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Treatment of comminuted mid-diaphyseal clavicle fractures by plate fixation using a bridging technique

Sami SÖKÜCÜ[1], Özgür MENGES[2], Engin ÇETİNKAYA[1], Atilla PARMAKSIZOĞLU[3], Yavuz KABUKÇUOĞLU[1]

[1]Department of Orthopedics and Traumatology, Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Istanbul, Turkey;
[2]Department of Orthopedics and Traumatology, Taksim German Hospital, Istanbul, Turkey;
[3]Department of Orthopedics and Traumatology, Taksim Training and Research Hospital, Istanbul, Turkey

Objective: The aim of this study was to determine the healing and functional results of the treatment of comminuted mid-diaphyseal clavicular fractures using a bridging plate technique with minimal surgical dissection.

Methods: This retrospective study included 23 patients (17 males and 6 females) with comminuted mid-diaphyseal clavicular fractures treated between 2004 and 2010. All fractures were operated on using a bridging plate technique with minimal surgical dissection. Patients were evaluated for function using the Constant shoulder scoring system.

Results: Mean follow-up was 22 (range: 6 to 68) months and healing occurred in all patients after a mean of 13 (range: 8 to 20) weeks. No implant failures or superficial or deep infections were observed. Iatrogenic neurovascular damage was not observed in any patient. Two patients had clavicle length discrepancy in comparison with the healthy side. Range of motion was normal in all patients. The mean Constant score was 89.6 (range: 72 to 100) points.

Conclusion: The surgical treatment of mid-diaphyseal fractures with the bridging plate technique using locking plates provides good patient comfort, allows early mobility and has a low complication rate.

Key words: Bridging; clavicle; fracture; midshaft.

Clavicle fractures are common, accounting for nearly 4% of all fractures[1] and constituting 35 to 40% of the shoulder region fractures.[2] Of all clavicular fractures, 70 to 80% are located in the mid-diaphyseal region, whereas 15 to 30% are lateral and 3% are at the medial end.[3,4] Among young adults, traffic accidents and sports injuries are the primary etiological factors.[5]

Although conservative methods are generally used to treat clavicle fractures, several published studies have recently argued that surgical methods improve functional outcomes compared with conservative treatment.[6-8]

Many implant options are available for the surgical treatment of clavicle fractures, including surgical plates and intramedullary implants. In a biomechanical study,

Correspondence: Sami Sökücü, MD. Metin Sabancı Baltalimanı Kemik Hastalıkları Hastanesi, Ortopedi ve Travmatoloji Kliniği, Baltalimanı Mh., 34470 İstanbul, Turkey.
Tel: +90 212 – 323 70 75 e-mail: dr_samis@yahoo.com

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Darren et al. reported that dynamic compression plates and locking plates are stronger against twists and torque loads compared with intramedullary implants.[9]

The use of open reduction and plate fixation of clavicle fractures has been reported in several papers. However, the use of bridging plates, a minimally invasive method in comminuted mid-diaphyseal fractures, has not been described in the literature.

This aim of this study was to investigate the union rates and functional outcomes of comminuted midshaft fractures of the clavicle following minimal surgical dissection and bridge plating.

Patients and methods

This retrospective study included 23 patients (17 males and 6 females; mean age: 37 years, range: 22 to 52 years) who underwent a surgical procedure for clavicle fracture between 2004 and 2010. All fractures were mid-diaphyseal and comminuted (Figs. 1a and b). According to AO/OTA classification, there were 14 B2 type bending wedge fractures with a third fragment, 5 B3 comminuted wedge fractures and 4 C2 segmental clavicle fractures. Clavicle fractures were caused by a fall in 10 patients, sports injuries in 5 and traffic accidents in 8.

Adult age and posttraumatic comminuted midshaft fractures of the clavicle with shortening of more than 20 mm were included in the study. Exclusion criteria were open fracture at injury site, pathological fracture, delay of more than 48 hours from accident to hospital admission and pediatric age. In addition, bridge plating was not suitable for several fracture types, including midshaft fractures with button hole soft tissue, open shaft fractures, fractures with neurovascular injury or fractures that cannot obtain reduction with close reduction techniques such as comminuted shaft fractures; thus, these fractures were also excluded. Pediatric patients were treated conservatively and open clavicle fractures with open reduction and internal fixation with a plate. Anteroposterior shoulder radiographs of all patients were taken at the emergency room during the early postinjury period. Patients with comminuted midshaft clavicle fractures were immobilized in a shoulder sling and were operated within 48 hours.

For surgical intervention, patients were placed in the beach chair position. Before surgery, 1 g of cefazolin sodium was given as antibiotic prophylaxis. The 3.5-mm anatomic locking plate was adapted directly to the bone using bridge plating beneath the soft tissue through incisions from the medial and lateral of the fracture line (Figs. 1c and d). After reduction with bone-fixation clamps, the reduction was checked on two separate planes with

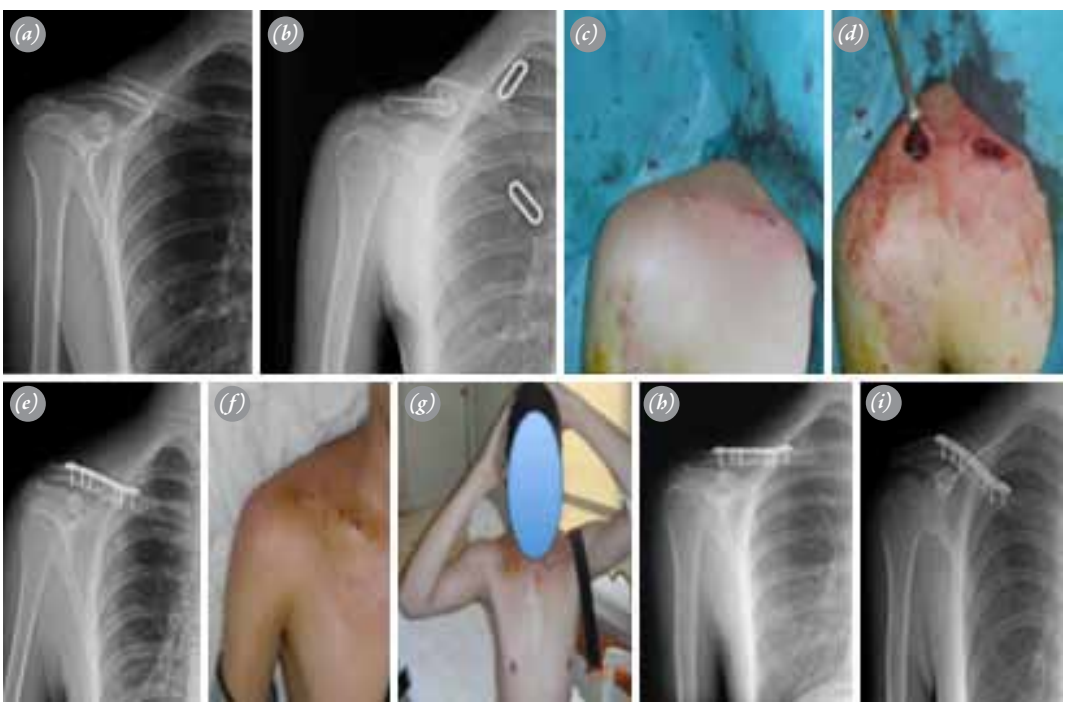

Fig. 1. **(a, b)** Preoperative radiographs of the patient. **(c, d)** Intraoperative views from the incision and plating application. **(e)** Early postoperative radiograph of the plate. Postoperative 10th day views of the **(f)** incision and **(g)** patient function. **(h, i)** Radiographs taken after union.

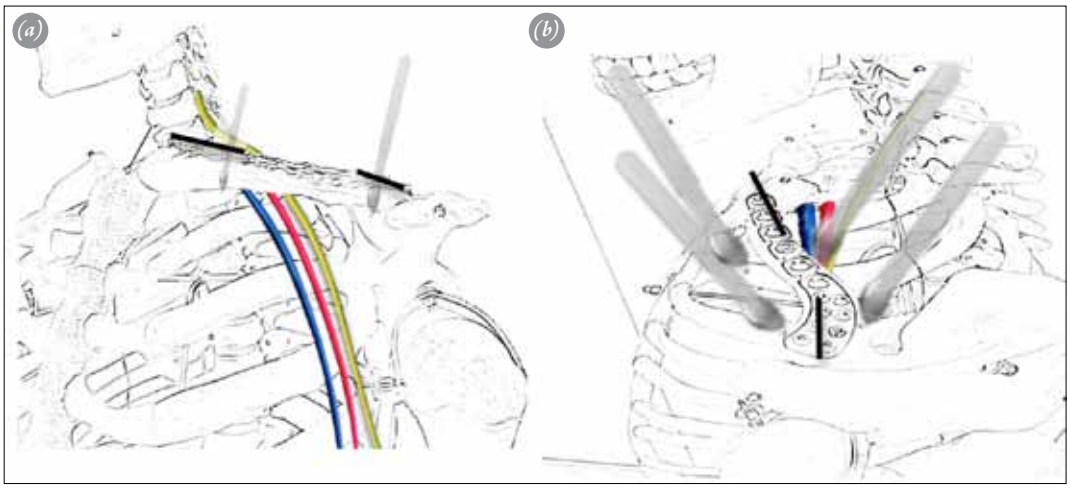

Fig. 2. **(a)** An oblique view of the clavicle and neurovascular bundle showing its position in relation to the incision lines and the position of the blunt elevator in relation to the clavicle. **(b)** Sagittal view of the anatomical relationships of the plate, clavicle, neurovascular bundle and incision lines. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

fluoroscopy and fixed with a plate. Bone grafting was not performed. During drilling, the soft tissue around the clavicle was displaced and a blunt elevator was placed under the clavicle periosteum from the medial and lateral windows to prevent neurovascular damage as shown in different planes in Figure 2. Control radiographs were taken on the first day following surgery (Fig. 1e).

Shoulder slings were used for 10 days postoperatively. At the end of the 10th day, patients were encouraged to begin passive-assisted movements, followed by active and early stretching exercises after their union findings had improved (Figs. 1f and g). Rotator cuff, deltoid muscle and trapezius muscle exercises were performed against resistance.

All patients were assessed at the 1st, 3rd and 6th postoperative months. Both clinical and radiographic evaluations were performed to assess bone union. Trabeculations across the fracture line in conventional shoulder radiographs and the absence of clinical pain were considered to indicate union (Figs. 1h and i). Patients were functionally evaluated using the Constant shoulder scoring system.

Results

Average follow-up time was 22 (range: 6 to 68) months. Clinical and radiological union was observed in all patients after an average of 13 (range: 8 to 20) weeks. No implant failures or superficial or deep infections were observed. Iatrogenic neurovascular damage was not observed in any patient. Healing with cutaneous scar tissue was not observed in any patient. After bone healing, all patients had a normal range of motion. When we compared the length of the clavicle with the healthy side, there was a difference in clavicle length in only two patients. One of these patients had a 5 mm and the other a 4 mm length discrepancy due to reduction. Plates were extracted in four patients. In one patient, the plate was removed after 13 months and a new transverse fracture occurred from the screw hole to the medial side of the fracture line due to a fall on the same shoulder 3 months after plate removal. The same procedure was performed and the patient healed without any complications.

Functional evaluation was performed using the Constant scoring at the final follow-up. Average Constant score was 89.6 (range: 72 to 100) points. The patient with refracture had the lowest Constant score. Based on Constant scoring, results were perfect in 15 patients, good in 4 and average in four. A functionally poor outcome was not observed.

Discussion

Traditionally, mid-diaphyseal clavicle fractures are treated using conservative methods. Neer[6] and Rowe[10] reported nonunion rates with conservative treatment of as low as 0.13% and 0.8%, respectively. However, both studies were limited by the lack of functional outcomes and the pediatric age of the majority of patients. Previous studies have reported nonunion rates ranging between 5.9% and 15% in adult patients with mid-diaphyseal clavicle fractures treated by conservative methods.[11-13]

All prospective comparative studies that have compared surgical and conservative treatment in displaced

mid-diaphyseal clavicle fractures have reported high functional outcomes, low nonunion rates, reduced pain, early mobilization and increased patient satisfaction in the surgical groups.[14-16] Potential infections, plate braking, vascular damage, pneumothorax and surgical scar formation have been reported as disadvantages of surgical treatment. Zlowodzki et al.[12] reported complication rates after plating in displaced acute midshaft clavicle fractures of 2.2% nonunion, 4.6% infection and 2% fixation failure. Schiffer et al.[4] reported implant failure and refracture after implant removal in approximately 10% of cases. In the current study, no patient had neurovascular damage, pneumothorax or nonunion or developed superficial or deep infection.

In a comparative study, Mirzatolooei[15] reported that one patient in the surgery group was dissatisfied due to an incisional scar. In our study, we preferred a minimally invasive approach, using small incisions and plate bridging. None of the patients complained of surgical scars or reported dissatisfaction.

Intramedullary fixation, plate fixation and fixation using an external fixator are possible surgical treatment options.[15,17-19] A biomechanical comparison of intramedullary fixation devices with plates showed that plate fixation was more resistant against cyclic loads and allowed for early mobilization.[20] It has also been reported that intramedullary implants resulted in shortening because they do not allow static locking and resulted in a high rate of implant failure.[21] Therefore, we chose to use plates for fixation in this study.

A comparison of conventional open reduction and mini-invasive plate osteosynthesis reported that the minimally invasive technique results in lower rates of dysesthesia and hypertrophic scarring, and a better cosmetic outcome than conventional open reduction.[22] This study also reported that functional outcomes and union time did not differ between the two groups and that satisfaction was higher in the mini-invasive group than in the conventional open reduction group.

Open reduction is necessary in order to use intramedullary implants in the surgical treatment of clavicle fractures.[23,24] However, the bridge plating technique used in this study provides biological osteosynthesis, aiming to preserve the blood supply to the bone and soft tissue during surgery to ensure the vitality of fragments, which is required to achieve improved fracture healing.[25] Although intramedullary fixation is considered less invasive in general than plating,[23] the plating method used in the current study is less invasive than intramedullary fixation.

In the consideration of plate fixation methods, the shape and location of the plate have been debated. Reconstruction plates, dynamic compression plates and locking compression plates are among the options. It has been reported that while reconstruction plates are better adapted to the clavicle by giving them shapes, these plates offered less stability.[26] In a biomechanical study comparing dynamic compression plates and locking compression plates, locking plates were more stable compared with dynamic compression plates against cyclic, torsional and twisting forces.[27] Anatomical locking plates are less likely to require extraction because they are more stable and less evident subcutaneously post-union and were chosen in this study for these reasons.

Regarding plate location, the merits of superior versus antero-inferior locations continue to be controversial. In the antero-inferior location, the plate is less evident subcutaneously and is away from the neurovascular structures, particularly during the drilling before screwing. Although some studies report that the superior plate location is more stable than the antero-inferior location, there are also reports that antero-inferior plating does not reduce mechanical stability compared with superior plating.[28,29] We chose to use superior plating because it offered more stable fixation and allowed for early mobilization.

Mirzatolooei[15] used the Constant functional scoring system to evaluate functional outcomes and found an average score of 78.8 points in non-surgically and 89.8 points in surgically-treated patients. The mean Constant score in our study was 89.6 points and was in line with the literature.

The retrospective nature of our study and the absence of a control group or any statistical analysis can be considered limitations of this descriptive study.

In conclusion, surgical treatment using a minimally invasive approach and bridge plating with a locking plate results in good patient comfort, allows early mobilization and has a low rate of complications in mid-diaphyseal comminuted clavicle fractures.

Conflicts of Interest: No conflicts declared.

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