary. We have found that this step is not required as experience increases.
- The intervening fragments should not be stripped. They should be teased into position, with preservation of soft-tissue attachments and ensuring that the length and rotation of the clavicle are correct.
- A postoperative chest radiograph is required only in rare circumstances where a pleural injury is suspected.

AUTHOR UPDATE:

- Currently, we are using a precontoured “anatomic” plate designed for the clavicle to decrease soft-tissue irritation and the intraoperative time required for plate contouring (Fig. 12).
- We have found that it is not necessary to have the arm draped free to obtain or maintain fracture reduction; rather, the arm is tucked into the side and the operative site is simply draped off.
- At present, the procedure is performed with use of a regional anesthetic with supplemented infiltration of local anesthesia. This method improves postoperative pain control and allows the procedure to be performed on an outpatient basis.
- A “minimally invasive” technique can be used as expertise increases. This includes shorter incisions, extensive mobilization of subcutaneous tissues, sliding of the plate under the myofascial layer, and the use of small stab incisions through the myofascial layer for placement of the screws.

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The line drawing in this article is the work of Joanne Haderer Müller of Haderer & Müller (biomedart@haderermuller.com).

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