Metacarpal and Phalangeal Fractures

Anatomical considerations: The normal MP joint is a diarthrodial, condylar type joint. The joint is stabilized by collateral ligaments which originate on the dorsal aspect of the metacarpal head-neck junction and insert on the volar aspect of the proximal phalanx. The metacarpal head has a greater surface area than the base of the proximal phalanx. The articular surface of the head is convex and has a wider palmar surface. The asymmetry of this surface accounts for the collateral ligaments to be slack in extension and taut in flexion, thus creating stability of the extended digits.
The collaterals are the primary stabilizers against varus, valgus and dorsopalmar stresses. Radial and ulnar deviation is maximized in extension and is decreased with flexion when collateral ligaments become tight.
Another important stabilizer of MP joint is the volar plate, which has a thin origin proximal to the metacarpal neck and becomes thicker distally where it attaches upon the proximal phalanx. The volar plate is the primary stabilizer against hyperextension. The sagital bands of the palmar fascia and tendons of the intrinsic musculature of the hand provide further support.

Pathogenesis of MP fractures: Metacarpal head intraarticular fractures are caused by direct trauma(crush or clenched- fist injury), penetrating injuries or high axial loads that can involve avulsion of the collateral ligaments, including a fracture fragment, fracture of one or both condyles, or shattering of the joint surface into many small-comminuted pieces. Intraarticular fractures of the metacarpal head can also occur following complex dorsal MP dislocations. Intraarticular proximal phalanx base fractures are due to an abduction force from sport injuries or a fall on an outstretched hand.

Epidemiology: Fractures of the metacarpal head are rare and are usually intraarticular. In a study done by Mcelfresh and Dobyns on 103 intraarticular metacarpal head fractures the injury involved the index metacarpal most frequently, presumably because it is a border digit. The incidence of metacarpal fractures peaks between 10-40 years, a time when athletic and industrial exposure is the greatest. Comminuted fractures occur most frequently.

Diagnosis of MP fractures:

Pain
Digit Deformity
X- ray

Nonoperative versus operative management of MP fractures:

In nondisplaced metacarpal head fractures, the injury can be treated with protective splints that hold the MP joint flexed at 50 to 70 degrees for 4 to 6 weeks. Displaced fractures require ORIF with fixation that allows early protected motion. ORIF also is indicated for fractures that involve more than 20% of the articular surface to prevent erosive joint changes and to allow AROM by the third week post fracture.
Comminuted fractures can be treated with closed immobilization in a radial/ulnar gutter splint with the MP joints flexed to 70 degrees to avoid extension contracture. Comminuted fractures

with substantial loss of bone length are better treated with external fixators or bridging plates that maintain bone length. Immobilization will be limited to only 2 to 3 weeks, because early motion benefits articular cartilage repair. Continuous passive motion started in the first postoperative week stimulates both bone and cartilage healing.
Intraarticular proximal phalanx base fractures require accurate reduction to restore normal joint kinematics. MP joint should be positioned in 70 degrees flexion. The PIP and DIP joints, buddy taped to an adjacent digit, are allowed early active motion. After 2 to 3 weeks, or 3 to 4 weeks, depending on callus formation, the splint can be removed for protected ROM at the MP joint. Techniques used for fixation of displaced proximal phalanx base fractures include intraosseous wiring with additional K-wire support, or screw fixation. Protective splinting must rest the MP joint in flexion. When active exercises are initiated to regain full MP flexion, the use of splints holding the wrist, PIP, and DIP joints immobilized during exercise, will facilitate all flexor strength directed towards the MP joint. Continuous passive motion (CPM) following ORIF with rigid fixation is recommended to decrease edema, maintain joint mobility, and stimulate the healing of articular cartilage.

Primary versus secondary bone healing

Primary bone healing: Implants introduced via open reduction internal fixation (ORIF) like screws, wiring and plates that provide absolute stability and compression of the fracture permit primary bone healing. Primary bone healing is direct bone to bone healing without any external callus. Compression across the fracture line eliminates the space-occupying hematoma and reduces the fracture gap. Since the need for peripheral callus to support the bone ends is avoided (the metallic implant is substituted for the callus), the potential problem of tissue adhesions to the callus during immobilization is eliminated too.

Secondary bone healing: Fractures treated by external support (cast, splint, brace, and external fixator) or with coaptive forms of fixation (Pins, K-wires, and interamedullary rods) that reduce the fracture but do not provide compression, must rely on callus formation to bridge the fracture gap. As the callus gains stiffness, the fracture becomes more stable. Excessive, unrestricted motion can overwhelm the fragile support offered by early soft callus, leading to loss of reduction. With secondary healing, ROM exercises are delayed or limited during the first 3 weeks, or until the callus has gained enough tensile strength to tolerate controlled movement.

<u>Complications of MP fractures:</u>
Loss of reduction
Dorsal hand edema
Dorsal skin scar contracture that prevents full fist
MP joint contracted in extension
Adherence of extensor digitorum communis tendon to fracture with limited MP joint flexion
Intrinsic muscle contracture secondary to swelling and immobilization
Dorsal sensory radial/ulnar nerve irritation
Deterioration and potential rupture of extensor tendon
Scissoring/overlapping of digits with flexion
MP joint extension lag
DJD

Postoperative Rehabilitation

Note: the following rehabilitation progression was developed from a publication by Maureen A. Hardey (principles of Metacarpal and Phalangeal fracture Management: A review of Rehabilitation Concept .J Orthop Sports Phys Ther 2004; 34:781-779). Refer to this publication to obtain further information regarding different types of fracture healing, potential problems with MP fractures, goals and rehabilitation interventions.
The progression of motion protocols is depend on the type of fracture healing, either primary or secondary, which in turn is determined by the method of fracture fixation.

Goals of rehabilitation following MP fractures:

Maintain and protect fracture stability for bone healing
Control edema
Introduce soft tissue mobilization for soft tissue integrity
Prevent osseous adhesions to tendons, ligaments, capsules, or skin
Maintain and regain joints ROM while maintaining fracture stability
Regain function and strength of the injured hand

Rehabilitation progression in closed reduction methods (cast, splint, brace, external fixator) or Coaptive fixation (pins, K-wires, intramedullary rods):

Phase 1: week 1-3

Goals: Control pain and edema
Maintain and protect fracture stability
Maintain ROM

Intervention:

- Rice –rest, ice, compression, elevation Rest: Edema is poorly tolerated in the digits due to the limited space. Expanded joints move into the positions that permit maximum stretch of the joint capsule and collateral ligaments. Edema causes “claw hand”. Functional splinting place the hand in a resting position that will avoid this deformed posturing.
- Ice: Ice packs or bags of frozen peas applied volarly and dorsally.
- Compression: Applying Coban elastic self-adhering bandage if possible.
- Elevation: Hand supported in elevation .Eccles showed that the greatest reduction in swelling was obtained with the hand supported in elevation overnight.
- Shoulder and elbow ROM exercise in elevation to facilitate proximal muscle pumping
- Protected ROM exercises during the first three weeks. One week after surgery a removable splint is applied in a” rehabilitation ready” position, which the patient removes for suture/pin site cleaning and perform protected AROM exercises. The callus is considered “clinically stiff” enough for free active motion.

Phase 2: week 4-8

Goals: Control pain and edema
Maintain and regain ROM

Intervention:

- Continue previous edema control measures
- At 4-6 weeks the K-wires and pins are removed, the splint is adjusted for proper fit and worn for continued fracture protection for another 2 weeks. AROM (out of the splint) should be performed to regain full mobility. The callus is considered clinically stiff enough for free active motion, but it is not stable enough to bear a functional load
- Exercises with functional load started at 6-8 weeks
- PROM to regain full joint mobility initiated at 6 weeks (early remodeling phase)
- Dynamic or serial static splints may be initiated after 6-8 weeks to overcome any soft tissue contractures

Phase 3: week 8-16

Goals: Regain function and strength of the injured hand

Intervention:

- Early Strengthening programs with light resistance start at 8 weeks(Late remodeling phase)
- Unrestricted return to sports and heavy work is delayed until after 10 weeks. (Callus remodeling to lamellar bone with increased fracture strength does not occur until this later stage of bone healing).

Rehabilitation progression in rigid fixation (screws, wiring, plates):

Phase 1: week 1-6

Goals: Control pain and edema
Maintain and regain ROM

Intervention:

- Wound or edema control measures once the surgical dressing is removed, usually in 3-5 days
- In polytrauma cases, soft tissue mobilization progress for repaired tendon can begin immediately without fear of displacing the fracture
- Permit early motion for good restoration of function(full AROM is the early goal as the edema diminishes)
- Dynamic splints may be used at 2 weeks for soft tissue stretching
- Passive ROM can be initiated 4 weeks (during repair phase)

Phase 2: week 6-10

Goals: Begin strengthening program
Intervention:

- Early strengthening exercises with light resistance can be initiated at 6 weeks (at the beginning of the remodeling phase)

Phase 3: week 10-16

Goals: regain hand function and strength

Intervention:

- General hand strengthening exercises and functional retraining
- Unrestricted return to sports and heavy work is delayed until after 10 weeks (similar to secondary healing)

Selected references:

Maureen A. Hardy. Principles of Metacarpal and Phalangeal fracture Management: A review of Rehabilitation Concepts. *J Orthop sports Phys Ther 2004; 34:781-799*

Green. Hotchkiss. Pederson. *Green's Operative Hand surgery*. Churchill Livingstone, 1999

Hunter. Mackin. Callahan. Rehabilitation Of The Hand And Upper extremity. St Louis, Mosby, 2002

Rene Cailliet. Hand Pain and Impairment. Philadelphia, F.A Davis, 1994