Cartilage Specific Rehabilitation: Progress & Considerations

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Objectives

- Highlight the key principles to consider when designing a rehabilitation program following articular cartilage injury and/or repair procedures
- Discuss how rehabilitation progression should be based on the biological phases of cartilage maturation

Articular Cartilage

- Has remarkable durability
- Absorbs mechanical shock
- Provides a low friction, resilient, weight bearing surface
  - Coefficient of friction 15 times less than that of ice on ice (Mankin 1971)

Articular Cartilage

- Vulnerable to traumatic or degenerative conditions
  - Avascular, aneural and hypocellular
    - Limited ability for repair or regeneration
    - No pain unless subchondral bone involved
    - Chondrocytes “imprisoned” in matrix

Articular Cartilage

- Biomechanical stresses result in both shear and compressive forces during normal ADLs
- If untreated, these defects can cause pain and progress to further degenerative changes
- Nonoperative rehabilitation is frequently unsuccessful and definitive treatment is often required to alleviate symptoms

Surgical Treatment Options

- Debridement/Shaving
- Penetration of Subchondral Bone
- Osteochondral Autografts
- Osteochondral Allografts
- Autologous Chondrocyte Transplantation

→ May need osteotomy to unload area of repair
Cartilage Rehabilitation

• Crucial for rehabilitation programs to be based on:
  – Knowledge of the basic science, anatomy and biomechanics of articular cartilage
  – The biological course of healing following surgery

• Goal:
  – Restore full function without overloading the healing articular cartilage

Rehabilitation Principles

• Individualization
• Encourage a healing environment
• Reduction of pain and effusion
• Restore soft tissue balance
• Understand biomechanics of the knee
• Restore muscle function
• Last but not least…

Communication with the surgeon

Individualization

Factors That Must Be Considered

<table>
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<tr>
<th>Lesion: Location</th>
<th>Size</th>
<th>Depth</th>
<th>Quality of Surrounding Tissue</th>
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<tr>
<td>Patient: Age</td>
<td>Body Mass Index</td>
<td>General Health</td>
<td>Nutrition</td>
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<tr>
<td>Surgery: Repair Procedure</td>
<td>Tissue Involvement</td>
<td>Concomitant Procedures</td>
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• The exact location of the lesion is one of the most important factors to consider when developing a rehabilitation program
  – Weightbearing surface of femoral condyle
    • Avoid damaging compressive forces
  – Within trochlea or undersurface of patella
    • Avoid deleterious shear forces
**Individualization**

Remember your anatomy in order to avoid deleterious contact on the lesion.

- Lesions that are large, deep or have poorly contained edges may require a slower progression.

**Smaller lesions**
- Are well shouldered and protected.

**Larger lesions**
- Are subject to a higher degree of force / wear.

**Rehabilitation Principles**

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**Encourage a Healing Environment**

- Have to ensure that the repaired tissue is loaded gradually based on biological phases of maturation:
  - Shown to stimulate matrix production and improve mechanical properties of the tissue.
- However, it is also possible that no stress to the tissue is detrimental to the health of the repair site as well as the surrounding bone, ligament and cartilage structures.

**Encourage a Healing Environment**

- Two very important facets of rehabilitation following articular cartilage procedures:
  - Weightbearing restrictions
  - Range of motion limitations

**Encourage a Healing Environment**

- Weightbearing Progression:
  - Communication with physician important
  - Partial weightbearing with crutches to gradually increase load applied to the repair tissue
  - Aquatic therapy may also be beneficial
  - Use of a scale or force platforms helpful to monitor weightbearing during gait, weight shifting and mini squats.
Encourage a Healing Environment

- Range of Motion
  - Concept based on principles that synovial joints are designed to move, that articular cartilage receives nutrition via the movement of synovial fluid, ROM helps prevent adhesions and prolonged immobilization of joints is detrimental to all involved tissues.
  - Performed early in a limited range
  - Use of CPM (supported by basic science but clinical evidence lacking)
  - Manual PROM
    - Patient relaxed to avoid compressive and shear forces

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Reduction of Pain and Effusion

- Increased pain and effusion causes quadriceps reflex inhibition (Spencer 1984)
- Increase in joint temperature shown to stimulate proteoglycic enzyme activity which is detrimental to articular cartilage (Horvath 1949, Goodfellow 1976, Hangody 1997)

Reduction of Pain and Effusion

- Treatment Options for the Rehabilitation Specialist to Control Effusion
  - Cryotherapy
  - Cryotherapy with compression (GameReady)
  - Elevation
  - High-volt electrical stimulation

Reduction of Pain and Effusion

- Treatment Options for the Rehabilitation Specialist to Control Pain
  - Cryotherapy
  - TENS
  - PROM to provide neuromodulation for pain
    - Maitland Grades 1 and 2 mobilizations through PROM within the beginning and middle ranges of the ROM limitations

Rehabilitation Principles

- Individualization
- Encourage a healing environment
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- Restore soft tissue balance
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- Restore muscle function
Restore Soft Tissue Balance

- Avoiding Arthrofibrosis is Critical to Recovery
  - Achieve full extension immediately post-op
  - Regain patella mobility
  - Restore flexibility about the knee and hip

- Achieve Full Extension Immediately Post-Op
  - To restore normal joint arthrokinematics
  - To decrease joint contact pressures
  - To improve quad function
  - Treatment Options
    - Manual PROM and gentle long axis distraction with posterior glide on the proximal tibia
    - Hamstring and gastroc stretching with heel prop in long sitting
    - Soft tissue mobilization to the posterior knee, hamstring and gastroc
    - Low load, long duration stretching (Exs: heel prop, prone hang, use of Extensionator device from ERMI)

Regain Patella Mobility

- To prevent adhesions
- To restore ROM, especially when prolonged limitations in ROM are required
- To prevent increased joint contact forces
- To improve quad function

- Treatment Options
  - Manual patella mobilizations all planes
  - Initiation of self mobilizations by patient for HEP
  - Scar mobilization

Rehabilitation Principles

- Individualization
- Encourage a healing environment
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  - Restore muscle function

Understand Biomechanics of the Knee

- When using the knowledge of joint arthrokinematics, the rate of weightbearing, PROM and exercise progression may be based on the exact location of the articular lesion (Blankenvoort 1991)

- Articulation between the femoral condyle and the tibial plateau
  - Constant throughout knee ROM
  - Near full extension the anterior femoral condyles articulate with the middle of the tibial plateau
  - During weightbearing, as the knee flexes the femoral condyles roll posteriorly and slide anteriorly
Understand Biomechanics of the Knee

Patella Contact Area

- Contact begins: 10° to 20°
- Contact area moves proximally with increasing flexion
- Superior facets engage the femoral chondyles at 90°
- Contact area increases from 20° to 90° flexion but never > 1/3 patella in contact at any one time

Patella Contact Area

Femoral Contact Area

- 0° - Lies laterally
- 30-90° - Trochlear groove
- >90° - Laterally over LFC
- 135° - Covers LFC

Contact Pressure

- Pressure increases with increased flexion
- Maximal at 60° to 90°

Examples of how to apply this information

- A lesion on the posterior femoral chondyle may require avoidance of deep knee flexion due to the rolling and sliding component of joint
- A lesion in the trochlea may allow for early partial weightbearing with a knee brace locked in extension, but ROM may be limited based on where the lesion is located in the trochlea

Examples of how to apply this information

- Weightbearing exercises such as the leg press, wall squats and vertical squats initially performed from 0° to 30° to limit tibiofemoral and patellofemoral joint reaction forces
- ROM then increased for greater strengthening as the repair site heals and effusion and patient report of symptoms decrease
- Always consider the biomechanics and healing time/maturity in order to protect the repair tissue
Rehabilitation Principles

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- **Restore muscle function**

**Restore Muscle Function**

- **The strengthening progression must follow the four biological phases of cartilage maturation (Reinold 2006)**
  - Proliferation Phase (Typically 1st 4-6 wks)
  - Transition Phase (Typically 4-12 wks)
  - Remodeling Phase (Typically 3-6 months)
  - Maturation Phase (Typically 6-18 months)

  Timeframes are typical but will vary based on the procedure(s) performed, tissue quality, location of lesion, surgeon preference

**Proliferation Phase**

- Use of neuromuscular electrical stimulation and biofeedback to facilitate maximal muscle fiber contraction while the patient has decreased or no ability to fire the quads (Delito 1988, Snyder-Mackler 1995)
  - Use immediately post-op along with isometric and isotonic exercises as able and depending on location of lesion: Quad sets, SLR flexion and abduction, knee ext
  - Weight shifting (within limitations)

**Transition Phase**

- Gradual progression into machine weights and weightbearing exercises as weightbearing status and ROM progresses to full
  - Examples:
  - Leg press, vertical squats, wall slides, lateral step ups, split lunges and progression of proprioceptive re-education
  - An overaggressive approach can lead to increased inflammation, pain, effusion and potentially arthrofibrosis or graft failure

**Remodeling Phase**

- Continuation of strengthening and proprioception re-education
- Low to moderate impact activities gradually incorporated such as cycling, golfing, recreational walking

**Maturation Phase**

- Impact loading activities gradually introduced
- Gradual return to full premorbid activities, including sports
  - Based individually on each patient’s distinctive presentation
Conclusion

- Rehabilitation is vital to the recovery following articular cartilage repair
- Rehabilitation will vary based on the key principles of healing and arthrokinematics while avoiding detrimental stresses to the repaired tissue
- Location, Location, Location!!

References
