An Overview of Distal Radius Fractures

A. Epidemiology
- 600,000 Emergency Department visits per year
- Bimodal Distribution
  - Young men after high energy trauma
  - Older women after low energy falls
- 170 million Medicare cost in 2007

B. Anatomy
- Distal radius articular surface is biconcave and consists of a scaphoid and lunate facet
- Articulates with ulna at sigmoid notch forming distal radioulnar joint (DRUJ)
- Lister’s tubercle- dorsal prominence, landmark for dorsal approach to wrist
- Metaphysis- thin cortex vulnerable to bending forces
- Distal radius bears 80% of axial load in normal wrist

C. Radiographic Analysis
- Wrist series consists of PA, AP, Oblique, and Lateral
- PA View
  - Dorsal rim projects 3 to 5 mm beyond the proximal cortex
  - PA view results in 0.5 mm of radial length
  - Increase in radial inclination, volar tilt, and radial height
- Radiographic Measurements
  - Average radial height 11 mm, inclination 22°, volar tilt 11°
- Lateral View
  - “Teardrop” projects 3 mm palmar from the radial diaphysis
  - 20 degree lateral used to evaluate articular surface
- Oblique views
  - Used to evaluate intra articular extension
  - Hardware penetration

D. Eponyms
- Colles- apex volar
- Smith- apex dorsal
- Barton- volar rim fracture
- Dorsal Barton- dorsal rim fracture
- Chauffeur- radial styloid fracture

E. Classification
- Mostly descriptive
- Over 10 classification systems
- Largely fail to help predict treatment or prognosis but familiarity of classification is useful

Frykman
- Type I- extraarticular
- Type III- enters radiocarpal joint
- Type V- enters radioulnar joint
- Type VII- enters both joints
- Types II, IV, VI, VIII include ulnar styloid fracture

Melone
- Four identifiable parts: radial styloid, shaft, volar medial, dorsal medial
- Type I-IV represent increasingly comminuted fractures of the four anatomic parts
- Type V is an extremely comminuted unstable fracture

Fernandez
- Type I- extra articular
- Type II- shearing injury
- Type III- articular compression
- Type IV- avulsion fracture with radiocarpal fracture dislocation
- Type V- combination fractures of type I-IV

AO
- A: Extra-articular
- B: Partial articular
- C: Intra-articular

AO classification
- A: Extra-articular
- B: Partial articular
- C: Intra-articular

4. Trumble TE et al, editors: Core knowledge in orthopaedics: hand, elbow, and shoulder, Philadelphia, 2006
5. Kozin SH, Berlet AC: Handbook of common orthopaedic fractures, West Chester, PA, 1989, Medical Surveillance
Non Operative Management

A. Description of technique
- Closed reduction and visualization of distal radius by x-ray
- Sugertong splint acutely
- Short arm cast once swelling decreases
- Cast is molded to maintain reduction using ligamentotaxis and hydrostatic pressure
- The cast is placed proximal to the distal palmar crease to allow full MP flexion of the fingers and should not immobilize the thumb in adduction
- Cast is removed after 5 to 7 weeks with radiographic or clinical confirmation of bone healing
- Transitional splint applied for 4 more weeks

B. Indications
- Incomplete fracture
- Nondisplaced complete fractures
- Displaced extra-articular alignment, able to be reduced with acceptable alignment
- If surgery contraindicated

C. Why use technique?
- Noninvasive
- Low cost

D. Complications

<table>
<thead>
<tr>
<th>Common Complications</th>
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<tbody>
<tr>
<td>Re-displacement</td>
</tr>
<tr>
<td>Carpal tunnel syndrome</td>
</tr>
<tr>
<td>Malunion</td>
</tr>
<tr>
<td>Finger stiffness</td>
</tr>
<tr>
<td>EPL rupture</td>
</tr>
</tbody>
</table>

Risk factors for re-displacement/ malunion- why it happens
- Initial dorsal angulation greater than 20°
- Dorsal comminution
- Radiocarpal intra-articular involvement
- Associated ulnar fractures
- Age > 60 years
- Poor reduction or molding

Carpal Tunnel Syndrome
- Hematoma from injury, trauma to nerve, and cast compression increases risk
- Symptoms
  - Decreased sensation, numbness, tingling in median nerve distribution, pain

Prevention
- Wrist immobilization should not exceed 20 degrees flexion
- Prompt reduction of deformity and elevation

Treatment
- Loosen splint, bivalve cast, elevation
- Carpal tunnel release with median nerve neurolysis

Malunion
- Most common complication
- Symptoms
  - Decreased grip strength and Mobility pain
  - Worsened cosmetic appearance

Prevention
- Obtain good reduction, adequate mold on splint, interosseous mold, ligamentotaxis to aid in reduction
- Close monitoring by weekly imaging to understand fracture morphology and stability

Treatment
- Corrective osteotomy +/- distal ulna resection
  - Preformed as soon as possible after diagnosis
  - Closing wedge osteotomy allows direct bone to bone contact, but the ulna must be shortened
  - Opening wedge osteotomy restores radial length and can correct angular deformities in the frontal and sagittal planes
- 83% of malunions treated with corrective osteotomy have good to excellent outcomes

Finger stiffness (extension contracture at MP joints)
- Causes:
  - Immobilization of MP in extension
  - Excessive wrist flexion positioning during immobilization
  - Pain inhibiting patient from doing range of motion exercises
  - Increased risk with age

Prevention
- Cast or splint proximal to palmer crease to allow full flexion of metacarpal phalangeal joints and inter phalangeal joints
- Range of motion exercises started within a week of injury
  - Finger and forearm range of motion exercises
  - Edema control allows flexor tendon pull through

Treatment
- Physiotherapy/occupational therapy
- Tendonys and capsulectomy of MP joints if operative intervention needed

EPL rupture
- Associated with non/minimally displaced fractures
- Intact extensor retinaculum increases incidence
- Associated with hematomas
- Watershed area in which EPL tendon lacks is poorly vascularized

Treatment
- EIP to EPL transfer
Volar Plating

A. Description of technique
- Incision is made overlaying the FCR tendon
- FCR tendon sheath is incised and the FCR is retracted ulnarily
- Pronator is released from the distal radius
- Direct reduction of metaphyseal fracture is performed
- Indirect reduction of articular fracture under fluoroscopy
- Volar locking plate is positioned under fluoroscopic guidance
- Final fluoroscopic images are obtained. The pronator quadratus can be repaired over the top of the plate

B. Indications
- Volar articular shear fracture
- Volarly displaced extra-articular fracture or “Smith fracture.”
- Unstable intra- or extra-articular fractures of the distal radius
- Osteoporotic elderly patients

C. Why use technique?
- Allows direct visualization and reduction of metaphyseal components
- Stable internal fixation
- Good soft tissue coverage
- Early mobilization during the healing period
- Less tendon irritation than dorsal plating
- Indirect reduction of articular fracture under fluoroscopy

D. Complications

<table>
<thead>
<tr>
<th>Major Complications</th>
<th>Minor Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complication</td>
<td>Percentage</td>
</tr>
<tr>
<td>Hardware failure</td>
<td>1.1%</td>
</tr>
<tr>
<td>Deep infection</td>
<td>0.2%</td>
</tr>
<tr>
<td>Tendon rupture</td>
<td>1.7%</td>
</tr>
<tr>
<td>CTS</td>
<td>2.8%</td>
</tr>
<tr>
<td>Removal of hardware</td>
<td>1.9%</td>
</tr>
<tr>
<td>Malunion</td>
<td>0.8%</td>
</tr>
<tr>
<td>Total</td>
<td>7.7%</td>
</tr>
</tbody>
</table>

Must capture volar marginal fragment
- Second generation plates have been extended volar ulnar distal
- Dedicated to volar ulnar escape

Tendon irritation and rupture
- Six fold higher risk of rupture with internal fixation vs non operative
- Causes of extensor tendon rupture:
  - Drill bit penetration
  - Dorsal screw prominence
- Most commonly ruptured tendon is flexor pollicis longus (FPL) tendon
- Plate placement distal to watershed line results in direct plate or screw head contact with deep flexor tendons
- Concurrent steroid use increases rupture risk

Prevention
- Drill to reach the volar cortex- up to but not through cortex
- Uncortical screws or pegs
- Screw lengths need to be 2/3rd of the way from volar to dorsal to be effective. Do not need full length screws unless dorsal rim fragments are unstable
- Do not place plate distal to watershed line
- Cover volar plate with the pronator quadratus muscle to reduce irritation

Carpal Tunnel Syndrome
- Can occur independently of treatment option
- Can be caused by hematoma from injury or trauma deformity
- Symptoms
  - Decreased sensation, numbness and pain in median nerve region

Prevention
- Prophylactic carpal tunnel release- not indicated
- Avoid excessive retraction on median nerve during surgery

Treatment
- Carpal tunnel release
- Loosen splint, avoid excessive extension with splinting

Hardware failure and removal
- More commonly seen in women and overweight patients
- Increased risk when unable to reduce before plate placement

<table>
<thead>
<tr>
<th>Most Common Reasons for Hardware Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complication</td>
</tr>
<tr>
<td>Pain</td>
</tr>
<tr>
<td>Tenosynovitis</td>
</tr>
<tr>
<td>Plate malposition</td>
</tr>
<tr>
<td>Malunion</td>
</tr>
<tr>
<td>Hardware failure</td>
</tr>
<tr>
<td>Infection</td>
</tr>
</tbody>
</table>
Percutaneous Pinning/Non-Spanning Dorsal Plating

Percutaneous Pinning

A. Description of Technique
- Fluoroscopy assisted closed reduction
- Small stab incisions made with blunt dissection down to bone to protect neurovascular structures
- Two to three K-wires inserted across fracture to stabilize segments usually from radial styloid or dorsolateral cortex
- Fluoroscopy confirms pin placement and stability of the fixation

B. Indications
- Segment specific fixation
- Displaced extra-articular fractures
- Displaced radial styloid fractures
- Stabilization required near the physes in skeletally immature patients
- Displaced, unstable intraarticular fractures in which the displaced fragment is large, amenable to being fixed percutaneously

C. Why use technique?
- Low Cost
- Less invasive
- Quick procedure
- Less scar burden
- Minimize risk of early physeal closure for skeletally immature patients

D. Complications

Risk factors for complications:
- Age
- Osteoporosis
- Severely comminuted fractures

Most Common Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>8.0%</td>
</tr>
<tr>
<td>Temporary nerve deficit</td>
<td>7.9%</td>
</tr>
<tr>
<td>Malunion</td>
<td>3.0%</td>
</tr>
<tr>
<td>CRPS</td>
<td>1.7%</td>
</tr>
<tr>
<td>CTS</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Infection
- Infection rate increases with age
- Prophylactic antibiotics do not alter rates of infection because infections tend to occur late in the post-operative period
- Symptoms include redness, erythema, drainage, pain, swelling

Prevention
- Relaxed skin incisions/open pin placement
- Application of dry and sterile dressing for wound care
- Pin site care not shown to make a difference versus no active pin care
- Stabilization of soft tissues to prevent shear
- Most infections are superficial and resolve with K wire removal
- Monitor K wire sites frequently, remove infected wires, stabilize fracture with splint or cast when K wires removed early
- Remove K-wires or pins before 8 weeks

Treatment
- Minor infection with symptoms of slight erythema and tenderness
  - Do not require pin removal
  - Oral antibiotics
- Major infection involving deeper soft tissue
  - Remove pins, IV antibiotics, Incise and debride
  - Monitor with close follow-up and radiographic imaging for osteomyelitis

Nerve Injuries
- Common nerves injured
  - Superficial branch of radial nerve (SBRN)
  - Lateral antebrachial cutaneous nerve
- Delays patient recovery and mobilization
- Four to six nerve branches located in close proximity to the radial styloid
- Nerve sensitivity may be lost or neurona may develop

Prevention of nerve injuries
- Small incision followed by blunt dissection to bone
- Wire insertion between points A and B
- Wire inserted through soft tissue guide

Treatment of nerve injuries
- Observation
- May require surgical intervention for neuromas

Non-Spanning Dorsal Plating

A. Description of Technique
- A 4- to 5 cm incision is made over Lister’s tubercle
- Two techniques may be used - incise third dorsal compartment or elevate two flaps
- Expose fracture site
- Wire insertion between points A and B
- Wire inserted through soft tissue guide

B. Indications
- Dorsal shear fracture patterns
- Dorsally comminuted fracture patterns
- Intercarpal ligament injury
- Dorsal rim fractures
- Radial styloid fractures

C. Why use technique?
- Can evaluated joint surface directly (limitation of volar plating)
- Stable internal fixation
- Early mobilization during the healing period
- Direct visualization of intercarpal ligaments
- Ease of exposure
- Does not require retraction on radial artery and median nerve
- Improved versatility if corrective osteotomies are needed
  - Treatment of nascent malunion with acute osteotomy and use of local callous as bone graft
Non Spanning Dorsal Plating Continued/Spanning Dorsal Plating

D. Risk Factors for complications
- Early studies reported complications as high as 50%
- Early designs associated with 20-30% extensor tendon tenosynovitis and rupture
- Osteoporosis

E. Common Complications
- Incidence of complications higher with dorsal plating than volar plating
- Significantly higher rate of implant removal seen with dorsal plating

Extensor Tenosynovitis
- Associated with:
  - Older designed prominent plates
  - Raised screw heads
  - Inability to contour plate to fit the bone
- Titanium vs. stainless steel is not associated with increased incidence

Prevention
- Use of low profile plates
- Multiple oblique fluoroscopic views recommended in every case to evaluate hardware prominence
- Local tissue interposition flaps to cover dorsal hardware
  - Flaps protect overlying tendons from dorsal plate
  - Protection by elevation of dorsal distal radius periosteum with third and fourth extensor compartments
  - Reapproximation of the periosteum over the dorsal plate
  - Results in decreased incidence of tenosynovitis, tendon adhesions, and tendon rupture
- Cover hardware with extensor retinaculum
  - Split to create ulnar and radial based flaps
  - Increased dorsal wrist pain observed with technique

Treatment
- Removal of plate after fracture healing to prevent tendon rupture commonly resolves symptoms

F. Overall Risk of Complications
- Comparison between dorsal versus volar plating
- Meta-analysis of 12 studies
- Complications consisted of: neuropathy, CTS, tendon rupture, tendon irritation, tenosynovitis, CRPS, screw loosening, infection, loss of reduction, and healing problems
- No significant difference in overall risk of complications between each group

Spanning Dorsal Plating

A. Description of Technique
- Similar to non spanning dorsal plating
- Fixed to 2nd or 3rd metacarpal
- Use 3.5 mm plate

B. Indications
- Used as a salvage technique
- Highly comminuted fractures

C. Why use technique?
- Can evaluated joint surface directly (limitation of volar plating)
- Stable internal fixation
- Direct visualization of intercarpal ligaments
- Ease of exposure
- Does not require retraction on radial artery and median nerve
- Salvage technique needed

D. Risk Factors for complications
- Early studies reported complications as high as 50%
- Early designs associated with 20-30% extensor tendon tenosynovitis and rupture

E. Common Complications and Prevention
- Significantly higher rate of implant removal seen with dorsal plating
- Avoid placing plate over third metacarpal due to entrapment of EPL, extensor retinaculum, extensor brevis longus, and adductor longus
- Plate placement on second metacarpal reduces tendon entrapment
A. Bridging External Fixation
- Initial closed reduction
- Fluoroscopy used to evaluate reduction
- Predrill to avoid heat necrosis
- Two 3 mm proximal pin are introduced into the radial shaft proximal to the zone of injury- inserted under direct visualization
- Two pins inserted in second metacarpal under direct visualization between ERCL and ECRB to protect the radial nerve
- Inserted on radial side to protect the extensor mechanism
- External fixator is tensioned to aid in fracture reduction

B. Indications
- Unstable fracture patterns (Lafontaine criteria)
- Unstable patient
- Need for indirect reduction
- Need for minimal surgical exposure
- Skeletally mature

C. Why use technique?
- Need for early motion
- Less invasive
- Quick procedure

D. Risk factors for complications
- Age
  - Must be skeletally mature
  - Age over 75 increases complications
- Osteoporosis
- Severely comminuted fractures
- Ligamentotaxis cannot elevate depressed articular fragments
- Failure to obtain adequate radiographs due to external fixator

E. Complications

- Most Common Complications
  - Pin Site Infection
  - SBRN Irritation
  - Over Distraction
  - Stiffness
  - RSD

Pin Site Infections
- Incidence of 19-21%
- Prophylactic antibiotics do not alter rates of infection
- Symptoms
  - Redness, erythema, drainage, pain, swelling, tenderness

Prevention
- Application of dry and sterile dressing for wound care
- No benefit to hydrogen peroxide wound care or chlorhexidine impregnated dressings
- Remove k-wires or pins before 8 weeks
- Pre drill to avoid heat necrosis

Treatment
- Minor infection with symptoms of slight discharge and tenderness
  - Do not require pin removal, pins and wound should be cleaned
- Major infection involves soft tissue
  - Antibiotics administered
  - Pins removed if failure of infection to improve
- Osteomyelitis
  - Surgical debridement, irrigation and pin removal
  - Long term antibiotics

Temporary nerve deficit
- Superficial branch of radial nerve (SBRN)- most commonly injured (20%)
- Four to six nerve branches located in close proximity to the radial styloid
- Nerve sensory may be permanent

Prevention
- Small incision followed by blunt dissection to bone to avoid nervous tissue (Limited open technique)
- Ex fix pin between points A and B found to prevent nerve injury in cadaver studies

Treatment
- Observation
- Prevention is best form of treatment

Distraction/ Stiffness
- Associated with bridging external fixation
- Over distraction associated with finger stiffness, worse functional outcomes, worse strength and pain scores
- Distraction causes finger stiffness due to extrinsic tightness
  - Wrist flexion increase tightness of extrinsics
- Stiffness associated with 4 to 8 mm of wrist distraction
- 5 mm of distraction associated with CRPS
- Distraction in a 2: 1 ratio of carpal to midcarpal
- Fingers should flex down to DPC easily

Prevention
- Distraction less than 4 to 8 mm
- Neutral wrist alignment
- Minimize edema and inflammation in order to prevent adhesions
- Non bridging external fixation
- Aggressive OT upon removal of external fixation
- Minimize time to removal of external fixation
Complex Regional Pain Syndrome

A. Background
4%-37% of cases associated with fractures of the distal radius

Early diagnosis and treatment essential for best possible recovery seen in 80%-90% of cases

B. Risk Factors
- Increase pressure under the cast
- Excessive distraction with external fixator
- Smoking
- Female
- Anxiety disorder
- Ages 50-70 years
- High energy trauma
- Severe fracture
- Genetic

*C. Diagnostic Criteria

IASP Criteria (Merskey, 1994)
1) Presence of an initiating noxious event or cause of immobilization.
2) Continuing pain, allodynia or hyperalgesia in which the pain is disproportionate to any known inciting event.
3) Evidence of edema, changes in skin blood flow or abnormal sudomotor activity in the region of pain.
4) This diagnosis is excluded by the existence of other conditions that would otherwise account for the degree of pain and dysfunction.

Modified Criteria (Harden, 2007)
1) Continuing pain, which is disproportionate to any inciting event.
2) The patient must present at least one symptom in each of the following categories and one sign in two or more categories:
   a) Sensory
      i) (allodynia, hyperalalgia, hypoesthesia)
   b) Vasomotor
      i) (temperature or skin color asymmetry)
   c) Sudomotor
      i) (edema, hyper- or hyposudation)
   d) Motor/trophic
      i) (muscle weakness, tremor, changes in hair, skin, nails)

D. Prevention
- Vitamin C fails to demonstrate significance against placebo

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Patients with CRPS</th>
<th>Patients without CRPS</th>
<th>Risk Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zollinger 1999</td>
<td>4</td>
<td>12</td>
<td>4.5 (1.6-12.2)</td>
</tr>
<tr>
<td>Zollinger 2007</td>
<td>8</td>
<td>43</td>
<td>1.8 (0.56-5.92)</td>
</tr>
<tr>
<td>Ekroll 2014</td>
<td>14</td>
<td>19</td>
<td>1.0 (0.45-2.01)</td>
</tr>
</tbody>
</table>

Total (95% CI): 26

Interpretation: Hazard ratio: 0.47, X² = 6.34, df = 2, p = 0.04, f = 0.79

E. Treatment

Multidisciplinary Approach
1) Physical Therapy/Occupational Therapy
2) Pharmacologic Therapy
3) Interventional Therapy

GOAL: Restore active range of motion while minimizing pain and to avoid atrophy and contracture

1) Physical Therapy/Occupational Therapy
- Increase range of motion, flexibility, strength
- Exercises performed below pain threshold
- Utilization of protective devices and maneuvers to minimize guarding, edema, and restore normal use of limb
- Massage, desensitization, isometric muscle work, muscular release, orthosis, active mobilization within non painful range of motion

Mirror Therapy
- Look in mirror and follow movement of healthy limb during exercises
- Significantly improves pain and tactile discrimination in affected limb
- Proprioceptive vibration
- Stimulate proprioceptive pathways using mechanical vibration
- Combined with conventional rehabilitation accelerates functional recovery

2) Pharmacologic Therapy
- Target symptoms

Pharmacologic Outcome

<table>
<thead>
<tr>
<th>Pharmacologic</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticosteroids</td>
<td>Significantly improves symptoms during acute stage abortive therapy, Treat inflammation associated with redness, heat, edema</td>
</tr>
<tr>
<td>Gabapentin</td>
<td>Moderate benefit, some improved sensory deficit</td>
</tr>
</tbody>
</table>

3) Interventional Therapy
- Psychological Therapy
  - Cognitive Behavioral Therapy focused on pain management
  - Benefit for patients with psychiatric history
- Medullary stimulation
  - Implant electrodes in epidural space to stimulate dorsal funiculi
  - Expensive, invasive, high complication rate
  - Last line therapy
- Low level laser + kinesio-therapy
  - Significantly reduced temperature of affected limb
  - Significantly better than interferential + kinesio-therapy
- Interferential current + kinesio-therapy
  - Significantly reduced temperature of affected limb
- Surgery
  - Relieve compression or entrapment of median, ulnar, and radial nerves