ACL Reconstruction in the Skeletally Immature. Where We’ve Been, Are and Going to

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Disclosure

• Speaker – Arthrex, DJO
Agenda

- Where have we been
  - Identify the past ideas and approaches
  - Is this where we should be
- Where we are
  - Surgical indications
  - Approach to decision making for surgical technique
- Where are we going
  - Reapplying old ideas into new techniques
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ACL-Scope

- 150,000+ reconstructions/yr in USA
- 3-4% skelletally immature
  - ½ have meniscal tears
    - Lipscomb (JBJS 1986)
Epidemiology

• Female ACL Injury
  • NCAA Surveillance Studies
    • 2x – 8x increased risk
    • basketball, soccer
  • Pediatric & Adolescent
    • Shea et al (POSNA 2005)
Traditional Care

- Too young
- Wait
- No Cutting Sports
- PT
- Bracing
Treatment

• **Non-operative:**
  • Mizuta et al *(JBJS-B 1985)*
    • 1/18 return to preinjury sport level, 6/18 meniscal tears
  • McCarroll et al *(AJSM 1988)*
    • 3/16 return to preinjury sport, 4/16 meniscal tears
  • Angel & Hall *(Arthroscopy 1989)*
    • 5/7 failure (ACL reconstruction)
  • Graf et al *(Arthroscopy 1992)*
    • 7/8 failure (ACL reconstruction, meniscal tears)
  • Janarv et al *(J Pediatr Orthop 1996)*
    • 16/23 failure (ACL reconstruction)
  • Millett et al *(Arthroscopy 2002)*
    • medial meniscus tears with delay in treatment
Treatment

- Ganley et al:
  - Comparison of early (<3 months)
  - Or Delayed (<6 Months)
    - Found up to 10x increased rates of cartilage damage or irreparable meniscal tears
- Anderson, personal communication: similar findings
ACL-Decision Making

• Surgery:
  • Fail non-operative course
  • Any Meniscal injury at least to preserve mensical function
  • Those who refuse to limit high demand sports
  • Counsel on risks of surgery prior to end of growth
    • Growth abnormality
    • Risk of short-term stabilization and possible future revision
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Treatment decision
8 Year old Male

Young

5 or more years of growth remaining
Tanner 1-2

Options=Physeal Sparing
Soft tissue transphyseal?
Eight year old male

- Evaluate remaining growth potential
  - Chronologic age
  - Menstrual history
- Bone age – Elbow/wrist films
- Growth charts – over time
- Tanner Stage – pubic hair
- Comparison to family height
- Growth plate appearance
  - Radiographic/ MRI
  - Size of Epiphyseal bone
Physeal-Sparing Reconstruction

Physeal-Sparing ACL

- **Brief** *(Arthroscopy 1991)*
  6 pts; 3-6yr F/U: 6/6 laxity, 1/6 instability

- **Guzzanti et al** *(AJSM 2003)*
  8 pts, tibial tunnel; 2-7yr F/U:
  1/8mm laxity, 0/8 instability

- **Anderson et al** *(JBJS 2003)*
  12 pts tunnels; 2-8yr F/U: 1.5 laxity, 0/12 instability

- **Kocher et al** *(JBJS 2005)*
  44 pts. ITB extra & intra-articular; 2-15 yr F/U: 4.5% revision
12 year old Female

- 3-5 Years growth remaining
- Elbow Growth Plates not Closed
- Options
  - All-epiphyseal
  - Partial Transphyseal
  - Soft Tissue Transphyseal
  - Quad with or without patella
15 year old Male

- <3 Years growth remaining
- Elbow Growth Plates now Closed
- Options
  - All-epiphyseal
  - Partial Transphyseal
  - Soft Tissue Transphyseal
  - Quad with or without patella
ACL Reconstruction

• Transphyseal ACL
  • Not OK
    • Campbell 1959 and Osterman 1994
    • Heuter Volkman 1862
    • Wester 1994
  • OK
    • Lipscomb & Anderson (*JBJS*-A 1986)
    • McCarroll et al (*AJSM* 1994)
    • Matava & Siegel (*Am J Knee Surg* 1997)
    • Aronwitz et al (*AJSM* 2000)
    • Lo 1997, Bisson 1998, Noyes 1994

• Soft tissue interposition with graft prevents osseus bridging in small defects
  • Stanitski 1959, Osterman 1994, Stadelmaier 1995
Growth Disturbance

Pallela, 2010, Presentation

• 10 year experience with T 1-2 ~ 50
• Followed to near skeletal maturity
  • Transphyseal HT
  • No disturbance
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• Where are we going
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Quad As a Graft
Why look?

- **Females**
  - Suggestions against use of hamstring autograft due to neuromuscular disadvantage.
  - Recent study
    - Retear rate 12% males but 22% Females

- **Allograft**
  - Recent reports of up to 55% re-tear in younger population
    - Singhal et al Arthroscopy 2007

- **Growth**
  - BPTB difficult to use in all epiphyseal and will be more likely to stop growth when used across physis
Graft Choices
Perceived Drawbacks

- Autograft
  - ITB  ? Strength
  - Hamstring  ? Weakness
  - BTB  Growth arrest
    Ant knee pain
    Patella Fx
- QTB  Growth arrest
  Quad weakness
  Patella Fx
What about the quad as a graft

- Stronger with the patella still attached
  - Without is still more than twice as strong as native ACL
- Comparable to BPTB and Hamstring with regard to overall strength
  - Less strength per unit area but more unit area per size of graft

Harris NL et al. AJSM 1997 and Staubli et al AJSM 1999
Comorbidities?

- No permanent weakness – Hamstring
- Same rate of anterior knee pain as previously reported for allograft ~8%
- Similar re-tear rate 5-7%

Han et al CORR 2008
Harvesting
All-Inside
Two Femoral options

10-12mm

30mm
Tibial side

- A drill bit and guide are placed through the medial portal and positioned on the tibia
  - 6-8mm anterior to the PCL
  - In the posterior portion of the ACL footprint
  - At the posterior aspect of the anterior root of the lateral meniscus
Results

Trans-Physeal Quad-Patella

• 100 patients with minimum 2 year follow-up currently being looked up
• Preliminarily, only 3 graft failures (both at 15 months) Post op
• ~93/100 returned to same level of sport
• No premature growth arrests partial or complete
Conclusions

• **Recommendations**
  • Know Growth Remaining
  • Shared Decision Making
    • Risks: Non-operative Treatment
    • Meniscal/ Chondral Injury
    • Risks: Operative Treatment
    • Growth Disturbance
  • Understand Pediatric Knee Anatomy
    • Distal Femoral Physis & Over-Top
    • Proximal Tibial Apophysis
ACL-Recommendations

• Extra-articular/OTT avoid dissection or elevation of physis
  • peripheral physeal damage, most dangerous
• Salvage Menisci
• Do Not cross physis with fixation or bone plugs
• Place tibial hole in most central/posterior portion of ACL footprint as possible
• Start tibial drill hole as far distal as possible
  • decrease size of defect in physis as more perpendicular
• Avoid over constraining
• Small tunnel
Conclusions

• Long-Term Complications of Pediatric Knee Injuries
  • ACL Reconstruction
    • Arthritis
    • Stiffness, Pain, Retear Graft
  • Meniscal Injury
    • Discoid Lateral Meniscus: Uncertain
    • Complete Menisectomy: Arthritis
    • Partial Menisectomy: Uncertain
  • Chondral Injury
    • Cartilage Injury: Arthritis
    • OCD: Arthritis
Future Direction

- Investigate strength of fixation constructs
  - Would like to avoid needing to use aperture screw fixation
    - Decrease risk of growth arrest on Tibia
Thank You
Graft Choices

- Allograft (N/(N/mm))
  - Tib A, Post T, PL: 3000/300
  - Hamstring: 4090/776
  - BTB: 2900/
  - QTB: 3500/
The Child’s ACL
Where We’ve Been, Are and Going To

Jay C Albright, MD
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Disclosure

- Arthrex
  - Speaker
    - Honoraria
An ACL Case Gone Bad
Treatment Algorithm

• 2?-3? Years growth remaining
  • All-epiphyseal
  • Partial Transphyseal
  • Soft Tissue Transphyseal
  • Quad with or without patella
Treatment Algorithm

• Not as young
  • Tanner 3-4
  • 1-2 years of growth remaining
• Transphyseal
Evolution

- Graft Choices
  - Have heard of others
  - Here is another viable option
  - For the middle to older adolescent
Why look?

- Females
  - Suggestions against use of hamstring autograft due to neuromuscular disadvantage

- Allograft
  - Recent reports of up to 55% re-tear in younger population
    - Singhal et al Arthroscopy 2007

- Growth
  - BPTB difficult to use in all epiphyseal and will be more likely to stop growth when used across physis
Graft Choices

- Reinhardt et al, Graft selection for ACLr: A Level I Sys Review ‘10
  - 6 studies qualified
  - BTB 11 failures (7.2 %)
  - HT 26 (15.8%) \( p = 0.02 \)
  - If eliminate 2s HT studies
    - BTB 4/106 (3.8%)
    - HT 4s 12/110 (10.9%)
Graft Choices

- Reinhardt et al, Graft selection for ACLr: A Level I Sys Review ‘10
  - 6 studies qualified
  - Strength
    - Variable
      - $\frac{1}{2}$ NS diff
      - $\frac{1}{2}$ HT (2 or 4s) Weaker at final follow-up
What about the quad as a graft

- Stronger with the patella still attached
  - Without is still more than twice as strong as native ACL
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Han et al CORR 2008
Graft Choices

• Allograft
  • Barrett et al BTB auto vs allo fresh frozen
    • FF 2.6-4.2x higher failure than auto in higher tegner/younger patients (<40)
  • Singhal et al
    • 23 % failure with 38% re-operation in frozen soft tissue <25 yo
  • Gorschewsky et al
    • 2 studies showing high failure in young patients returning to level I ACL dependent sports
What about growth
Growth Disturbance

• Physeal defects okay:
  • No leg length disturbances
  • 3 reruptures with activity
  • Majority close to skeletal maturity
  • Soft tissue interposition with graft prevents osseus bridging in small defects
    • Stanitski 1959, Osterman 1994, Stadelmaier 1995
13 Yr Old Female

• Soccer Player
  • Travel Select State Team
• BA 13
• Olecranon Apophysis Closing
Harvesting

- 3-4 cm incision
- 12-15mm bone (imm)
  - 75-80mm graft length
- ¼ inch curved osteotome
  - Strip proximally
- Close tendon
  - Fill bone defect with Allograft or substitute later

Diagrams from Han et al
Load the graft onto a Chinese fingertrap shortening device
Tunnel Prep

• Femoral Options
  • Acorn reamer
  • Low profile Reamer
  • Flip cutter
    • Especially revisions
Tunnel Prep

• In Skeletally immature
  • Femoral tunnel depth needs to be 30mm
    • 3 mm distance of the perichondral ring to the over the top position
  • Average distance from joint to superior aspect of growth plate in tunnel
    • Posteriorly = 5mm
    • Anteriorly = 10mm
Tunnel Prep

• Tibia
  • Antegrade/intra-articular cutter
  • Depth so no bottoming out of graft
Pass Graft

• Standard
  • Into femur first
    • Flip button
    • Shorten device fully to seat bone block at top of tunnel
Pass Graft

- Into tibia
  - Fix with aperture screw
  - Check to make sure screw not crossing growth plate
  - Back screw by tying sutures in graft over button
From the inside
What now
What Now
Fixation Gone

• New Graft?
• New Fixation?
  • Skeletally immature
Whip Stitch
Whip Stitch, Hay Bail, Rip Stop, ....
Whip Stitch, Hay Bail, Rip Stop, New Button Fixation, Hail Mary
Rehab

• Hinged Post op knee immobilizer
• WBAT
• Immediate PT
  • FROM – no meniscal repair
    • Goal 0-90 within 1 week
Rehab

• Immediate SLR, Quad Sets
• No meniscal repair, out of brace
  • 75 perfect SLR
Rehab

• At 3 Months post op
  • ACL brace
  • Jogging
• At 4-6 months
  • Sprinting
• At 5-8 months
  • Cutting/twisting
RTP?

• For my patients
  • PT – functional tests within 85-90% opposite leg
  • My manual muscle test ~90% opposite leg
  • +/- isometric strength test
    • Absolutely if the patient/therapist has access
My experience

- Over 80 with more than 2 years follow-up
- 2 Failures in under 18 at time of surgery
- No growth arrests partial or complete
Future Direction

• Expand age range to perform surgeries in kids with up to 2.5-3.5 years remaining
  • To this point only kids that have past peak height velocity (elbow closed)

• Investigate strength of fixation constructs
  • Would like to avoid needing to use aperture screw fixation
    • Decrease risk of growth arrest on Tibia

• Could use this graft in the all epiphyseal construct
Thank You
Femoral growth plate measurement.mov
acl femoral seating1.mov
Tibial seating.mov