ACL Rehabilitation in the Pediatric/Adolescent Population

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Overview

- Epidemiology of ACL Injuries in the skeletally immature
- Current management of ACL injury in the skeletally immature
- Special considerations for rehabilitation within the pediatric population
- Big picture ACL re-injury prevention

Pediatric ACL Injury

- Skeletally Immature
  - Ages 11-14 y/o
  - Open physeal
    - Chronologic age
    - Skeletal age (Radiography – epiphyseal closure)
    - Physiologic Age (Tanner scale)

- ACL Injury in pediatric population
  - Greater exposure through increased sport participation
  - More intra-substance tearing observed in recent years (compared to tibial eminence avulsion)

Management Considerations

- Interventions
  - Transphyseal technique
  - Physeal sparing technique
  - Delayed reconstruction (after epiphyseal closure)
  - Non-surgical?

- Graft material
  - Harvest site?
  - Commonly hamstrings autograft

- Concomitant procedures??
  - May add precautions, delay progressions

Management Goals

- Keep kids healthy and active during youth and beyond
  - Maximize long term joint health

- Keep kids involved in their social world (often sport)
  - Minimize risks involved with choosen treatment
    - Surgical interventions: Growth disruption, (post)surgical complications
    - Non-surgical interventions: joint instability, meniscal/chondral health
Concerns with Children

- Retrospective reports of meniscal pathology associated with ACL injury:
  - 26-90%
  - Observed with operatively managed cases
- Increased time to surgery cited to be associated with increased non-repairable meniscal tears and chondral injuries (>12 wks post-injury)
- Question: what's happening during that time??

PT Skill Set Intervenes

Physical Therapy
Acutely?
Pre-Operatively?
Non-Operatively?

Mis-managed Acute Injury Phase??

Effusion & Pain
Quadriiceps Inhibition
Functional Joint Instability

Re-Injury/Flare-up

Non-Operative Management

Håvard Moknes, PT, PhD
Olympiatoppen-Norwegian Olympic Training Center
Norwegian School of Sport Sciences

- Only prospective randomized trial looking at secondary injuries (meniscus or cartilage) following non-operative treatment of ACL injuries in skeletally immature children

Moknes et al.

- 41 total knees: 14 girls, 26 boys (11.0 +/- 1.4 yrs at time of injury)
- F/u time mean of 3.8 +/- 1.3 years
- 88% confirmed monthly participation in cutting/skipping in school
- 63.4% (25 children) did NOT undergo surgery
- Incidence of new meniscus pathology over 3.8 yrs
  - 19.5% (8/41 knees)
  - 31.7% (13) of these underwent ACL-R
  - 0 had concomitant meniscal surgery
  - Timing of ACL-R = 1.6 +/- 0.9 years from original injury
  - 7.3% (3) underwent isolated meniscal procedure without ACL-R (off pain with RICE)

Moknes et al.

- Repeated 3T MRI
- Self-reported outcomes/activity reports + hop testing + isokinetic testing
- PT Intervention:
  - Custom fit knee brace
  - 4 phase rehab progression with continued home mgmt
  - Phase 4: re-injury prevention
- Referred to surgery if...
  - 2 episodes of giving way w/associated pain & effusion within 3 month period
  - Symptomatic meniscal injury
  - Unacceptable reduction in activity level
Moksnes et al.
- 2 meniscal & 1 chondral injury identified in uninvolved knees
- 88.0% (40 children) reported high rate of strenuous sport participation without restrictive symptoms during flu period
- Demographic differences affecting non-operative outcomes between cultures?
  - Access to regular, supervised physical therapy over 3-5-12 month period (community mobility)
  - Baseline physical activity or fitness levels
    - Obesity

Pediatric Considerations
- Children are NOT small adults
  - Different anatomy
  - Different biology
  - Different neurology
  - Different motivators
- Children are moving targets
  - Taller, heavier, different body composition over a period of time
  - Psychosocial impact of injury and associated activity restrictions

Biological Considerations
- Greater healing potential in children
- Children exhibit greater ligamentous laxity
- Generalized laxity has been observed to increase in females as they move through puberty

Biomechanical Concerns
- Skeletal growth = Increasing lever arm length
- Increasing body mass
- Changing body mass distribution

Increasing Lever Arm Length

The Big Bad 3
- Valgus Collapse
- Asymmetrical Loading
- Poor Postural Limb Stability
Neuromotor Considerations

- Non-linear development of multiple systems
- Several not fully developed by puberty
- Periods of regression with development
- Increased risk of injury??

Sensorimotor Function

Vestibular Mechanisms
- Among the slowest to mature

Visual Mechanisms
- Slower processing of visual changes

Somatosensory Mechanisms
- Slower detection of joint position changes

Neuromotor Considerations

- Landing strategies
  - Children exhibit reduced muscular stiffness compared to adults
  - Boys observed to increase muscular stiffness through development
    - Effective hip strategy emerges
  - Post-pubertal girls do not show symmetrical gains
    - Decreased knee control observed
    - Poor hip strategy
- Fadl, KR et al. AJSM 2010

Surgical Preparation

- EDUCATION
  - Child and parent
  - The exact mechanics of the surgical process
  - What will it feel like (what is normal, what is NOT)?
  - What will my incision look like?
  - What will wreck it??

Kid-Friendly Rehab

- Establish a trusting relationship
  - Include parent, coach, gym teacher, etc. pm
- Limit the # of exercises prescribed
- Turn exercises into games!
- Technology!
  - My favorite apps: "Egging", "Ubersense", "Tiltmeter", “Silver Dial” (metronome)
- Rewards!
  - Challenge them & then celebrate meeting milestones
Kid-Friendly Rehab
- Minimize burden of care:
  - Cost of care
  - Travel time
  - Missed school & work (child & parent)

- Don’t create a burden
  - Pre-op & post-op educational visits help avoid preventable issues & need for even more PT visits down the road
  - Minimize in-clinic distraction
  - Maximize in-clinic safety (supervision, cuing)

Post-Op Precautions
- More conservative approach often recommended
  - Concerns re: strength of graft integrity, general laxity
  - Concerns re: concomitant procedures
  - Concerns re: a child’s decision-making??

Criteria for Lifting Precautions
- Surgeon approval!
- Resolving effusion (1+ to 2+)
- Full knee extension ROM
  - Pain-free
  - PROM→AROM
- Adequate early quadriceps control
  - No extensor lag with SLR
  - TKE control in CKC observed

Acute Post-Op Goals
- Activity Modification
- Protect Graft
- Resolve Effusion
- Activate Quads
- Restore ROM

Joint Nutrition
- Edema/soft-tissue massage:
  - Suprapatellar pouch, infrapatellar fat pad, Med/Lat Gutter
- Gentle, repetitive, reciprocal joint motion

Adhesion Prevention
- Patellar Mobilizations
- Soft tissue mobilization adjacent to (unhealed) over (healed) incision(s)

Flexibility
- Early Post-Op:
  - Gentle Gastroc, HS (caution w/autograft)
- Later Post-Op (6+ wks):
  - Quadriceps

Quadriceps Activation Strategies
General ACL Re-injury Concerns & Rehab Priorities

- Gluteal Strength
- Quad Strength
- Core Stability
- Proprio. Drills
- CKC Kinematic Corrections

The Big Bad 3
- Asymmetrical Limb Loading
- Valgus Collapse
- Poor Postural Limb Stability


Treatment for BB3: Asymmetrical Loading

Treatment for BB3: Correcting Movement Faults

Weak Gluteals

= Functional Valgus

= Increased ACL injury risk

Treatment for BB3: Correcting Movement Faults

- Start with holds or shallow, slow motions
- External tactile & visual feedback to improve proprioceptive awareness/control
- Band around thighs
- Scales
- Mirrors
- Manual pressure/cuing
- Gradually reduce/remove cuing to internalize motor plan

Sallomen A.W. & Psychological Bulletin 1994

Treatment for BB3: Postural Instability
Treatment for BB3: Postural Instability

Add Postural Stability Challenge to CKC Drills

Progressing Rehab

- May show caution with...
  - Higher impact tasks
    - Aggressive joint loading may be a concern
  - Use of external load*
  - Cutting/pivoting tasks
  - Sport
    - 9-12 mos. RTS

What about strength training for kids?

- Not detrimental to skeletal growth
- Healthy effect on developing bone structure, bone mass

Strength & Neuromotor Training

- Children are very responsive to strength training (neuroplasticity)
- Proper supervision, technique instruction & execution are critical
- Strength and NMT training helps develop/improve motor skills and reduce injury risk
  - Greater effectiveness observed when initiated at younger age (early adolescence)


Strength Progression Mechanisms

<table>
<thead>
<tr>
<th>Contraction Type</th>
<th>Resistance/Load</th>
<th>Contraction Speed</th>
</tr>
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<tbody>
<tr>
<td>Isometric</td>
<td>OKC</td>
<td>Slow &amp; Controlled</td>
</tr>
<tr>
<td>Isotonic:</td>
<td>CKC: 2→1 leg</td>
<td>Progressively Faster</td>
</tr>
<tr>
<td>Concentric</td>
<td>Eccentric</td>
<td>Combine speed &amp; load (Power)</td>
</tr>
<tr>
<td>External load/resistance</td>
<td></td>
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What about NMES for kids?
- Very little specific to the "sports medicine" pediatric population
  - Used in the cerebral palsy population for spasticity management
- Supported for quadriceps recovery in adult population s/p ACL reconstruction
- Helpful when greater quad deficit present:
  - Prolonged WB restriction, extension deficit, etc.
- Proper patient education and thoughtful dosing

Functional Testing
- Hop testing comparable with isokinetic strength testing for children & adolescents
- Target = ±90% limb symmetry
  - Single leg hop for distance
  - Triple hop for distance
  - Cross-over hop for distance
  - 6M timed hop

Bracing??
- Generally advocated for post-operative management with kids
- Little empirical evidence
- Err on the side of caution
- May only be prescribed based on child's chosen sport/activities
  - Alpine skiing, snowboarding
  - Motor sports
  - Contact/collision sports

In Summary
- Children pose a unique challenge to surgeon and therapist alike because of their ongoing development.
- Maximizing long term health and short term happiness through activity engagement are central goals.
- Rehabilitation is a big part of any treatment plan.
- Make physical therapy scientifically based, but kid-friendly.
- Use the opportunity to educate & imprint healthy movement patterns for continued injury-prevention.

References
- Intrasubstance tears:
- Distal femoral physeal
- Pediatric ACL anatomy

Thank You!
References

- Pediatric Laxity

References

- Cartilage and meniscus tissue differences in ped's

References

- Neurokinins:

References

- Post-Operative Outcomes:

References

- Greater healing potential in pediatric knees:
  - Re-capture rates in ped's:

References

- Non-operative management/Outcomes:
References

- NMES

- Performance Testing
    http://dx.doi.org/10.1097/01.ppt.0000202007.76939.0e