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CURRENT CONCEPTS REVIEW
SOUBORNÝ REFERÁT

Treatment of Forearm Fractures

Diafyzární zlomeniny předloktí

N. R. MACINTYRE[1], A. M. ILYAS[2], J. B. JUPITER[3]

[1] Department of Orthopaedic Surgery Temple University Hospital, Philadelphia, USA
[2] Temple Hand Center, Temple University Hospital, Philadelphia, USA
[3] Harvard Medical School, Boston, USA

SUMMARY

Fractures of the forearm represent common injuries. Understanding the anatomy and funkction of the radius, ulna, interosseous membrane, proximal and distal radioulnar joints is critical to appropriate management. Diagnosis can readily be made by examination and radiographs. Well established surgical approaches including the anterior Henry, dorsal Thompson, and ulnar approaches provide excellent access to both the radius and ulna. Multiple fracture patterns are recognized including isolated radius and ulna fractures, combined fractures, Galeazzi fractures, and Monteggia fractures. Surgical management regularly requires open reduction internal fixation with plates (DCP) and screws with vigilance being paid to stable reduction of the proximal and distal radioulnar joints. New directions in the management of forearm fractures include the use of intramedullary fixation and locking plate technology.

OVERVIEW

The radius and ulna comprise the two bony structures of the forearm. These two bones function symbiotically as a unit. As such, their anatomy and movement should be viewed as a single dynamic process as opposed to two isolated anatomic structures. Both bones are connected by the distal radioulnar joint (DRUJ), proximal radioulnar joint (PRUJ), and the interosseous membrane (IOM). The IOM is a fibrous sheath that separates the anterior and posterior compartments and is a secondary restraint to proximal migration of the radius relative to the ulna. According to Skahen et al this sheath, which originates on the radius and inserts onto the ulna, consists of central band, accessory band, a proximal band, and a membranous portion (31). The average length of both the radius origin and ulna insertion is approximately 10.6 cm (31). The IOM serves primarily as a ligament and is critical in the maintenance of longitudinal forearm stability. According to Hotchkiss et al, the IOM contributes approximately 71% of the longitudinal forearm stiffness when the radial head is excised (13). The radial head serves as the primary restraint to proximal migration of the radius with the central band of the IOM and the triangular fibrocartilage complex (TFCC) acting as secondary restraints. These structures together facilitate transition of stress and permits fluid motion of the forearm from pronation to supination.

The radius, ulna, IOM, TFCC, DRUJ, and PRUJ form the forearm ring (6). This ring works in concert to allow for forearm pronation and supination. A disruption of this ring at any site can result in loss of normal forearm motion. Therefore, the goal of forearm fracture management is anatomic maintenance of the ring in order to preserve motion and function.

DIAGNOSIS

A patient with a forearm fracture typically presents with a painful right arm. Tenderness is noted and is worsened with hand motion and forearm rotation. Vigilant evaluation of the radial, median, and ulnar nerves is warranted. The radial and ulnar artery must also be evaluated. If palpable pulses are not felt, Doppler examination is warranted. Neurovascular injury in closed radius and ulna fractures is an uncommon but serious complication. Compartment syndrome of the forearm is second only to the leg and must be considered in all cases of forearm fractures with significant swelling, pain out of proportion, and altered neurovascular examinations.

The risk for neurovascular embarrassment is increased with open fractures. All wounds should be diligently evaluated with the understanding that the site of a wound and fracture may not be at the same level at presentation but may have communicated at the time of injury. Most nerve injuries are neuropraxic, however hard signs of a nerve injury should be treated accordingly.

Thorough radiographic evaluation of the forearm should include anteroposterior and lateral views of the forearm, as well as dedicated views of the wrist and elbow. The radius and ulna must be examined thoroughly across their entire lengths including the DRUJ and PRUJ. Traction views can aid in characterization of a fracture. Radiographs can readily make the diagnosis of forearm fractures and advanced imaging modalities including computed tomography or magnetic resonance imaging are rarely necessary except in cases of pathologic lesions.

APPROACHES

The radius and ulna are intimately enveloped in muscle and understanding of the multiple internervous planes is mandatory prior to surgical intervention. Multiple internervous planes are available and each provide exposure to specific aspects to both the radius and ulna. Three main approaches exist and include: Anterior Approach (Henry), Dorsolateral Approach (Thompson), and Ulnar Approach. These three approaches and their pertinent anatomy will be briefly discussed.

Anterior approach (Henry)

This approach was original described by Henry in 1970(12). It has been termed the "workhorse of the forearm". When done correctly, it allows for excellent volar exposure to the entire radius. Henry described two groups of muscles. The first group, originating from the lateral elbow and innervated by the radial nerve, he termed the "mobile wad" (brachordialis, extensor carpi radialis, extensor carpi radialis brevis). The second group, originating from the medial elbow and innervated by both the median and ulnar nerves, he termed the "flexor-pronator mass." The flexor-pronator mass consists of three distinct layers: (1) the superficial layer includes the pronator teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris, (2) the middle layer consists of the flexor digitorum superficialis, and (3) the deep layer consisting of the flexor digitorum profundus, flexor pollicis longus, and pronator quadratus. The internervous plane exists between the laterally oriented radial innervated muscles and the medially oriented median innervated muscles. Specifically, the interval is between the brachioradialis and the pronator teres / flexor carpi radialis. Deeper dissection involves retracting the flexor digitorum superficialis and profundus ulnarly.

Surgical exposure

Identify the flexor carpi radialis at the wrist flexion crease distally and follow it proximally. Its tendinous nature will give way to muscle at approximately the mid-forearm. Identify the brachioradialis that originates along the lateral epicondyle of the elbow and is the most superficial muscle mass along the lateral forearm. Distally and laterally it has a broad insertion along the flare of the radius. Identify the biceps tendon, which is the broad and taut continuation of the biceps muscle. It crosses anterior to the elbow joint and dives towards its insertion into the radius ulnar to the brachioradialis. Identify the radial artery at the wrist. It is found between the flexor carpi radialis and brachioradialis tendons. The incision should be placed immediately radial to the flexor carpi radialis tendon. Begin superficial exposure by developing the interval between the flexor carpi radialis and the brachioradialis. The radial artery lies just ulnar to the brachioradialis tendon and lies underneath the brachioradialis in the mid-forearm. The superficial radial sensory nerve exits from under the brachioradialis at the mid-forearm and travels adjacent to the tendon distally. The nerve bifurcates proximal to the wrist joint. Proximally the interval between the pronator teres and brachioradialis is developed. Dissection through the middle layer involves ulnar retraction of the flexor digitorum superficialis and profundus. In the deep layer, the radius is covered by several muscles: the pronator quadratus and flexor pollicis longus distally, the pronator teres in the middle, and the supinator proximally. To expose the radius, these muscles are released along their volar radial aspect of the radius and raised in a subperiosteal fashion medially. The supinator is the exception. The posterior interosseous nerve runs through the supinator as it travels to the dorsal compartment of the forearm. In order to expose the radius proximally the supinator is released along the ulnar border of the radius and raised radially in a sub-periosteal fashion. The radius must be kept fully supinated to protect the posterior interosseous nerve at all times.

Dorsal approach (Thompson)

The dorsal or dorsolateral approach, as described Thompson in 1918, provides exposure to the posterior aspect of the radius. Three groups of muscles comprise the dorsal aspect of the forearm. The first: the radial nerve innervated mobile wad (brachoradialis, extensor radialis longus, and extensor carpi radialis brevis) and the posterior interosseous nerve innervated finger or wrist extensors (extensor digitorum communis, extensor digitorum minimi, and extensor carpi ulnaris). The deep muscles consist of the abductor pollicus longus, extensor pollicus longus, and extensor pollicus brevis distally. Proximally the deep muscles are the supinator and extensor indices. All of the deep dorsal muscles are innervated by the posterior interosseous nerve.

Proximal elbow exposure is through the Kocher interval which is bordered by the radial nerve innervated anconeous muscle and the posterior interosseous nerve innervated extensor carpi ulnaris. Proximal dorsal radius approach requires identification of the posterior interosseous nerve as it travels through the supinator for safe exposure.

Surgical exposure

Identify Lister's tubercle at the distal and radial aspect of the radius and the mobile wad proximally up to its origin in the lateral epicondyle. The incision begin at Lister's tubercle and extend proximally along the medial border of the mobile wad towards the lateral epicondyle. The length of the incision depends upon the extent of bone that needs to be exposed. Develop the interval between the extensor carpi radialis brevis and the extensor digitorum communis proximally and extensor pollicis longus distally.

To expose the distal radius, the sheath of the extensor pollicis longus tendon is opened and the tendon is retracted radially. The floor of the sheath is incised longitudinally and the extensor tendons are raised sub-periosteally with the extensor carpi radialis longus and brevis taken radially and the finger extensors taken ulnarly. Exposing proximally, the abductor pollicis longus and extensor pollicis brevis cover the middle third of the radius. To expose the radius, these muscles are release along their radial border and raised ulnarly in a sub-periosteal fashion. The proximal third of the radius is covered by the supinator. Within its substance and between its two heads runs the posterior interosseous nerve. Exposure of the radius proximally requires exposure and protection of this nerve prior to elevating the supinator off of the radius. First, identify the nerve as it exits between the two heads of the supinator. Follow the nerve proximally through the substance of the supinator's superficial head while taking care to preserve all branches. Once the nerve is identified along its entire course, the supinator can be released along its radial border and raised ulnarly in a sub-perisoteal fashion.

Ulnar approach

The ulnar approach is the most straight forward of the three intervals. The interval is between the ulnar nerve innervated flexor carpi ulnaris and the posterior interosseous nerve innervated extensor carpi ulnaris. These are the two most medial structures innervated by their respective nerves. The ulnar nerve traverses the forearm between the flexor carpi ulnaris and the flexor digitorum profundus. It should be noted that the dorsal sensory cutaneous branch of the ulnar nerve crosses the interval distally approximately 8 cm proximal to the ulnar styloid.

Surgical approach

The incision is placed in line with the ulnar styloid distally and directed to the olecranon proximally along the subcutaneous border of the ulna. The length of incision depends upon extent of bone that needs to be exposed. Both the flexor carpi ulnaris and the extensor carpi ulnaris muscles can be raised volarly and dorsally, respectively, off of the ulna in a sub-periosteal fashion. The ulnar artery and nerve travels under the flexor carpi ulnaris. The nerve is protected by diligent sub-periosteal elevation. The proximal aspect of the ulna receives the insertion of the triceps' tendon. To expose the ulna while maintaining the integrity of the tendon, the triceps' fibers should be cut in line with its fibers across the border of the ulna and raised volarly and dorsally in a sub-perisoteal fashion. The ulnar nerve travels around the medial epicondyle and dives between the two heads of the flexor carpi ulnaris. Prior to exposing the ulna volarly at its proximal extent, the ulnar nerve should be identified and protected followed by sub-periosteal elevation of the flexor carpi ulnaris.

FRACTURES

Forearm fractures can be divided into four distinct fracture patterns : Isolated radius or ulna fracture, Combined radius and ulna fracture, Galleazi Fracture, and Monteggia Fractures. Each fracture will be discussed including treatment principles and techniques.

Isolated radius fractures

Isolated radius shaft fractures are controversial and are typically assumed to be a Galeazzi Fracture until proven otherwise. Standard treatment involves an anterior approach to the radius with plate fixation. Recently we have come to realize that not all isolated radial shaft fractures necessarily involve the DRUJ. Rettig et al reviewed 40 patients with a Galeazzi fracture at an average period of 38 months who underwent fracture stabilization via the anterior approach and standard plate fixation. They found that fractures of the shaft within 7.5 cm of the "mid-articular" surface of the radius were at high risk for DRUJ involvement whereas those beyond 7.5 cm were not so and acted as an isolated radial shaft fracture (25).

Similarly, Ring et al. reviewed their series of 36 patients with radial shaft fractures (27). They used a DRUJ disruption with greater than 5 mm of positive ulnar variance as an indicator of a Galeazzi fracture. Nine such patients were treated with plate fixation and DRUJ repair with either temporary pinning and/or large ulnar styloid repair, whereas the remaining 27 patients only underwent plate fixation without DRUJ stabilization and early mobilization with good results. They identified that isolated radial shaft fractures are more common than Galeazzi fractures.

Galeazzi fracture

A Galeazzi fracture consists of a fracture of the shaft of the radius with an associated DRUJ disruption. The extent of DRUJ injury can be classified as either stable, partially unstable (subluxable), or unstable (dislocated). (7) Macule et al further classified Galeazzi fractures based on the location of the radius fracture relative to the radial styloid; type 1: 0 – 10 cm, type 2: 10-15 cm, and type 3: > 15 cm from styloid. (8) Again, Rettig et al identified that the risk for DRUJ injury is greatest when the radial shaft fracture is within 7.5 cm from the articular surface (25).

Closed treatment of this fracture has been uniformly poor with Hughston et al citing a 92% unsatisfactory outcome in a group of 38 patients treated without operative intervention (14). Operative fixation is the treatment of choice hence its eponym: "fracture of necessity." The preferred technique is an anterior approach followed by plate fixation of the radius and reduction of the DRUJ. Plate fixation is best achieved with a dynamic compression plate and screw purchase of 6-8 cortices on each side of the fracture. Concentric reduction and stability of the DRUJ is best achieved by anatomic reduction of the radius. Residual DRUJ instability after radius fixation can be treated with temporary pinning of the DRUJ in supination and/or repair of an ulnar styloid fracture, size permitting.

Mohan et al. reviewed 50 Galeazzi fractures treated only with anatomic plate fixation and without DRUJ repair that resulted in 40 good, 8 fair, and 2 poor results

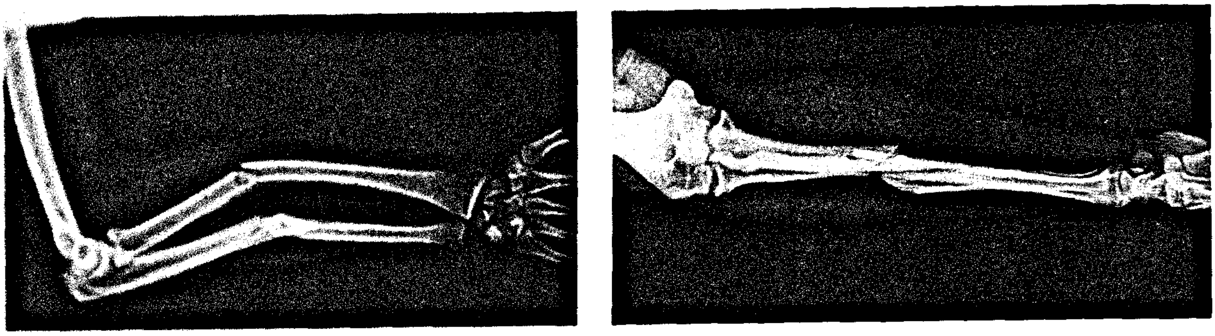

Fig. 1a,b. Anteroposterior and lateral views of a both bones fracture of the forearm.

(22). Similarly, Strehle & Gerber identified that anatomic plate fixation of the radius and indirect reduction of the DRUJ was sufficient (32). Bhan & Rath reviewed their experience with Galeazzi fractures and recommended that fractures with delayed treatment should be immobilized in supination in a long arm cast after open plate fixation of the radius and DRUJ reduction (4).

Isolated ulna fractures

The isolated ulna fracture, also known as a "night stick" fracture, is a common injury usually resulting from a direct blow to the ulna. The treatment of such injuries is highly variable and is based on the fracture's stability. Fractures are deemed unstable if there is more than 10 degree angulation, more than 50% displacement of ulnar shaft, proximal one-third ulnar shaft involvement, and DRUJ or PRUJ instability (30). Multiple non-operative measures have been shown to be effective in the management of isolated ulnar fractures including: ace wraps, forearm braces, short arm casts, or long arm casts (2, 24, 29, 36).

Atkin et al. 31 studied patients with isolated stable forearm fractures and compared ace wrap vs short arm cast vs long arm cast. They found that all fractures united by 7.2 weeks, although 6 of 9 patients initially treated with an ace wrap were converted to short arm casts secondary to pain. They concluded that short arm casting for eight weeks is sufficient for closed treatment of ulnar shaft fractures (2). Pollack et al. treated seventy one patients with isolated ulna fractures. They showed that a long arm cast for 10.5 weeks resulted in an 8% non-union rate and cast less than two weeks along with motion as tolerated after cast removal resulted in a 100% union rate. A five percent loss of forearm rotation was noted (24). Zych et al. reported a 100% union rate with 2 weeks of long arm casting followed by forearm bracing. The necessity of an interosseous mold within the brace was stressed in order to limit radial angulation (36). Sarmiento et al studied 287 patients treated with functional bracing and reported a 12 degree loss of pronation and 1 degree loss of supination in proximal fractures, a 10 degree loss of pronation and 2 degree loss of supination in middle third fractures, and 5 degree loss of pronation and 7 degree loss of supination in distal third fractures (29).

Operative intervention should be reserved for unstable fractures. The goal of operative intervention is avoidance of malunions or nonunions and preservation of forearm rotation with anatomic reduction and plate fixation. Open reduction and internal fixation with dynamic compression plates has resulted in consistently good outcomes. Leung and Chow performed open reduction and internal fixation on twenty nine isolated ulnar shaft fractures and noted a 100% union rate (19).

Combined radius & ulna fracture

Combined radius and ulna fractures of the forearm, also known as a "both bones fracture" are defined as an isolated diaphyseal fracture of both the radius and ulna with no injury to the DRUJ or PRUJ (see FIGURE 1a & 1b). Closed treatment of both bones fractures has routinely led to poor outcomes with significant losses in forearm rotation. In 1951 Evans et al reviewed his series of 50 patients treated with closed reduction under general anesthesia and reported on the high incidence of residual loss of forearm rotation with residual malalignment (7). Thus closed treatment should be reserved for critically injured patients or for those with substantial medical comorbidities.

The goal of operative intervention for both bones fractures is stable anatomic reduction and plate fixation of both the radius and ulna with restoration of radial bow and forearm rotation. Restoration of the radial bow is particularly imperative and is defined as the maximal height of the radius arch and is on average around 15mm. The usual location is 60% of radial length distal to the radial ulnar joint. Mathews et al showed that a 10 degree malreduction of the radius will not limit anatomic forearm rotation however a 20 degree loss of forearm rotation was shown to limit range of motion (21).

Multiple surgical treatment options exist for the treatment of both bones fractures, and include open reduction and plate fixation, external fixation, and intramedullary rodding.

External fixation is typically reserved for management of open fractures or associated soft tissue injuries. Intramedullary fixation will be discussed at greater length in the last section.

Open reduction and fixation with dynamic compression plates has become the workhorse for management

Fig. 2a,b. Anteroposterior and lateral views of a both bones fracture after fixation with dynamic compression plate fixation.

of both bones fractures (see FIGURE 2a & 2b). Principles of fixation include restoring length, radial bow, and preservation of forearm rotation. Complications include loss of forearm rotation, shortening, and wrist pain. To ensure stable fixation and minimize the risk for non-unions six to eight cortices should be obtained on each site of the fracture. In addition, separate incisions should be placed to approach both the radius and ulna individually to avoid post-operative sysnostosis formation. Anderson et al reviewed 330 fractures of the radius, ulna, or both bones. All were treated with compression plating. They reported a 97.9% union rate for radius fractures and 96.3% union rate for ulna fractures. Only 11% of this patient group was observed to have a poor functional outcome (21).

Monteggia fracture

A Monteggia fracture consists of a fracture of the proximal ulna with an associated dislocation of the radial head (23). It has been estimated that the Monteggia fracture pattern represents approximately 1-2% of all forearm fractures (Recking 1982). The associated radial head fracture implies an inherent violation of the annular ligament, which binds the radius to the ulna (6). The Bado classification has divided Monteggia fractures into four distinct categories with respect to the location of the radial head (3): Type I is an anterior dislocation of radial head, and occurs with excessive forearm pronation. Type II is a posterior dislocation of radial head, and occurs with excessive axial loading of the forearm along with elbow flexion. Type III is a lateral dislocation of the radial head, and occurs with forced abduction of the elbow. Finally, Type IV represents both a proximal ulna and radius fracture. This dislocation occurs with excessive forearm pronation and subsequent fracture through the radial neck. Jupiter et al further sub-divided the Bado type II fracture has been subdivided into four groups (15). In type IIa, the fracture of the ulna involves the distal part of the olecranon and the coronoid process, in type IIb the fracture is at the metaphyseal-diaphyseal juncture, distal to the coronoid process, in type IIc the fracture is diaphyseal and in type IId the fracture extends to the proximal half of the ulna.

Ring et al. reviewed their experience with 48 Monteggia fractures with an average follow-up of 6.5 years that were treated with plate fixation or tension-band wiring of the ulna and closed reduction of the radial head (26). According to the Broberg & Morrey system they yielded 38% excellent, 46% good, 4% fair, and 12% poor. Three quarters of the fair and poor outcomes were Bado type II injuries with concomitant fractures of the radial head.

Konrad et al. reviewed their experience with 47 Monteggia fractures with an average follow-up of 8.4 years that were treated with plate fixation or tension-band wiring of the ulna and closed reduction of the radial head (16). According to the Broberg & Morrey system they yielded 47% excellent, 26% good, 19% fair, and 8% poor. The poor outcomes were correlated with Bado Type II, Jupiter Type IIa, radial head, and coronoid fractures. All radial head and coronoid fractures were treated with screw fixation. Their results support the hypothesis that posterior radial head dislocations and the more proximal ulna fracture (Jupiter IIa) might be a poor prognostic indicator. In contrast Bado type I fractures are less common in adults but consistently yielded superior results to Bado type II. Both of these results are consistent with Ring et al's findings.

Anatomic reduction of the radiocapitellar joints and PRUJs are vital to successful treament of this fracture pattern. Bado type II patterns needed to be approached cautiously particularly if associated with a radial head or coronoid fracture. Closed reduction should be limited to patients with significant comorbidities that precludes operative intervention.

NEW DIRECTIONS

Intramedullary fixation

Intramedullary fixation of forearm fractures is an old concept that has recently regained popularity. Although open reduction and plate fixation has well-established success in forearm fracture management, complications secondary to extensive open dissection, disruption of periosteal blood supply, and the risk for re-fracture at the end of the plates exists.

Intramedullary fixation was used routinely prior to open plating techniques for both bones fracture but fell out of favor due to inadequate fracture reduction and failure to restore forearm motion. The first intramedullary nail results were reported by Sage et al. Post operatively the intramedullary nail was protected with a long arm cast for three months (28). A 6.2% non-union rate was reported as well as difficulty in restoring normal forearm motion.

More recently, improved designs for intramedullary nails for forearm fracture has been introduced with precontoured fluted designs and interlocking screws. The-

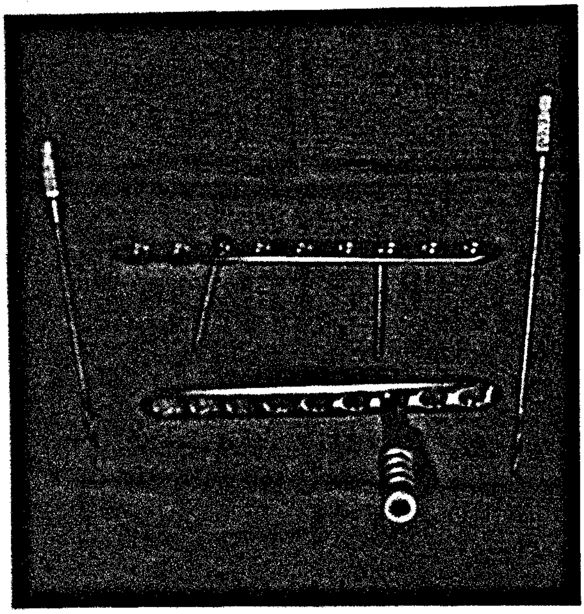

Fig. 3. A fixed trajectory locked plate illustrating a locked screw and guide and non-locking screws.

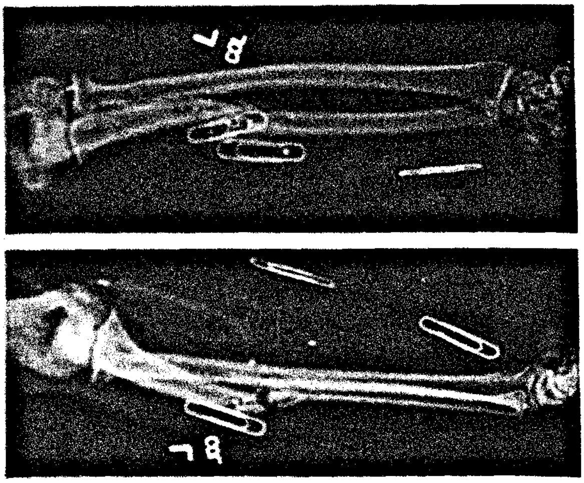

Fig. 4a,b. Anteroposterior and lateral views of an ulna shaft fracture from a gunshot injury with extensive comminution and bone loss.

se newer designs afford better restoration of normal anatomy, particularly radial bow, and fracture rotational control with interlocking screws. Weckbach et al treated 33 forearms with fractures of the radius, ulna, or both bones with a new intramedullary nail and they reported a 97.5% union rate at 4.4 months with an average DASH score of 13.7, and full range of motion restored in 86% of cases (33). Radial bow was maintained by pre-bending of the nail prior to insertion. Lee at al applied precontoured fluted intramedullary nails in 38 patients with either isolated or combined fractures of the radius and ulna (18). All fractures healed within 14 weeks except

Fig. 5a. Placement of non-locking screws in a locking plate. By placing non-locking screws on both ends of the fracture first helps to bring the plate down to bone.

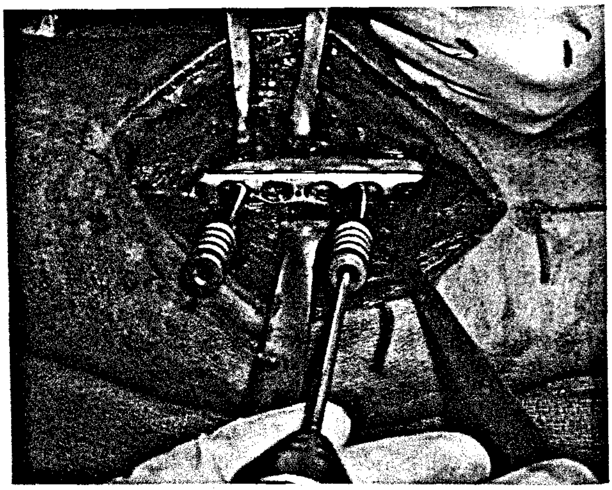

Fig. 5b. Placement of fixed trajectory locking screws through drill guides.

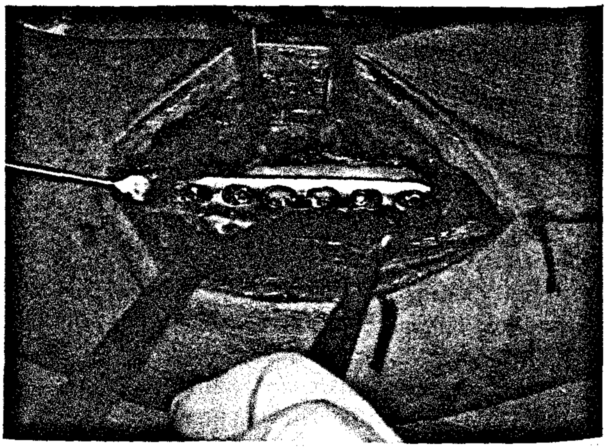

Fig. 5c. Locking plate fixed with a combination of locking and non-locking screws.

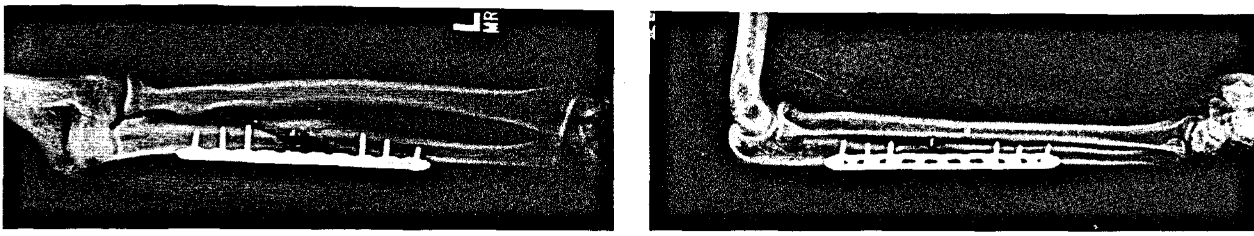

Fig. 6a,b. Anteroposterior and lateral views of an ulna shaft fracture with extensive comminution and bone loss after fixation with a locking plate and screws.

for one nonunion in the case of an open fracture. They achieved 92% good to excellent results with an average DASH score of 15.

Locked plate technology

Locked plating technology has become ubiquitous in orthopaedic fracture management. The first broad application of this technology was with the Less Invasive Stabilization System (LISS; Synthes, Paoli, PA) The LISS system involved a titanium alloy plate and utilized unicortical self drilling, self locking screws placed through an external jig. Improved rates of union were noted for distal femur fractures when compared to traditional plates (35). Today there are two types of locked plate systems, either fixed trajectory (see FIGURE 3) or variable trajectory locking systems.

The earlier designs with fixed trajectory screws promoted unicortical locked screw constructs but yielded proximal plate pull-out with torsion (17). Limitations in screw placement with fixed trajectory screws harkened the development of variable trajectory screws. This design is particularly useful in peri-prosthetic and periarticular fractures where the ability to re-direct screws is critical for adequate fixation. The variable trajectory plates allow angulation of screw placement followed by end-point tightening. These designs rely on hoop stresses and additional interface between the screw head and plate (11). Unfortunately no studies to date compare the strength of either the fixed or variable trajectory construct to the other.

Indications for locked fixation include osteopenic bone, segmental bone loss, or excessive comminution (8, 9). Specific fracture applications with support for its use in the literature includes peri-articular fractures (specifically the distal femur, proximal tibia, proximal humerus, and distal radius), peri-prosthetic fractures, and nonunions (10). Several complications also exist with locking plate technology which include but are not limited to nonunion, malunion, fracture distraction, loss of diaphyseal fixation, and difficulty with hardware removal (10). The cost, estimated to be as much as three times for conventional systems, is also a major concern (10).

Unlike peri-articular fractures of the forearm where the management of fracture fixation has been improved with locking technology, its role in the treatment of shaft fractures of the radius and ulna remains unclear. Fulkerson et al., using a synthetic ulna, compared strength of either conventional or locked plates when place under repetitive axial loads (8). They concluded that the bicortical locked screw configuration was superior to conventional non-locked screws in comminuted osteopenic bone. The use of only unicortical locked screws was not recommended. In contrast, Weiss et al studied the role of locking plate technology in an ulna osteotomy model with a 1 cm residual fracture gap and they did not identify a mechanical advantage with the locked plates (34).

We recommend routine consideration of the use of locking plate technology in the management of peri-articular fractures of the forearm such as with distal radius of olecranon fractures. In the case of radius and ulna shaft fractures, we recommend considering its use in cases with advanced osteopenia, bone loss, and extensive comminution (see FIGURE 4a & 4b). In applying a locked plate the same approaches are utilized as with traditional plates. Locked plates do not require intimate contact between the plate surface and bone. To avoid mal-reduction of the bone and to maximize plate to bone contact, locking plates can be pre-contoured and should initially be fixed with non-locking screws. To avoid deformation of the locked screw sites, contouring is done with all locking guides in place. The placement of non-locking screws first allows for the plate to be pulled down to bone (see FIGURE 5a). This is followed by placement of locking screws (see FIGURE 5b & 5c). Once locking screws are placed further reduction of the plate down to bone cannot be achieved. Lastly, six cortices should still preferably be obtained on both sides of the fracture (see FIGURE 6a & 6b).

ZÁVĚR

Diafyzární zlomeniny předloktí patří mezi běžná poranění. Pro jejich úspěšnou léčbu je důležitá znalost anatomie a funkce radia, ulny, mezikostní membrány a obou radioulnárních kloubů. Diagnóza zlomenin je poměrně snadná na základě klinického a rtg vyšetření. Běžně používané přístupy – volární Henryho, posterolaterální Thompsonův i přímý přístup k ulně zcela dostačují pro provedení osteosyntézy. Existují různé typy diafyzárních zlomenin předloktí včetně izolovaných zlomenin radia a ulny, zlomeniny obou kostí i luxační zlomeniny Galeazziho a Monteggii. Operační léčba vyžaduje zpravidla otevřenou repozici a osteosyntézu pomocí DCP dlah a šroubů. Dostatečnou pozornost je

nutné věnovat i dosažení stabilní repozice obou radioulnárních kloubů. Novými trendy v osteosyntéze diafyzárních zlomenin předloktí jsou zamykací dlahy a nitrodřeňové hřebování.

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Neil R. MACINTYRE, M.D.,
Department of Orthopaedic Surgery
Temple University Hospital,
Philadelphia, Pensilvania, USA

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