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TECHNICAL NOTE

Open reduction of medial epicondyle fractures: operative tips for technical ease

Atul F. Kamath · Stephanie R. Cody · Harish S. Hosalkar

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Abstract In the pediatric population, medial humeral epicondylar fractures account for nearly 12% of all elbow fractures. There is ongoing debate about the surgical management of medial epicondyle fracture cases. Our technique in the operative management of medial epicondyle fractures uses the external application of an Esmarch bandage, as well as provisional fixation with needle rather than K-wire fixation. This technique decreases the need for soft-tissue release and, therefore, theoretically, maintains soft-tissue vascularity of the small fracture fragments. Moreover, it preserves the soft-tissue tension medially. It involves the use of a bandage that is universally available in orthopedic operating rooms, including those in developing nations. It is easy to apply by either the principal or assisting surgeon. With practice, it cuts down operative time and can help substitute for an assistant. This relatively simple operative technique makes for a more seamless operative process, improved reduction, and key preservation of soft-tissue vascularity.

Keywords Medial epicondyle humerus fracture · Pediatric elbow fracture · Medial epicondylar humeral fractures · Valgus overuse elbow injuries · Open reduction humerus fracture

S. R. Cody · H. S. Hosalkar
Division of Pediatric Orthopaedic Surgery, The Children's Hospital of Philadelphia, 34th Street and Civic Center Boulevard, Philadelphia, PA 19104, USA

A. F. Kamath · H. S. Hosalkar (✉)
Rady Children's Hospital, UCSD, 3020 Children's Way, San Diego, CA 92123, USA
e-mail: HHPEDPOD@gmail.com

Introduction

In the pediatric population, medial humeral epicondylar fractures account for nearly 12% of all elbow fractures, with a notable proportion associated with elbow dislocations [1, 2]. Males represent nearly three-fourths of those injured, with a peak age of 11–12 years [1].

The common origin of wrist flexors and medial collateral ligament attachments exert traction forces on the medial epicondyle [3, 4]. The fractured fragment is usually displaced distally due to these soft-tissue attachments [5]. Acute fractures involve either a direct force applied to the medial epicondyle or an avulsion force from valgus or extension loading; dislocation also plays an important mechanical role in affecting this fracture pattern [6, 7]. While not the focus of this technique paper, chronic injuries involve valgus overuse, including repetitive pitching and throwing activities such as those seen in "Little Leaguer's elbow" [8].

Documented indications for surgery include incarceration of the fractured epicondylar fragment within the joint—occurring 15–18% of the time, which is often not reducible by closed means (e.g., maneuver described by Roberts)—or open fracture [1, 9–12]. Relative indications include ulnar nerve dysfunction (either in the acute setting, with sub-acute callus formation or frank nerve entrapment, or with chronic scarring) and gross valgus instability [13, 14]. Displaced fractures in patients requiring high-demand upper-extremity function remains to be another potential operative indication [1, 8].

There is ongoing debate about the management of cases that do not meet the above indications based on the degree of displacement, handedness, and athletic and performance demands. Medial epicondyle fractures may be managed non-operatively with good or excellent functional results, even when healed with fibrous union [15]. There is some consensus that fractures that are non- or minimally displaced (generally <2 mm) may be treated non-surgically [1, 3] with good functional outcomes, whereas those fractures that exhibit greater displacement may benefit from open reduction and internal fixation [2, 16, 17]. Other studies point to equivalent results with both non-surgical and surgical treatment [11, 18–20].

The debate over which fractures need eventual open reduction and internal fixation is not the focus of this manuscript. However, when an open reduction is deemed indicated, especially in notable displacements (either acutely or those that displace following conservative treatment within a subacute timeframe, less than 2 weeks), we wish to provide the readers with some technical tips that could afford a more easy operative experience. The senior author (HH) has been using this technique for several years with consistent results, and, therefore, we chose to report this for the benefit of the readership.

Surgical technique

After appropriate anesthesia, the patient is placed in the supine position with the entire operative extremity extended onto a hand table. Alternatively, based on surgeon comfort, a lateral position may be used. A non-sterile pneumatic tourniquet is placed on the upper arm. The non-sterile extremity tourniquet—along with preliminary Esmarch bandage (narrow rubber tourniquet) exsanguination—is inflated prior to surgical dissection, as in any other routine upper-extremity surgery. Thus, limb exsanguination is performed prior to application of the Esmarch bandage in the fracture milking technique described in the following.

After appropriate sterile precautions and appropriate draping, a posteromedial incision of adequate length is made just anterior to the medial epicondyle (Fig. 1). This incision must allow exposure of both the fracture site and, if needed, the ulnar nerve. The fracture site is identified and the medial epicondylar fragment (usually displaced anteriorly and distally) is located. The base of the fractured humeral surface is exposed and freshened up, while removing any soft-tissue obstructions to anatomic fracture reduction. The reciprocal exposed surface of the fractured fragment is cleaned up as well.

Potential associated injuries are ruled out, including other fractures, incarcerated bony fragments or loose bodies, interposed soft tissues, or compromised ligaments. These injuries are ruled out by visual inspection, intra-operative physical examination/stressing, and additional fluoroscopic radiographic views, if necessary. See Fig. 2 for fluoroscopic stress views taken pre-operatively to show the association of soft tissue in situ. Any small cartilage fragments or non-fixable floating pieces are removed. Collateral ligament stability is confirmed.

With the wrist fully flexed (and fingers flexed and relaxed), forearm supinated, and elbow flexed to 90°, an Esmarch bandage is applied distally to proximally to gently milk the soft tissues toward the fracture site (Fig. 1). With each succeeding turn of the bandage, the fracture fragment is moved closer to the base piece and is eventually successfully approximated with as little tension as possible (Fig. 1).

An 18-gauge needle is then used to transfix the fragment to the base piece, such that the needle path is distinct from and not an obstacle to the ultimate fixation screw (Fig. 1). The guide wire of the 4.0 cannulated cancellous screw is placed in the center of the fragment. The 18-gauge needle helps in preventing rotation of the fragment, and the needle hub can be used for subtle stabilization of the fracture fragment. The trajectory of the cannulated screw guide wire is superomedial and follows the roof of the olecranon fossa, with fixation purchase in the dense bone found there. Fluoroscopy is used to confirm the position of the wire, and a partially threaded, cancellous screw is subsequently placed for interfragmentary compression (Fig. 3). The fracture site and surgical wound are well irrigated.

Routine exploration and/or dissection of the ulnar nerve are not performed. Hardware is introduced into the fracture fragments under direct visualization. The ulnar nerve and surrounding soft tissues are retracted out of the way. We believe that the first assistant is better able to focus on ulnar nerve protection because the fracture fragment apposition is accomplished by tension of the applied Esmarch, rather than the assistant's manipulation.

Range of motion is then tested under anesthesia. Strong Vicryl (0 or 1-0) stitches approximate the periosteal soft tissues, and the wound layers are closed in a sequential fashion with careful attention paid to protecting the ulnar nerve. We use a bulky, soft-tissue dressing and a sling for support. In non-compliant patients, a splint/split cast may be used. The post-operative treatment goal is early therapy and mobilization after sufficient wound healing: we typically start mobilization at 7–10 days to prevent elbow stiffness and to obtain maximal range of motion.

Discussion

Concerns with the non-operative management of medial epicondyle fractures include unrecognized incarcerated fragment, ulnar nerve dysfunction (10–16%, but up to 50% with an incarcerated fragment), tardy ulnar neuritis, malunion, loss of terminal extension, and patient demand for high-functional activity [1, 8, 21]. Current absolute

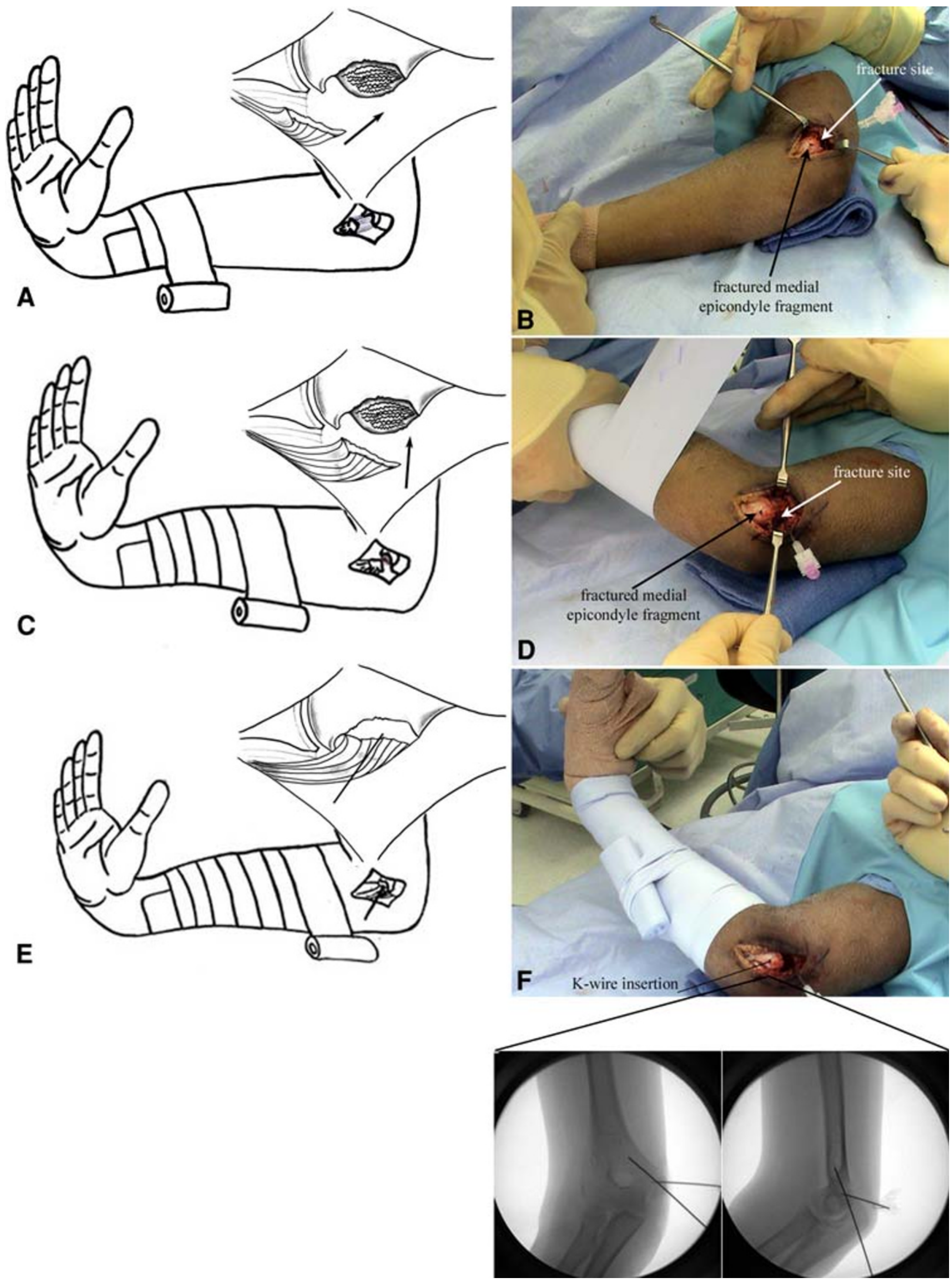


Fig. 1 Diagrammatic (*left panel*) and corresponding intra-operative (*right panel*) views presenting the serial reduction of medial epicondyle fracture fragment with Esmarch application after provisional 18-gauge needle fixation. Intra-operative fluoroscopic views demonstrate the placement of Kirschner wire after provisional fragment stabilization with 18-gauge needle (diagrammatic illustration drawn by Stephanie Cody and Harish Hosalkar)

indications for open reduction and internal fixation of medial epicondylar fractures include incarceration of the epicondylar fragment into the elbow joint, suspected entrapment and dysfunction of the ulnar nerve, marked instability, or open fracture.

Other indications for operative fixation of medial epicondyle fractures have changed over the years. For the most part, it remains an athletic injury, and, therefore, the demand for complete recovery and full function remains high in most referral centers that commonly treat these injuries. Thus, patient and parent expectations for return to high-demand athletics represent an evolving indication.

Operative fixation has increased in most centers despite the lack of particular scientific evidence that patients do better with anatomic reduction. The one specific advantage, however, may be early mobilization and achievement of full range of motion (following compression screw fixation). This remains a possible, albeit not yet proven, advantage in athletics and sports with heavy demands on the elbow.

The classic supine position technique uses a towel clamp or Weber clamp as a reduction and temporary fixation device [1, 6]. In comparison, our goal is to reduce the amount of force applied to the fracture fragments by

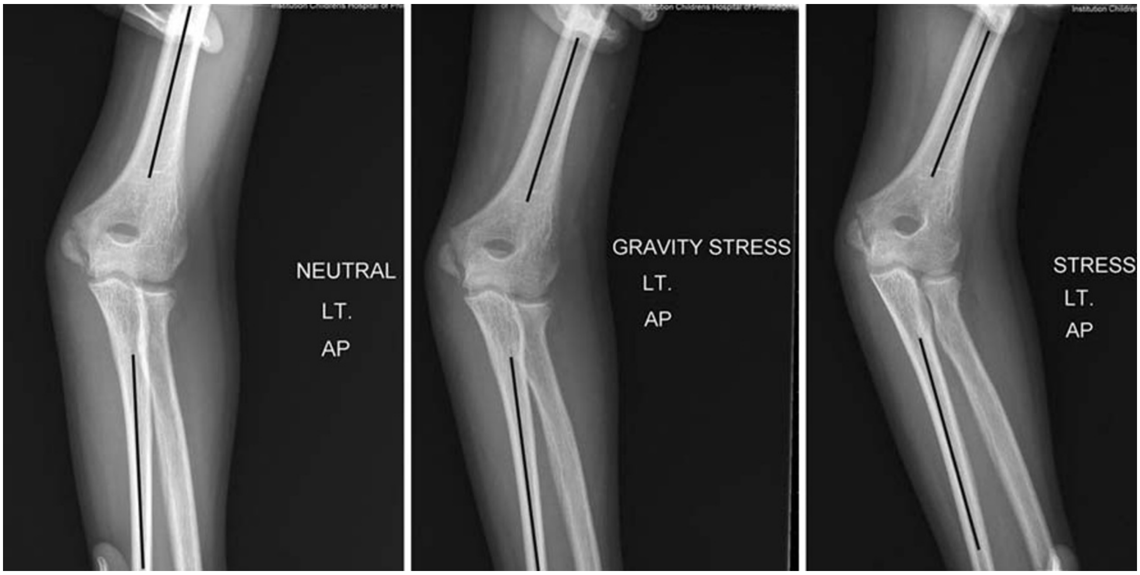
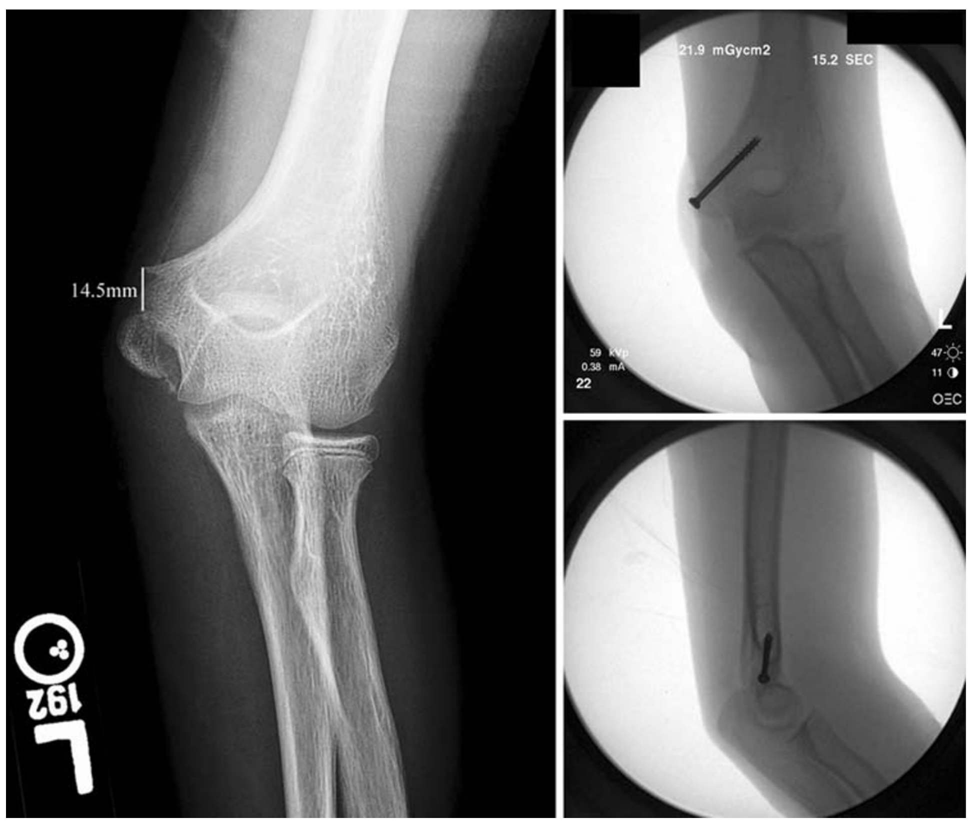


Fig. 2 Fluoroscopic stress views taken pre-operatively demonstrating the association of soft tissue in situ and fracture distraction under valgus load

Fig. 3 Pre-operative radiograph (*left panel*) demonstrating displayed medial epicondyle fracture in a 12-year-old, right-hand dominant, female status post-fall onto outstretched hand. The *right panel* presents intra-operative anteroposterior and lateral fluoroscopic views after fixation with 4.0 cannulated cancellous screw



surgical instruments, including reduction clamps on small fracture fragments. By indirectly milking the fracture fragment towards its mated fracture end on the distal humerus, there is less need for clamp manipulation and/or stripping of the fragments. Therefore, there is also less chance of intraoperative damage to the fracture fragment and risk of splitting with towel clip temporary fixation.

Another commonly employed technique is the prone position with placement of the operative limb pronated and flexed behind the patient's back. This is thought to improve muscle relaxation, affording easier reduction of the fracture fragments [6, 22, 23]. We like the ease of the supine position with the patient's arm extended onto the fluoroscopic machine, rather than prone positioning. The Esmarch bandage technique provides relaxation forces on the fracture fragment without having to manipulate the patient's entire arm. The prone position has its own issues, including anesthesia risks and increased operation room time. We personally find no advantage of the prone position, especially when using the present technique.

External application of the Esmarch bandage decreases the need for soft-tissue release and, therefore, theoretically, maintains soft-tissue vascularity of the small fracture fragments. Obviating the use of accessory clamps, including any soft-tissue crushing required for clamp purchase, theoretically reduces the risk—even if minor—of compromise of soft-tissue vascularity. Furthermore, any attempts at direct fracture manipulation, when compared to the indirect Esmarch milking technique, risk stripping and decreased vascular supply to the small fracture fragments.

Moreover, this technique preserves the soft-tissue tension medially. The use of the bandage, which can be tied to itself after each turn of compression, minimizes the effort on the surgical assistant or resident: the assistant no longer needs to hold the wrist, forearm, and elbow position while attempting to retract in the surgical wound during reduction. In this manner, a more controlled and constant soft-tissue tension can be applied, with focus turned to the fracture reduction and protection of vital structures, including the ulnar nerve. It minimizes the risk of redisplacement of fracture fragments with repeated manipulations or when having to release deforming forces (e.g., when the operative assistant needs to exchange surgical instruments).

It has been suggested that the ratio of elbow growth to width has the same biomechanical importance as longitudinal growth in terms of muscle balance and stability [22]. To these authors, temporary apophysiodesis with screw in the preadolescent group is also relatively contraindicated; they recommend screw fixation only for adolescents [22, 24]. We agree with this concept that K-wire fixation should be used in the very young. However, the type of fixation should be modified depending on age. In our own experience, more than 75% of these injuries have occurred in adolescents, in which screw fixation may be preferable to K-wire fixation due to increased stability. In younger patients, K-wire fixation may be used due to decreased physiologic stresses. Cannulated screw fixation may provide earlier mobilization and more stable fixation in high-demand athletes. Also, when using a cannulated screw, the threads of the screw do not, per se, cross the physis, but are positioned in the hard cortical bone above the olecranon fossa.

The goal of any treatment of a fracture is full union. This can only be achieved with compression using screw fixation. Reducing a fracture with K-wire fixation only stabilizes the injury without compressing fracture fragments. Although the screw may cause uncomfortable prominence and the need for subsequent hardware removal [24], we believe that this should not deter the orthopedist from performing an open reduction to achieve complete union of medial epicondylar fractures, and this view has been supported by other experts [25]. Furthermore, the risk of symptomatic non-union is clearly evident when using either non-operative management or simple K-wire fixation that does not employ compression principles [15].

In summary, our technique has several unique features. It involves the use of a bandage that is universally available in orthopedic operating rooms, including those in developing nations. It is easy to apply by either the principal or assisting surgeon. In the senior author's experience (HH), bandage compression is necessary for only 10–12 min. With practice, it cuts down operative time and can help substitute for an assistant. This relatively simple operative technique makes for a more seamless operative process, improved reduction, and key preservation of soft-tissue vascularity.

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