ACL Reconstruction in the Skeletally Immature: The Case for Anatomic Transphyseal Reconstruction

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Incidence of ACL Injury in the Skeletally Immature

• Originally thought to be RARE
• Now widely recognized diagnosis
• Incidence/prevalence UNKNOWN

Clinical History
Physical Exam
Imaging Studies
Natural History

Similar to Skeletally Mature!!!
Classic Treatment

Non-Surgical

Natural History

• Graf et al, Arthroscopy 8, 1992
• Janarv et al, J Ped Orthop 16, 1996
• Mizuta et al, JBJS 77, 1995
  – Instability symptoms, decreased activity level
  – Resulting meniscal tears
  – Subsequent need for ACL reconstruction
• McCarroll et al, AJSM 1988, 1994
  – 38 Tanner stage 1,2 treated non-op
    • 27/38 developed meniscal tears
Effects of Treatment Delay?

- Ganley et al (2009 AOSSM)
  - 70 skeletally immature patients
  - Early (<12 wks) vs Delayed (>12 wks)
  - Delayed Surgical Reconstruction
    - 4x irreparable medial meniscus tears
    - 11x lateral compartment chondral injuries
    - 3x patello-trochlear chondral injuries
    - Single instability episode = 11x medial meniscus tear

Our Fears?

- Physeal injury with premature closure
- Leg length discrepancy
- Angular deformity

Are those fears grounded in reality?
**Basic Science Studies**

SUPPORT conclusion that complete transphyseal reconstruction using soft tissue graft is likely **SAFE!**

- **Guzzanti et al**
  - Rabbit Model
  - Risk of Growth Arrest
    - related to drill hole size
  - Tibial side
    - 12% frontal plane
    - 4% cross-sectional area
  - Femoral Side
    - 11% frontal plane
    - 3% cross-sectional area

- **Stadelmaier et al**
  - AJSM 1995
  - Canine Model
  - fascia lata graft vs empty
  - sacrificed at 2 & 16 wks
  - Non-grafted animals
    - 100% bone bridges
  - Grafted animals
    - 0% bone bridges
    - no limb length abnorms.

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**Transphyseal Tibial Tunnel/Soft Tissue Graft**

- Central placement
- Anatomic position
- Small % physeal area
- Low risk for physeal bar
Femoral Tunnel Alternatives

• Over-the-Top
  – Avoids drilling through physis
  – Non-anatomic placement
• Transverse Tunnel (Anderson)
  – Distal to physis
  – Potential for “longer” physeal injury
• Transphyseal
  – Anatomic

The Relationship of the Femoral Attachment of the ACL to the Distal Femoral Physeal Plate in the Skeletally Immature Knee: An Anatomical Study
Behr, CT, Paletta, GA, Jr., and Potter, HG. (AJSM 2002)

• 12 fresh frozen fetal specimens
  – Gestational age: 23-36 wks
• 13 Skeletally Immature Knees
  – Age range 5 to 15 years
Distance remains constant (2.5 mm) throughout skeletal growth!
Over-the-Top position AT LEVEL of PHYSIS!

What does our clinical experience tell us?

Non-anatomic vs Anatomic
ACL Reconstruction in the Skeletally Immature: A Comparison of 2 Techniques
Paletta et al, ACL Study Group, Big Sky 1999

Over-the-Top vs Transphyseal

- 21 skeletally immature patients
- ACL Insufficiency + functional instability
- Group I (10 pts)
  - Trans-tibial, OTP femoral
- Group II (11 pts)
  - Complete transphyseal
- Min 24 m, ave 30 m f/up
Results

• Group I (OTP)
  – Mean Lysholm = 88
  – 9/10 satisfied
  – 9/10 returned to play
  – 1/10 Instability
  – 7/10 Pivot Shift
  – KT-1000
    • Mean 3.6 mm**
    • Range 1-5 mm
  – 5.9 cm mean limb growth
  – 0/10 LLD or angulation

• Group II (Transphyseal)
  – Mean Lysholm = 96
  – 11/11 satisfied
  – 10/11 returned to play
  – 0/11 Instability
  – 1/11 Pivot Shift
  – KT-1000
    • Mean 1.18 mm**
    • Range 0-3 mm
  – 6.4 cm mean limb growth
  – 0/11 LLD or angulation

Conclusion

• Complete Transphyseal Reconstruction
  – More predictable clinical outcome
  – Improved stability
  – No evidence of significant risk premature physeal closure
What are the results of transphyseal reconstruction?

Are our fears realized or do they remain just fears?

Transphyseal Reconstruction: Reported Results

• Lipscomb and Anderson (JBJS 68-A, 1986)
  – 24 pts < 14 yrs age
  – No leg length or angular deformities
• Fowler (AOSSM, 1994)
• Parker et al (AJSM, 1994)
  – 1 Patient with > 2 cm LLD = Staples across physis
• Andrews et al (AJSM, 1994)
  – Trans-tibial, over the top femoral
  – No leg length or angular deformities
• McCarroll et al (AJSM, 1988, 1994)
Shortcomings of Prior Studies

- Study Design Faults
  - Retrospective series with small numbers
- Lack of Specificity of Diagnosis
  - Concomitant pathology
- Lack of Skeletal Maturity Documentation
  - Skeletal vs. chronologic age
- Lack of Physiologic Maturity Documentation
  - Tanner staging, menarchal status

Transphyseal ACL Reconstruction in Skeletally Immature Prepubescent Adolescents
Kocher et al, JBJS 89, 2007

- 59 patients Tanner stage III, ave age 14.7 yrs
- Quad hamstring transphyseal reconstruction
- Follow-up = 3.6 yrs (2-10)
- Lysholm = 91.2 +/- 10.7
- IKDC Score = 89.5 +/- 10.2
- Lachman normal/near normal 59/59
- Pivot normal/near normal 59/59
- NO LLD or angular deformities
ACL Reconstruction in the Skeletally Immature: 50 Cases
Paletta et al, Personal Comm

- 50 patients, Tanner stage I,II,III or pre-menarchal
- Average chronological age 11.5 yrs (7-13)
- Quad hamstring transphyseal reconstruction
- Follow-up: 3 yr min, 4.5 yrs ave (3-10), 29/50 maturity
- Lysholm = 94.5 +/- 8.2
- IKDC – normal, nearly normal 49/50
- Mean KT-1000 = 1.2 mm (-2 – 4), 1/50 > 3mm
- 49/50 NO functional instability
- 44/50 returned to pre-injury sports/activities
- NO LLD or angular deformities

Summary

- Transphyseal Reconstruction is SAFE and EFFECTIVE
- No role for extra-articular reconstruction
- Soft tissue graft
- Fixation proximal/distal to physes
- LOW risk of physeal injury
- Clinical LLD or angular deformity rare without technical errors