Operative Management of Pediatric Medial Epicondyle Fractures: Lessons Better Learned the Easy Way

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Abstract:
While nonoperative management of medial epicondyle fractures has been traditionally described, an average of 49% of patients develop a nonunion with conservative treatment. Historical studies lack specific patient reported functional outcome metrics or return to sport data. There is a trend toward operative fixation due to a rising concern for symptomatic valgus instability, stiffness, and long-term functional effects of nonunion in patients treated nonoperatively. Operative decision-making focuses on the prevention of chronic valgus instability and desire to return to high level athletics or future employment. Nonetheless, surgical treatment is not without risk, including postoperative stiffness, comminution of the medical epicondyle fragment, nerve damage, persistent rotational instability of the fragment, nonunion, and symptomatic hardware. In order to assist the surgeon considering operative management for a medial epicondyle fracture, we have compiled a series of challenging cases due to delayed presentation or complications as well as several unique techniques that may be helpful to either prevent or navigate one's way out of these situations.

Key Concepts:

- Recent trends in increasingly younger high demand athletics and expanding indications have increased the number of medial epicondyle fractures managed operatively.
- A number of surgical techniques have been described for medial epicondyle fractures.
- Soft tissue integrity is recognized as critical for postoperative elbow stability with increasing use of anchors as an adjunct to bony fixation.

Introduction

Medial epicondyle fractures are common, accounting for 11–20% of all pediatric elbow fractures.[1,2] Historically, nonoperative management has been the mainstay of treatment, but with increasing upper extremity demands of young athletes, valgus instability after nonoperative management, and limited historical long-term functional results, there has been increased interest in operative management.

We present a review of current concepts followed by a case series of complex medial epicondyle fractures with the dual purpose of highlighting the potential challenges associated with the operative management of these fractures so that surgeons can provide families with a more comprehensive informed consent and share useful technical tricks to help the treating surgeon get out of trouble should similar complications arise.

Anatomy

The medial epicondyle is a traction apophysis which begins to ossify between 4 and 6 years and is the last distal humerus ossification center to fuse between 15 and 20 years of age.[2] Medial epicondyle fractures have a 4:1 male predilection[2,3] and occur most commonly around 9–14 years of age with peak incidence around 11–12 years.[3–5] The incompletely ossified apophysis is susceptible to mechanical failure before the more robust soft tissue attachments, namely the flexor-pronator mass and the ulnar collateral ligament (UCL).[2-4,6] Of note, the ulnar nerve enters the cubital tunnel just posterior to the medial epicondyle, putting it at risk when fixing a medial epicondyle fracture.

Three primary mechanisms of injury have been described, including avulsion due to muscular pull, avulsion due to elbow dislocation, and direct trauma, in which case the medial epicondyle may be fragmented.[3,5] Avulsion injuries are most common and are usually caused by valgus stress producing traction on the medial epicondyle through the flexor-pronator muscles during a fall on an outstretched hand with hyperextended wrist, supinated forearm, and extended elbow.[5,7] Isolated avulsion fracture may also occur due to the pull of the flexor pronator mass during pitching or arm wrestling in high demand athletes.[4,7] Sixty percent of avulsion fractures are associated with elbow dislocations in which the avulsion fracture may be caused by the pull of UCL.[2,5,7]

Management of Medial Epicondyle Fractures

There remains equipoise in the ideal management of medial epicondyle fractures. Historically, treatment has been based on the amount of fracture displacement with conflicting recommendations. While some have recommended operative management for as little as 2 mm of displacement,[8,9] others have found good function and range of motion with nonoperative management of fractures displaced up to 15 mm.[10] Historically, operative management was indicated for fractures displaced greater than 5 mm, nonoperative management indicated for fractures displaced less than 2 mm, and fractures with 2–5 mm of displacement were in a gray zone.[11] However, in a recent study assessing intra-observer and inter-observer reliability in the measurement of medial epicondyle displacement when using a criterion of a difference of at least 2 mm, orthopaedic surgeons disagree with their own measurements 26% of the time and disagree with a colleague's measurements 54% of the time.[11] When radiographs are compared with CT, up to 10 mm of displacement may be missed.[12] Such studies cast doubt on whether patients in historic series were appropriately categorized based on degree of displacement and whether perceived displacement should be used as criteria for management.[7]

Current recommendations for operative intervention are less focused on measured fragment displacement and include high energy mechanism of injury, open fractures, incarcerated medial epicondyle fragment present in up to 25% of cases, ulnar nerve dysfunction (present in 10–16% of cases), gross elbow instability, instability to valgus stress, and desire to return to high level athletics or employment.[3,5,7] Operative intervention is considered especially for those who need a stable elbow for work or sports, such as manual laborers, overhead athletes, and upper-extremity weight-bearing athletes out of concern for symptomatic nonunion with persistent valgus instability.[6]

Nonoperative Treatment

Nonoperative management generally consists of long arm cast immobilization with the elbow flexed to 90 degrees for 3–4 weeks.[2,13] Functional results in retrospective studies are reported to be similar to operative management, although historically there is an average nonunion rate of 49%.[10,13–17]

Operative Treatment

The surgical technique for open reduction and internal fixation of medial epicondyle fractures is classically described with the patient in a supine position with the injured extremity on a hand table; however, prone positioning has gained favor in recent years. A direct medial

approach to the elbow is performed with the incision centered over the medial epicondyle and following the supracondylar ridge proximally and flexor-pronator mass distally. Care should be taken to avoid transecting the posterior branch of the medial antebrachial cutaneous nerve during superficial dissection. The ulnar nerve should be identified proximal, at, and distal to the medial epicondyle, and then freed of soft tissue restraints and protected out of the operative field. Next, the fracture fragment should be mobilized and prepared for fixation, and the donor site should be cleaned of any interposing tissues and irregular edges noted for cortical reads when reducing the fragment. The forearm may be pronated and wrist flexed to relax soft tissue tension to assist in the reduction. Fixation with cannulated screw or Kirschner wires (K-wires) is classically implemented, positioned centrally on the fragment to minimize comminution risk. A washer can be added to screw fixation if there are concerns for fragmentation. An anti-rotation wire can be temporarily placed if fragment large enough, or manual pressure with digits or forceps if not, to prevent loss of reduction during implant placement. Following placement of fixation, orthogonal view with fluoroscopy should be obtained to confirm and ROM tested prior to waking the patient.

A trend favoring surgical fixation has developed as a result of the concerns of functional outcomes, as well as a result of the increasing number of children participating in competitive and specialized sports.[6,13,18] Open reduction and internal fixation with a cannulated screw (gold standard) or K-wires are the most common technique with reported excellent outcomes.[3,13,18] Due to concern for hardware removal requiring a second procedure, resorbable devices and suture anchor fixation have recently gained popularity with minimal complications and good reported outcomes.[6,20-22] Acute management with fragment excision and UCL repair is controversial with complications rate as high as 66%.[13] However, the outcomes have been more favorable in patients with chronic nonunion, fibrous union, or delayed presentation with incarcerated fragments.[23-25]

Complications

There is a high risk for nonunion with nonoperative treatment.[10,13-17] Although the majority of patients with nonunion are asymptomatic, up to 21% become symptomatic and experience chronic medial elbow pain, valgus instability, restricted range of motion, and/or ulnar nerve symptoms.[6,10,13,15,22,26–28] There is increasing concern for symptomatic nonunion in high demand patients, overhead athletes, and upper-extremity weight-bearing athletes.[6,22,26–28] Stiffness is a known complication following both nonoperative and surgical management. The need for removal of implants is quite high due to the medial epicondyle being superficial and it therefore frequently resting on surfaces when the arm is in pronation. Up to 46% of patients treated with screw fixation require a second procedure to remove symptomatic hardware.[3,18,27,29-31] In rare instances, cannulated screws may de-thread, complicating hardware removal.[32] Comminution during fixation intraoperatively can limit fixation options. These smaller fragments also have a theoretically higher risk of nonunion secondary to reduced area of contact for bony healing in the setting of significant soft tissue stresses.[24] Overall, nonunion after ORIF is rare and has been seen in up to 10% of cases. Iatrogenic ulnar neuropathy can occur in up to 6% of cases. Additionally, iatrogenic radial nerve injury with cannulated screw fixation and varus and valgus deformity have been reported.[8,33–35]

Getting Out of Trouble

Patient 1

Complication: Nonunion after ORIF, followed by intraoperative fragment comminution during repair of nonunion

A 13-year-old RHD female dancer initially desired conservative management for a 5 mm displaced medial epicondyle fracture sustained from a fall while running (Figure 1).

Due to continued valgus instability and intermittent ulnar neuropathic pain, we elected for ORIF with a 4.5-mm cannulated screw, which was performed 8 months after injury (Figure 2). While her images demonstrated a

satisfactory reduction, she continued to have tenderness to the medial epicondyle and limited range of motion. Radiographs at 4 months suggested persistent nonunion, with no bony healing and peri-hardware lucency (Figure 3). Revision ORIF was performed 5 months postoperatively. The cannulated screw was removed, and the medial epicondyle was carefully identified. Interposed soft tissues were noted at the fracture site.

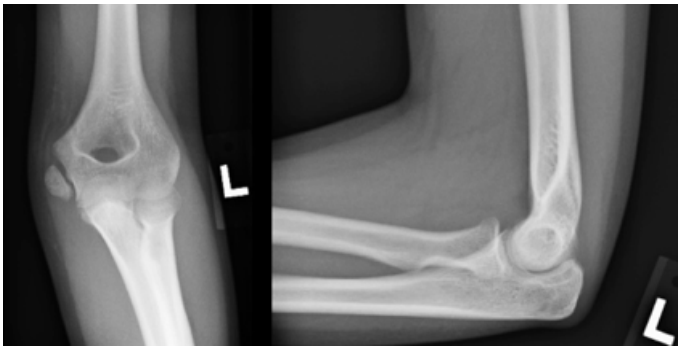

Figure 1. *Initial injury x-rays.*

Figure 2. *Postoperative x-rays.*

Figure 3. *Eight weeks postoperation x-rays without bony union and concern for hardware loosening.*

The fracture bed was carefully debrided along with the physis and a longer 4.5-mm cannulated screw was placed up the medial column. In order to provide de-rotational stability, a transverse K-wire also placed across the fracture (Figure 4). Radiographs continued to demonstrate minimal bony healing, and CT was obtained at 4 months postoperatively confirming nonunion fragment with sclerosis and lucency around the screw and pin (Figure 5).

After this, the patient was lost to follow-up for a year but presented again after slipping on ice, with a return of medial elbow pain. She noted satisfaction with the function of her elbow for the previous year and had returned to competing with her dance team in that time. Images obtained at that visit demonstrated continued nonunion with peri-hardware osteolysis (Figure 6). In light of her earlier successful return to sport, the patient and her family desired continued conservative management. However, 1 month later she noted increasing pain, tenderness to palpation about the medial epicondyle, and increased prominence of medial epicondyle. Repeat radiographs demonstrated persistent nonunion.

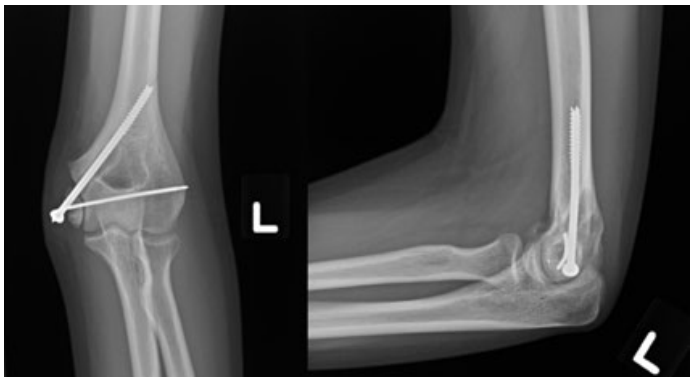

Figure 4. *Revision ORIF with supplemental K-wire fixation.*

A second revision ORIF was recommended. The ulnar nerve appeared compressed due to tight overlying fascia; ulnar nerve neurolysis was performed and prior implants removed. There was periosteum and fibrous tissue about the main medial epicondyle fragment. The anterior bundle of UCL was intact in anatomic position, the posterior bundle was intact, but its humeral insertion had not reunited. Other comminution was excised, the posterior UCL bundle was captured with suture anchors and reduced to its anatomic position with a 3.5-mm PushLock anchor (Arthrex, Naples, FL) (Figure 7). Elbow range of motion was 0-130 with full pronation/supination and was stable to valgus stress and symmetrical to her

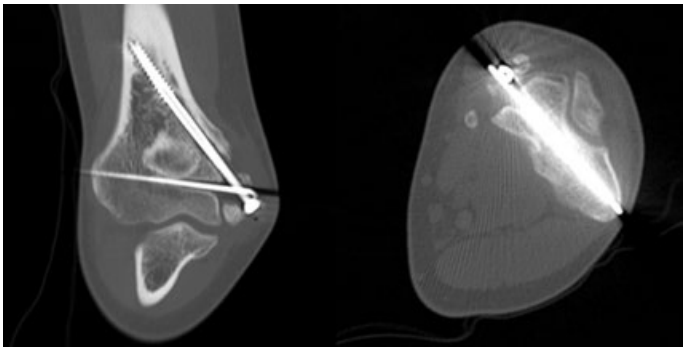

Figure 5. *CT at 4 months showing persistent nonunion and fragmentation.*

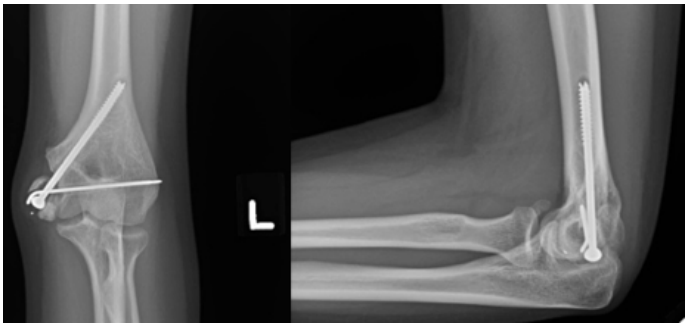

Figure 6. *One-year x-rays demonstrate continued nonunion.*

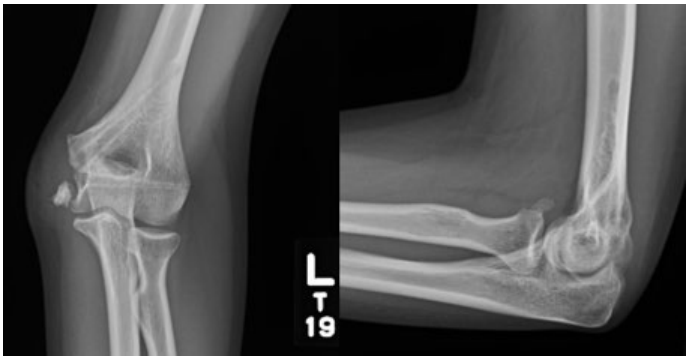

Figure 7. *Postoperative x-rays of hardware and comminution excision and ligamentous repair.*

contralateral side. She returned to dance and martial arts activities without subjective pain or instability at 2 months.

Lessons Learned and Technical Pearls

- When repairing an established nonunion, one should consider debriding the nonunion site so that bleeding bone on the humerus and the epicondyle are present.
- Use of local bone graft (taken from the olecranon) should be considered when repairing a nonunion.
- Consider use of a longer screw that can have better purchase by engaging the opposite cortex.
- A K-wire can be added for de-rotation.
- Suture anchors can be used as a supplement to screw or K-wire fixation, especially in cases of fracture comminution.

Patient 2

Complication: Delayed presentation leading to an irreducible fragment

A 9-year-old RHD male state champion wrestler presented to clinic 7 weeks after a left elbow injury with significantly reduced elbow range of motion (60 to 90 degrees), medial elbow pain, and intermittent parasthesias in ulnar nerve distribution. Radiographs demonstrated a 20-mm displaced medial epicondyle fracture (Figure 8). As a result of his limited motion and substantial displacement, ORIF was recommended. Intraoperatively, the ulnar nerve was entrapped in significant scar tissue requiring extensive neurolysis. The fragment was unable to be reduced secondary to severe soft tissue contraction. We elected to focus on elbow stability and soft tissue restoration. The fracture fragment was excised and the flexor-pronator mass and the UCL were then reattached to the medial condyle using suture anchors (Figure 9). At 5 months postoperatively, he was painless with stability to valgus stressing on exam and near full range of motion, lacking only terminal 10 degrees of extension. At 11-month follow-up, the patient reported continued relief of symptoms and had successfully returned to wrestling, having won a tournament prior to the appointment.

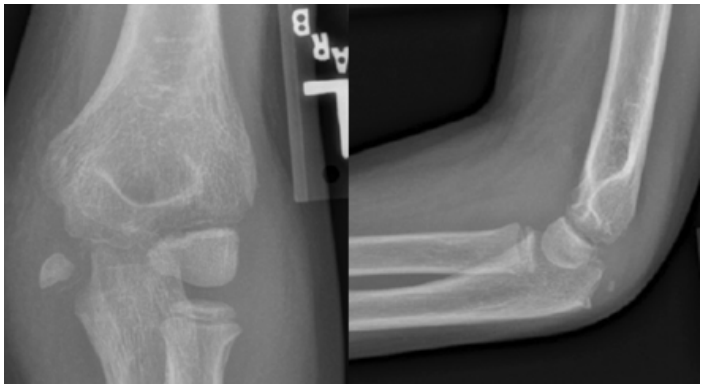

Figure 8*. Initial presentation x-rays showing significantly displaced fragment.*

***Figure 9**. Five months postoperative x-rays following fragment excision and soft tissue repair.*

Lessons Learned and Technical Pearls

- Beware of the late presenting, severely displaced fracture—it may be irreducible! In some cases, the epicondyle can be restored back to its anatomic position by carefully transversely cutting and lengthening the flexor pronator fascia. In this case, the fragment was too far to be repaired.
- Remember, one of the primary objectives of surgery is restoration of UCL stability and function of the flexor-pronator tendons. As a result, in cases of irreducible shortening or severe comminution, a soft tissue repair to meet those objectives can be considered rather than ORIF. In these cases, careful attention to postoperative valgus stability is critical as historically simple fragment excision has higher complication rates relating to instability and further reconstruction may be necessary if present.[15]

Patient 3

Complication: Failure to recognize intraarticular displacement and subsequent nonunion after ORIF with hardware failure

A 12-year-old female gymnast presented to clinic after having her elbow dislocation reduced and splinted in the emergency room 2 weeks earlier. She had paresthesia in the ulnar nerve distribution and poor motion that was painful. Images obtained in the emergency room demonstrated an intraarticular displaced medial epicondyle fracture that was missed by the ED attending (Figure 10).

***Figure 10**. Initial injury x-rays.*

A satisfactory reduction was achieved intraoperatively and the medial epicondyle was secured using a 4.0-mm cannulated screw and washer (Figure 11). She was placed in a long arm cast for 3 weeks and transitioned to hinged-elbow brace for 3 weeks. At 7 weeks postoperatively, cut-out of the screw and washer were noted on x-ray with increased displacement of the fracture; however, she was asymptomatic. CT at 3 months postoperative was obtained for persistent pain which showed nonunion with displaced medial epicondyle fragment and complete hardware cut out (Figure 12). The screw and washer were removed, the fragment was excised, and UCL and flexor-pronator mass was repaired using suture anchor. Patient reported improvement in pain postoperatively and successfully returned to gymnastics 9 months postoperation lacking only 5 degrees terminal flexion and extension.

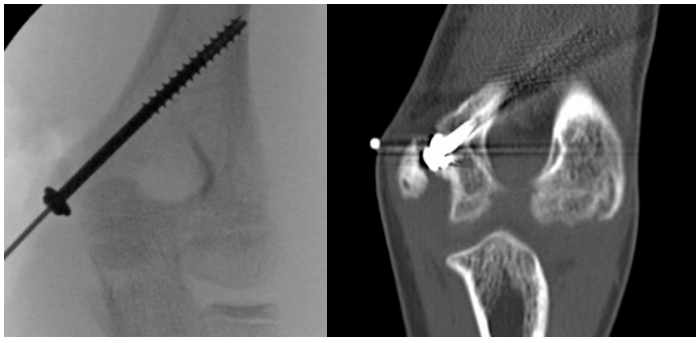

***Figure 11 (left).** Intraoperative x-rays. **Figure 12 (right)**. Three months postoperative CT showing hardware cutout and nonunion.*

Lessons Learned

- After reduction of an elbow dislocation, intraarticular displacement of medial epicondyle should be carefully

ruled out and one may need contralateral elbow radiographs in order to compare.

- Medial displacement of the fragment and widening of the elbow joint are common signs of an entrapped medial epicondyle.
- Late presentation of entrapped medial epicondyle include ulnar neuritis and poor elbow range of motion.
- One needs to be careful to prevent fracture of the fragment when tightening the screw down.

Patient 4

Complication: Soft tissue interposition leading to flexion contracture

A 12-year-old male RHD presented with right medial epicondyle fracture, significant valgus laxity, and reduced range of motion 2 days after fall off a bike (Figure 13). On exam under anesthesia, he was noted to have an elbow flexion contracture with elbow extension only to 30 degrees; however, full ROM was noted after soft tissue dissection and prior to fixation. The fragment was then reduced with two diverging K-wires and the UCL with flexor retinaculum was secured to humeral metaphysis using suture anchors (Figure 14). Good bone healing was noted postoperatively, and K-wires were pulled in clinic at 3.5 weeks postoperatively. At 3 months, he was pain-free with restored valgus stability and full ROM.

Figure 13. *Initial injury x-rays.*

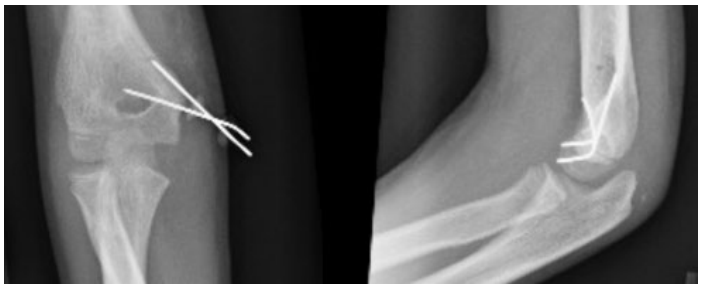

Figure 14. *Postoperative x-rays.*

Lessons Learned and Technical Pearls

- Any intraoperative lack of full elbow motion requires careful investigation as to its etiology.
- Smaller fracture fragments can be fixed with a hybrid construct utilizing K-wires and suture anchors, thereby eliminating future need for hardware removal.

Patient 5

Complication: Lack of rotational stability following single screw fixation

An 11-year-old RHD female gymnast presented to emergency room and was found to have a medial epicondyle fracture dislocation (Figure 15 A, B). Post-reduction films demonstrated incarcerated medial epicondyle fragment (Figure 15 C).

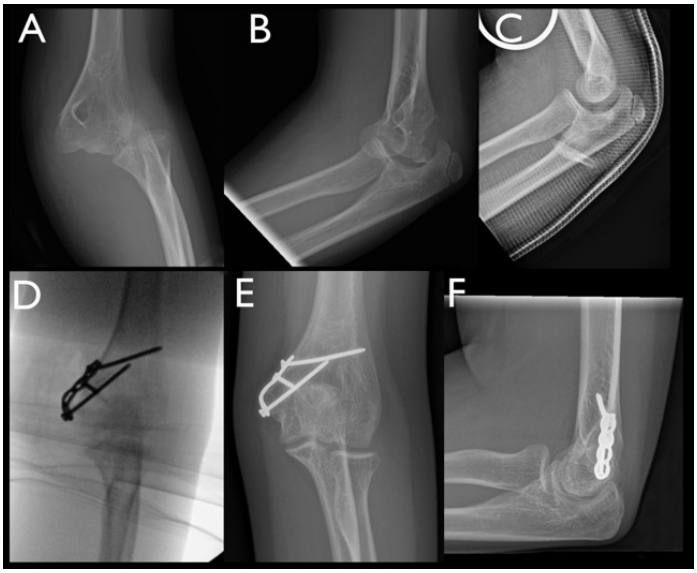

Figure 15. *A/B: Initial injury films demonstrating fracture dislocation. C: Post-reduction films demonstrating incarcerated fragment. D: Intraoperative films demonstrating excellent reduction. E/F: Three-year follow-up films demonstrate continued well-positioned hardware without cutout.*

Intraoperatively, ORIF with a cannulated screw did not provide adequate stability. The construct was converted to utilize a contoured 2.4-mm recon plate fixation for additional stability (Figure 15 D). At her first postoperative visit, she did not experience pain with ROM, had full extension and lacked 15 degrees of flexion, and was without neurological complication. At 3-year follow-up, x-rays showed union without hardware cutout. On exam, she noted some tenderness over medial epicondyle hardware but painless ROM only lacking 5 degrees of flexion (Figure 15 E, F).

Lessons Learned

- Should a single screw not be adequate for stability, consider standard orthopaedic trauma principles such as a de-rotation pin or a plate construct as used here.

Patient 6

Postoperative radial nerve palsy

Patient presented with medial epicondyle fracture for which she was taken to the operating room for open reduction internal fixation (Figure 16).

Figure 16*. Initial injury x-rays before and after reduction.*

Preoperatively, her neurologic exam was intact. Intraoperatively, the guide pin was placed bicortically with fluoroscopic confirmation that it just barely penetrated through the far cortex. The cannulated drill was then advanced over the pin to the lateral cortex and again, fluoroscopic confirmation of not past pointing was obtained. At this point, it was noted that the guide pin had advanced into the lateral soft tissues (Figure 17). During the drilling, spontaneous movements within the extensor wad were noted. Postoperatively, the patient had complete loss of finger and wrist

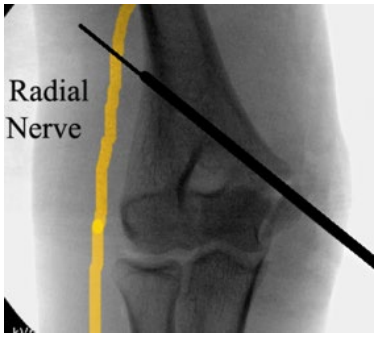

Figure 17. *Intraoperative fluoroscopy demonstrating the guide pin advancement and projected radial nerve course.*

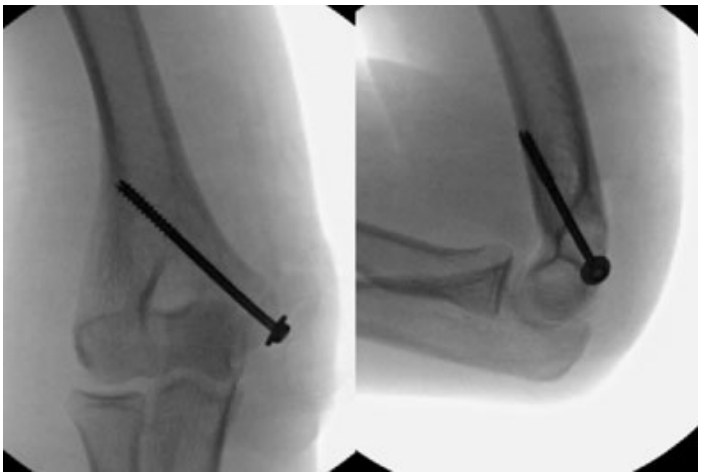

Figure 18. *Intraoperative x-rays demonstrating well-positioned screw.*

extension and sensation in the radial nerve distribution (Figure 18). At 5-week follow-up, she had paresthesias in the radial nerve distribution. At 3-month follow-up, she demonstrated 30 degrees of active wrist extension and bony union. Ultimately, she fully regained complete radial nerve motor and sensory function.[31]

Lessons Learned

- The radial nerve lies in close proximity to the lateral cortex of the humerus in the typical trajectory of the medial column screw and care must be taken to avoid iatrogenic injury.
- If using a threaded guide pin, one should not penetrate the far cortex with the guide pin as the friction of the drill and the guide pin could unexpectedly advance the pin.
- One should consider smooth guide pins as they are less likely to wind up the nerve.
- One should carefully watch the guide pin as the drill is advanced across the far cortex.

Summary

Current relative indications for operative management of medial epicondyle fractures have shifted focus from magnitude of displacement to now focus on minimizing functional deficits and elbow laxity in high demand athletics and employment. This expansion of indications, along with the increase in high demand athletics at younger ages, has led to an increase in medial epicondyle fractures managed operatively. We present and discuss several cases with heightened challenge due to either delayed presentation or intraoperative/postoperative complications and present various techniques used to prevent or address them in order to help our readers anticipate and manage similarly complicated cases.

Additional References

- *Suture Anchor Supplemental Fixation:* Illustrated as a salvage method in several cases, suture fixation can also be utilized as a supplemental strategy to aid reduction and provide de-rotation during index operations.[22]
- *Tapping prior to screw fixation:* Screw de-threading has been described after fixation and may be more likely with smaller sized screws. Consider formally tapping prior to screw fixation to prevent this complication.[32]
- *Prone patient positioning:* During these procedures, supine patient positioning is traditionally implemented; however, recent years have seen increasing use of prone patient positioning. The prone position requires more preoperative time to position but may provide improved fracture visualization–especially if the fragment is posteriorly displaced–and overall operative time was not increased. Increasingly, surgeons are adopting prone positioning, including many of the authors.[4,36,37]

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