Considerations in Multiligament Knee Injuries

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Disclosures

Neither I nor my spouse/partner has a relevant financial relationship with a commercial interest to disclose.
Knee Dislocations

Incidence - Higher than previously reported

Spontaneous or on-field reductions (50%)
  ◦ Equivalent risk of neurovascular injury with knees presenting with frank dislocation (Wascher 1997)

#1 High speed motor vehicle collisions
#2 Sports
Multi-ligament injuries

Limb threatening – high risk complications and long term disability

Complex and Challenging

Heterogeneous

Variable outcomes

Lack of Level I or II studies – Most IV or V

Controversies...

Return to principles
The Principles

1. Define the Injury: Every patient is different
2. Don’t rely only on the MRI
3. Watch for important associated injuries: biceps, meniscus/meniscal root
4. Recognize and treat neurovascular injuries
5. Use an external fixator when necessary
6. Sometimes the conservative treatment is surgery.
7. Repair and reconstruct using anatomic techniques
8. Recognize synergy between ligaments
9. Successful rehab requires patient compliance, excellent physical therapy, cautious progression
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## Knee Dislocations: Kennedy’s Classification

<table>
<thead>
<tr>
<th>Direction</th>
<th>Mechanism</th>
<th>Injury Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Hyperextension</td>
<td>Post capsule -&gt; ACL -&gt; PCL</td>
</tr>
<tr>
<td>Posterior</td>
<td>Dashboard</td>
<td>PCL</td>
</tr>
<tr>
<td>Medial</td>
<td>Varus blow ± rotational</td>
<td>Collaterals, cruciates</td>
</tr>
<tr>
<td>Lateral</td>
<td>Valgus blow w flex/add</td>
<td>Collaterals, cruciates</td>
</tr>
<tr>
<td>Rotatory</td>
<td>Rotate around PLC</td>
<td>MCL, ACL, PCL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MFC buttonholed through anteromedial capsule</td>
</tr>
</tbody>
</table>

- Tibia relative to femur
- Up to half unclassifiable
- Ability to predict vascular injury
## Energy Classification

### High energy
- Motor Vehicle accidents
- Falls from heights
- Higher incidence of other organ system injury
- More common neurovascular involvement, open dislocations, associated fractures

### Lower Energy
- Sports related
- Lower incidence of NV Injury

### Ultra Low Energy
- Morbidly obese
- Higher incidence of NV injury
## Knee Dislocations: Shenck’s Classification

| KD I  | PCL intact, ACL and PL out  
|  | (rarely ACL intact, PCL out) |
| KD II | ACL, PCL torn, collaterals intact |
| KD III | ACL, PCL, and either collateral |
| KD IV | All four ligaments out |
| KD V  | Periarticular fracture dislocations |

Number of ligaments out:
- M if posteromedial corner injured
- L if posterolateral corner injured
- V for periarticular fractures
- N for nerve injuries
- C for vascular injuries

Possible to have corner incompetence without collateral ligament injuries

(Washer; Schenck 1992)
Timing Classification

Acute
◦ < 3 weeks

Chronic
◦ > 6-12 weeks
  ◦ Consider alignment
  ◦ High rates chondral/ meniscal injuries
The Patient

Understand patient
- Goals
- Levels of physical activity
- Ability to participate in complex recovery

Set expectations
- Serious injuries initially – vascular and nerve injuries
- Often takes multiple surgeries
- Complications rates high
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PE/MRI

Office PE can be difficult/inaccurate

**Difficult due to pain and swelling**

**Verify extensor mechanism function**

**Exam under anesthesia helpful**
- Stabilized Lachman
- Varus/valgus in extension
- Dimpling medially indicative of unreduced posterolateral dislocation
Knee Dislocations: Radiographs

Initial films often of poor quality but helpful in direction of injury
Knee Dislocations: Radiographs

Post-reduction films to verify relocation and identify bony avulsions.
Knee Dislocations: MRI

Exam of choice to determine pattern and extent of injury

Residual rotational subluxation makes interpretation more difficult

MRI most important to determine collateral and capsular injury to determine treatment approach
Stress Radiography
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Classification: Associated injuries

- Bony fractures
  - Small fractures important

- Extensor mechanism
  - Patellar tendon

- Biceps tendon

- Iliotibial band

- Skin
  - Swelling – Consider doppler

- Vascular

- Neurologic

- Anterolateral complex

- Meniscus (55%)  (Krych 2015)

- Cartilage (48%)  (Krych 2015)
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Vascular Injury

Popliteal artery tethered at adductor hiatus and soleus arch distally

Incidence 3.3 to 64% (Natsuhara CORR 2014)

Any delay in diagnosis of ischemia can lead to an above knee amputation!

- WWII 73%, Korean War 29%

There is no such thing as vascular spasm in this injury. Collaterals cannot maintain limb viability. When in doubt ARTERIOGRAM.
Vascular Assessment

Abnormal pedal pulse not sensitive enough

- Sensitivity 0.79, Specificity 0.91, PPV 0.75, NPV 0.93
  (Barnes et al JOT 2002)

ABI has excellent predictive value

- Sensitivity, specificity and PPV of ABI < 0.90 is 100%
- NPV of ABI > 0.90 is 100%
  (Mills et al JOT 2004)

\[
\text{ABI} = \frac{\text{Dopler systolic Ankle}}{\text{Dopler systemic Brachial}}
\]
Vascular Assessment

CT Angio / Arteriography only in abnormal physical examination
- ABI < 0.9 with well-perfused foot
- Any color temp or pulse alternations of ipsilateral foot
- Expanding hematoma in popliteal fossa
- Don’t delay surgery

Intimal tears
- Non-flow limiting intimal tears rarely progress to occlusive lesions

Serial Examinations for 48 hours (Stannard JBJS 2004)
Risk of further injury / problems with later reconstruction
Don’t forget vein in neurovascular exam!

- Significant immobilization period preoperatively
- Consider pre-op doppler
- Don’t need other risk factors to have problem
- Preop filter to allow early surgery
Neurologic Injuries

25-36% acute neurologic injury

Traction injury – lateral
  ◦ Fibular neck, distally at intermuscular septum

Peroneal nerve >> tibial nerve
  ◦ Neuropraxia – local ischemia and demyelination.
  ◦ Axonotomesis – axonal disruption with an intact endoneurium.
  ◦ Neurotomesis – Complete peripheral nerve disruption (relatively rare in knee dislocations)

1/3 will recover completely
  ◦ Regeneration occurs after one month delay at rate of 1 mm/day or 3 cm/month.
Peroneal Nerve Injuries: EMG

Axonal degeneration may not be detected for 2-3 weeks
- Both branches have a sensory component
- Fibrillation potentials indicate denervation
- Polyphasic action potentials indicate reinnervation

Posterior tibial tendon transfer for Foot drop that persists at least one year
- Good improvement in motion and dorsiflexion strength (Molund Corr 2014)
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Acute Management Principles

Acute Management
- Inspection
  - Deformity, malalignment, open wounds, compartment syndrome, dimple sign
- Reduction
  - Document neurovascular status
  - Immobilize in 20-30° flexion
  - Document radiographic reduction
- Immediate surgery
  - Open dislocation
  - Vascular injury
    - Repair collaterals
    - Delay cruciates
  - Uncontrolled instability
  - Consider spanning Ex-fix
- AFO for neurologic injury
- Follow vascular status
- DVT prophylaxis
**Knee Dislocations: External Fixation**

**Indications**

- Vascular repair
- Gross instability in anteroposterior plane
- Non-anatomic joint reduction
  - Subluxation on post-reduction xrays
- Inability to tolerate immobilization in knee brace alone
  - Very low velocity knee dislocations

**Most knee dislocations do not require external fixation**

- if the Knee is reduced after radiographs, ex-fix usually not necessary

**Not associated with post-op stiffness** (Hanley J Knee Surg 2016)

**No increased DVT rate** (Sems Jounral Trauma 2009)

Anterior frame external fixation to maintain reduction 3-6 weeks.

- Two pins lateral femur and anterior tibia
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Controversies: Operative vs Nonoperative

Surgical Indications
- Evidence supports surgical management
  - Less end-stage arthritis, better outcome studies (Richter 2002)

When not to operate:
- Larger, older, low demand individuals without residual instability
- Inability to complete complex rehab
Timing

Allow acute swelling to subside
Restore ROM!
Give capsule chance to seal

Timing dependent on:
- Vascular status
- Soft tissue injury / open wounds
- Degree of instability
- Risk of arthrofibrosis
- Other injuries, multisystem injuries
Early Surgical Intervention

Hohmann The Knee 2017 Early or delayed reconstruction in multi-ligament knee injuries: A systematic review and meta-analysis

8 studies, 260 patients (low quality, Level IV case series)

Early: less than 3 weeks  Late up to 1800 days

31% early had normal or near normal knee
15% delayed reconstruction
Early Surgical Intervention

- Proponents: better functional and clinical outcomes and suggested risk of further chondral and meniscal injuries reduced

**Relative Indications**
- Bucket-handled meniscal tears
- Avulsion lateral collateral ligament / Biceps avulsions
- Larger fractures
  - ORIF Emergently
  - Plan incisions carefully
- Grade III Lateral corner
- Certain MCL Injuries

Fluid extravasation during arthroscopy increased risk of compartment syndrome

Ligaments can be partially injured and can heal - especially the MCL and PCL
Staged Acute Reconstruction

Acute surgery of extraarticular injuries with staged reconstruction of cruciates

- Easier identification of anatomy
- Highest percentage of good outcomes in KD-IIIM and KD-IIIL (Jiang KSSTA 2014)
- Lowest likelihood of requiring additional procedures for joint stiffness (Mook 2009)
Delayed Reconstruction

- Better preoperative knee range of motion
- Avoid unnecessary reconstruction of extraarticular ligaments that may heal with sufficient stability
- Recovery of soft tissues with resolution of swelling
- Less stiffness and wound complications post-operatively (Fanelli 1996, 2002)
- Difficult to interpret literature as tend be more severe injury patterns. (Levy JAAOS 2009)
Repair or Reconstruct?

Better outcomes with acute reconstruction

**POSTEROLATERAL CORNER:**

- Stannard AJSM 2005
  - Level II prospective: 56 patients PLC injury
  - Repair failure 37% at 24 months
  - Reconstruction failure 9%

- Levy AJSM 2010
  - Repair failure 40%
  - Reconstruction failure 6%

*Usually combinations: Augment repairs with reconstruction*

**MEDIAL / POSTERIOR:**

**PCL : Mariani 1999**

- Retrospective review 7 years
  - Better stability and ROM

**PMC: Stannard 2012**

- 20% failure with repair,
- 4% after autograft reconstruction
Delay initial surgery when possible
  ◦ But operate early for fractures and biceps avulsions

Anatomic repairs/ reconstruction
Recognize synergy between ligaments

Graft Choices
  ◦ Allografts work well
  ◦ Autograft preferred for ACL when possible

Watch stiffness carefully (10-15%)
  ◦ Focus on full extension post-operatively
  ◦ Consider arthroscopic lysis of adhesions early (12 weeks) if loss of flexion (<90 degrees)
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Meniscus affects ACL

Meniscal Deficiency influences success of ACL reconstruction:

Posterior horn medial meniscus as secondary restraint anterior translation in ACL deficient knee:
- 33%-50% increase in force seen across ACL graft
  - Papageorgiou AJSM 2001
  - Can lead to early atraumatic failure
  - Shelbourne AJSM 2000

Proprioception feedback (Kennedy AJSM 1982)
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Meniscus affects ACL

Posterolateral corner protects ACL
Failure to treat posterolateral corner injuries associated with increased risk for graft failure after ACL
  - LaPrade AJSM 1999
  - Hughston JBJS 1985
  - Corten, Bellemans AJSM 2008
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Meniscus affects ACL
Posterolateral corner protects ACL
PCL does better with intact posterolateral corner
Delay initial surgery when possible
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**MCL protects ACL**
Increased forces on ACL graft with MCL injury (Shapiro JBJS 1991)
Delay initial surgery when possible
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MCL protects ACL
Simultaneous repair...
Practical Answers of Surgery

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**Anatomic repairs/ reconstruction**

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- MCL protects ACL

Simultaneous repair...
Surgical technique

Cruciates
- PCL tibia tunnel
- PCL femur tunnel
  - Pass PCL and fix on femur
- ACL tibia tunnel
- ACL femoral tunnel
  - Pass ACL and fix on femur
- Tension PCL at 90 degrees
- Tension ACL at 0 degrees

Posterolateral corner at 30 degrees
Medial Knee at 30 degrees

Redefined by Moatsge (LaPrade) AJSM 2018

Tensioning
- PCL First
  - Avoids too much anterior translation
- ACL
  - Avoids too much internal rotation of the tibia
- Posterolateral corner
- MCL
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Post-Op

DVT Prophylaxis
- ASA if no risk factors
- Anticoagulation if risk factor (including neurologic injuries, birth control)

**Fanelli Arthroscopy 1996**
- Full extension x 4 weeks
- TDWB x 6 weeks
- Passive prone ROM
- no hamstring x 4 mo

**Laprade JBJS 2010**
- Immediate ROM
- NWB x 6 weeks
- No hamstring x 4 mo

- Brace locked in extension sleeping and walking
- Immediate ROM
- TDWB x 6 weeks
- No hamstring x 4 mo
- Return to sports 9-12 mo

Canadian RCT MacDonald, Whelan Pending
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Thank you.
ACL, PCL, Posterolateral corner, Peroneal nerve
Achilles Graft Preparation
Establish PM Portal
Expose Posterior Tibia
Placement of Tibial Guide
Drilling Tibial Tunnel
PCL Femoral Tunnel

Femoral tunnel
- “2-incision” avoids killer angle
- Half-way from medial trochlea to epicondyle
- Stay proximal
- 6mm posterior to articular surface
- 12:30pm
Femoral Guide Placement
Passing Graft
LCL / PLC Repair