Management of Hand Stiffness s/p Burn
Scott Dewey, PT, CHT
Chief, Rehabilitation Services
Army Burn Center
U.S. Army Institute of Surgical Research

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Prevention vs. Mitigation
- What should be considered in order to prevent contractures following a burn?
- Mitigation can be challenging, particularly when compounded by hand anatomy complexity
- Wound healing, cutaneous and non-cutaneous factors should all be considered

Disclaimer

Objectives
- Explain the relationship between the wound healing process and contracture risk
- Identify cutaneous and scar implications affecting range of motion (ROM)
- Differentiate other soft tissue factors that could impair ROM
- Define pertinent biomechanical principles related to rehabilitation
- Understand considerations for post skin graft mobilization

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Fascia / Muscle / Tendon / Bone

**Burn Classification**

- Superficial/Epidermal
- Superficial Partial - Thickness
- Deep Partial - Thickness
- Full Thickness

**Wound Healing Implications**

- **Superficial Partial - Thickness**
  - Heals by Re-epithelialization (regeneration)
  - Less of a rehabilitation concern
    - no risk of scar contracture or hypertrophy with epidermal wound healing

- **Deep Partial - Thickness**
  - Heals by contraction & scar (repair)
  - Huge rehabilitation concern
    - high risk of scar contracture and hypertrophy with dermal wound healing

*Richard/Staley, Burn Care and Rehabilitation, 1994*
Wound Healing Implications

Wound orientation also has an influence on scar formation

Langer’s Lines: denote lines of normal skin resting tension
- Parallel – less risk for scarring
- Perpendicular – more risk for scarring

Cutaneous Considerations

Cutaneous Functional Units (CFU)
- Fields of skin that are involved in ROM
- Skin is recruited serially as ROM increases
  - most movement occurs closest to the skin crease overlying the joint
  - skin is recruited far beyond the joint itself
- Clinical Implications
  - Skin is recruited from the CFU proximal to the skin crease overlying the moving joint
  - Skin movement occurs in the direction of motion
  - Distal aspect of CFU demonstrates the most recruitment
  - Potential for increased contracture risk if distal portion of CFU is involved
  - Contracture risk regardless of skin crease involvement

Distal CFU
3.80 mm

Mid CFU
2.25 mm
• Metacarpophalangeal (MCP) vs composite flexion
  – In uncompromised skin, there is no difference in recruitment of dorsal hand skin (excluding fingers)
  – Likely due to reservoir of skin located over the interphalangeal (IP) joints (separate CFU)

• Location is key: CFU Comparison of 20% Total Body Surface Area Burn

Cutaneous Functional Units

Soft Tissue Differentiation

Both active and passive ROM should be assessed to determine involved tissue

General Guidelines
• Passive deficit: tissue shortening (“soft tissue issue”)
• Active deficit (passive normal)
  – tendon adherence suspected
  – no tendon rupture or neuropathy

• Thorough assessment is key for determining cause of restriction
• Assess ROM of affected areas in multiple positions to determine presence of joint, tendon, muscle, or skin/scar tightness
  – Target tissue placed on slack and then on tension
  – Compare measurements

ROM Assessment

Scar Tightness

• Scar tightness is initial limitation s/p burn
  – May also be limited by pain and/or edema
  – CFU involvement must be considered

  Example: Dorsal hand scar tightness

  Target tissue on slack
  Target tissue on tension

Joint measurements were compared in isolated vs. composite position. ROM was significantly less measured compositely (p<0.0001). JBCR, 2017 – publication pending
We must also think “beyond the scar”
• If skin/scar tightness is not addressed, eventually joint tightness will occur
• Involved joint ROM does not change regardless of adjacent joint position
• ROM gains harder to obtain at this stage

Non-Cutaneous Factors

• Extrinsic problems: Tendon adherence and/or shortening
  - Risk Considerations
    • Scar location
    • Duration and/or position of immobilization
    • Presence of motor loss and resulting muscle imbalance

• Intrinsic problems: Tightness
  - Risk Considerations
    • Edema presence and duration
    • Duration and/or position of immobilization
    • Accommodating movements if skin limits composite flexion

Flexor Tendon Tightness
• Greater finger extension with wrist in flexion
• Less finger extension with wrist in extension

Extensor Tightness
Greater interphalangeal (IP) flexion w/ wrist in extension

Less IP flexion w/ wrist in flexion
**Intrinsic Drawing**

- Line simulates intrinsic muscle
- “Intrinsic +” position

- PIP flexion with MCP flexion
- PIP flexion with MCP extension

**Intrinsic tightness**

- PIP flexion greater with MCP flexion
- PIP flexion less with MCP extension

**Tissue Biomechanics**

- Once the “Target Tissue” is identified, how is it lengthened?
- What is the most effective method of addressing this tightness?
- How do treatment techniques work biomechanically?

**Normal Skin vs. Scar**

- **Skin**
  - Composition
  - Collagen
  - Elastin
  - Ground Substance

- **Immature Scar**
  - Composition
  - Collagen only
  - Altered Ground Substance

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Normal Skin vs. Scar

Fibers align in the direction of stress for both skin and scar

- Skin: Elongates 60% when appropriate stress applied
- Immature Scar: Elongates 16% when appropriate stress applied

Clinical Relevance

True or False?

Your finger is an inch longer in full flexion compared to full extension.

Tissue Biomechanics

Considering immature scar has limited extensibility, how can we meet tissue length demands required to perform range of motion (ROM)?

<table>
<thead>
<tr>
<th></th>
<th>Skin</th>
<th>Scar</th>
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</thead>
<tbody>
<tr>
<td>Elongates</td>
<td>60%</td>
<td>16%</td>
</tr>
<tr>
<td>Elongates</td>
<td>60%</td>
<td>16%</td>
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</tbody>
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Answer: Tissue Growth! Not stretching

Tissue Biomechanics

How long do we need to stress tissue to allow growth?

Answer: Unknown in burn patients

What we do know comes from a study done on rats:

- Collagen fibers orient in direction of stress applied to young scar
- 6 hours per day showed length change in young scar
- 3.5 month old scar had no change in length after 1 month of tension treatment

Arem AJ, Madden JW. Journal of Surgical Research, 1976
Stress - Strain Curve

Force (Stress) vs. Elongation (Strain)

- Elastic
- Plastic
- Yield Point
- Break Point

Scar Stress – Strain Curve

Force (Stress) vs. Elongation (Strain)

Tissue Stress – Strain Curves

Force (Stress) vs. Elongation (Strain)

- Tendon
- Costal Cartilage
- Skin
- Ligamentum Flavum

Successive Length Induction Curves (i.e. pre-conditioning)

Force (Stress) vs. Elongation (Strain)

1 → 5

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Tissue Hysteresis (lagging behind)
a.k.a. recoverable deformation

Elongation (Strain)

Force (Stress)

Stress Relaxation of Tissue

- Progressive reduction in force required to maintain tissue at a constant length

Examples
- Static splinting
- Serial casting

Tissue Creep

- The progressive elongation of tissue over time with the application of a constant force

Examples
- Dynamic splinting
- Tissue expanders
Tissue Creep

Elongation

Time

Post Skin Graft CFU Implications

- Immobilization period s/p split thickness skin graft varies amongst surgeons
- Beginning ROM on post op day 1 can be safe since skin moves in the direction of motion, no shear forces with ROM alone
- Exercises should move in the direction of graft lengthening (flexion - if on dorsal hand)
- Communication with surgeon and interdisciplinary team is crucial
- Patient must be compliant
- Prospective study needs to be done to document ultimate gains

Strain Rate: Force applied to Tissue per unit time

Force (Stress)

Elongation (Strain)

Post Skin Graft Implications

POD 1

POD 2

POD 1

POD 2

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**References**


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