Safe Return to Sports Following ACL Reconstruction Surgery in the Young Athlete

Betty A. McNeff PT, DPT, PCS
Alex Altamiranda PT, DPT, SCS
Disclosure

Speaker should disclose any relationship that could reasonably be viewed as creating a conflict of interest, or the appearance of a conflict of interest, that might bias the content of the presentation. Speaker should disclose any significant financial interest in any product, instrument, device, service or material discussed in the presentation, including the source of any third-party compensation related to the presentation. By way of examples, significant financial interest or other relationships could include employment or stockholder status or funding. Speaker is ultimately responsible for determining whether particular information should be disclosed. Disclosure should be made orally and in writing during the live presentation.
Learning Objectives

1. Analyze and synthesize the current data regarding youth sports and prevalence of ACL injuries.
2. Discuss the implications of youth ACL injury on long-term sports participation and functional outcomes.
3. Identify and review the anatomical structures, biomechanics, and functional norms of the knee joint.
4. Identify and discuss the most common mechanisms of ACL injury in youth sports.
5. Identify and discuss the medical management of ACL tears in young athletes.
6. Discuss the role of the physical therapists as part of an inter-professional team member in the rehabilitation of ACL injuries in youth sports.
7. Discuss and synthesize a patient/client management model for ACL reconstruction based on current research evidence with recent advances in rehabilitation.
8. Discuss research evidence and issues which impact the quality of care and rehabilitation outcomes of the pediatric athlete following ACL reconstruction.
9. Analyze and synthesize current research evidence on ACL return to sports criteria and injury prevention programs
10. Introduce, discuss, and analyze a proposed ACO model for the young athlete with ACL injury: from diagnosis to return to sports.
11. Identify areas for future research as it pertains to the rehabilitation of sports injuries and the prevention of re-injury in the pediatric population.
Introduction to Content

Statistics  [http://www.stopsportsinjuries.org](http://www.stopsportsinjuries.org)

- Sports-related injuries in pediatric and adolescent athletes are on the rise.
- Approximately 30 million young athletes participate in youth sports annually.
- High school athletes account for an estimated 2 million injuries and 500,000 doctor visits and 30,000 hospitalizations each year.
- Every year, more than 3.5 million children aged 14 and younger are treated for sports injuries.
- Overuse injuries are responsible for nearly half of all sports injuries to middle and high school students
  - Year-round competition
  - Early specialization
  - Intense training
Why Talk about the ACL?

• The Anterior Cruciate Ligament (ACL) is one of the most common injuries during sports participation, especially those that involve cutting, pivoting, jumping.
  14.08 per 100,000 exposures (female soccer players)
  13.87 per 100,000 exposures (male football players)
• Annual ACL reconstruction procedures in US: 100,000-200,000.
• Occur in 1 in 3,500 individuals each year
Youth Considerations

• Knee accounts for 2/3 growth of the leg
• Any injury to the knee in the early years is likely to result in severe shortening.
• **BIG DEBATE**: Surgical vs. Non-surgical Management
• An athlete’s (and/or parent’s) desire to return to sports is a major indicator for operative management of any sports-related injury.
• Operative management of the ACL:
  – Risk damaging the growth plate if procedure includes drilling through the growth plate (transphyseal techniques).
  – May lead to LLD or angulation deformity
• Non-surgical management of the ACL:
  – Risk of future meniscal tears and chondral injuries.
  – Long-term: Osteoarthritis
Anatomy-Review

Tibiofemoral joint
“hinge joint”
Anatomy (cont.)

Menisci
- Medial (less moveable) & Lateral
- Medial
  - C Shaped
  - Thicker Posteriorly
  - Excursion 2mm
- Lateral
  - O Shaped
  - Equal Thickness Throughout

Ligaments
- ACL
- PCL
- LCL
- MCL

not within synovial sleeve
Anatomy (cont.)

Anterior Cruciate Ligament

– AMB lengthens and tightens in flexion
– PMB shortens and becomes slack during flexion
– IR lengthens ACL more than ER (especially in 30 degrees of flexion)

Anatomy (cont.)

Innervation of ACL

– Receives nerve fibers from the posterior articular branches of the tibial nerve.
– Penetrate posterior capsule and reaches as far anterior as infrapatellar fat pad.

Innervation of ACL

A. Ruffini receptors
   - sensitive to stretching
   - located on surface of ligament, primarily at femoral portion
     - importance?

B. Pacini receptors
   - sensitive to rapid movements
   - located at femoral and tibial ends of ACL

Anatomy (cont.)

The “ACL Reflex”

• activation of afferent nerve fibers cause motor activity of muscles around the knee joint
• elicited by stimulation of group II and III mechanoreceptors
• 110 ms would elapse before substantial forces could be produced by muscles after application of load to ACL.

• Clinical Implication??
Anatomy (cont.)

Vascuclature of ACL

- Middle genicular artery provides blood supply
- greater distribution of blood vessels in proximal versus distal portion of ACL
- fat pad highly vascularized
- clinical implications?

Duthon et al., Knee Surg Sports Traumatol Arthrosc, 2006
Anatomy (cont.)

Other structures
• Joint capsule
  plicae – 20 to 60% of population not reabsorbed from birth
• Fat pad
• Bursa
• ITB

The Anatomy of ITB Syndrome
ACL Function

ACL FUNCTION/TENSION

- Primary: Restrains anterior translation of the tibia on the femur
- Secondary: Restrains varus and valgus angulation
- Forces walking: 154 N
- Peak forces: 30-45 degrees knee extension
- No anterior tension during squat/leg press.
- Seated knee extension anterior tension: 142 N
Mechanisms of Injury

1. Contact
   - predominantly males (dominant kicking leg)
   - fall on knee or forceful blow

2. Non-contact
   - predominantly females (dominant supporting leg)
   - landing with too much knee extension
   - sudden change in direction (pivoting, cutting)

Signs/Symptoms: (similar to adult)
* Typically hear a “pop” at time of injury.
* In ½ ACL injuries, a hemarthrosis ensued between 6-12 hours post injury
* Pain and instability
Management of ACL Tears

Guided by:

1. Skeletal Maturity (X-ray of wrist/hand)
2. Physiologic Maturity (Tanner Stages)
3. Chronological Maturity (age)
4. Extent of the ACL tear or injury
<table>
<thead>
<tr>
<th></th>
<th>STAGE 1</th>
<th>STAGE 2</th>
<th>STAGE 3</th>
<th>STAGE 4</th>
<th>STAGE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BOYS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td>5-6 cm/y</td>
<td>5-6 cm/y</td>
<td>7-8 cm/y</td>
<td>10 cm/y</td>
<td>None</td>
</tr>
<tr>
<td>Testes, penis</td>
<td>Testes &lt; 4mL or 2.5 cm</td>
<td>Testes &lt; 4 mL or 2.5-3.5 cm penis usually not yet enlarged</td>
<td>Testes 12 mL or 3.6 cm, enlargement, lengthening of penis</td>
<td>Testes 3.1-4.5 cm, increased size and breadth of penis</td>
<td>Testes fully mature in shape and size</td>
</tr>
<tr>
<td>Pubic hair</td>
<td>None</td>
<td>Sparse, at base of penis</td>
<td>Pubic hair over pubis, darker, coarser and more curled</td>
<td>Adult like but over a smaller area</td>
<td>Fully mature in shape and quantity, extending into thighs</td>
</tr>
<tr>
<td><strong>GIRLS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td>5-6 cm/y</td>
<td>7-8 cm/y</td>
<td>8 cm/y</td>
<td>7 cm/y</td>
<td>None</td>
</tr>
<tr>
<td>Breasts</td>
<td>No development</td>
<td>Buds</td>
<td>Elevation and Areolar enlargement</td>
<td>Areolae and papillae form secondary mound</td>
<td>Mature</td>
</tr>
<tr>
<td>Pubic hair</td>
<td>None</td>
<td>Sparse, on labia, slightly pigmented</td>
<td>On mons pubis, darker, coarser, and more curled</td>
<td>Adult-like, but over a smaller area</td>
<td>Fully mature in shape and quantity, extending into thighs</td>
</tr>
</tbody>
</table>

(Taken from: Frank & Gambacorta, 2013)
ACL Management Algorithm for the Young Athlete

ACL tear in the skeletally immature patient

Partial (<50% fibers torn)
- Activity modification
  - Physical therapy
  - Bracing

Prepubescent
  - Tanner stage 1 or 2
  - Males ≤12 y
  - Females ≤11 y
  - Physeal-sparing combined extra- and intra-articular reconstruction with autogenous iliotibial band

Complete

Adolescents with growth remaining
  - Tanner stage 3 or 4
  - Males ≤13–16 y
  - Females ≤12–14 y
  - Transphyseal reconstruction with autogenous quadrupled hamstring tendons and metaphyseal fixation

Older adolescents with closing physes
  - Tanner stage 5
  - Males ≥16 y
  - Females ≥14 y
  - Adult-type anatomic ACL reconstruction with hamstrings or patellar tendon (autograft preferable)
Physeal-Sparing Techniques

(Taken from: Frank & Gambacorta, 2013)

Combined extra- and intra-articular ACL reconstruction using autogenous iliotibial band

All-intra epiphyseal ACL reconstruction using autogenous hamstring tendon
Rehabilitation- Pediatric Considerations

“Proper rehabilitation after ACL reconstruction in the skeletally immature patient is paramount to ensure an excellent outcome and a successful and timely return to sports.”

“Child and adolescent athletes can pose a challenge to traditional physical therapists who specialize in working with adult patients.”
- risk-taking behaviors
- socialization/peer pressure
- attention span
- motivation levels
- physiological and mental immaturity

“Thus, it is important to work with a therapist who has experience with young patients and who can make therapy sessions both engaging and beneficial.”

(Quotes: Frank & Gambacorta, 2013)
Pre-Operative Management

PT frequency: 1 visit only prior to surgery to teach program.

**We need full ROM and strength of injured knee prior to ACL reconstruction.**

Bracing: none (wean from knee immobilizer or brace if pt is wearing a brace)

Weight bearing: WBAT

Pain management: teach home modalities (ice, elevation, oral pain medication, etc.)

Home exercise program:

- ROM
  - Passive and active knee ROM exercises
  - Stationary bike for ROM
  - Heel slides/wall slides/etc.

- STRETCHING
  - Gastroc/soleus, hamstring, quadriceps stretching

- STRENGTHENING
  - Calf raises
  - Quad sets
  - Hamstring sets
  - Glute sets
  - SLR series with and without weight (goal: no extension lag)
  - Mini-Squats
  - Front step ups
  - Core strengthening

- PROPRIOCEPTION
  - S/L stance on a stable surface with eyes open

(Children’s Orthopaedic & Scoliosis Surgery Associates, LLP)
Key Elements to Early Rehabilitation

1. Eliminate pain and inflammation
2. Restore full knee extension ROM
3. Gradually progress knee flexion ROM
4. Maintain patellar mobility
5. Restore volitional quad control
6. Restore independent ambulation

(Reinold, 2013)
Week 1

PT frequency: 1-2 x wk
Bracing: knee immobilizer (KI)
Weight bearing: WBAT with crutches; may wean from crutches 3-7 days; cont KI
Pain management: modalities (ice, e-stim, etc.)

Home exercise program (out of brace):
   Passive and active knee extension exercises to 0°
   Heel slides/wall slides/short sitting active assisted
   4 direction patellar mobilizations
   Quad sets
   Glute sets
   SLR series (goal: no extension lag)
   Ankle pumps

* Scar massage to incisions after day 10
• May use EMS or biofeedback with active exercise for muscle re-education
Week 2-4

PT frequency: 1-2 x wk
Bracing: continue KI
Criteria to wean from KI:
  5# SLR without extension lag or 5% of body weight if less than 100 lbs.
  Non-antalgic gait
Exercise options to add:
  Add weight to SLR series (if no extension lag)
  Stationary bike for ROM
  Mini-squats / wall sits with gym ball (0-40°, knee not past toes)
  Leg press (begin at wk 3; 0-90°)
  Multiple angle isometrics (40°, 60°, 90°) flex and ext
  Proprioception: S/L stance on a stable surface eyes open (once 30 sec progress to eyes closed, airex pad, rocker board and plyotoss)
  Calf raises
  Core strengthening
  Hip strengthening
  Cardio: UBE

*May continue to use EMS, biofeedback with active exercise for muscle re-education
**Open chain exercise resistance not to exceed 10-15 lbs
Week 5-6

PT frequency: 1-2 x wk
Pain management: modalities PRN

- Exercise options to add:
  Gastroc/soleus and hamstring stretching
  Front, lateral step-ups
  Lateral step-overs
  Front, lateral lunges
  Leg press single leg and eccentric
  *Hamstring curls (t-ball, standing, prone)
  Retrowalking with tubing

Cardio: UBE, walking program, pool running (fwd, bkwd), stair stepper
Week 6-8

MD typically decides about use of functional brace at 6-week follow up appointment.

PT frequency: 1-2 x wk; at least 2 x wk self-directed gym

- Exercise options to add:
  - Long strides with plyocord
  - Slide board

Cardio: stepper, walking; elliptical

Biking and Swimming (flutter kicks only) for cardiovascular endurance
Week 8+

• Isokinetic test when ready. Progress with functional activities if test passed at ≥ 75%.

• Criteria to take isokinetic test: S/L eccentric squat on the leg press with greater than 45 degrees of flexion and 50% of pt’s body weight.
Functional Activities

PT frequency: 1-2 wk; at least 2 x wk self-directed gym

Exercise options to add:
- Straight-line running
- Plyometric leg press
- Fitter
- Isokinetic concentric/eccentric exercise 90-40 at speed: 120-240/sec

Functional activities (in functional brace if applicable):
- Running figure 8s
- Cutting to half speed
- Closed space agility drills
- Dot hops
- Lateral shuffles
- Backward running
- Cariocas

**ROM goal: Full-pain free ROM as compared to non-involved knee**
Functional Testing

• Leg symmetry index ≥ 90%
  - Single leg hop for distance
  - Single leg hop for time
  - Single leg vertical jump

www.youtube.com/watch?v=Ct0BYwN11-I

**Begin sports specific activity program**
Discharge

Criteria:
- Full pain-free ROM
- No joint effusion
- Non-antalgic gait
- Good knee stability
- Completed SSAP
- Biodex test (or equivalent): 75% of uninvolved leg; ham/quad ratio > 70%
- LSI ≥ 90%

**Cleared by physician

- Final follow up with physician: 6-12 months post-op
- Final visit with PT: ??? May extend beyond.
Return to Sport

9-12 months

Depends not only on physical readiness but also MENTAL readiness.

Each patient requires an individualized intervention program based on ongoing education and support.

- Include parents/coaches.
- Maintain open communication with physician.
Current Post-Operative Model of ACL Rehabilitation for Safe Return to Sports

Point of Entry to Physical Therapy

One month Pre-Op

Physical Therapy Management for the Young Athlete Post-ACL Reconstruction

Three Month Progress Report: Functional Testing

Four Month Progress Report: Functional Testing

Discontinue PT: 16-20 weeks post-op: Pass Functional Testing and Independence in HEP

Three Month Progress Report: Functional Testing

One Month Progress Report

Two Month Progress Report: Functional Testing

3 days Post-Op Dressing Change
PT Re-evaluation New HEP

ACL Tear Diagnosis
Pre-Op Eval

HEP Delivery

One Month Progress Report

Functional Testing

Discharge Planning

ACL Reconstruction Surgery

Discontinue PT: 16-20 weeks post-op: Pass Functional Testing and Independence in HEP

ongoing PT
Outcomes Research

• Unfortunately, ACL failure rates and re-injury rates have been high with studies reporting up 19% (contralateral leg) and up to 29.2% (same leg).

• Research has shown that most failures happen between 3 and 9 months post-surgically.
Consequences of Recurring ACL Injuries

1. The need for repeat surgery
2. Reduced rates of return to prior level of activities
   - Recent research reports that less than 50% of players returned to sports at their pre-injury level 2-7 years post-ACL reconstruction
3. Increased risk of joint deterioration.
http://www.youtube.com/watch?v=NTVnVqKbwfM
Significance to Physical Therapy

• Rehabilitation following an ACL reconstruction has been shown to play a vital role to recovery and successful outcomes.

• Unfortunately, many young athletes are discharged from PT too early and returning to sports (the time when most failures occur, 3-9 months post-op).

• Answer?: Extended post-operative rehabilitation protocols and education.
Factors Used to Return to Sports - Review of Research (Barber-Westin & Noyes, 2011)

- Time from Post-op (84)
- Knee ROM and Joint Effusion (15)
- Stability (1)
- Muscle Strength Testing (quads, hams, hip, core) (25) or Thigh Circumference (3)
- Dynamic Function (single leg hop tests) (10)
- Neuromuscular Function (drop jump tests)
- Aerobic Capacity Assessment for Maximal Oxygen Uptake
- Sports-Specific Testing
- Validated Questionnaire Results (41)
Recommended Objective Criteria for Return to Sports Following ACL Reconstruction (Barber-Westin & Noyes, 2011)

- Isokinetic Testing or 1 RM Test (quad and ham strength)
- Single Leg Triple Crossover and Timed Hop Tests (symmetry)
- Video Drop Jump Test (LE neuromuscular control)
- Single Leg Squat to 90 Test (LE neuromuscular control)
- Knee Arthrometer Test (anteroposterior tibial displacement)
- Lachman, Pivot Shift Tests
- Knee Examination (ROM, effusion, patellar mobility, crepitus)
- Trial of Function during Running, Plyometrics, Sports-Specific Drills

**What about Validated Questionnaire??**
Video Drop Jump Test

Barber-Westin et. al. (2010)
SportCord Test
(Beecher et al., 2010)

• The SportCord Test is a return to sports assessment that incorporates a series of dynamic multiplanar functional activities against resistance from a Sport-Cord

• Components of the test include:
  • Single-limb squats for 3 minutes
  • Lateral bounding for 80 seconds
  • Forward/backward jogging for 2 minutes

• SportCord Test (video link)
Recommended Objective Criteria for Determining Safe Return to Sport

KOOS Questionnaire
www.koos.nu/koos-english.pdf
Preventative Exercises

Important considerations:
1. Must be done daily
2. Hard for young athletes to comply with exercises because they are boring.
3. Compliance is a problem

Answer?: Monthly follow up with PT; Get coaches involved (buy into ACL injury prevention program)
Training Programs for ACL Prevention

Noyes, FR, Barber-Westin, SD, Smith, STT, and Campbell, T. (2011)

Subjects: Female high school soccer players (ages 12-18)
Training: 3X/week for 6 weeks (90-120 min)
• Dynamic warm up
• Jump training
• Strength training
• Speed and agility (sports-specific)
• Aerobic conditioning
• Flexibility

Results:
1. Significant improvements in LE alignment on landing from drop jump (video drop jump test)*
2. Increases in speed and agility (t-test)
3. Improvement in VO2 max

Limitation: No control group


Subjects: Female league soccer players (ages 14-18)
Training: PEP (Prevent Injury and Enhance Performance) 20 min 2-3 X week for two years
• Warm up
• Stretches
• Strengthening
• Plyometrics
• Agilities

Results: 88% reduction in ACL injuries with intervention (2000); 74% reduction (2001)

Limitation: Non-randomized, coaches volunteered
Proposed Post-Operative ACO Model of ACL Rehabilitation for Safe Return to Sports and Prevention of Re-injury

Re-entry into PT for monthly re-evaluations and HEP/Preventative Program monitoring:
Assess recommended criteria for safe return to sports

Determine regression or new impairments indicative of high risk for repeat injury

Initiate treatment to address impairments 2X/wk for 3-6 weeks, or as needed to meet established PT goals

Resume monthly follow-up re-evaluations: *EDUCATION is Key**
HEP: SPORTS-SPECIFIC PROGRAM
PREVENTATIVE PROGRAM

No Concerns

FULL UNRESTRICTED RETURN TO SPORTS
Patient meets all recommended criteria for safe return to sports (physical and mental readiness)

Ongoing collaboration

Parents
ATC
Coaches
Physician
Areas for Future Research

• Test the proposed criteria for safe return to sports in the young athlete

• Randomized controlled trials on ACL prevention programs for the young athlete

• Compare re-injury rates associated with timing of return to sports and participation in physical therapy in the young athlete.

• Investigate the reliability and validity of instruments/tests used to determine return to sports in the young athlete.

• Investigate the long-term outcomes of proposed ACO model for safe return to sports following ACL injury in the young athlete.
References

References (cont.)


Question and Answer

Allow for at least 20 minutes of formal Q&A at end
Closing and Thanks