ICL # 8: Current Concepts in PCL Insufficiency
ISAKOS – Tue May 17th 2011
7:30 – 9:00
Rio de Janeiro, Brazil

AGENDA

7:30-7:42  Dr. Christopher Harner
Anatomy/Biomechanics, kinematics, my approach to PCL

7:42-7:54  Dr. Fabrizio Margheritini
Gr III PCL, Gr III PLC with LCL intact

7:54-8:06  Dr. Mark Miller
Gr III PCL, Gr PLC (blow out of the lateral side with peroneal nerve injury)

8:06-8:18  Dr. Sung-Jae Kim
Combined ACL/PCL injury

8:18-8:30  Dr. Rodrigo Maestu
Gr III PCL, Gr III MCL

8:30-9:00  Q&A
Christopher D. Harner, MD - Medical Director, Center of Sports Medicine
Professor, Department of Orthopedic Surgery
University of Pittsburgh Medical Center

Gustavo A. Rincon, MD - Sports Medicine Research Fellow
University of Pittsburgh Medical Center

- Anatomy/Biomechanics
  - PCL has 3 components
  - AL is largest and strongest component
  - All three components have specific insertions
  - AL and PM have reciprocal and specific tensioning patterns

- Kinematics/In situ forces (Robotic studies)
  - PCL forces change with knee flexion angle and loading
  - Posterolateral corner deficiency affects PCL graft forces
  - Double bundle restores in situ forces and kinematics better than single bundle
  - Sagittal slope – axial compression results in anterior tibial translation
    - ↑ slope, ↑ anterior translation, ↓ in situ forces

- My approach to PCL injuries:
  - Practice profile:
    - Location: academic medical center (44 residents and 6 fellows)
    - Research: Clinical, Basic Science
    - Years in practice: 23
    - Number of primary PCL’s /yr: 15-20
    - Number of Revision PCL’s /yr: 3-5
  - Principles of treatment:
    - Different injury patterns will dictate different approaches
    - Partial PCL injuries exist and the PCL (unlike the ACL) can heal
  - In general:
    - Isolated PCL injuries are treated non-operatively
    - Combined injuries are treated surgically
o Non operative treatment:
  - ~10-15 per year
  - GI-GII (PLC is intact)
  - Goal: Protect partially injured PCL (and PLC)
  - Brace in extension: 4 weeks
  - Followed by Quad rehab program
  - Usually 8-12 weeks to return to Sports

o Surgical approach:
  - Depends on pattern of injury
  - EUA, arthroscopy and MRI dictate surgical approach
  - Do not miss an associated PLC injury
  - Repair/reconstruct acutely when possible (esp. PLC)
  - Known the anatomic insertion sites!

Arthroscopic views

AL & PM femoral bundles
AL & PM tibial bundles
PCL cases 2001 – 2004:
- ~ 165 PCL related cases
- 63 non op cases
  - (isolated PCL)
- 102 operative cases
  - 46 PCL/PLC (LCL ok)
  - 21 PCL/ACL/PLC (+LCL)
  - 18 PCL/ACL/MCL
  - 17 other (4 revisions, 4 PCL/ACL/MCL/PLC)

Current Surgical Approach
- 3 different techniques
  - Single bundle (AL) – 40%
  - Double bundle (AL,PM) – 40%
  - Single bundle augmentation – 20%
- I do not use a tourniquet or leg holder
- I use intraop fluoroscopy on all cases to confirm tunnel position
- Graft preference:
  - Allo 80% (AT, Tib ant)
  - Auto 20% (quad tendon, younger patients)
Post-operative Management:
- **0 – 1 weeks:** Brace in full ext. and WBAT
- **1 – 4 weeks:**
  - Unlock brace for mini squats
  - Lock when ambulating
  - Brace for 6 weeks
- **4 – 12 weeks:**
  - Unlock brace
  - Quad rehab
  - Return to ADLs
- **3 – 9 months:** FROM
- **9 – 12 months:** Return to full activity

Conclusions:
- Not all PCL injuries are the same
- Most isolated PCL injuries are still treated non-operatively
- Decision regarding single bundle, double bundle and augmentation techniques are based on injury patterns and insertion site anatomy
- Remember to address all secondary restraints

REFERENCES

Fabrizio Margheritini, MD

University of Rome “Foro Italico”
Department of Sciences Health
Unit of Orthopaedics and Sports Traumatology
Director Prof. P.P. Mariani

Practice Profile

- Rome, Italy
- Practice since 1998
- 30-40 PCL reconstructions/year
- 5-10 PCL revisions/year
- 200 ACL reconstructions/year
- 100 TKRs/year

PCL/PLC Insufficiency

Diagnosis
- Posterior Drawer Test
- Posterolateral Drawer Test
- ERTFA
- MRI (Acute) Gross’s Classification (I,II,III)
- MRI (Chronic) PCL elongation
- Stress x-ray(subacute,chronic)

Preferred Technique

- Arthroscopic transtibial technique, Transeptal approach
- Grade II/III “Isolated” (up to 10 mm of posterior translation) AL bundle augmentation with ST/GR
- Grade III (more than 10 mm of posterior translation) single bundle (AL) reconstruction with autologous Quadriceps tendon and preservation of the remnant and the MFL’s
Case Presentation

• History
  – Sports injury or MVA, trauma on the antero/medial side of the knee posteriorly directed with a combined twisting of the knee

• Physical Examination
  – Posterior Drawer 90° +++
  – Posterolateral Drawer 90° ++
  – ERTFA @30°knee flex> 15°, @90°> 15°
  – Varus stress negative

Imaging

• MRI
  (T1, T2 weighted sequence)

• Stress X-Ray (13 mm side to side)
  (Telos®:Hamstring’s contraction, Kneeling view)

Diagnosis

• Clinical examination
  – Grade III Chronic PCL insufficiency + Grade III PLC insufficiency (LCL intact)

Technique of Surgery

• Transtibial arthroscopic AL bundle reconstruction using Quad Tendon
  – Supine Position, full table, tight support, tourniquet at tight no inflated
  – AL and AM standard approach and PM and PL approach with transeptal technique
  – Tibial tunnel first drilled at @90° knee flexion
  – Femoral tunnel drilled outside-in technique
Technique of Surgery

- Quad graft harvesting (9-10mm diameter, length 9 cm, bone block 9x14mm)
- Graft passed from tibia to femur, bone block on tibia
- Femoral fixation first, bioabsorbable screw
- Posterolateral corner reconstruction using a modified Larson technique with ST graft
- Fixation of PLC reconstruction with bioabsorbable screw @30° knee flexion
- Tibial PCL fixation @90° knee flexion, maximum anterior drawer, anatomical tibial fixation with bioabsorbable screw (+ staple or screw as post if possible)

Post op Care

- No weight bearing for 4 wks, then increase
- Straight knee brace (PTS) for some 6 wks day and night, then other 4 wks only night
- If possible PCL Jakob brace from week 4th p.o.
- Passive mobilization after 2 wks, no active hamstring contraction for some 5 mos
- Hydrotherapy from 4th p.o.
- Resume full sports activity 7/8 mos

Complications

- Stiffness (passive mobilization and early hydrotherapy)
- Graft elongation-failure (stress reduction on the graft: protection with brace, no hamstring contraction)

Reference

Speaker’s Preferred Technique
  o Posterior Cruciate Ligament (PCL)
    ▪ Tibial inlay
    ▪ Single bundle
    ▪ Graft preference: BPTB autograft versus allograft
  o Posterolateral Corner (PLC)
    ▪ Muller popliteal bypass & Larsen Figure 8
    ▪ Graft Preference: semitendinosus autograft versus allograft

PCL reconstruction—Tibial Inlay
  o Implies inlay, NOT onlay
  o Positioning is important
  o Inlay the graft onto the trough and secure with posterior to anterior screw(s) and washer

Posterolateral Corner Injuries
  o Rarely isolated injuries
  o The posterolateral corner is made up of:
    ▪ Biceps femoris
    ▪ Iliotibial band
- Popliteofibular ligament
- Arcuate ligament
- Lateral collateral ligament

○ Function
  - Resists external rotation and varus force

○ Mechanism of Injury
  - Direct blow to anteromedial tibia
  - Hyperextension/varus

○ Physical Examination
  - Varus Laxity
  - Increased External rotation (30°, 90°)
  - Posterolateral external rotation test
  - Reverse pivot-shift test
  - External rotation recurvatum

○ PLC Injury Treatment
  - Partial (grade I & II Instability with a good end point)
    • Nonsurgical Treatment
    • 3 week immobilization in extension
  - Complete Acute
    • Primary repair best
    • Augment with allo/auto graft
  - Complete Chronic
    • Reconstruct Popliteus and LCL

○ PLC Surgical Treatment
  - The peroneal nerve
    • Pre-op—document exam!
    • Intra-op—identify and protect!
    • Post-op—document exam!
    • Wait—6+ months
    • Late options for nerve damage
      ○ Benign neglect
      ○ Nerve repair
      ○ Tendon transfers

  - Primary Repair
    • Goal: restore anatomy (as much as possible)
    • Primary repair (with augmentation) yields the best results.

  - Reconstruction (speaker’s preference)
    • Tibial and Fibular based
      ○ Tibial: Muller popliteal bypass
      ○ Fibular: Larson figure 8
Our Experience at UVA

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</table>

Multiligamentous Knee Reconstruction
2000 to 2010 (n = 169)
References and Suggested Reading:

Combined PCL & ACL injury

1. Introduction
   A. Mariani et al., *Arthroscopy*, 2001: combine ACL and PCL lesion are rare, usually caused by high- or low-velocity knee dislocations.
   B. Often accompanied with other injuries such as medial collateral tears or posterolateral corner injuries
      i. Fanelli GC, *Arthroscopy*, 2002
         1. PCL + ACL; 1/35
         2. PCL + ACL + Posterolateral corner; 19/35
         3. PCL + ACL + MCL; 9/35
         4. PCL + ACL + MCL + PLC; 6/35
   C. Vascular and nerve injuries may complicate the already severely injured knee, making treatment a challenge.
      i. Vascular compromise; 32–50%
      ii. Nerve injury; 20 – 30%
         1. Peroneal N. or Tibial N.
   D. Surgical treatments have advanced dramatically over the years to become a mainstay for the management of this condition.
   E. However, there is a lack of consensus over proper surgical timing, order of fixation, rehabilitation, etc.

2. Ligament injury evaluation
   A. ACL – Lachman test
   B. PCL – Post. drawer and sag test
   C. Collateral ligaments – Varus and valgus test
   D. PLC – External rotation dial test
   E. Radiographs
      i. to confirm reduction & look for bony injuries
   F. MRI
      i. to visualize an characterize better the pattern of soft-tissue & occult bony injuries

3. Surgical Management
   - Frassica et al., *Clin Orthop*, 1991: Better outcome with surgical management than with conservative management
   A. Surgical timing
      i. Recent trend: Early surgical intervention
         1. Liow RY et al., *JBJS*, 2003: improved outcomes in patients treated with early reconstruction (<2 weeks after injury)
         2. Harner CD et al., *JBJS*, 2004: Clinical results were significant higher in the acute group
         3. Chhabra A et al. *JBJS*, 2005: better objective restoration of knee stability when surgery was performed within 3 weeks
A. ACL-PCL-lateral sided injuries → within 10 to 14 days
B. ACL-PCL-medial sided injuries → Waiting 1 or 2 months (allow for medial sided injuries to heal)

B. Reconstruction fixation sequence
i. No single determined order of fixation exists
ii. Wascher. D.C. et al., AJSM, 1999:
   1. PCL → ACL → collateral ligament
   2. PCL fixed at 90 flexion with 45 N & ACL fixed at 20 flexion with 45 N
iii. Mariani. P.P. et al., Arthroscopy, 2001
    1. ACL PCL simultaneously tensioned
iv. Fanelli. G.C. et al., Arthroscopy, 2005
   1. PCL (70 flexion with 20 lb) → PLI (30 flexion) → ACL (70 flexion with 20 lb) → MCL (30 flexion)
v. Hayashi et al., KSSTA, 2008
   1. ACL & PCL reconstruction simultaneously tensioned at 90 flexion

C. Techniques
i. Hayashi et al., KSSTA, 2008
   1. Two-incision technique & anteromedial tibial tunnels with multi-strand STG graft for combined ACL + PCL reconstruction
ii. Fanelli GC, Arthroscopy, 2002
   1. Single incision ACL technique & single femoral tunnel-single bundle transtibial tunnel PCL technique with various auto- & allo-grafts

4. Results of various studies
A. Ohkoshi et al., Clin Orthop, 2002
   ➢ Postoperatively,
   i. all knees showed negative Lachman test results, 66% negative posterior drawer test, 44% grade I posterior drawer test
   ii. KT-1000 arthrometer side-to-side difference: 2.3mm ± 1.9 mm
B. Mariani. P.P. et al., Arthroscopy, 2001
   ➢ Preoperatively & Postoperatively
   i. Lysholm score: 65 & 95 respectively
   ii. HSS knee ligament rating scale score: 32 & 89 respectively
   iii. KT-2000 arthrometer side-to-side difference(Postoperatively): 5.8mm ± 1.1 mm

5. Rehabilitation
A. Shapiro et al., AJSM, 1995
   i. 1st week: 0°–70° ROM
   ii. 2nd week onward: increase ROM 10° every week
B. Shelbourne et al.Orthop Rev,1991
   i. Full extension in early postoperative period and protected ROM exercise
C. Wascher et al., AJSM, 1999
   i. Nonweight bearing ROM between 20°–70° in a hinged knee brace for 6 weeks

6. Our Surgical Technique
- **Posterior Cruciate Ligament**
  - *Kim SJ et al., Arthroscopy, AJSM,2009*
  
  A. Modified One-incision technique for PCL reconstruction
   - i. anterolateral tibial tunnel
     1. the least von Mises stress & Maximum shear stress on biomechanical study
   - ii. Comparable with two incision technique.
     1. No significant differences in Lysholm scale, KT-2000 arthrometer measurement
     2. Better HSS score : 92.6 vs 87.7 (1 incision group vs 2 incision group, p=0.037)
  
  B. Remnant preserving technique
   - i. Preserved continuity of the attenuated PCL
   - iii. Tibial Tunnel Preparation: The remnant is laterally peeled from the tibial attachment with a narrow osteotome
   - iv. Femoral Socket Preparation:
     1. to preserve as much of the PCL remnant as possible: direction of rotation of the reamer is counterclockwise without waggling during reaming

- **Anterior Cruciate Ligament**
  
  A. Single-Bundle
  
  B. transtibial tunnel
  
  C. Remnant preserving technique
   - i. *Georgoulis AD et al. KSSTA, 2001*: Potential source of re-innervation
     1. Mechanoreceptors a long time after injury in those patients who retained a large portion of the ACL remnant, readapted on the PCL
  
  - **Our reconstruction fixation sequence & amount of graft tensioning**
    - A. Posterolateral corner → Medial Collateral Ligament → ACL→ PCL
    - B. PCL + ACL ; tension 120N
    - C. After ACL fixed at 0° flexion, PCL fixed at 90° flexion

7. Our rehabilitation protocol
   - A. Initial 3 weeks
     - i. immobilization in full extension
     - ii. isotmetric quadriceps sets
   - B. 3 ~ 6 weeks
     - i. passive flexion limited to 90 degrees
     - ii. partial weight bearing
   - C. 6 ~ 12 weeks
     - i. advance to full weight bearing, brace off by the end of this period
   - D. 9 ~ 12 months
     - i. return to sports activities

8. Conclusion
   Combined PCL/ACL injuries which frequently occur in knee dislocation may accompany other pathologies such as medial collateral ligament injury and/or posterolateral corner injury.
Although reconstruction fixation sequence differs according to various authors, these conditions may well be addressed with surgical techniques such as one incision & remnant-preserving technique with anterolateral tibial tunnel, especially for PCL reconstruction.

References

Gr III PCL, Gr III MCL
Case based

Maestu Rodrigo, MD
Buenos Aires
Argentina

Preferred Technique in MCL GIII with PCL GIII
- Acute lesion: Immobilization - Repair
  - Chronic lesion: Reconstruction
- Graft preference:
  - Semitendinosus autograft
  - Anterior Tibialis allograft

Preferred Technique in PCL GIII with MCL GIII
- Acute lesion:
  - avulsion = Surgery
  - If not = first : nonoperative treatment
    If fail : Reconstruction
- Chronic lesion: Reconstruction
- Double Bundle in femur
- Transtibial Single Bundle
- Graft preference:
  - Hamstring tendons autograft
  - Achilles allograft

Practice Profile
- Location of Practice:
  - Public: University of Buenos Aires
  - Private: Trinidad Clinic - San Isidro
- Years in Practice: 22
- Number of primary PCL surgeries/year: 24
- Number of revision PCL last year: 1?

Physical Exam – Case Based
- Injury Mechanisms: Posterior-Medial direct blow
  - PAIN-Effusion
  - Posterior and Medial Instability
  - Combined Injuries
  - Vascular status

Physical Exam
- Step Off
- Thumb Sign
- Godfrey
- Posterior Sag
- Quadriceps active test
- POSTERIOR DRAWER
- Reverse Pivot Shift
- MEDIAL STRESS

PCL History
- Combined Injuries: Over 80 %
  - Fanelli G C. “Surgical Management of Combined Knee Ligament Injuries” Isakos, 2005
- Multiligament Injuries: SURGERY

Disclosure
- Consulting income: Smith and Nephew

May 17
Rio de Janeiro, Brasil
IC # 8
Current Concepts in PCL Insufficiency
### Imaging

- **X-ray:**
  - Step Off
  - Medial (30 degrees) and Posterior Stress (90 degrees)
- **Grades:**
  - I (5mm), II (5 to 10MM) and III (over 10mm)
- **MRI:**
  - Associated Injuries

### Diagnosis

- **Clinic**
- **Physical Exam**
- **Imaging**

### Treatment

- Initially conservative: MCL + PCL and later reconstructed as dictated by symptoms and activity level
- MCL and PCL: intrinsic ability to heal

Combined Anterior and Posterior Cruciate and MCL Injury: Nonsurgical and Delayed Surgical Treatment

Donald Shelbourne and Donald Carr

AAOS Instructional Course Lectures, 2003

### Surgery Technique

- **Acute cases:**
  1. MCL Repair
  2. PCL Reconstruction: DB femur
     - SB tibia
- **Chronic cases:**
  1. PCL Reconstruction: DB femur
  2. MCL Reconstruction: superficial and oblique band

### Surgery: PCL Graft Selection

- **Autografts:**
  - Hamstring Tendons
  - Contralateral
- **Allografts:**
  - Achilles
  - Anterior Tibialis
  - Quad

### Surgery: MCL Graft Selection

- **Autografts:**
  - Semitendinosus
  - Contralateral
- **Allografts:**
  - Anterior Tibialis
  - Semitendinosus
  - Peroneus

### Surgical Technique

#### PCL Tibial Tunnel

- 15 mm below joint line
- Lateral approach provides straighter pathway
- Care post cortex
- Special curette
- Chamfer upper edge

#### PCL Femoral Tunnel

- Anatomy and Biomechanics: AL and PM
  - Double Bundle
- IC San Francisco 2001 (Fenton, Paulos, Morgan, Race, Amis, Veltri, Matthews, Noyes, Harner)
- Larson and Metcalf
- Markolf
- Griffin, Haemmerle, Vogrin and Harner

#### PCL Femoral Tunnel

- **ANTEROLATERAL**
- **POSTEROMEDIAL**
  - < postop Laxity
  - + Anatomic
  - It is Better
PCL Femoral Tunnels

- **ANTEROLATERAL**: 11 or 1 o’clock (High-Forward) 6-8 mm from art. cartilage
- **POSTEROMEDIAL**: Inferior and Deeper
  - Footprint
  - Bone bridge > 6 mm

PCL Grafts Fixation

AL: 70 to 90°
PM: 20 to 30°

Anatomy of MCL:

- **Superficial** attachment: prox-post medial epicondyle (femur) to prox tibia semimembranosus (soft tissue) and distal crest tibia (bone)
- **Deep** attachment: Meniscocapsular structures (meniscocapsular and meniscotibial)

Surgical Technique

MCL

Repair: In acute cases

- Treatment of combined ACL-PCL-medial side-knee injuries
  - Wijdicks, Edmon, Driscoll, Harris and Zlotta
  - The Journal of Knee Surgery, 2005

Reconstruction: in chronic cases

- **POL**
- **MCL**: Superficial (TCL)
- Deep

- Single-Achilles Allograft PCL and MCL Reconstruction: Technique note
  - Christopher J. Wahl, M.D., and Gregg Nicand
  - Arthroscopy, 2008

- Current Concepts Review
  - Injuries to the MCL and Associated Medial Structures of the Knee
  - Wijdicks, Griffith, Johansen, Engebretson, and LaPrade
  - J Bone Joint Surg Am. 2010

Postop care

- Protection from posterior forces
- Quadriceps Strengthening
- Avoid flexion exercises

- Cold
- Knee Brace: 2 months
- Non-weight Bearing: 6 weeks
  - Bike - swimming
  - Proprioception
  - Sports after 9 months

- Poor results
- Technical errors
- Infections
- Loss of Motion
- Anterior Knee Pain (donor site pain)
- Neuropathic complications: Arteriogram
- Heterotopic ossification on the post. femur
- Reflex Sympathetic Dystrophy
- Osteonecrosis (Athanasian. Outside-in)

Complications

- Long term results of the arthroscopic PCL reconstruction one incision technique, 67th AAOS Annual Meeting, 2008
## Conclusion

- Multiligament injuries: Surgery
- Acute MCL: Nonoperative? or Repair
- Chronic MCL: Superficial and POL?
- PCL DB is better in objective tests and fewer ruptures
- PCL SB fewer grafts and easier surgery
- Future in our group: Tibia inlay or double bundle in tibia

**THANK YOU**