Tissue Repair: Rehabilitation Guideline

Lane Bailey, PhD, PT

Disclosures

• US-DOD: “STaR Trial” Consortium

OUTLINE

1. Review the Biology of Soft-Tissue Injury & Healing
   • Muscle
   • Tendon
   • Ligament
2. Applied Rehabilitation Principles
   • Acute & Sub-Acute Injury Management
   • Post-Operative Exercise Progression

TISSUE INJURY

• Prognosis based on several factors
• Many Classification Systems Exist
• MLG-R: Valle Sports Med 2016
  • mechanism of injury (M)
  • location of injury (L)
  • grading of severity (G)
  • number of re-injuries (R)
• Collective severity = Delayed/Poor Prognosis

MUSCLE INJURY

• Muscle Force Thru ECM
• Mechanical Connection
  1. Epimysium
  2. Perimysium
  3. Endomysium
• ECM Injury Linked to Prognosis
• Central Tendon Injury = Poorer Outcomes

TENDON & LIGAMENT INJURY

• Key Features of Injury
  • Disorganized collagen fiber arrangement
  • Increased non-collagenous ground substance
  • Increased number and rounded morphology of the tenocytes
  • Fatty deposits and ectopic ossification
  • Ultimately decreased load capacity
  • Can create acute or chronic injuries
**HEALING TIMELINES**

- Inflammation*
- Proliferation
- Maturation
- *Can occur at any time

"We want to Facilitate Protein Synthesis"

**HEALING CAPACITY**

- Blood Supply!!!
- Use knowledge of blood supply density as a guide
- Basis of many rehab protocols
- Influencing by patient specific factors (comorbidities)
- Not always good! – Neovascularity
- Mechanical stimuli can cause acute tissue perfusion to augment healing
- Tissue Matters ->

**Key Considerations**

**Location Matters**

- Intra-articular vs Extra-articular
- Intra-synovial vs Extra-synovial
- Acute Healing Requires a Provisional Scaffold (Blood Clot)
- Several factors influence the body’s ability to form clot
- Synovial fluid may wash away Clot Formation Murray JOR 2013

**LIGAMENT INJURY**

Murray JBJS 2000 & JOR 2007; Frank JOR 1983

- ACL & MCL Fibroblast
- Comparing in-vitro cell culture
- Results:
  - Similar Cell Proliferation
  - Similar Healing Potential

**LIGAMENT REPAIR**

**SOFT-TISSUE HEALING**

- Muscle, Ligament & Tendon are mechanosensitive tissues
- Mechanical Forces are Converted To Biochemical Signals
- Biochemical signals elicit cellular responses by the local cells
- Similar mechanical and biological signals are involved in homeostasis, inflammation and repair
- Understanding mechanobiology in tissue development, homeostasis and repair is critical to designing therapies for soft-tissue injury
STRESS MANAGEMENT

TISSUE STRESS

LOAD TOLERANCE

ENVELOP OF FUNCTION

• Use Lab & Basic Science Research to determine stress at a tissue level
• Use physics & clinical judgement when no evidence available
• Consider All Tissues Involved
  • What’s good for one tissue may not be for another
  • i.e. Graft vs Harvest Site

Enjoy! 

ENVELOP OF FUNCTION

• “Envelope of Function” Dye CORR 1996
• Capacity of joints and tissues to accept, transfer, and dissipate loads
• 3 Zones
  1. Homestasis
  2. Supraphysiologic Overload
  3. Structural failure

Dye CORR 1996

“The upper limit of a given tissue’s envelope of function is a threshold between homostatic loading and loading sufficiently great so as to initiate the complex biologic cascade.”

Table 1. ACL Loading Scale

<table>
<thead>
<tr>
<th>Activity</th>
<th>ACL Load (N)</th>
<th>ACL Strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat/Sit to Stand</td>
<td>20</td>
<td>3.6 - 4.0</td>
</tr>
<tr>
<td>Wall Squats</td>
<td>0 - 90</td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td>2.0</td>
<td>38</td>
</tr>
<tr>
<td>Step Down</td>
<td>2.5 - 2.6</td>
<td></td>
</tr>
<tr>
<td>Stair Climbing</td>
<td>146 - 25</td>
<td>2.8 - 2.8</td>
</tr>
<tr>
<td>Single Leg Squat</td>
<td>124 - 142</td>
<td>3.2 - 4.0</td>
</tr>
<tr>
<td>Walking</td>
<td>303 - 355</td>
<td>15 - 20</td>
</tr>
<tr>
<td>Lachman test</td>
<td>-</td>
<td>3.0 - 3.7</td>
</tr>
<tr>
<td>Isokinetic Knee Extension</td>
<td>248 - 349</td>
<td>2.8 - 3.8</td>
</tr>
<tr>
<td>Isometric Knee Extension</td>
<td>396 (@ 35-40°)</td>
<td>2.8 - 4.4</td>
</tr>
<tr>
<td>Double Leg Drop Landing</td>
<td>220 - 33</td>
<td>33 - 48</td>
</tr>
<tr>
<td>Single Leg Running Stop</td>
<td>1294 - 25</td>
<td>15 - 20</td>
</tr>
</tbody>
</table>

Reproduced from Escamilla (JOSPT 2012).

*pACL Load is defined as the amount of external force applied to the ACL in pounds with the stated activities.

*Strain percentage represents the amount of linear change (as a percentage) of original resting ligaments length.

Escamilla AJSM 2010
**Graded Progression**

![Theoretical Load Chart](chart.png)

**Acute Management**

1. **Protection, Rest, Ice, Compression, Elevation**
2. Return to Homeostasis!!!
3. Create an Ideal Healing Environment
   - Unloading of injured structures
   - Facilitate vascular mobility (dependent vs elevated position)
4. Avoid further tissue damage
5. Begin with muscle activation in a safe environment which doesn’t elicit inflammatory response

---

**Early Management**

- Return to the Principle Foundations of Rehab
  1. PROM
  2. AAROM
  3. AROM
  4. Resistive ROM
  5. Functional Movements

- Low load activity:
  - Isometrics - Quad sets, Scap Retractions, table exercises are ok!
  - Move criteria to progression
  - Move don’t get

**Tissue Irritability**

- Utilize Irritability Scales* to Monitor Load Tolerance
  - Be a Good Historians
  - Signs & Symptoms
    1. Numeric Pain Rating Scales
    2. Recent history of faction
    3. Duration and nature of symptoms
    4. Joint effusion (swell tests, etc.)
    5. Current clinical assessment
    6. Sleep disturbance & Appetite

*Can’t rely on these solely to make decisions

---

**Acute Post-Op = ADL’s**

1. Restore functional PROM
2. Initiate muscle activation safely
3. Resume Joint & Soft-Tissue Loading when appropriate
4. Loading is different in this phase
   - Dosing is likely ok to perform on a daily basis – NM Control
   - Repeated cycles may be needed to facilitate tissue compliance
   - ...Or they may be contra-indicated!
5. Physician Communication is key to understanding tissue load tolerance

---

**Post-Op - Phase 1 is Key!**

- “Normal Knee” Ambulation
- No Need to Rush Past This Phase!
**EARLY STRENGTHENING BFR**

1. Increase strength & hypertrophy at 30% MVIC
2. Shown to improve muscle protein synthesis
3. Avoiding excessive tissue loading in compromised settings
4. Diminish Muscle Atrophy after injury
5. Strong Basic Science Evidence

---

**SUMMARY**

1. Understand healing principles of various soft-tissues
2. Consider differences in healing capacity based on location, severity and vascular supply
   - Age, comorbidities, activity loading
3. Develop a strategy for monitoring tissue irritability
4. Utilization of rehab aids to augment therapeutic effects

---

**HEALING CAPACITY**

- Blood Supply!!!
- Use knowledge of tissue blood supply density
- Neovascularity – Not always good!
  - Signs of poor or compromised healing
- Acute perfusion is needed and produced by mechanical stimuli in PT