Centromedullary Manipulation and Stabilization of Completely Displaced Proximal Humerus Fractures in Adolescents

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Abstract: Completely displaced metaphyseal fractures of the proximal humerus in older children may need reduction and stabilization. The authors describe a technique for closed reduction and intramedullary stabilization of these fractures using a centromedullary pin inserted from the distal humerus through a small distal incision. This technique was used successfully in 2 adolescents. Retrograde elastic nails avoid scars in front of the shoulder, impingement problems from prominent extramedullary metal work, and further surgery of a similar magnitude to remove the metalwork. Based on the authors’ experience, they recommend this method for reduction and stabilization of displaced irreducible metaphyseal fractures of the proximal humerus in older children and adolescents.

Proximal humeral fractures are rare in children and represent approximately 3% of pediatric long-bone fractures. The considerable degree of translation and angulation of these fractures can be accepted in younger children because the proximal humeral physis has excellent remodeling potential. However, displaced fractures in older children and adolescents who have less remodeling potential may need reduction and stabilization using intra- or extramedullary devices.

The authors describe a technique for closed reduction and intramedullary stabilization of these fractures using a centromedullary pin inserted from the distal humerus through a small incision over the lateral aspect of the arm. Metaizeau et al invented and popularized this technique for closed reduction and stabilization of radial neck fractures in children. To the current authors’ knowledge, this technique has not been described in the management of proximal metaphyseal humeral fractures in adolescents.

Materials and Methods

The authors describe their experience with stabilizing displaced proximal humerar fractures in 2 adolescent girls. The mechanism of injury was a fall off a horse in one patient (Figure 1) and a traffic accident in the other. Both injuries were closed, and the affected limbs had no neurological or vascular deficits. The first patient had no other injuries. The second patient had an ipsilateral closed midshaft clavicle fracture that was also stabilized using an elastic stable intramedullary nail.

Surgical Technique

Positioning and Draping

In the operating room, the radiolucent table is positioned with the head end facing away...
From the anesthetic machine to obtain adequate access for the image intensifier. Under general anesthesia, the patient is placed in the supine position with the affected arm resting by the edge of the table. Intravenous broad spectrum antibiotics are administered.

Before the procedure begins, an image intensifier screening is performed to ensure that the entire length of the affected humerus can be adequately visualized. The affected limb is painted with 2% chlorhexidine and draped with 2 sterile extremity exclusion drapes, ensuring that the affected shoulder area extending from base of the neck superiorly, nipple line inferiorly, midline medially, and lateral half of the scapula posteriorly are included in the draped field.

**Approach**

A 2-cm longitudinal skin incision is made over the lateral humeral supracondylar ridge with its center approximately 3 cm above the tip of the lateral epicondyly (Figure 3). Blunt dissection through the subcutaneous fat followed by a sharp dissection in the interval between the brachioradialis (anterior) and triceps (posterior) is performed to expose the lateral supracondylar ridge. The periosteum over the supracondylar ridge is divided longitudinally to expose the bony ridge.

**Entry Point**

An entry hole is made on the ridge using a 2-mm drill bit. A drill guide should be used to prevent the drill bit from wandering off the ridge while drilling. A bone awl (Figure 4A) is then used to enlarge this opening and direct it upward and medially toward the medullary canal of the humerus.

**Nail Insertion, Reduction, and Stabilization**

A 3.5-mm titanium elastic nail is selected, and its curved tip maintained (Figure 4B). The nail is then contoured using hand pliers or manually (Figure 4C) to achieve a large radius smooth curvature for intramedullary interference fit. This nail is inserted through the supracondylar opening and manually pushed up with the help of a T-insertion handle (Figure 4D) until resistance is met and is then gently hammered with the curved nail tip sliding on the inner cortex (Figure 5A). The distal bend on the nail is directed posteriorly and laterally toward the displaced humeral head under radiographic control (Figure 5B). The nail tip is then advanced to engage the humeral head (Figure 5C). The nail is then rotated through 180° to achieve good reduction of the fracture (Figure 5D). The nail is then advanced and seated in the subchondral bone (Figure 5E).

Screening under an image intensifier is performed to confirm rotational stability of the fracture. The distal end of the nail is cut off with nail cutting pliers, leaving 1 cm of the nail proud of the bone.

**Wound Closure**

The elbow wound is sutured with 3.0 undyed subcuticular Vicryl suture (Ethicon, Inc, Somerville, New Jersey), and a waterproof dressing is applied.

**Postoperative Care**

The arm is placed in a collar and cuff for 2 weeks postoperatively, and the extremity is mobilized at this stage. The patient is followed up at regular intervals (2, 4, 8, 16, and 24 weeks) with repeat radiographs to assess fracture healing and shoulder function.

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**Figure 2:** Illustration of a patient positioned supine on a radiolucent table with the injured arm resting by the edge of the table. (Image reprinted with permission from Synthes Inc.)

**Figure 3:** Entry point for the nail.

**Figure 4:** Bone awl for widening the entry point (A). Titanium elastic nail with its curved tip (B). Manual contouring of the nail (C). T-insertion handle with nail (D). (Images reprinted with permission from Synthes Inc.)
Metal Removal

Metal removal is performed at approximately 16 weeks, once the fracture has fully healed and is consolidating. It requires another general anaesthetic and involves incision of the previous scar, exploration of the distal nail end by sharp dissection, and extraction of the nail with a mole wrench or an extraction device engaged on the exposed nail.

RESULTS

In the current patients, repeat radiographs performed at 2 and 4 weeks confirmed satisfactory position of the fractures, and radiographs at 2 months showed healing of all the fractures. At 2-month follow-up, both patients had full shoulder range of motion. Both humeral nails and the clavicular nail were removed within 4 months postoperatively (Figure 6). By 6 months postoperatively, both patients had no shoulder-related symptoms, full shoulder range of motion, and normal shoulder function.

DISCUSSION

Completely displaced proximal humeral metaphyseal fractures are uncommon in children. Displaced fractures may be treated nonoperatively in younger children due to the excellent remodeling potential of the proximal humeral physis. Reduction and stabilization may be required in older children and adolescents in whom some contact between the fracture fragments is desirable in both views.

Gravity-aided closed reduction can be successful in some patients. If this cannot be achieved, a manipulative reduction should be attempted while the patient is under general anesthesia. Good muscle relaxation is essential because the displaced fragments are held apart by various muscle groups. The pull of the pectoralis major and other adductors proximally and the deltoid distally on the humeral shaft tend to displace it anteriorly and medially. The rotator cuff muscles will then abduct the humeral head. Despite good muscle relaxation, some fractures remain irreducible. Difficulty in controlling the spherical proximal fragment and soft tissue interposition are likely to be the most common reasons for irreducibility.

Kapandji described a palm tree technique for inserting 3 Kirschner wires on the humeral head to joystick it and enable closed reduction has also been described. Pin breakage and migration into vital organs, such as the heart and the great vessels, with serious consequences have been reported with the use of smooth pins around the shoulder girdle. This, along with the proximity of the axillary nerve and the likely requirement for internal fixation of this fracture, made the authors decide against using this option.

Other internal fixation devices that may be used for stabilizing fractures in this area include standard dynamic compression plates, T-shaped plates, Angle Blade plates (Synthes Inc, Paoli, Pennsylvania), locking plates, and tension band wiring. All require open fracture reduction through a deltopectoral or anterolateral deltoid splitting approach. These approaches involve significant stripping of the soft tissue envelope at the fracture site. This may delay bone healing and increase

Figure 5: Nail being advanced up the shaft (A). Nail twisted 180° toward the humeral head (B). Impaction of the nail into the humeral head (C). Nail twisted by 180° to achieve fracture reduction (D). Final position of the nail (E).

Figure 6: Final image intensifier image at the time of nail removal.
the incidence of fracture nonunions. These approaches will leave fairly large and unsightly scars in front of the shoulder. Also, scars in this area have a higher predilection to become hypertrophic or develop into keloids. Further surgery to remove the metalwork at a later stage could make this worse.

Fracture stabilization with an external fixator is a potential option. However, closed reduction may be challenging, even in experienced hands, and open reduction is associated with the disadvantages discussed previously. In addition, multiple scars, pin-tract infections, and the risk of radial nerve injury with a blind pin insertion technique are potential complications of external skeletal stabilization.

The senior author (P.D.H.) has successfully used the centromedullary technique several times in reduction and stabilization of radial neck fractures in children with a high success rate (unpublished data). When applied to proximal humerus fractures, this would avoid scars in the shoulder area, and metalwork removal at a later date would be a straightforward procedure. Adequate fracture stability can be achieved without risking pin breakage and migration associated with smooth pins in this area. The soft tissue envelope of the fracture is not interfered with. Therefore, although open reduction and fixation was perfectly acceptable, in the current patients, the authors decided to attempt centromedullary manipulation and pinning and keep the former as a backup option.

The axillary nerve runs close to the fracture site and a theoretical risk exists of damaging this nerve with any form of closed manipulation of fractures in this area. The other potential disadvantages of this technique include radial nerve injury with more proximal dissection for nail entry, cortical perforation and fractures caused by the nail with forceful advancement, injury to any of the neurological or vascular structures that may be trapped in the fracture site, migration of the tip of the nail into the shoulder joint, creation of a scar in an uninjured area, and the need for another general anesthetic for nail removal. None of these complications occurred in the current cases.

Contraindications for performing a centromedullary reduction and stabilization in proximal humeral fractures includes open fractures, presence of a major neurological or vascular injury, presence of an infected wound at the nail entry site, presence of displaced ipsilateral humeral shaft and humeral neck fractures, pathological fractures, and failure of reduction (ie, an inability to engage the humeral head by manipulation of the nail).

The technique of using a centromedullary pin for fracture reduction and stabilization was originally described by Metaizeau et al in the treatment of displaced radial neck fractures in children. The current authors have proved its application with a good success rate in proximal humerus fractures in adolescents. Both types of fractures have relatively small, deep, perarticular fragments that are difficult to control to achieve closed manipulative reduction.

A similar situation may be encountered in intracapsular fractures of the femoral neck in older children. The authors have no experience with using this technique in pediatric femoral neck fractures. In principle, achievement of anatomical reduction and absolute stability are essential for good outcome following treatment of these fractures. The centromedullary pinning technique is merely capable of restoration of length alignment and rotation with relative stability. Therefore, the authors feel that this technique should not be used in the setting of a displaced pediatric femoral neck fracture.

**CONCLUSION**

The authors have used the centromedullary reduction and stabilization technique with a good success rate, fracture healing, and functional outcome in 2 adolescents. They recommend this technique for manipulation and stabilization of completely displaced 2-part proximal humerus fracture in older children and adolescents.

**REFERENCES**