Open Reduction and Internal Fixation of Displaced Midshaft Clavicle Fractures

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The traditional management of displaced (2 cm or more) midshaft clavicle fractures has been nonoperative (5, 6). Recent studies (2, 3, 4, 8, 9, 10), however, have demonstrated high rates of nonunion and symptomatic malunion with non-operative treatment. We report our experience with open reduction and internal fixation (ORIF) in 17 healthy adults with displaced closed midshaft clavicle fractures.

METHODS

From 2003 until April of 2008 we performed ORIF on 17 adult patients, 12 men and 5 women, aged 19-67 with displaced midshaft clavicle fractures who met the following inclusion criteria: acute midshaft clavicle fracture with 2 cm or more displacement, closed fracture, no neurovascular deficit, no prior closed treatment. 15 patients had their procedure within the first week after their injury, and two patients had their procedure approximately 2 to 3 weeks later.

Patients were excluded from the study if they had an open fracture, a neurovascular injury, skin abrasions compromising the overlying skin, metasatic cancer of the clavicle, severe osteoporosis, or ORIF of a previous clavicle fracture. Two of the patients were smokers.

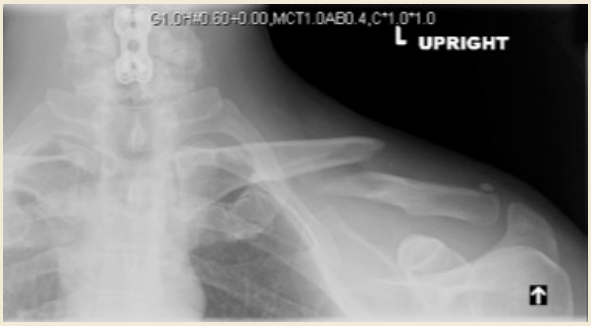

Figure 1. Displaced mid-shaft clavicle fracture

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Surgical Technique

All procedures were performed at the same facility by the senior authors (JLZ and LR). A typical displaced midshaft fracture is seen in Figure 1. Informed consent was obtained by the operating surgeon, and it was explained to the patient that they might require a second surgery to remove implanted hardware, if symptomatic, once the fracture had healed. All patients underwent a general anesthetic and received a perioperative antibiotic (usually a first-generation cephalosporin) within 30 minutes of the skin incision. The procedure was performed with the patient in a modified beach chair position with the affected extremity draped free. A transverse incision was utilized overlying the clavicle. The supraclavicular nerve was dissected out and tagged with a vessel loop to avoid neuroma formation. The fracture site was identified and all intervening soft tissue removed. The fracture was anatomically reduced and held in position with a clamp according to standard AO techniques. Lag screw fixation with a 3.5 mm cortical screw was performed when compatible with the fracture pattern. If significant comminution was encountered then careful initial reapproximation of the smaller fragments was performed with one or two 3.5 mm interfragmentary screws, if possible. If not, then the larger fragments were reduced and fixed with a 3.5 mm low contact (LC) plate (9 patients) or pelvic reconstruction plate (8 patients) per surgeon preference, with the comminuted pieces added as bone graft. The plate was usually placed superiorly, but in two cases the plate was placed anteriorly as this seemed to give the best fit in those patients. At least three 3.5 mm cortical screws were carefully placed through the plate and through both cortices of the clavicle on either side of the fracture site. The

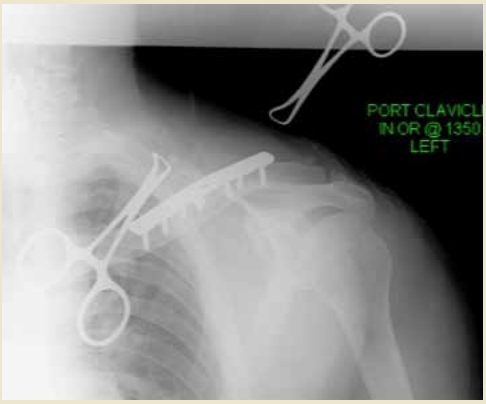

Figure 2. Intraoperative radiograph

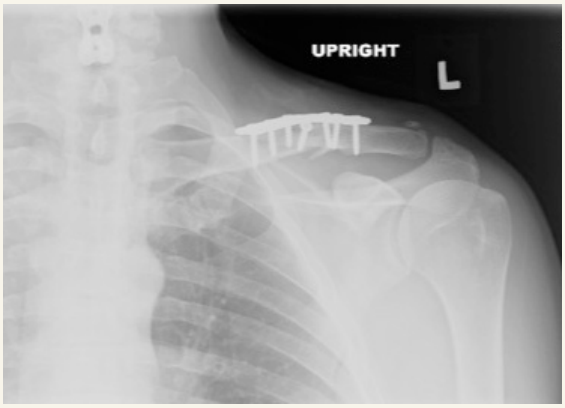

Figure 3. 6 week post-operative radiograph

plate was placed in compression mode if an interfragmentary screw was not possible. Great care was taken to avoid "plunging" through the inferior cortex and potentially damaging the underlying neurovascular structures and pleura. With the drill in our right hand we would either brace it on top of our left fist, which was firmly held against the patient's body, or brace our right forearm against our body to help prevent "plunging." We did not routinely strip off the entire periosteum circumferentially to help preserve bone vascularity. Occasionally we utilized a 4.0 mm cancellous screw if near the AC joint laterally for better purchase. We performed an intraoperative radiograph at the end of the procedure with the patient asleep and adjusted screw length if needed prior to skin closure. A typical intraoperative radiograph is seen in Figure 2 using a 7-hole LC plate and an interfragmentary screw.

The overlying periosteum and skin was closed, and a soft dressing, sling, and cryocuff were applied. The patient was awakened and transferred to the Recovery Room. Per surgeon preference, 8 patients were admitted overnight for pain control and IV antibiotics (JLZ), and 9 patients were treated as outpatients (LR) with a large field block utilizing 0.25% bupivicaine with epinephrine. Each patient was seen approximately 10 days postoperatively at which time skin sutures were removed. The patient was allowed to do supine passive range-of-motion exercises only for 6 weeks. The sling was worn until the fracture healed but removed for bathing and typing.

At 6-8 weeks postoperatively the patient returned to the office for a clinical exam and radiographs. A typical healed fracture is seen in Figure 3. If the fracture had healed then the sling was removed and the patient sent to physical therapy for active range-of-motion exercises. Strengthening exercises were added at approximately 10-12 weeks postoperatively with a gradual increase in weights. Contact sports were permitted at 4 months postoperatively.

RESULTS

All 17 of the fractures healed within 9 weeks with the majority radiographically healed by 6 weeks. There were no malunions. There were no neurovascular complications and only one minor superficial infection treated with a 10 day course of oral antibiotics and local wound care. There was no evidence of hardware failure. All patients had returned to their previous activity level at approximately four months follow-up with full range-of-motion and strength in the affected extremity.

Seven of 17 patients requested hardware removal within 6 months after the procedure due to intermittent discomfort overlying the hardware with certain activities, such as backpacking, wearing a seat belt, etc. In some cases it appeared that it was the skin overlying the prominent lateral end of the plate which was painful, in other cases the skin overlying the entire plate. Hardware removal was performed at a minimum of 6 months postoperatively on an outpatient basis. A sling was worn for less than one week. The 7 patients undergoing plate removal were instructed to avoid contact sports and heavy lifting for 6 weeks after hardware removal. No complications were seen in those patients, including no refractures. All patients returned to their preinjury activity level at 6 weeks postoperatively.

DISCUSSION

Beginning in the 1960's with the classic papers by Drs. Neer and Rowe, most authors have recommended that ORIF of displaced midshaft clavicle fracture be avoided because of the high rate of union with non-operative treatment, high rate of failure with operative treatment, and the perceived high risk of neurovascular complications due to the close proximity of the underlying subclavian artery, vein, brachial plexus, and pleura (5, 6).

Over 20 years ago Jupiter and Leffert noted that fracture displacement of greater than 2 cm was associated with nonunion in their series of patients (1). Since then, the treatment of displaced midshaft clavicle fractures has evolved over the past several years based on recent clinical studies demonstrating high rates on nonunion and symptomatic malunion with non-operative treatment (2, 3, 4, 8, 9, 10, 11, 12).

Our series of ORIF of 17 displaced midshaft clavicle fractures revealed operative treatment to be safe with excellent clinical outcomes and no serious complications. However, 7 of 17 patients did require a secondary operation to remove symptomatic hardware. This rate of hardware removal is higher than in some other studies (7, 13) and lower than one other series of 111 patients using semitubular plates with 4.5 mm or 6.5 mm screws in which 82 patients required plate removal (14).

We found that many of the patients in our series requesting hardware removal were somewhat thin with less soft tissue overlying the plate, which might be a factor in our higher rate of plate removal. Somewhat surprisingly, we found no difference with regards to plate removal in using either pelvic reconstruction plates or the thicker 3.5 mm LC plates. Some authors have recommended avoiding using the thinner pelvic reconstruction plates due to the possibility of hardware failure but we found no evidence of that in our series. We do, however, feel that if a surgeon uses the pelvic reconstruction plate they should do this only in reliable patients who are willing to wear a sling and to limit their activities in the postoperative period until the fracture has healed.

Some authors have recommended that the clavicle plate be placed anteriorly, and it is possible this might decrease the incidence of symptomatic hardware removal (15), but we found that in the majority of our patients the larger superior clavicle surface was most amenable to satisfactory plate placement. In addition, superior plate placement is thought to be biomechanically more stable than anterior plate placement (16). One prior large series (3) recommended using specific S-shaped clavicle plates to possibly decrease the incidence of symptomatic hardware removal, however the plate is designed to be placed in the superior position therefore possibly still irritating the overlying skin in thin individuals. Because of the high incidence of hardware removal in our series we inform patients undergoing ORIF of displaced midshaft clavicle fractures preoperatively that they may require a second procedure to remove the hardware at a later time.

We feel that our low rate of serious intraoperative complications is comparable to more recent studies (3, 12, 13, 14) and may be replicated by other surgeons using the same technique described in our methods section, most importantly carefully avoiding "plunging" the drill bit through the inferior cortex of the clavicle.

In summary, we believe that ORIF of displaced midshaft clavicle fractures is a safe procedure with excellent clinical outcomes. In the near future we plan to report function of this group using a standardized assessment metric with a minimum two year follow-up. We also will compare the outcome of these patients with a group of patients fixed using a specific S shaped clavicle plate.

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