COMPLEX UPPER EXTREMITY INJURIES WITH EXTENSOR INVOLVEMENT

6TH ANNUAL MEETING:
HAND THERAPY ASSOCIATION OF NORTHERN CALIFORNIA

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DISCLOSURES:

I have no personal or financial interest in the products contained within this presentation.

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GOALS & OBJECTIVES:

• To review reconstructive principles in the context of upper extremity trauma with a focus on extensor injuries

• To provide a framework for integrating reconstruction of the upper extremity.

• To present a surgical perspective with respect to understanding and planning soft tissue injury.
HISTORY:

• Sterling Bunnell MD

  – Trained as a General Surgeon & served in the US Army in WWI

  – Particular interest in extremity injuries

  – Taught integrated upper extremity surgery throughout the US, establishing centers for hand reconstruction
HISTORY:

- Harry J. Buncke MD
  - Plastic Surgeon
  - Pioneering in microvascular repair (<1mm vessels)
  - Revolutionized the ability of extremity surgeons to salvage and reconstruct injured extremities.
HISTORY:

• **Robert Danis MD**
  - General Surgeon
  - Developed the concept of internal osteosynthesis

• **Maurice Muller MD**
  - Orthopaedic Surgeon
  - Brought internal fixation into the clinical realm
  - Rarely the limiting component in extremity reconstruction
PERSPECTIVE:

- Linked by:
  - Osseous Foundation

- Enveloped by:
  - Soft Tissue

- Powered by:
  - Musculotendinous Units

- Osseous Foundation

- Mobile Articulations
PERSPECTIVE: COMPLEX INJURIES

• Injuries that involve multiple types

• As a whole, injuries to the Upper Extremity are not isolated to a single structure or tissue type.
PERSPECTIVE:

How Do I Think About these Complex Injuries?

- **Simple Answer** is *Tissue Type by Tissue Type, Inside to Out*
  - What is the ideal scenario?
  - Is there anything about the injury that would force me to choose another option?
  - What is my plan for the future?

- **Tissue Types (Role)**
  - Bone / Ligament (Fixed Components)
  - Muscle / Tendon (Mobile Components)
  - Neurovascular (Essential Input)
  - Skin (Cover)
How Do I Think About these Complex Injuries?

• **Basic Rules:**

  1. *Preserve critical tissues (i.e., those that are difficult to replace)* so long as they are viable. All nonviable tissue must go.

  2. *Fix stable components before mobile components*

  3. *Any fixation/repair is inconsequential without provision for soft tissue cover.*
OSSEOUS FIXATION
OSSEOUS FIXATION:
OSSEOUS FIXATION:

- **Goal:** To obtain fixation sufficient to attain osseous union and, if possible, to allow for early mobilization.

  - Percutaneous Fixation
  - Intramedullary Fixation
  - Extramedullary Fixation
OSSEOUS RECONSTRUCTIVE LADDER:

- Increasing order of complexity to treatment of bony injuries

- Must have justification for performing something more complex

- Considerations:
  - Time
  - Bone Quality
  - Rehabilitation Demands
TIMING OF DEFINITIVE OSSEOUS FIXATION

• As soon as wound is amenable

• Clean Injuries:
  – Fixation at time of initial management

• Contaminated Injuries:
  – Provisional Fixation
  – Definitive Fixation at time of wound closure

• Infected Injuries:
  – Provisional Fixation, Abx Beads
  – 6 weeks to 3 months
CLEAN INJURY

- **Saw Injuries**
- **Non-contaminated open fractures**
- **Must be able to reliably close wound following fixation**
CONTAMINATED INJURY

- MVC
- Farming Accidents
- Industrial Accidents
Fix & Flap: The Radical Orthopaedic and Plastic Treatment of Severe Open Fractures of the Tibia. JBJS 2000

Authors: Gopal S, Majumder S, Batchelor AG, et al.

84 pts with Gustilo IIIB tibial fractures

<table>
<thead>
<tr>
<th></th>
<th>Internal Fixation (N=65)</th>
<th>External Fixation (N=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonunion</td>
<td>0</td>
<td>5%</td>
</tr>
<tr>
<td>Infection</td>
<td>9.5%</td>
<td>37% (10%)</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>
CONTAMINATED INJURY

The Role of Early Internal Fixation in the Management of Open Fractures

Authors: Chapman MW, Mahoney M. Clin Orthop & Related Research

101 patients with open femur fractures

- Clean Wounds: 1.9% rate of infection

- Contaminated Wounds: 8% rate of infection (1% osteomyelitis)
  - Comparable rate of infection with external fixation
SOFT TISSUE RECONSTRUCTION
SOFT TISSUE RECONSTRUCTION

- **Goal:**
  - *Favorable Environment for Healing*
    - Prevent Desiccation
    - Minimize Risk of Infection
    - Provide Blood Supply
  - *Durable/ Stable*
  - *Supple to allow for unrestricted motion*
FLAP VS. GRAFT:

**Graft:**
- Tissue of any composition that may be transferred from a donor site to a recipient site without an intact blood supply
  - Survival dependent on wound bed
  - Examples: skin graft, tendon graft, bone graft.

**Flap:**
- Tissue of any composition that may be transferred from a donor site to a recipient site with an intact blood supply
  - Survival independent of wound bed
  - Used to cover structures that are not amenable to grafting.
  - Examples: Pedicled and Free Flaps
TISSUE SURVIVAL:
ANGIOSOMES:

- 3-Dimensional Anatomic units of tissue (skin, subcutaneous tissue, fascia, muscle and bone) fed by a source artery.

- Analogous to organ perfusion throughout the body
  - SMA: Small Intestine
  - Renal Artery: Kidney
CUSTOMIZING SOFT TISSUE RECONSTRUCTION
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EXTENSOR
RECONSTRUCTION
EXTENSOR RECONSTRUCTION:

• **Goal:** To restore integrity to the extensor mechanism while preserving appropriate biomechanics

• **2 Keys:**
  1. Re-establish continuity
  2. Re-establish appropriate length

• **Options:**
  – Direct Tendon Repair
  – Tendon Grafting
  – Tendon Transfer
EXTENSOR RECONSTRUCTION:

• Direct Tendon Repair
  (1° Repair)

• Requirements:
  – High Tensile Strength
  – Low Rate of Rupture
  – Minimal Tendon Shortening
EXTENSOR RECONSTRUCTION:

• **Tendon Grafting**

• **Necessary when there has been tendon loss**

• **Donors:**
  – Palmaris Longus
  – Plantaris
  – Toe Extensors
  – Split FCR
EXTENSOR RECONSTRUCTION:

• **Tendon Transfers**
  – Repurposing an expendable musculotendinous unit

• **Requirements:**
  – Adequate Donor Power
  – Similar Excursion of Donor and Recipient Muscles
  – Function in Phase
    • Wrist flexion / finger extension
    • Finger extension / thumb extension
SECONDARY SURGERY
TENOLYSIS

**Extensor Tenolysis**

- **Indication:**
  - Restricted active and passive motion
  - Dorsal “tether”

- **Timing:**
  - 4 months post primary repair
    - Sufficient strength
    - Collagen remodeling

**Flexor Tenolysis**

- **Indication:**
  - AROM < PROM
  - Deficit of flexor “pull through”

- **Timing**
  - 6 months
    - Must have achieved full passive motion
EXTENSOR TENOLYSIS: INDICATIONS

- Limitation of full passive flexion
- Lack of active extension with full passive extension
EXTENSOR TENOLYSIS

• **Must Preserve**
  - Radial Sagittal Band
  - Central Slip Insertion
  - Terminal Insertion

• **May Sacrifice**
  - Ulnar Sagittal Band
  - Lumbrical Tendon
  - Accessory Collateral Ligaments
  - +/- Proper Collateral Ligaments
EXTENSOR TENOLYSIS

Limited Active Motion

Long Finger Passive Motion

Index Finger Passive Motion
EXTENSOR TENOLYSIS
EXTENSOR TENOLYSIS: TECHNICAL TIPS

- Plan incision one joint proximal and distal to suspected location of adhesion
- Carve out the normal anatomic structures sharply
- Perform intra-op Bunnel Intrinsic Tightness test.
- Release MCP collateral ligament through the sagittal band
- Sequentially release the PIP joint proper, and if necessary accessory collateral ligaments
- Do not leave the OR without full passive flexion

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COMPLICATIONS OF EXTENSOR TENOLYSIS

• **Extensor Attenuation**
  - Address post flexor tenolysis
  - Shorten
  - Rehab with relative motion extension splint

• **Extensor Tendon Rupture**
  - Immediate Repair +/- Graft

• **Insufficiency of radial sagittal band**
  - Reconstruct with extensor slip

• **Nonunion**
  - Revisional Fixation
CLINICAL CASES:
CLINICAL CASES: CASE 1

Tendon Grafting
CASE 1: TENDON GRAFTING
CASE 1:  TENDON GRAFTING

- 6cm palmaris tendon graft
- Distal insertion into central slip
- Pulley / Sagittal Band Reconstruction
CASE 1: TENDON GRAFTING
CLINICAL CASES: CASE 2

Tendon Transfer
CASE 2: TENDON TRANSFER
CASE 2: TENDON TRANSFER
CASE 2: TENDON TRANSFER

FCR to EDC

ECU to ECRB
CASE 2: TENDON TRANSFER
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Complex hand trauma involving the extensor mechanism should be treated with consideration given to the osseous fixation, soft tissue reconstruction and ultimately rehabilitation.

The extensor mechanism may be reconstructed primarily (if no tendon loss) or with tendon grafting or tendon transfer.

Key Considerations include:
- Restoration of continuity
- Restoration of appropriate functional length
- Balance
THANK YOU