

Adolescent Displaced Midshaft Clavicle Fracture

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THE PATIENT

A 14-year-old girl presents with an injury to the left shoulder 1 day after a motor vehicle accident. She reports pain and deformity of the left clavicle. She was evaluated in the emergency department and given a sling. On examination, she has mild soft tissue swelling and obvious deformity of the left clavicle, mild bruising, no skin tenting, and no lacerations. She is tender at the middle part of the diaphyseal clavicle. The radiograph reveals a 100% displaced mid-shaft clavicle fracture with no comminution.

THE QUESTION

What are the advantages of operative treatment of closed displaced clavicle shaft fractures in adolescents?

CURRENT OPINION

The clavicle is a commonly fractured bone in both children and adults.¹ Most are midshaft and one-half of them are displaced.² Traditional teaching has emphasized the great potential of clavicle fractures for remodeling and union with consistent excellent results after nonsurgical treatment in children. On the other hand, recent literature in adults emphasizes the possibility of nonunion and malunion shortened and displaced midshaft clavicle fractures.³ Adolescence is a transitional period of physical and psychological development that occurs between puberty and adulthood. The World Health Organization defines adolescents as aged 10 to 19 years.⁴ Clavicle fractures in

adolescents are included in the pediatric as well as adult literature, which makes specific recommendations for this age group less clear.^{2,5}

Plate fixation is increasingly offered to adolescent patients with displaced and/or shortened midshaft clavicular fractures. Current opinion is that shortening of the fractured clavicles tends to persist after union⁶ and remodeling of the fracture bump is less predictable past age 10 years.⁷ Some surgeons offer operative treatment to patients with comminution with a segmental butterfly fragment and high-demand athletes with fracture of the dominant arm. It also seems that patient and parent expectations may be drifting toward reduction and fixation in select adolescents with special skills and functional demands. Reported benefits to operative treatment include restoration of length and alignment and more predictable union.

Carry et al⁸ surveyed the members of the Pediatric Society of North America regarding their preferred treatment in 4 common midshaft clavicle fracture patterns. The response rate was 32% (302 of 949 members). Most physicians preferred nonsurgical treatment for all fracture patterns. Physicians were more likely to operate on adolescents aged 16 years and older. Half of the respondents reported that they were influenced by the recent adult literature. Patients aged 16 or more years with angulated, displaced, and segmental clavicle fractures would be offered surgery in 8%, 25%, and 48% of cases, respectively.

THE EVIDENCE

Clavicle fracture potential for remodeling

The potential to remodel a diaphyseal clavicle fracture in children older than age 10 to 12 years may be limited.^{6,7,9} The clavicle reaches 80% of its length by age 9 years 3 months in girls and 12 years in boys. Above age 12 years, clavicles grow at a rate of 2.6 mm/y in girls and 5.4 mm/y in boys.⁹

Nonsurgical treatment

Schulz et al⁶ described 16 patients aged 10 to 18 years with isolated, completely displaced, shortened, midshaft clavicle fracture treated with an arm sling. All of the fractures united, some with shortening, but there

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were no differences in range of motion, an 8% decrease in maximal shoulder external rotation strength, and an 11% loss of shoulder abduction endurance strength. The researchers used Single Assessment Numeric Evaluation, *Quick*–Disabilities of the Arm, Shoulder, and Hand (DASH) (shortened version of the DASH questionnaire), and Constant scores to evaluate functional outcome 12 to 36 months after the injury. Fifteen of the 16 patients were satisfied with the appearance of the clavicle, and all returned to full activity.

Bae et al¹⁰ evaluated 16 patients presenting to the office with radiographic malunion after nonsurgical treatment of midshaft clavicle fractures with more than 2 cm of initial displacement. Compared with the contralateral side, forward flexion and abduction were reduced 7.3° and 6.5°, respectively. Strength was similar on both sides. Although functional outcomes measured by DASH questionnaire and the Pediatric Outcomes Data Collection Instrument were consistent with excellent overall global and upper limb function, 4 patients (20%) were unsatisfied and 4 (20%) reported substantial pain 2 years after nonsurgical treatment. Only 1 patient requested an osteotomy.

A Cochrane review comparing figure-of-eight bandage with an arm sling for acute middle-third clavicle fractures in adolescents and adults found no important differences.⁵

Nonunion of the clavicle in the pediatric and adolescent population after nonsurgical treatment is uncommon. I found a total of 5 published case reports; patients were aged 7, 8, 10, 12, and 13 years.^{11–15} All patients underwent surgical intervention for persistent pain and healed uneventfully.

Operative treatment

Kubiak and Slongo¹⁶ described 15 children aged 9 to 16 years who had open reduction internal fixation of a fracture of the clavicle. They represented 1.6% of 939 similar patients treated for clavicle fractures over 20 years. Eight of those 15 fractures were displaced midshaft fractures. Five were fixed using nonlocked intra-medullary nailing, 2 were fixed with an external fixator, and 1 was fixed with a screw. Indications for surgery included marked superior displacement of the medial fragment (6 patients), shortening (3 patients), concern for potential skin perforation/necrosis (4 patients), and concern for potential neurovascular risk (1 patient). The fractures all healed but 13 of 15 patients developed skin irritation and bursae formation at the tip of the implant.

Grazyński et al¹⁷ studied 23 fractures of the clavicle in children treated by K-wire stabilization (22 open and 1 percutaneous) between 1999 and 2001.

The only complication reported was irritation of skin at the protruding end of the pin. The pins were removed after 2 to 4 months.

Mehlman et al¹⁸ described 24 patients aged 7 to 16 years with a displaced clavicle shaft fracture treated between 2002 and 2007 with open reduction internal fixation. The authors reported no infections and no nonunions. Twenty-one patients (87%) returned to unrestricted sports activities. Two patients had scar sensitivity and 1 experienced transient ulnar nerve neurapraxia. Implants were routinely removed.

Namdari et al¹⁹ retrospectively reviewed 14 skeletally immature patients (mean age, 13 y) with closed, displaced, midshaft clavicle fractures treated with open reduction internal fixation with a plate and screw construct. Indications were defined as shortening more than 2 cm, 100% displacement, and skin tenting. Cosmetic concerns were taken into consideration. Eight patients reported numbness at the site of surgery, 4 underwent a second surgical procedure for removal of hardware, and 4 noted persistent deformity. There were no nonunions. *Quick*–DASH scores averaged 7 (range, 0–37) and 93% of the patients returned to sports with no limitation. Eight patients were very satisfied, 4 were somewhat satisfied, and 2 were neutral.

Vander Have et al² retrospectively reviewed 42 patients (aged 12–17 y) with 43 closed midshaft clavicle fractures. Surgery was offered to patients with 20 mm or more of shortening. Twenty-five patients were treated nonsurgically and 17 were treated with open reduction plate fixation. Mean time to radiographic union for displaced fractures was 8.7 weeks in the nonsurgical group and 7.4 weeks in the operative group ($P = .02$). There were no nonunions in either group. The operative group had 3 local hardware prominences that required removal. The nonsurgical group had 5 symptomatic malunions; 4 patients elected to undergo corrective osteotomy. They defined symptomatic malunion as pain with overhead activity, weakness, fatigability, and neurologic symptoms. Of note, the symptomatic malunions had 21 mm or more of shortening, whereas all other patients in the nonsurgical group had 21 mm or less of shortening. Mean time to return to activities was 16 weeks in the nonsurgical group and 12 weeks in the operative group.

SHORTCOMINGS OF THE EVIDENCE

The current evidence regarding treatment of displaced midshaft clavicle fractures in adolescents is limited to small retrospective case series and one retrospective comparison. Available high-level data are from adult

patients and it is not clear whether they apply to adolescents, particularly those who are skeletally immature. Although studies try to group patients based on age, evaluation of the growth plate on radiographs may be more relevant to the determination of remodeling potential of clavicle fractures than an age cutoff or designation of adolescence. Indications for surgery are imprecise, subjective, and not supported by evidence.

DIRECTIONS FOR FUTURE RESEARCH

We need to determine the degree to which age and skeletal maturity affect the risk of nonunion and the capacity for remodeling with a displaced midshaft clavicle fracture. Malunions and nonunions do not cause much objective impairment (eg, stiffness, diminished sensation). It would be useful to observe a large cohort of nonsurgically treated displaced midshaft clavicle fractures in children and adolescents to document union and remodeling potential as well as factors associated with symptom intensity and magnitude of disability.

There is room for the development of adolescent-specific outcome measures that address upper extremity function, modeled after already established adult questionnaires. Adolescents are not little adults. They may have different outlook toward pain, function, and cosmesis. They also may have different tolerance to deformity or functional limitation with respect to future academic, athletic, and career plans, factors that may have less weight in adults who already have well-defined roles.

Studies can also evaluate patients' attitude toward initial nonsurgical treatment, taking a chance of future surgery for symptomatic nonunion or malunion compared with immediate operative treatment with attendant operative risks and the possible need to remove a symptomatic or unsightly implant. In addition, studies may evaluate satisfaction with aesthetics, comparing fracture site prominence (bump) versus exposed surgical scar and implant prominence.

OUR CURRENT CONCEPTS FOR THIS PATIENT

We discuss scar or implant prominence versus fracture deformity and the risks of anesthesia and surgery versus the risks of nonunion and symptomatic malunion with each patient and his or her parents. After operative or nonsurgical treatment, I advise 2 to 4 weeks of sling immobilization. Contact sports and

heavy lifting should be avoided for 6 to 12 weeks. We check radiographs periodically until union is documented. Implant removal is discretionary.

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