Rehabilitation Strategies for the ACL Deficient Knee Patient

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Non-Operative Treatment of ACL Injuries: Proprioception & Dynamic Control

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ACL Injuries in Football

Introduction

• When someone tears their ACL what happens?
• Can they play that season?
• Should they play that season?
• What’s the best Rx for that patient/athlete?

Is It Safe To Return to Play?

ACL INJURIES

Introduction

• ACL injuries common in sports & strenuous work
  » So frequent that the seriousness is often forgotten
• Totally disrupted more than any other knee ligament
• 200,000 ACL injuries annually
  Fu: AJSM ’99
• 148,714 ACL surgeries in 2013
• 19 yrs: 58% increase in number ACL surgeries
  Wilk: JOSPT ’15
• Rehab has changed in the past 10 yrs

Evidence Based Rehab

Knee Homeostasis
ACL Injuries
Introduction

• Somewhat common injury
• Occurs in sports & strenuous work activities
  » So frequent that seriousness is often forgotten
• 200,000 ACL injuries annually
• Often associated with other injuries
  Not an isolated injury

ACL Injuries
Overview

• Usually occurs in “high risk” sports
  ✓ Football
  ✓ Basketball
  ✓ Volleyball
  ✓ Soccer
  ✓ Skiing
  ✓ Snowboarding
  ✓ Team Handball
Active Lifestyle

ACL Injury
Return to Sports

• Levels of Sports (Based on Loading/Stress)
  ✓ I: Basketball, Soccer, Volleyball, Gymnastics, Football, Skiing, Lacrosse
  ✓ II: Baseball, Softball, Kickball, Nordic Skiing, Hiking, Bowling
  ✓ III: Golf, Running, Biking, Swimming, Walking

ACL Injuries
Introduction

• 200,000 ACL injuries annually
• 62-66% sports related, usually non-contact – 70%
• Over 60% in males
• 67% occurs in individuals 15-29 yrs of age
• 26% occurs in 30-44 yrs
• 7% occurs in individuals above 45 yrs of age
Injuries in Football 2016

ACL Injuries

- **Not an isolated injury**
  - Meniscus injury
    - Indelicato: CORR '85
    - 77% acute meniscal injury
    - 91% chronic meniscal injury
  - Noyes: JBJS '83
    - 50-62% meniscus tears

Potter, Jain, Ma, et al: AJSM '12

- 42 knees in 40 patients (28 ACLR, 14 non-op)
- MRI at time of initial injury then annually for a maximum of 11 yrs
- **All patients sustained initial chondral injury 100% incidence**
- Risk of cartilage loss doubled from yr 1 for the lateral & medial compartment & 3x for patella
- By 7 to 11 years: LFC 50x, MFC 19x, & patella 30x
- Size of the bone bruise associated to degeneration from yr 1 to yr 3

ACL Injuries

- **Not an isolated injury**
  - Bone bruises present 71-100% patients
    - Potter et al: AJSM '12
    - Spindler: AJSM '93
    - Rosen: Arthroscopy '91
    - Graf: AJSM '93
    - Johnson: AJSM '98
  - 65% exhibited marrow changes & cartilage thinning 6 yrs after ACL injury
    - Faber: AJSM '99

ACL Injuries

- Injury affects mechanoreceptors
  - Within 24 hrs after injury
    - Lephart: AOSSM '97
  - Deficits may last 6 yrs or more
    - Denti: Knee Surg Sports Trauma '00
  - “Quadriceps avoidance gait”
    - Andriacchi: CORR '94
    - Berechuck: JBJS '90
The Effects of ACL Injury on Lower Limb Proprioception

Unilateral ACL Injury Affects Both Lower Extremities
Wilk: CSM '04

ACL Injuries

- Not an isolated injury
- Injury affects both extremities
- Quadriceps weakness & activation failure following ACL injury &/or reconstruction bilaterally
Hart et al: J Athletic Trn '10
Chmielewski: J Orthop Res '04
Farquhar: Muscle Nerve '05
Holder-Powell: Eur J Appl Physiol 01

ACL Injuries

- Not an isolated injury
- Injury affects both extremities
- For at least 3.6 mos
Wilk, et al: CSM '03
- Alters firing mechanism
Wojtys, Huston: AJSM '94

Shah, Andrews, Fleisig, Lemak: AJSM '10
- 49 NFL players underwent ACL/PTG
- 63% returned to NFL play (31/49)
- Average length of time to return 10.8 mos
- Age, position & number of procedures not a factor in return rate
- Players who had more than 4 yrs of experience higher rate of return
- Players drafted in first 4 rounds – higher rate of return to play

Return to Sports

After ACL Reconstruction:

- Systematic review of 48 studies reporting return to sports of 5770 individuals after ACL reconstruction at mean follow-up of 41.5 months

Return to:
- Some Form of Sports: 82% (95% CI 73 to 90%)
- Pre-Injury Level of Sports: 76% (95% CI 54 to 71%)
- Competitive Sports: 44% (95% CI 34 to 56%)

Ardern CL et al. 2011

Return to Sports

- Reasons for reduced sports participation for those that did not return to prior level:
  - Fear of re-injury (19%)
  - Problems with structure/function of knee (13%)
  - Family commitments or lifestyle changes (11%)

Ardern, BJSM: 2011
Kinesiophobia

- Fear of movement/reinjury
- “I’m afraid that I might injure myself if I play a sport or exercise”
- Tampa scale for kinesiophobia
  Woby et al: Pain '05
- Interventions which improve self efficacy may improve knee function short term
  Chmielewski et al: JOSPT '08
  Chmielewski et al: Phys Ther '11

Fitzgerald, Axe, Snyder-Mackler: Phys Ther: '00

- Perturbation training ACL deficient knee patients (athletes)
- 26 patients isolated ACL rupture
- Randomly assigned to group:
  » A standardized program
  » Standardized program & perturbation training
- Results: 91% perturbation group return to play (6 months)
  50% standardized group return to play (6 months)

ACL Deficient Knee Rehab

Treatment Options

- Kids
  Skeletal Immaturity
- Adults
  Skeletal Maturity

ACL Injuries

Treatment Choices

- Reconstructive surgery – immediately
- Reconstructive surgery – delay surgery until knee normalizes
- Non-operative rehab & return to sport assess effectiveness
- Partial ACL injury – non-operative
  What’s the treatment best approach?
  High school athlete – College athlete – Professional athlete – Recreational athlete

Noyes et al: JBJS ‘83

- 103 patients ACL deficient
- Treated rehab, activity modification, brace
- Follow-up 5.5 yrs to 11.2 yrs
  » 82% returned to sports
  » 33% continued sports 5 yrs from injury
  » Giving way 51% (1 yr) 68% (2 yrs)

How well did they do ???
Noyes et al: JBJS ‘83
“Rule of Thirds”

33% compensate know limits → **do well**
33% compensate ??? → **aggravate**
33% become worse → **surgery**

ACL Injuries
Treatment Choices ??

- Most appropriate treatment approach:
  - Patient profile:
    - Professional athlete
    - Recreational athlete
    - Strenuous work situation
  - “Knee Abuser” Noyes: “89”
  - “Knee Preserver”
  - What do you want to get back to ??

Success Depends on Patient!!
Type of Patient
Desired Activities
Compliance
Level of Neuromuscular Control

ACL Deficient Knee Patients
% Return to Pre-injury Level

- Bonamo: AJSM ‘90 – 45%
- Barrack: JBJS ‘90 – 6%
- Friden: CORR ‘91 – 46%
- Anderson: CORR ‘91 – 31%
- Daniel: AJSM ‘94 – 40%
- Buss: AJSM ‘95 – 54%
- Fitzgerald: PT’00 – 91%

Specific Rehabilitation Program
ACL Deficient Knee
3 – 3 - 4 - 4 Program
ACL Rehabilitation
Limb Confidence

Perturbation Training to Enhance Neuromuscular Control
- Various levels of dynamic stability
  Stability → Mobility
  Controlled Mobility → Skill
- Perturbation skill one of highest level
- Improves clinical outcomes
  Wilk: J Athl Trn ’99
  Fitzgerald: Phys Ther ’00
  Must gradually progress to skill level drills !!

Linking Arms & Lower Extremity

Movements & Change of Planes
I. Acute Phase (first 3 weeks)
   - reduce swelling – normalize knee
   - restore range of motion
   - voluntary quadriceps activation

II. Subacute Phase (week 4-7)
   - return to normal strength levels
   - proximal & distal stability – H/Q ratios

III. Advanced Phase (weeks 8-12)
   - restore neuromuscular control
   - dynamic stabilization

IV. Return to Activity Phase (weeks 13+)
   - gradual return to sports
ACL Deficient Knee Rehab
I: Immediate Post-injury (Week 0-3)

- Initiate voluntary quadriceps contraction
  - Early WB (equal wt bilat)
  - Wt shift
  - EMS to quads
  - SLR flexion, ¼ squats

Immediate Stimulation of Receptors

- Immediate stimulation of mechanoreceptors
  - "neurologic insult" – train immediately
  - Passive/active repositioning
  - OKC/CKC SportsRAC
  - Balance – Biodex stability system
  - Re-establishing confidence in leg

Train Bilaterally
Johnson D, et al AJSM '00

- 40 patients isolated ACL rupture with bone bruise
- MRI within 1 week of injury
- Compared with patients without bone bruise
- Patients w/ bone bruise had:
  - Larger effusions
  - Prolonged effusion (2 vs 4 wks)
  - Prolonged gait problem (2.8 vs 4 wks)
  - More pain (level 3 vs 6.1)
  - Slower quadriceps hypertrophy

Treat The Osseous Lesion Bone Bruise

Rehabilitation Guidelines:
- Control wt. bearing forces (crutches)
- No early running & jumping
- Cryotherapy & compression
- Train & restore proprioception
- Emphasize unloading programs
- Progress to gradual/progressive loading program
- Pool exercises, bicycle, etc...
- Muscle stimulation to quads
- Motion, motion, motion ...
- Delay compressive loading (running ...)

ACL Deficient Knee Rehab
I: Immediate Post-injury (Week 0-3)

- Train **uninjured extremity** immediately
  - Single leg balance Biodex
  - Single leg bicycle Unicam
  - Lateral step-down / front

Co-Activation to Enhance Dynamic Stability

ACL Deficient Knee Rehab
I: Immediate Post-injury (Week 0-3)

- Train **uninjured extremity** immediately
  - Single leg balance Biodex
  - Single leg bicycle Unicam
  - Lateral step-down / front
Stimulation to Uninjured Extremity

Train the Uninjured Extremity Too!!

ACL Deficient Knee Rehab
II: Dynamic Stabilization Phase (weeks 4-7)

- Maintain knee motion
  ✓ Normalize unilateral muscle ratio
  ✓ Enhance stabilization proximal & distal
- Improve proprioception & NM control

Co-Activation to Enhance Dynamic Stability

ACL Deficient Knee Rehab
II: Dynamic Stabilization Phase (weeks 4-7)

- Progress strengthening program
  ➢ Leg press 40-100 deg.
  ➢ Wall squats 0-70 deg.
  ➢ Decline squats
  ➢ Lateral step-ups
  ➢ Front step-downs
  ➢ Knee extensions 90–40 deg
    » Hip & hamstrings
    » Calf muscles
Wilk - Rehabilitation of the ACL Deficient Knee Injuries in Football 2016

Establish Hip Control

Establish Proper Foot Position

Stabilization From ABOVE & BELOW

Wilk et al: AJSM ’94

Wilk et al: AJSM ’94

Escamilla & Wilk: JOSPT ’08
Escamilla & Wilk: Clin Biomech ’08

EMG Activity of Quadriceps & Hamstring During the Leg Press

EMG Activity of Quadriceps & Hamstring During the Squat
ACL Deficient Knee Rehab
II: Dynamic Stabilization Phase (weeks 4-7)

- Enhance stabilization proximal & distal
  - Lateral lunges
  - Lateral / front step downs
  - Hip strengthening
  - Lunges on foam
  - Balance beam
  - Strengthening ankle /foot

Co-Activation to Enhance Dynamic Stability
ACL Deficient Knee Rehab

II: Dynamic Stabilization Phase (weeks 4-7)

- Improve proprioception & NM control
  - Retrograde stepping
  - Unilateral restrict movements
  - Front & back lunges
  - Tilt board squats
  - Balance drills

Tilt Board Progression

- 2 legged squats with taps
- Single leg stance “balanced” with taps
- 2 legs throws with holds
- 1 leg stance throws “balanced” with taps
- 1 leg stance throws rotation with taps

3 levels to the Tilt Boards

Co-Activation to Enhance Dynamic Stability

ACL Deficient Knee Rehab

III: Neuromuscular Activity Phase (weeks 8-12)

- Enhance neuromuscular control
  - Perturbation training drills
  - Tilt board squats – perturbation
  - Biodex stability system
  - Plyo-drills (gravity eliminated)

Perturbation Training to Enhance NM Control
Challenge the Neuromuscular System

ACL Deficient Knee Rehab
III: Neuromuscular Activity Phase (weeks 8-12)

• Promote endurance
  » Stairmaster (30-45 min)
  » Bicycle (30-45-min)
  » Elliptical
  » Pool exercises

Establish Core Stability

ACL Deficient Knee Rehab
III: Neuromuscular Activity Phase (weeks 8-12)

• Improve core stability
  » Core stabilization program
  » Sit-ups on ball
  » Trunk exercise on ball
  » Alternating leg / arms
  » Trunk & hips training
**ACL Deficient Knee Rehab**

**III: Neuromuscular Activity Phase (weeks 8-12)**

- Gradually increase applied loads
  - Running in pool
  - Plyometric program
    - Leg press
    - Pool
    - Floor
    - Boxes
  - Jump lunges
  - Scissors jumps

**IV: Return to Activity Phase (weeks 12+)**

- Running & agility program:
  - Backward run → lateral movements
  - Lateral movements → forward running
  - Jogging → jog / stops
  - Jogging → run / stops
  - Running → yo-yos
  - Cutting drills → 45 deg. → 90 deg.

**Lower Extremity Plyos**

- Sportmetrics Program: Gradually increase box height
ACL Deficient Knee Rehab

**Bracing / Orthotics**

- Consider functional ACL brace
- Effective at lower loads
- Proprioceptive benefits
- Evaluate for orthotics
- Consider shoe wedge

**Functional Testing**

- Single leg hop testing
- Perform 3 tests:
  - Single leg for distance
  - Single leg timed
  - Single leg cross-over triple hop
- Goal: 85% bilateral comparison

   Barber, Noyes: Clin Orthop 90
   Barber, Noyes: AJSM 91

**Isokinetic Testing**

**Overview**

- Biodex system
- Full ROM: 100° – 0°
- Distal pad placement
- Speeds: 180 & 300 °/sec
- Repetitions 10 & 15
- Standardized warm-up

**Interpretation of Data**

- Q PT / BW ratio:
  - (180°/sec)
  - Males: 60-65%
  - Females: 50-55%
- H/Q ratio:
  - (180 °/sec)
  - Males: 66-72%
  - Females: 75% 
- HPT / BW ratio:
  - (180°/sec)
  - Males: 40-43%
  - Females: 37-40%

**Summary**

- Similar rehab as for the reconstructed ACL patient
- Emphasize proprioception & NM control training
  - Perturbation training
  - Enhance NM control
- Promote unilateral muscle ratios
- Prevent negative effects to mechanoreceptors
- Train contralateral extremity immediately
- Requires 10-12 weeks before sports
- Is it effective for the ACL deficient patient??
- Depends on type of patient

   Competitive Athlete--- Recreational Athlete--- Non-athlete
Thank You !!!

Waikiki Beach