Complications After Plate Fixation of Displaced Pediatric Midshaft Clavicle Fractures

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Background: Operative treatment of displaced pediatric midshaft clavicle fractures has become increasingly popular, despite lack of evidence that surgical management leads to superior outcomes. Complications, such as plate irritation necessitating removal and wound infection, have been reported in adults. The purpose of this study was to evaluate complications after plate fixation of midshaft clavicle fractures in the pediatric population.

Methods: We retrospectively identified patients 10 to 18 years old who had undergone plate fixation of a displaced midshaft clavicle fracture between 2009 and 2014. Patients who had surgery for a malunion or nonunion, and patients with <6 months of follow-up were excluded. Demographic data, radiographic union, time to return to activity, and complications were recorded. Any complication that led to unplanned surgery was considered a major complication.

Results: We analyzed 36 patients (25 males, 11 females) with 37 fractures. The average age at surgery was 14.5 ± 1.7 years and mean follow-up was 1.3 ± 1.0 years. All of the fractures healed and average time to return to activity was 58 ± 28 days. The overall postoperative complication rate was 86% (32/37): 59% (22/37) implant prominence or irritation, 16% (6/37) anterior chest wall numbness, 5% (2/37) superficial wound dehiscence or infection, 3% (1/37) refracture adjacent to the plate, and 3% (1/37) refracture after implant removal. The major complication rate was 43% (16/37). Fifteen patients underwent a second surgery for implant removal secondary to prominence or pain. One patient underwent revision open reduction and internal fixation after he sustained a refracture at the distal aspect of the plate that resulted in a painful nonunion. Only 1 patient had a refracture after implant removal and this was treated nonoperatively.

Conclusions: Implant prominence or irritation is common after plate fixation of displaced pediatric midshaft clavicle fractures. A second surgery for implant removal may be necessary. Patients should be appropriately counseled regarding complications before plate fixation of midshaft clavicle fractures.

Level of Evidence: Level IV—therapeutic.

Key Words: clavicle fracture, midshaft, pediatric, plating, complications

Over the past decade, several studies have shown improved short-term functional outcomes and radiographic union after plate fixation of displaced midshaft clavicle fractures compared with nonoperative treatment in adults. As such, operative treatment of displaced pediatric midshaft clavicle fractures has become increasingly popular, despite evidence that nonoperative management does not result in higher rates of nonunion or clinically significant decrease in shoulder range of motion or strength.

Although surgical treatment of displaced midshaft clavicle fractures in adults may lead to lower rates of nonunion and symptomatic malunion compared with nonoperative treatment, operative fixation is associated with implant-related and wound-related complications. A second surgery for implant removal has been reported in up to 27% of adults after plate fixation. Studies have shown high rates of fracture union and return to activity after plate fixation of displaced midshaft clavicle fractures in children and adolescents. However, no study has focused on the complication rate after plating. The purpose of this study was to evaluate complications after plate fixation of displaced midshaft clavicle fractures in the pediatric population.

METHODS

Approval from our Institutional Review Board was obtained before the start of this study. We retrospectively identified patients 10 to 18 years old who had undergone plate fixation of a closed, displaced midshaft clavicle fracture between 2009 and 2014. Patients who had an open fracture, pathologic fracture, congenital pseudarthrosis, surgery for a malunion or nonunion, surgery for a refracture, and <6 months of follow-up were excluded.

Demographic data, mechanism of injury, radiographic union, time to return to activity, complications, and treatment of complications were recorded. Any complication that led to unplanned surgery was considered a major complication. Complications that resolved...
with nonoperative management or did not require any treatment were considered minor. Descriptive analyses were performed. A χ² test of independence was performed to examine the relationship between sex and implant removal. Significance was set at P < 0.05.

RESULTS
We identified 85 patients with 86 fractures. Forty-nine subjects were excluded based on previously described criteria. We included 36 patients (25 males, 11 females) with 37 fractures in the final analysis. There were 14 right clavicle fractures and 23 left clavicle fractures. The mechanisms of injury included sports (27), fall (5), motor vehicle accident (3), and pedestrian versus car accident (2). The average age at surgery was 14.5 ± 1.7 years (range, 10.6 to 17.2 y). Mean follow-up was 1.3 ± 1.0 years (range, 0.5 to 4.4 y). All of the fractures achieved radiographic union. Average time to return to activity was 58 ± 28 days (range, 15 to 154 d).

The overall postoperative complication rate was 86% (32/37) (Table 1). The major complication rate was 43% (16/37). Fifteen patients (41%) underwent a second surgery for implant removal secondary to prominence or pain and 1 patient (3%) experienced a refracture that necessitated revision surgery. Four females (36%) and 11 males (44%) underwent implant removal. There was no significant difference in rates of implant removal between females and males (P = 0.736). Average time to implant removal after the index surgery was 1.4 ± 1.1 years (range, 0.5 to 4.3 y).

The minor complication rate was 43% (16/37). Seven patients (19%) had implant prominence or irritation, 6 (16%) had anterior chest wall numbness, 2 (5%) had superficial wound dehiscence or infection, and 1 (3%) had a refracture after implant removal. Three of the individuals with implant-related complaints continued to have pain at final follow-up. One patient presented over 3 years after his index surgery secondary to pain over his prominent implants that was interfering with swimming. He is contemplating implant removal. Five of the patients with anterior chest wall numbness had resolution of their symptoms at final follow-up (mean 0.7 ± 0.3 y). The remaining patient with residual chest wall numbness did not report any associated functional problems. The patient with wound dehiscence was treated with observation and the patient with a superficial wound infection was treated with antibiotics with no long-term sequelae.

Two patients had more than 1 complication. One patient sustained a refracture of his right clavicle at the distal aspect of the plate during football that resulted in a painful nonunion. The refracture was initially treated nonoperatively and resulted in a painful nonunion. Seven months after his refracture, he underwent revision open reduction and internal fixation with iliac crest bone grafting (Fig. 1). The same patient had also previously sustained a left clavicle shaft fracture during football that was treated with plate fixation. He chose to have the implants removed from his left clavicle when he underwent surgery for his right clavicle nonunion. The second patient had a refracture after implant removal. This patient underwent implant removal 6 months after his index surgery. He sustained a refracture while snowboarding 22 days after implant removal. The fracture was treated nonoperatively and healed uneventfully.

TABLE 1. Postoperative Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>n (%)</th>
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<tr>
<td>Implant prominence or irritation</td>
<td>22 (59)</td>
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<tr>
<td>Anterior chest wall numbness</td>
<td>6 (16)</td>
</tr>
<tr>
<td>Superficial wound dehiscence or infection</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Refracture adjacent to plate</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Refracture after implant removal</td>
<td>1 (3)</td>
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FIGURE 1. A, 17-year-old male with a refracture of his right clavicle at the distal aspect of the plate during football that resulted in a painful nonunion. B, Radiograph obtained 2 weeks after revision open reduction and internal fixation with iliac crest bone grafting.

DISCUSSION
This is the first study to our knowledge that has focused on complications after plate fixation of displaced pediatric midshaft clavicle fractures. Luo et al19 reported on complications after nonoperative and operative treatment of adolescent clavicle fractures. Fifteen percent of their patients underwent operative fixation with either a plate or intramedullary nail. Complications were found in 21.7% of the fractures treated surgically: 2 refractures, 2 implant removal for prominence, and 1 nonunion with implant failure. Four of the complications occurred in patients who had undergone plate fixation.
The majority of the literature has focused on union rates and short-term functional outcomes after plating of displaced pediatric midshaft clavicle fractures.\(^8,16–18\) Although these studies reported on complications, it is unclear whether complications that did not result in a second surgery but were still potentially bothersome to patients, such as the cosmetic effect of prominent implants or chest wall numbness, were recorded. Our overall complication rate is higher than published rates in the literature because we reported both major and minor complications. All of these potential complications should be discussed with patients and families during the decision-making process for nonoperative versus operative treatment of a displaced midshaft clavicle fracture.

Nearly 60% of the patients in our study reported implant prominence or irritation. Two thirds of these individuals chose to undergo a second surgery for implant removal. Our rates of implant removal are comparable to the published literature. Vander Have et al\(^16\) found that 17.6% of adolescents who had undergone plate fixation of a displaced clavicle fracture at our institution between 2000 and 2008 underwent implant removal. Namdari et al\(^17\) reported an implant removal rate of 28.6%. All of the patients in the series published by Mehlman et al\(^18\) underwent implant removal. It is unclear what percentage of these individuals had implant-related complaints. Elective implant removal may have been recommended to all of these patients, as routine implant removal in the pediatric population is still standard practice for many surgeons. Our study included patients of 5 surgeons, 4 of whom are fellowship-trained in pediatric orthopaedics. It is difficult to assess in a retrospective chart review the magnitude of symptoms that led to implant removal. Female sex has been found to be a risk factor for implant removal after open reduction and internal fixation of midshaft clavicle fractures in adults.\(^9,13,14\) Clothing and body habitus have been hypothesized as reasons for the difference in implant removal rates between females and males.\(^9,13\) We did not find a higher rate of implant removal in females but our study was likely underpowered to detect this difference.

The rate of anterior chest wall numbness in our study was 16.2%. Vander Have et al\(^16\) and Mehlman et al\(^18\) did not report on chest wall numbness. Namdari et al\(^17\) found numbness at the site of the incision in 57% of their patients. None of these individuals had any functional limitations secondary to residual numbness at final follow-up. Christensen et al\(^20\) noted that 83% of adults who underwent plate fixation of a displaced midshaft clavicle fracture reported numbness at 2 weeks postoperatively. These adults were followed prospectively and 52% still noted numbness at 1 year, although the area of numbness had decreased by 66%. All of these patients had excellent functional outcomes scores at final follow-up, with no correlation between numbness and outcome measures. Only one of our patients reported residual chest wall numbness at final follow-up. He had no functional limitations associated with the numbness or his clavicle surgery.

Although wound dehiscence and infection have been reported after plate fixation of displaced midshaft clavicle fractures in adults,\(^1,5,10,11,13\) these do not appear to be common complications in the pediatric population. The 2 patients in our study are the first to our knowledge to be reported in the literature. Both patients had superficial wound problems that were managed successfully with nonoperative treatment. Refracture after plate removal appears rare in pediatric patients as well, despite published rates of up to 10% in adults.\(^21–23\) To our knowledge, the patient in our study who sustained a refracture 3 weeks after plate removal while snowboarding is the first to be reported in the pediatric literature. Restriction from high-risk activities and contact sports should be considered after plate removal. We had 1 patient with a refracture adjacent to the plate. Hagstrom et al\(^8\) reported 3 patients with a subsequent fracture adjacent to the plate. Two of these patients were treated conservatively and 1 patient underwent revision open reduction and internal fixation.

Despite evidence that plate fixation of displaced pediatric midshaft clavicle fractures results in high union rates and good short-term functional outcomes, our high complication rate should be a reminder that nonoperative treatment has not been shown to result in higher rates of nonunion or worse functional outcomes in children and adolescents.\(^6–8\) Both Schulz et al\(^6\) and Bae et al\(^7\) demonstrated a 100% union rate in their series of pediatric midshaft clavicle fractures with >100% displacement and >2 cm of shortening that were treated nonoperatively. Although all of these fractures went on to radiographic malunion, no clinically significant difference in shoulder range of motion or strength was noted. Most patients in those studies reported low pain scores, high functional outcome scores, and no difficulty returning to full activity. No randomized-controlled trials of nonoperative versus operative treatment of displaced pediatric midshaft clavicle fractures have been conducted.

Limitations of our study include the small sample size. A large percentage of our patients did not return for follow-up after they were released back to full activity and were excluded for having <6 months of follow-up. Even if the 46 patients with insufficient follow-up were included in our analysis and were assumed to have no complications, we still would have had a complication rate of 39%. We did not collect any pain scores or functional outcome measures. Lastly, this is a retrospective study so data collection was dependent on accurate documentation in the medical record.

In conclusion, plate fixation of displaced midshaft clavicle fractures in children and adolescents is associated with a high complication rate. Over half of patients may complain of implant prominence or irritation. A second surgery for implant removal may be necessary in a large percentage of these individuals. Anterior chest wall numbness is a minor complication that should be discussed preoperatively, as some patients may have residual numbness long term. Patients and their families should be appropriately counseled regarding major and minor complications before plate fixation of midshaft clavicle fractures.
REFERENCES


