ACL reconstruction in the Skeletally Immature Patient
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**Types of pediatric ACL lesions**
- Cartilaginous avulsions
- Bony avulsions
- Midsubstance tears

**In-house ACL registry: 2011-2012**

![Graph showing percentage of ACL ruptures by age and gender]

- Few precise epidemiological data

**Surgical treatment**

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment</th>
<th>Unstable Knees (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Nonoperative</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Autographs</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Extraarticular</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Reconstructions</td>
<td></td>
</tr>
</tbody>
</table>

**2013**

- Surgical rules well established!

1. Evaluate remaining growth
2. Know specific anatomy
3. Fill the tunnels with soft tissues
4. Small tunnels (< 3 mm)
5. Perpendicular to physis
6. Graft tension not too high
7. No physeal-crossing fixation

**Growth and maturation of knee joint**

Many physiologic and pathologic issues poorly understood in this young population.

Children before puberty:
- Good stability control despite unfavourable biomechanical conditions

**High physiologic laxity**

- Landing in Valgus

Presence of osteoligamentous laxity

- High physiologic laxity

- Presence of growth plates

**Surgical rules**

- Landing in valgus
- High physiologic laxity
- Presence of growth plates
- Changing osteoligamentous laxity
Growth and maturation of knee joint

Knee function & laxity in children

End of growth period: Knees stiffen, injuries increase

Current understanding of knee maturation at end of growth period is poor.

Changes of physiological laxity and their influence on active knee stabilization need further analysis

Treatment

The Current Evidence for Treatment of ACL Injuries in Children Is Low

A Systematic Review

Isolated ACL tear:
- NO early reconstruction!
- Explanations +++
- Rehabilitation for 3-6 mo.
- Limitation of physical activity
- Close FU
- (Brace)

Indication for surgery:
1. If primary meniscal tear
2. @ skeletal maturity
3. If secondary meniscus tear
4. If functional instability
5. High sports demand (?)

No international consensus, expert-opinion level discussions

Nonoperative treatment debate

- children < 12 years, no surgery
- 65% returned to pre-injury level of sport
- Tanner I or II (median 11 years)
- 42% of conservatively treated children did not need surgery over a 5-years period
- 58% developed instability and received an ACL-reconstruction
- more medial meniscus & cartilage lesions if surgery > 3 months after injury
- higher MMT rate in late surgery group
Nonoperative treatment debate

Functional tests

Patients’ & families’ adherence to:
- Less active lifestyle
- Damocles sword of later surgery and subsequent meniscus tear / cartilage lesions
- Level II sports
- Brace

Limited option for some patients & their family

Preoperative planning

- Remaining knee growth
- Leg length
- Alignment
- Skeletal age
- Tanner staging non reliable

No international consensus

Preoperative evaluation: growth assessment

Growth and maturation of knee joint

3 physiological stages

Growth speed

Skeletal age

Preoperative planning

- ACL tear @ 12
- Chronological age: 14.9 y.
- Skeletal age: 12.9 y.

Growth and maturation of knee joint

Growth Plate Disturbance After Transphyseal Reconstruction of the Anterior Cruciate Ligament in Skeletally Immature Adolescent Patients: An MRI Imaging Study

Yoo WJ, J Ped Orthop 2011

Focal bone bridge formation without growth disturbance in 11% of adolescent patients

Adequate timing for surgery debatable
Surgical techniques

Physseal sparing

Transphyseal 4-fold Semi-tendinosus/Gracilis graft
- 6-8 mm
- distal fixation
- no transphyseal hardware or bone block
- anatomic technique?

Surgical technique

Fate of graft? Bollen S, JBJS-B 2008

Anatomy

Tibial tuberosity apophysis

Tibial drill injury

Drill injury < 7-9% of surface

Principles of physeal injuries

Can be prevented with soft tissue filling

Stoddard D, 1995

Femoral drill injury

posteriolateral
**Principles of physeal injuries**

Peripheral damage

Axial deviation

3-4% of surface

Ford & Key, JBJS-A, 1956

**Rehabilitation**

Isolated ACL replacement:
- 6 weeks brace
- FWB
- Free ROM

Meniscal repair:
- 6 weeks brace
- 6 w. 0-0-90°
- 6 w. FWB in extension
- Return to sports 9-12 months

**Complications**

- Rare in experienced hands (< 50 cases)
- Most related to surgical technique
- If they occur:
  - continue until end of growth

Chotel F, KSSTA 2010

**3 types of growth changes**

- Arrest
- Boost
deceleration

**4 types of gross complications**

- Arrest distal lateral femur physis: valgus knee
- Arrest tibial tubercle: recurvatum
- Arrest medial Proximal tibial physis: Varus knee
- NO transphyseal hardware placement

**Results**

- IKDC A&B: 84 %
- Retears: 5 %
- Return to sports: 91 %

Caution is necessary when interpreting study results
Moksnes H, JBJS-A 2012

Bonnard C, Chotel F, RCO 2007
Laxity profile at maturity

ACL-replacement @ 11 y.; Control @ 16 (+ 20 cm)
Lachman -; pivot shift –
No recurvatum
GOOD RESULT

ACL-replacement @ 13 y.; Control @ 17
Lachman +; pivot shift ++
Recurvatum ++
BAD RESULT

Results less predictable than in adults

Distribution of laxity in IR at 5 Nm in healthy legs

Individual laxity profile at maturity unforeseeable

Summary

<table>
<thead>
<tr>
<th>Topic</th>
<th>Problem</th>
<th>Need for further investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidemiology</td>
<td>No register</td>
<td>Yes</td>
</tr>
<tr>
<td>Growth / maturation / evolution of laxity</td>
<td>Little investigations</td>
<td>Yes</td>
</tr>
<tr>
<td>Prevention</td>
<td>No studies for children</td>
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<tr>
<td>Injury risk factors</td>
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<td>Yes</td>
</tr>
<tr>
<td>Treatment indications / algorithms</td>
<td>No consensus</td>
<td>Yes</td>
</tr>
<tr>
<td>Surgical techniques / algorithms</td>
<td>/</td>
<td>(No)</td>
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<tr>
<td>Surgical risk factors</td>
<td>Types of complications</td>
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</tr>
<tr>
<td>Outcome</td>
<td>Graft evolution</td>
<td>Yes</td>
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<tr>
<td></td>
<td>Knee function</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Return to sports</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Long term outcome</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Pediatric ACL Monitoring Initiative (PAMI)

- Online survey on the current treatment of pediatric ACL injuries
- Planned submitted to ESSKA members and affiliates
- Potentially 2500 recipients

Example survey

10) When you perform pediatric ACL reconstructions, which is your preferred graft?
- Hamstring
- Quadriceps
- BMP
- Allograft
- Other

11) When you perform pediatric ACL reconstructions, which is your preferred method of graft fixation?
- Interference screw
- Button
- Other
Objectives

- To establish knowledge on
  - The magnitude of pediatric ACL injuries
  - Current trends in treatment algorithms
  - Preferred surgical techniques
  - Rehabilitation protocols
  - Success criteria

Clinical, functional and radiological data to share knowledge and to improve:
- the understanding of the injury’s occurrence
- the current treatment approaches
- the understanding of the long term effects
- the knowledge on the specific anatomy and the biomechanics subsequent to ACL injury

Graft selection

- Quadriceps tendon
- Hamstrings
- Patellar tendon without bone blocks

Femoral drill injury

- Transtibial: 7 mm tunnel: 42 mm² x 3.5 = 148 mm²
- Anteromedial: 9 mm tunnel: 70 mm² x 3.5 = 245 mm²

Surgical technique

Acute setting: clinical examination

- Lachman test: High physiologic laxity in children!
  (BOSTER MP, J Ped Orthop, 1999)
- Pivot-shift test: Easily pathologic in healthy children
  (Halt F, Müller W 1993)
- Haemarthrosis:
  - 1/3 ligamentous tears (♂>♀)
  - 1/3 patella dislocations (♀>♂)
  - 1/3 meniscal tears

Acute setting: MRI

- sensitivity specificity
  - < 12 y.: 62 % 90 %
  - 12-16 y.: 78 % 96 %

BEWARE false positive (up to 25 % !)