Technique for Intramedullary Stabilization of Ulnar Neck Fractures

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Abstract

Background: Distal ulna fractures at the ulnar neck can be seen in association with distal radius fractures, and multiple techniques have been described to address the ulnar neck component of these injuries. We have found that treatment of ulnar neck fractures can be challenging in terms of anatomy and fracture fixation. We present a new percutaneous fixation technique for ulnar neck fractures commonly seen with distal radius fractures. **Technique:** Fixation of the ulnar neck fracture is performed after fixation of the distal radius fracture. Our technique uses antegrade intramedullary fixation to stabilize the fracture with a 1.6-mm (0.062 inch) Kirschner wire or a commercially available metacarpal fixation intramedullary nail. The fixation is introduced into the intramedullary space of the ulnar shaft 4 to 6 cm proximal to the fracture at a separate surgical site along the subcutaneous border of the ulna. The fixation is also supported with a sugar-tong splint for the first few weeks after surgery and requires removal of the ulnar implant approximately 10 weeks after implantation. **Conclusion:** Our technique utilizes a percutaneous approach with minimal fracture exposure. It provides a relatively simple and reproducible method to address ulnar neck fractures commonly seen in association with distal radial fractures.

Keywords: distal ulna, percutaneous, fracture, distal radius, fixation

Epidemiology of Distal Ulna Fractures

Fractures of the distal end of the ulna usually occur in 2 forms as either isolated distal ulna fractures or accompanied with a distal radius fracture. Isolated distal ulna fractures have an incidence of 4 to 20 fractures in a population of 100 000^{8,12} and are typically seen in male patients at a mean age of 43 years and in the elderly.¹² Distal ulna fractures, not including the more common ulnar styloid fractures, have been noted to occur in 5.6% of all displaced distal radius fractures.¹ Many of these fractures are located proximal to the base of the ulnar styloid and are centered at the ulnar neck with varying involvement of the ulnar head and shaft. When the distal ulna is fractured with the distal radius, it occurs in the same bimodal distribution as distal radius fractures with young patients sustaining high-energy fractures and older patients sustaining low-energy fractures. Nonoperative treatment of distal ulna fractures is possible with nondisplaced fractures in isolation or in association with distal radius fractures. Ulnar styloid fractures associated with distal radius fractures may often be treated nonoperatively as well. These fractures usually heal without issue.^{2,11,19}

Anatomy of the Distal Ulna

The primary function of the ulna in the forearm is to serve as a stable axis around which the radius rotates through the distal and proximal radioulnar joints. Distally, the ulna is a thin, straight bone that continues into the ulnar head and styloid where it supports the distal radius and carpus in a subcutaneous location. The congruence of the ulnar head in the sigmoid notch of the distal radius plays an important role in stabilizing the distal radioulnar joint (DRUJ). The ulnar head is separated into 2 parts¹⁴: the dome and the seat. The dome is located distal to the sigmoid notch, whereas the seat articulates with the sigmoid notch and is covered with 130° of articular cartilage.¹⁴

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Figure 1. Distal ulna fracture classification. (a) AO distal ulna fracture classification and (b) Biyani distal ulna fracture classification.

The ulnar styloid is a bony prominence extending distally from the dorsal and ulnar aspects of the ulnar head. The superficial components of the triangular fibrocartilage complex (TFCC), with the dorsal and volar radioulnar ligaments, attach to the ulnar styloid and assist in stabilization of the distal ulna.¹⁴ Additional stabilization of the distal ulna is provided by the distal oblique band of the interosseous membrane (IOM) through its connection to the radius.¹⁴

Neurovascular structures near the distal ulna include the ulnar artery and ulnar nerve which travel longitudinally volar to the distal ulna. The dorsal ulnar sensory nerve traverses from the volar to dorsal within the subcutaneous tissues 1 to 4 cm proximal to the ulnar styloid.⁷

Mechanism of Injury and Classification of Distal Ulna Fractures

Fractures of the distal ulna typically present in isolation or with an associated distal radius fracture, which results from a fall on an outstretched hand. Isolated distal ulna and distal ulnar shaft fractures are caused by direct blows to the

subcutaneous border of the ulna in 38% of cases, causing “night stick fractures.”¹² Additional mechanisms of injury include simple falls (31%), pedestrian road traffic accidents (14%), and non-sport-related mechanisms (17%).

Two different classification systems for distal ulna fractures are available: the AO Comprehensive Classification of Fractures and the Biyani classification for distal ulna fractures that are associated with distal radius fractures.¹⁴ The AO distal ulna fracture classification includes a Q modifier with 6 different fracture types (Figure 1a). The Biyani classification describes 4 different types of distal ulna fractures associated with distal radius fractures¹ (Figure 1b). Both classification schemes attempt to classify the spectrum of injury that includes styloid fractures, head fractures, neck fractures, and combined injuries involving more than 1 component of the distal ulna.

Current Fixation Techniques

When distal ulna fractures present with associated distal radius fractures (Figure 2), the fracture type is commonly

Figure 2. Preoperative fracture films. (a) Anteroposterior and (b) lateral views of distal radius fracture with associated distal ulna fracture.

an ulnar neck fracture and can be the more challenging component of the injury to address and can also be the limiting factor when planning rehabilitation. Nondisplaced or minimally displaced fractures can demonstrate late angulation and deformity. Ulnar neck fractures that are displaced can be difficult to stabilize with some of the popular forms of fixation. Multiple options exist for the stabilization of ulnar neck fractures, and our experience with some of these options has factored into our development of our proposed technique.

Some treatment options are percutaneous options. Percutaneous treatment maintains the soft tissue envelope, which in turn may add to the stabilization of these fractures. Retrograde percutaneous fixation with Kirschner wires¹⁸ provides an option for quick and easy placement of fixation by closed means. However, Kirschner wires if left exposed may be prone to pin site irritation and infection that can be worsened with wrist motion. In addition, a satisfying starting point may be difficult to establish in some cases. Kirschner wire fixation can be augmented with a tension band construct¹⁰ that can provide stability; however, this technique does not allow for adequate fixation across comminuted fractures and requires more soft tissue dissection than simple percutaneous pinning. Headless screws have been used to treat intra-articular ulnar head fractures^{9,17} with minimal soft tissue stripping and less hardware prominence. However, headless screws can only be used in limited fracture patterns and with patients who have satisfactory bone quality. Percutaneous Kirschner wire fixation, headless screws, and tension band constructs all limit soft tissue stripping but may not adequately stabilize comminuted or osteoporotic fractures.^{9,10,17,18}

Some treatment options include formal exposure of the fracture and various forms of plate fixation. Plate options include nonlocking plates, locking plates,⁴ condylar blade plates,¹⁵ and hook plates. Open reduction of these fractures compromises the soft tissue envelope that may be providing some stability of the distal fragment. Also, when compared with the distal radial fracture reduction, the alignment of the ulnar neck fracture reduction may be difficult to judge and the fixation may not be as satisfying. While plate fixation may achieve stable fixation of distal radius fractures even in osteoporotic bone, plate fixation of distal ulna fractures may irritate the thin overlying soft tissue and may require hardware removal due to the subcutaneous location of the distal ulna.

When fracture fixation is not possible due to severe comminution, salvage options include ulnar head replacement⁶ or distal ulnar resection with soft tissue reconstruction.¹⁶

Technique

As a result of our experience with other techniques, we developed a different approach with the goal of providing a simple method of stabilizing ulnar neck fractures that leaves the fracture closed and the soft tissue envelope intact, does not hinder motion at the wrist, and minimizes risk of injury to the dorsal ulnar sensory nerve branch. This technique can be utilized for either isolated distal ulna fractures or distal ulna fractures associated with distal radius fractures. Our method uses an antegrade intramedullary (IM) pin to stabilize ulnar neck fractures. While the technique can be performed with any 1.6-mm (0.062 inch) Kirschner wire, we have found the commercially available IM nail for metacarpal fixation

Figure 3. Intraoperative steps. (a) Small bone fixation system, (b) distal ulna exposure via ulnar approach, (c) introduction of intramedullary implant into ulna, (d) trimmed and bent intramedullary implant, (e) introduction of locking blade to control intramedullary implant migration, (f) trimming locked implant, (g) application of radiopaque protective end cap, and (h) closed ulnar incision.

(Small Bone Fixation System; Biomet, Warsaw, Indiana) to be more useful (Figure 3a).

Considering that the majority of ulnar neck fractures are associated with distal radius fractures, the first step is to reduce and stabilize the distal radius fracture, usually with volar plate distal radial fixation. Reduction of the distal radius is the most important step toward achieving reduction and alignment of the distal ulna.³ The distal ulna is then provisionally manipulated, reduced, and fluoroscopically reviewed to see whether an acceptable alignment can be achieved without the need for a more formal distal ulna fracture exposure. The reduction of the distal ulna can be performed with external manipulation or can be facilitated by palpating and controlling the distal ulnar fragment internally through the distal radius exposure. Alternatively, percutaneous reduction can be considered using a joystick technique or intrafocal manipulation. If the distal ulna fracture reduction is acceptable with manipulation, we then proceed to IM pin stabilization (Figure 4).

The transverse level of the fracture is noted with fluoroscopy and marked on the skin. About 4 to 6 cm proximal to the level of the fracture, a 2- to 3-cm longitudinal incision is

made along the subcutaneous border of the ulna (Figures 5 and 6a). The periosteum over the subcutaneous border of the ulna located between the volar and dorsal compartments is defined with blunt dissection. The dorsal ulnar sensory nerve branch must be protected. The periosteum is incised longitudinally and elevated from the bone surface. It is important to expose enough of the ulna in a palmar and dorsal direction to properly judge the width of the ulnar shaft. An awl or 2- to 3.5-mm drill bit is used to make a unicortical hole in the midwidth of the shaft. Once access to the medullary space has been achieved, the awl or drill bit is used to carefully angle this portal into an anteroposterior trajectory to a degree determined by the patient's anatomy and the fracture configuration.

The awl supplied with the commercially available IM pin has a slot that facilitates the introduction of the IM pin into the IM space. Alternatively, one could fashion a standard 1.6-mm Kirschner wire for the same purpose. The 1.6-mm Kirschner wire should have a blunt tip, and the tip should be angled approximately 20° at 10 mm from the tip. The IM pin is then introduced into the IM space and advanced by hand with a slight back and forth twisting

Figure 4. Pre-distal ulna fixation. (a) Anteroposterior and (b) lateral views of distal ulna fracture after distal radius fixation.

motion until just proximal to the fracture zone. The fracture is then reduced and the pin is advanced into the distal fragment, setting the tip of the pin in the ulnar head. If the head has nondisplaced or minimally displaced comminution, then the tip is advanced into the area of the ulnar head where there is the least comminution and the largest fragment (Figures 3b-3e and 6b-6e).

The commercially available pin includes a locking mechanism that helps stabilize the proximal end of the pin into the shaft. The pin and locking mechanism are cut below the level of the skin, and the radiopaque plastic cap that is included with this implant is placed over the cut end (Figures 3f-3h and 6f). If one uses a 1.6-mm Kirschner wire, the proximal end of the pin is bent and cut deep to the skin but external to the ulnar surface. The site is closed, and the components are buried beneath the skin with anticipated staged removal 10 weeks after implantation. At the conclusion of the surgery, the extremity is supported with a sugar-tong splint and the patient is encouraged to pursue unrestricted digital and thumb range of motion (Figure 7).

The surgical sugar-splint and dressing are removed for suture removal, and a custom removable thermoplast sugar-tong orthosis is applied. The sugar-tong splint restricts forearm rotation for the first 4 weeks after surgery so that early fracture healing can supplement the IM pin fixation, which has no intrinsic rotational stability. After suture removal, we allow removal of the sugar-tong orthosis for wrist (flexion/extension and radio/ulnar deviation), digital, and thumb range of motion while still restricting

forearm rotation. Four weeks after surgery, the sugar-tong splint is removed and exchanged for a simple volar wrist brace and the allowance of unrestricted forearm rotation range of motion is added to the patient's therapy protocol. Six weeks after surgery, splinting is discontinued. A gradual strengthening program is usually added to the patient's therapy regimen at 6 to 8 weeks postoperatively. About 10 weeks after the initial surgery, secondary surgery to remove the buried ulnar implant is performed. The patient's therapy program is resumed after suture removal for the secondary surgery.

Pearls and Pitfalls

With IM pin fixation of the distal ulna, it is not necessary to achieve "three points" of stabilization. Rather, our goal is to place the distal pin tip as far as possible across the fracture and capture as much of the distal fragment as possible. Most commonly, this means that the distal pin tip is directed into the ulnar head and toward the DRUJ.

Fracture alignment must be achieved before the pin is advanced into the distal fragment. Once the pin is advanced, it is difficult to correct and hold any adjustment of the reduction by withdrawing and readvancing or rotating the pin. Therefore, before we set our final reduction, we advance the pin tip to a position a few millimeters proximal to the fracture. We then swivel and rotate the pin tip into the anticipated desired trajectory into the distal fragment. The fracture is then reduced, confirmed with fluoroscopy, and the pin is pushed distally into the distal fragment.

Figure 5. Initial steps of distal ulna fixation. (a) Localization of distal ulna fracture, (b) localization of incision 4 to 6 cm proximal to fracture, and (c) introduction of intramedullary wire.

It is important to maintain the integrity of the ulnar shaft during instrumentation. We center the insertion point on the ulnar shaft to avoid potential shaft fractures around the IM entry site. To this end, it is important to center the portal in the width of the shaft. Angling the hole facilitates passage of the pin and minimizes tendencies to lever the pin against the shaft. Finally, if one uses the commercially available IM pin, the locking mechanism simply needs to be engaged into the

far side cortex and does not need to penetrate through the cortex where it may risk shaft fracture.

To date, we have not had any issues with this technique in regard to infection and all patients have healed uneventfully without any loss of reduction.

Discussion

Maintenance of the soft tissue envelope around the distal ulna and ulnar head is advantageous in providing secondary stabilization of the distal ulna fragment and its relationship with the distal radius. Retrograde pin fixation of these fractures maintains the benefit of an undisturbed soft tissue envelope. While the concept seems simple, the reality of placing pins retrograde through the ulnar head with the proper starting point can be challenging. The ulnar carpus and habitus of the limb may interfere with a proper starting trajectory. Wrist pronation and ulnar deviation subluxates the ulna away from the carpus for a better starting point, but the distal ulna pin position interferes with wrist motion during early rehabilitation. In addition, the starting point for pin placement is often alongside the dorsal ulnar sensory nerve branch and extensor carpi ulnaris and risks complications related to these structures.

More invasive techniques such as tension band and plate fixation require dissection around the fracture zone that risks compromise of the dorsal ulnar sensory nerve branch and loss of the integrity of the soft tissue envelop around the ulnar head. In the face of any significant comminution, tension band fixation risks shortening the ulnar length if any significant tension band tightening is generated. Attempting to maintain ulnar length with the addition of oblique pins as part of the tension band fixation technique may lead to early pin migration.

Plate fixation has the theoretical advantage of more rigid stabilization and the ability to span fracture comminution and maintain ulnar length. One might anticipate the ease of obtaining a more anatomic reduction with direct fracture exposure. However, while distal radial fractures are relatively easy to reduce and stabilize with volar plate fixation, ulnar neck fractures are more challenging. Ulnar neck fractures have a smaller distal fragment, are often comminuted, and have an orientation that can be difficult to align. The dissection necessary for the exposure may compromise the stabilizing effect of the soft tissue envelop around the ulnar head. In addition, screw placement in the ulnar head is difficult to judge and risks inadvertent breaching of the articular surface.

A variation of the plate technique involves a distal hook to capture the ulnar styloid intending to achieve a point of distal ulnar stabilization through the styloid and its soft tissue attachment. In addition to some of the limitations of standard distal ulna plating, the hook plate design may lead

Figure 6. Intraoperative fluoroscopy images. (a) Localization of distal ulna fracture, (b) perforation of cortex with awl, (c) introduction of intramedullary wire proximal to fracture site, (d) advancing intramedullary wire across fracture site, (e) intramedullary wire bent to accommodate locking blade, and (f) introduction of locking blade.

to overshortening the distal ulna when attempting to improve the hook purchase distally by pulling or sliding the plate in a proximal direction. The potential for shortening may be greater in comminuted fractures or when the styloid is fractured from the head.

Anterograde IM stabilization of ulnar neck fractures has not been previously reported. The technique that we have described has advantages of simplicity, ability to span fracture comminution, maintenance of the soft tissue envelope, and less risk to the dorsal ulnar sensory nerve branch. The anterograde placement avoids tendencies to shorten the bone in the face of comminution and places the hardware out of the way of wrist motion. In addition, this technique could be expanded upon with the addition of tension band fixation or additional IM pins for more of a “bouquet” type of fixation⁵ as described with the treatment of metacarpal neck fractures.

Indications for nonoperative and operative treatment of distal ulna fractures differ. The nonoperative treatment of these fractures is typically reserved for fractures that are nondisplaced or minimally displaced. Outcomes for nonoperative management are good to excellent.¹³ However, when these fractures are displaced significantly or there is associated DRUJ instability, operative fixation is recommended.¹⁴ Our experience with this distal ulnar fracture IM

technique suggests that acceptable fracture union and alignment can be achieved with satisfactory clinical function and pain relief. We have not observed any complications to date.

Several limitations with this technique must be considered. First, our technique provides limited rotational stability of the fracture and relies on external splint support and restriction of forearm rotation during the early weeks of fracture healing to help minimize fracture displacement. These postoperative precautions are similar to those of other techniques due to limited fixation capacity. Second, the implant is not designed for long-term implantation and requires a second, albeit small, procedure for its removal. Third, the implant locking mechanism is prominent and can be palpated along the subcutaneous border of the ulna. In our experience, the implant has been well tolerated even in the thinnest patients and has not been a significant issue during the interval between implantation and removal. Fourth, some fracture patterns may not be amenable to any meaningful IM stabilization due to excessive distal ulnar fracture comminution or to loss of bone substance such as in an open injury. Finally, fractures that have more than 1 to 2 cm of associated ulnar shaft comminution may not be appropriate for this technique. However, one could consider full-length anterograde IM stabilization of these types of

Figure 7. Postoperative fluoroscopy and splinting. (a, b) Postoperative fluoroscopy radiographs and (c, d) postoperative sugar-tong splint.

fractures with a long IM nail introduced from the tip of the olecranon.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: CEF receives personal fees from Skeletal Dynamic outside of the submitted work. The remaining authors declare that they have no conflict of interests.

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