Traumatic Hand Injuries
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Introduction
The Mutilated Hand – Involves trauma to multiple anatomic systems of the hand resulting in a varied clinical picture.

The systems include:
- Skin
- Vascular
- Tendon and Muscle
- Skeletal
- Nerve

Introduction
Potential Mechanisms of Traumatic Injuries
- motor vehicle accidents
- machinery accidents
- explosions
- gun shots

Goals
The overall goal is to
- regain maximal functional use of the hand
- which is aesthetically acceptable to the patient.
- In the case of amputation with replantation, the hand must function better than a prosthesis.

Common names associated with traumatic or mutilating injuries of the hand
- crush injuries
- degloving injuries
- complete amputations with or without replantation
- partial amputations with or without revascularization

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GOALS for the Traumatic Injury

- ROM - normal as PRACTICAL
- maximal function with minimal pain
- assess what level of function is possible given the extent of the injury
- Pain free and functional is better than pushing to gain a few degrees of ROM while jeopardizing stability, possibly increasing pain, edema, etc.

GOALS

- set reasonable goals and expectations at initial evaluation
  - for yourself
  - with patient
- establish rapport
- Be Accommodating!
- educate patient on "the future"
- nearly every post-op patient with a traumatic injury is a pre-op patient as well

GOALS

- Plan ahead - future surgery is likely so make it part of goals, therapy planning from day one
- maximal PROM is needed prior to likely secondary surgery
- maximize strength of donor muscles prior to tendon transfer; maximize strength of all muscles prior to tenolysis
- normalize movement patterns in hand

Patient Education - signs of infection or vascular insufficiency

- Extreme redness
- Heat
- Sudden increase in pain or swelling
- Very pale or cold skin

Protocols Don’t Work

- There are no “hard and fast” rules
- prioritize precautions and problems
- be as aggressive as able without damaging surgery
- treatment is driven by an understanding of healing, and limited by precautions
- Balance of established treatment guidelines

Patient Education

- Educate patient on the importance of reducing or eliminating the use of tobacco products and caffeinated drinks or foods. It is essential for the patient that has had microvascular reconstruction.
Overview/Considerations

- Home programs should be well structured and easy for the patient to follow.
- The patient should demonstrate complete understanding before he or she leaves the clinic.
- Educate patient in *movement of all uninjured joints*.
- Educate patient and family for better compliance and follow through.

Overview/Considerations

- Healing generally occurs in three phases
  - **Acute**
    - (inflammatory phase)
    - from injury onset to approximately three weeks post op
    - Primarily focuses on immobilization, protection, pain, edema, scar, moving uninvolved joints, home program

Overview/Considerations

- **Intermediate**
  - from approximately three weeks to eight weeks post op
  - mobilization, A/AA/PROM, upgrade HEP
  - (proliferative, fibroplasia)

- **Late**
  - from eight weeks on
  - strengthening, moving to “full go”
  - (remodeling)

Multiple System Chart Review

- Directs the course of treatment
- When multiple systems are involved, the goals of treatment must protect repaired structures according to their individual healing time frame with respect to current status and precautions
- Think “systems” instead of protocols
- Each system has different treatments, precautions, considerations

Multiple System Chart Review

- Even though healing occurs in a continuum of phases, in the complex injury, each system may be in a different phase of healing and require different treatments. You will probably be treating a “mixed bag” of injuries
- Phases may also be prolonged beyond “normal” timelines

Getting the Right Information

- Chart or Operative Note Review.
- Diagnosis (specific!)
  - what was disrupted, type/mechanism of the injury
  - how was it “fixed”
  - what wasn’t fixed
  - treatment to this point
Questions

- What can we move?
- How much can we move it in each direction?
- Does risk of moving outweigh risk of immobilizing?
- What was repaired? And anything not repaired?

Systems Review

- Skin/Wound/Scar:
  - skin loss
  - type of closure/coverage
  - open wounds/fasciectomies

- Vascular
  - vessels repaired or not repaired
    - Often only one digital artery repaired in complex injuries
  - any tension on these structures
  - vascular patency

- Tendon:
  - repairs, implants (tendon rods)
  - tension on repairs
  - balance of repairs (extension vs. flexion)
  - tendon quality
  - suture type and technique

- Skeletal
  - fractures, osteotomies, joint implants
  - type of fixation
  - skeletal shortening will affect muscle and tendon function
  - stable or unstable fracture - unstable fractures will limit mobilization activities whereas stable fractures will allow for more aggressive therapeutic management
  - fixation type/location may impede movement
**Systems Review**

- Nerve:
  - Damage to peripheral nerve will result in sensory, motor and sympathetic fiber loss
  - Note repairs, type of repair
  - Tension to repair
    - Orthosis position

**Skin/Wound/Scar - General Principles**

- Wounds heal along a continuum
- Most information on wound healing describes the clean, tidy and uncomplicated wound.
- Wounds typically seen with mutilating injuries are often untidy wounds, complicated by extensive soft tissue and skin loss, and possibly also contaminated.
- They may heal along “different” timelines from “normal” wounds

**Inflammatory Phase**

- Often prolonged.
- *Edema may be extensive* due to significant soft tissue loss and damage to the lymphatic and superficial veins located in the dorsum of the hand.
- Epithelialization can be prolonged secondary to extensive skin loss

**Fibroplasia**

- The body heals all injured structures in the same manner, resulting in *“one wound with one scar”*
- Many structures may become adherent in the same scar
- Extensive scarring, soft tissue loss, and edema lead to joint fibrosis and tendon tightness.
- Therapy during this phase is important to control edema and scar formation, and minimize stiffness.

**Maturation or Remodeling Phase**

- During the maturation phase collagen lysis equals collagen synthesis.
- It is during this phase that we must work vigorously to *reorient the collagen fibers* in dense, disorganized scar tissue to allow functional range of motion.
- Many techniques are used to elongate scar adhesions that restrict motion and tendon gliding.

**Evaluation: Skin/ Wound/ Scar - Acute Phase**

- General Information
  - Location
  - Is there skin loss, type of closure/coverage
  - Open wounds/fasciectomies
  - Measurements: width, length, shape, and depth
  - Color
    - Black, yellow, red
  - Status of surrounding tissue
Evaluation: **Skin/Wound/Scar - Acute Phase**

- Exudate characteristics
  * color, odor, consistency (viscosity)
- Wound Bed Characteristics
  * necrotic tissue
  * granulation tissue
  * epithelial budding
  * vital structures exposed

Evaluation of the **Wound**

- Presence of Grafts and Flaps
  * adherence
  * drainage
  * vascularity
  * Viability
    * Dusky, gray suggests restricted arterial flow
    * Purplish indicates restricted venous outflow
- Signs of infection: redness, warmth, pain, edema, drainage, odor

**Skin/Wound/Scar Treatment - Early phase**

- Patient may have several wounds in various stages of healing
- Dressings:
  - The purpose is to maintain a clean environment, prevent contamination, and minimize mechanical stress until extensive skin and soft tissue wounds heal.

**Wound Management**

- Dressings should be applied from distal to proximal and should not be constrictive.
- Initially, dressings should be changed daily to observe wounds. If skin is macerated, dressing changes may be more frequent.
- Wounds with well approximated margins may only require light, dry dressings.

**Wound Management**

- If patient has external hardware such as K-wires or external fixators, patient should be instructed to perform pin care and monitor pin sites for signs of infection.

**Wound Management**

- Wound care should ideally be performed in a neutral temperature room, away from vents.
  * Keep in mind that the revascularized hand is very sensitive to temperature change.
- Bandages should be carefully removed to avoid shearing forces on healing tissues, especially if grafts and flaps are present.
Whirlpools Guidelines

- Whirlpools may be contraindicated with complex injuries due to many precautions such as:
  - dependent positioning
  - unstable fractures
  - soft tissue damage such as tendon repairs
  - loss of sensation

- Temperature must be closely monitored or it may compromise the vascularity:
  - too cold may cause vasospasms
  - too warm may increase edema
  - shock of temperature changes may affect vascular status when removing the hand from water to room temperature

- Whirlpools may be utilized for cleansing and debridement of superficial necrotic tissue.

Whirlpools

- Mechanical effects of agitation may stimulate granulation tissue, soften necrotic tissue and increase circulation.
- Preferred temperature is 94 degrees F, with the hand and forearm in an anti-gravity position.
- Following the whirlpool, the hand should be placed under running tap water to remove surface contaminants.

Wound care - other options

- General debridement may be performed via pulsed lavage
- Selective debridement may be performed by hand with scissors and forceps.
- Autolytic debridement and debriding enzymes may be used to clean a wound

Skin/Wound/Scar Evaluation and Treatment - Intermediate Phase

- Continue to monitor wound status and response to treatment
  - If open wounds or external hardware still present, continue to monitor for signs of infection
  - Continue wound care as indicated
    - Wounds should be smaller, less bandage should be necessary, pin care required if external hardware

Scar Management may generally begin 24 hours following suture removal

- Transverse Friction Massage
- Continuous Pressure Garments
- Compression tubes, sleeves, bandages, or gloves
- Scar Molds
- Prosthetic foam
- Gel sheeting
Stump care

- Performed with complete amputations or fingertip injuries
- Stump wrapping for shaping and edema control
- Desensitization for stump hypersensitivity including massage, textures, vibration, particle immersion

Skin/Scar Treatment - Late Phase

- Same as intermediate phase, but if no improvement noted, consider changes in treatment plan.
- Scar management techniques should be vigorous, with longer periods of scar and retrograde massage
- Scar molds, gel sheets, pressure pads applied with continuous pressure

Edema

- Increased edema causes
  - Increased resistance with AROM (relevant with early ROM)
  - Leads to increased fibrosis and scar formation

Edema/Vascular Treatment - Acute Phase

- Elevation
  - The hand should be elevated slightly above heart level at all times except in the case of vessel repairs.
  - In these cases, the hand should be positioned at the same level as the heart to avoid stress on either the venous or arterial systems.

Edema/Vascular Treatment - Acute Phase

- Compression (after blood supply is well established)
  - Garments: elastic bandage, coban®, isotoner® or jobst® glove
  - Vasopneumatic compression may be considered
  - Compression is contraindicated with vessel repairs for the first 6 weeks post-op

Edema/Vascular Treatment - Acute Phase

- Active exercise
  - Motion usually limited due to pain and edema, therefore adjunct therapy to reduce pain and edema should facilitate active motion.
  - May be limited due to contraindication for movement of involved structures
Edema/Vascular Treatment - Acute Phase

- Thermal Agents (if used before 8 weeks, must be with caution and extra insulation)
- Cryotherapy applied with hand positioned in elevation
- Heat is not commonly used during the initial stages of acute management.
  * the area is insensate
  * the lymphatic system cannot dissipate heat effectively thus causing burns.
- Manual Edema Mobilization

Edema/Vascular Evaluation and Treatment - Intermediate to Late Phase

- Edema is usually less of a problem in this phase
- Monitor for signs of acute inflammation due to increased therapeutic exercise, functional overuse or vigorous exercise

Edema/Vascular Evaluation and Treatment - Intermediate to Late Phase

- More vigorous Techniques
- Compression garments should not restrict functional use or exercise
- Retrograde massage or manual edema mobilization
- Vasopneumatic compression devices
- Active exercise, especially in elevation
- Continue with caution for 6 weeks after vessel repairs

Sensibility/Nerve/Pain Evaluation

- Nerve:
  * damage to peripheral nerve will result in sensory, motor and sympathetic fiber loss
- Specific Assessment
  * more appropriate after wounds heal and edema decreases
  * pain and edema may alter sensibility status

Sensibility/Nerve/Pain Evaluation

- Pain Evaluation
  0-10 scale
  visual analog pain scale
  body pain diagram
  quality of pain: sharp/dull, burning, etc.
- Pain Management
  * thermal and electrical agents have limited use in the early phase due to precautions for sensibility and vascular compromise - please refer to the modalities chapter for more information
  * Thermal Agents
    - Heat discouraged during acute phase
    - Cold may provide analgesia and control edema with hand elevated above heart level
    - Contraindications if autonomic efferent function is impaired

Sensibility

- At 6-8 weeks post-injury, formal sensibility examinations will reveal status of nerve damage to cutaneous tissue and signs of nerve regeneration
  * Monthly evaluations performed to assess for the return of protective sensation.
  * Begin sensory re-education upon return of protective sensation
  * If protective sensation is not returned, patient must be aware of potential hazards in daily use
**Pain Treatment – Intermediate Phase**

- Physical Agents
  - Heat and cold can produce an analgesic effect and may also reduce residual edema
  - Thermal agents may still be contraindicated if protective sensation is not evident.
  - Contraindicated if repaired vessels or nerves for ~ 8 weeks
  - Electrical Stimulation

**Desensitization techniques**

- Texture
- Vibration
- Massage
- Fluidotherapy
- Particle immersion

**Mirror Box**

**RANGE OF MOTION Evaluation – Early Phase**

- Evaluate Non-involved proximal joints and any uninvolved joints of the involved hand
  - shoulder
  - elbow
  - wrist and forearm
- Check non-involved hand for comparison
- Measure involved joints of the hand only as permitted, depending on damage to structures that cross the joint

**Flexors/Extensors: Tendon Repair: ROM - EARLY**

- With replant, or if both are lacerated, protect flexors over extensors
- Maintain balance between flexors and extensors along the length of the muscle-tendon unit
- Essential to begin some gliding ASAP to manage scar formation, enhance tendon healing, reduce edema

**RANGE OF MOTION Evaluation – Intermediate Phase**

- Considerations
  - Precautions are governed by the restrictions of all systems
  - Note response to treatment
  - Pay particular attention to developing contractures
RANGE OF MOTION Evaluation
- Intermediate Phase

- Joint Contracture, capsule tightness - check A/PROM
- Adhesions - suggested if PROM>AROM
- Weakness - cannot move actively, check place and hold
- Self limited by pain

RANGE OF MOTION and ADL Evaluation and Treatment - Intermediate Phase
- Function and Purposeful Activity
  - Encourage functional independence without risk to repaired structures
  - Light prehension activities
  - Use of adaptive equipment
  - One-handed techniques

RANGE OF MOTION and ADL Evaluation
- Intermediate Phase

- Differential diagnosis to determine the cause of restricted motion will dictate course of treatment such as splinting, and therapeutic exercise
  - Intrinsic Tightness
  - Extrinsic Flexor or Extensor Tightness
  - Oblique Retinacular Ligament Tightness

RANGE OF MOTION and ADL Treatment - Intermediate Phase
- Therapeutic exercise
  - Precautions for healing structures still apply
  - Tendon gliding exercises initiated at approximately 4 weeks post-op, if skeletal structures are stable
  - Composite motion initiated for digital flexion and extension

RANGE OF MOTION and ADL Treatment - Intermediate Phase
- Passive stretching exercises in opposite direction of normal action of injured tendon permitted at about 6 weeks post-op
- At 4-6 weeks post-op, full PIP flexion permitted with digital replant; minimizes risk for attenuation of central slip of extensor mechanism

RANGE OF MOTION and ADL Treatment - Intermediate Phase
- Initiate non-resistive functional grasp and prehension activities as soon as able to encourage normalization of movement patterns
**RANGE OF MOTION and ADL Evaluation and Treatment – Late Phase**

- There should no longer be any precautions to motion in this phase.
- Differential diagnosis to determine the cause of restricted motion is essential.
- ROM assessment will continue to direct course of splinting and therapeutic exercise.

**Strengthening and Aerobic Exercise**

- Grip evaluation may still be contraindicated.
- Manual muscle testing may be performed to determine extent of nerve involvement.
- Light resistive exercises initiated when cleared by MD and when healing structures can tolerate applied tension (usually between 6-8 weeks).

**Exercise**

- Isometric resistive gripping exercise at multiple angles to enhance tendon gliding.
- Strengthening for involved hand as tolerated. Continue strengthening as indicated for non-involved joints or extremities.
- Aerobic exercise to return to work and overcome deconditioning.

**Emphasis on functional strength, endurance, and dexterity.**

- A Functional Capacity Evaluation may be performed to assess patient’s ability to return to work or establish the need for alternative work.
- Purposeful Activity
- Work simulation, conditioning.
**Strengthening**
- Training for specific ADL problems
- Return to work Issues
- Patient may not be able to return to previous job
  - Vocational training
  - Disability and impairment ratings

**Patient may return to previous job with modifications**
- Modified tools
- Protective gloves
- Limitations to cold (due to intolerance)
- Considerations for hypersensitivity
- Limited exposure to vibration

**Orthoses**
- Static orthoses provide
  - rest
  - support
  - protection
  - position to prevent deformity
- Protected position orthosis
  - Dorsal block orthoses are often used with replants, flexor tendon repairs and nerve repairs
  - For a full hand replant, include protection over thumb

**Orthoses**
- The goals of existing orthoses should be continually re-evaluated to determine if they are still indicated
- Static orthoses - indicated for support, protection, or to minimize potential developing contractures

**Static Progressive or Dynamic Orthoses**
- May be initiated once healing structures have enough tensile strength to tolerate applied forces
- Often needed to address PIP flexion/extension, MP extension, and 1st web space contractures

**Management in the Late Phase**
- (8 weeks or more)
- Orthoses
  - Apply low-load prolonged stress to tissues contributing to loss of motion
  - Provide support or improve functional use of hand such as anti-claw orthosis or opponens orthosis
Early Protective Motion
(EPM, Silverman, JHT 2:2, 1989)

- Rationale for Early Protected Motion (EPM) Protocol
  - differential glide of tendons
  - movement of joints
  - protection to hand from composite motion which may disrupt repairs
  - to give enough tendon gliding without tension to prevent adhesions

Early Protective Motion I

- begin 4-14 days post op (or 24 hours after pt is off anticoagulants)
- Fit orthosis with wrist neutral to slight flexion, fingers in maximum MP flexion and IP extension

EPM I: controlled active tenodesis

- Patient actively flexes the wrist, therapist may assist - the digital joints will go into extension

EPM I - First phase

- Patient actively extends the wrist to neutral - the digits will go into flexion with the assistance of gravity and therapist applying light pressure into flexion
EPM I

- Modify if
  - MP’s tight & severely limited by edema, joint stiffness, or bony fixation
  - structures repaired under tension
  - ROM in uninvolved digits ok if they do not stress vascular or tendon repairs
- AROM to all proximal joints
- 4-6x/day

EPM II (passive intrinsic minus)

- Begin at 7-14 days after replant
- Continue EPM I
- With wrist held in neutral, therapist performs passive intrinsic plus “table top” fists and intrinsic minus “hook”, to enhance differential gliding of FDS/FDP

EPM II (passive phase)

- ROM depends on level and structures repaired
- until 4-6 weeks post op, PIPs are limited to 60 degrees of flexion or less to prevent attenuation of the central slip
  - dependent on edema, amount of extensor tendon tissue loss, location of vascular repairs

EPM II (active phase)

- Same as EPM II passive phase, but patient progresses to place and hold, and then to full active
- Therapists may perform active assisted motion
- Initiated at ~14-21 days post op
- Add active gliding, isolated superficialis exercise
- Strengthen lumbricals and interossei in intrinsic plus position

EPM II (active phase)

- 4-5 weeks post: begin gradual wrist extension past neutral with digits flexed
- 4-6 weeks post: begin full composite flexion and extension (depends on tightness)
- Add NMES as indicated for adhesions
- Passive stretch
- Blocking exercises
- Light functional exercises

Conclusions

- There are not any specific protocols for therapeutic management of the mutilated hand
- Each component of the injury needs to be considered during the evaluation and treatment planning
- Therapeutic interventions must be considered in the total picture of the complex injury
### Conclusions
- Psychosocial needs can not be ignored.
- Communication with all team members is essential.
- Therapist must have knowledge of normal and pathologic healing of all injured tissues.
- Remember reconstruction is essentially a salvage procedure to restore hand function, therefore therapeutic intervention should emphasize restoration of maximum function.

### End Result
- Return to function after a complex hand injury is the result of the collaborative effort among the treating physician, the therapist, and the patient.

### Questions
- This one was on “an EXAM” and tends to resurface often!!!!!!
- After a vascular repair (replant), what should your instructions be regarding elevation for edema control??

### Answer
- Heart level only - (above heart stresses the venous and / or arterial vessels)

### Questions
- What are your general responsibilities in the acute phase??

### Answer
- Wound care
- Protection
- Edema control
- Movement of uninvolved structures
- Patient education
### Question
- Describe the appropriate diagnosis and indications for use of the EPM protocol
- What are some components of EPM I?
- EPM II?

### Answer
- Replant
- Stable fixation
- Clean injury
- Components –
  - EPM I – Dorsal Block, Controlled Active Tenodesis
  - EPM II – passive – Modified intrinsic (-) hook position – PIP limit to 60
  - EPM II – Active – progression to wrist ext past neutral and full fist