The Knee Evidence based evaluation, treatment, surgical intervention, and therapeutic nuggets

Andrew Starsky BSEE, MPT, PhD
Clinical Associate Professor
Marquette University
Milwaukee, WI

Objectives

• Evaluate the evidence base of outcomes measures and diagnostic tests for the knee
• Examine new and upcoming medical and surgical interventions for the knee
• Examine evidence based interventions for the knee

Outcomes measures

• Objectively examine findings
• Needs to be
  – Reliable – correlation coefficient
  • Inter-rater
  • Intra-rater
  – Valid – criterion based validity
  – Sensitive to change –
  • Minimum detectable change
  • Minimum clinically important difference

AAOS hip and knee score

Instructions
Please answer the following questions for the hip/knee being treated or followed up. If it is BOTH hip/knee, please answer the questions for your worse side. All questions are about how you have felt on average, during the past week. If you are being treated for an injury that happened less than one week ago, please answer for the period since your injury.

1. During the past week, how stiff was your hip/knee? (Circle one response.)
   - Not at all
   - Mildly
   - Moderately
   - Very
   - Extremely

2. During the past week, how swollen were your hip/knee? (Circle one response.)
   - Not at all
   - Mildly
   - Moderately
   - Very
   - Extremely

AAOS hip and knee

• Reliability = 0.91
• Valid against SF-36, WOMAC (.86+)
• MDC = 8.8 out of 100
Rated 9/10
- Content/construct/criterion validity, reliability, patient friendly, clinician friendly

Cincinnati knee rating system

- Rated 6/10
  - Construct and criterion validity good
  - Reliability and responsiveness good
  - Patient friendly
- Content validity no score
- Internal consistency no score
- Clinician friendliness limited
KOOS – Knee injury and osteoarthritis outcome score

- Rated 8/10
- Limited only in clinician friendliness
- Examines:
  - Pain (36 points)
  - Symptoms (28 points)
  - ADLs (68 points)
  - Sports and recreation (20 points)
  - Quality of life (16 points)
Kujala Patellofemoral Score

- Rated 6/10
- Lacking in:
  - Content validity
  - Internal consistency
  - Clinician friendliness
- Maximum 100 pts, lower score = greater disability

https://www.hss.edu/secure/files/WSMC-kujala.pdf

LEFS

- Functional assessment
  - Lower extremity functional scale (LEFS)
  - Physical Therapy 1999; 79:371-383
    - Reliability = 0.94
    - MDC = 9 points (about 10% of full scale)
    - MCID = 9 points
    - Criterion based validity of 0.80 to SF-36
Special tests of the knee

- **Sensitivity - SNOOut**
  - Best for negative result as a test with high sensitivity has FFN
- **Specificity - SPin**
  - Best for positive result as a test with high specificity has FFP

**QUADAS – quality assessment of diagnostic accuracy tool**

- **What characterizes a good test?**
  - Large +LR (>5.0)
    - change the odds favoring the diagnosis given a + test
    - helpful for ruling in the condition.
  - Small -LR (<0.30)
    - reduce the odds favoring the diagnosis given a - test
    - helpful for ruling out the condition.

**An Example from the Literature**

- All tests had higher specificity than sensitivity, therefore each is better as a rule in test.
- The posterior drawer test has a high +LR, and small -LR, making it an excellent diagnostic test
Your patient is a 23 year-old male s/p MVA whose knee hit the dashboard, you think he may have injured his PCL (25% probability). You perform a diagnostic test to rule out the PCL injury. The result is negative.

\[
\text{Pre-Test Ratio} \times \text{Likelihood Probability} = \text{Post-test Probability}
\]

**Posterior Drawer Test:**
\[
25\% \ (0.33:1) \times 0.10 = 3\% \ (0.033:1)
\]

**Reverse Pivot Shift Test:**
\[
25\% \ (0.33:1) \times 0.78 = 20\% \ (0.19:1)
\]

Positive test example
- Soccer player fell and hit tibia on another player’s foot, 50% possibility of PCL injury based on mechanism
- Pos post drawer test
- \((1:1) \times 90 = 90/91 = 99\% \text{ likely that you tore your PCL}\)

Summary of diagnostic test

<table>
<thead>
<tr>
<th>Test Characteristics</th>
<th>Potential Problems with this type of test</th>
<th>Most meaningful finding</th>
<th>Usefulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>High SENS</td>
<td>High False positives</td>
<td>NEG TEST (low false negatives)</td>
<td>Rule out (SnOUT) Screening tool for further testing</td>
</tr>
<tr>
<td>High SPEC</td>
<td>High False negatives</td>
<td>POS TEST (low false positives)</td>
<td>Rule in (SpIN) Further intervention</td>
</tr>
<tr>
<td>High SENS High SPEC</td>
<td>awesomeness</td>
<td>Anything</td>
<td>awesomeness</td>
</tr>
</tbody>
</table>
The knee and the gait cycle

- Kinematics of the knee
- Kinetics of the knee
- Muscle usage

Sagittal Plane: Knee

- Requires flexion of 60° and nearly full extension
- Lack of extension affects stance and swing phases
- Lack of flexion affects the swing phase

Stance Phase Knee Flexion

- Requires flexion of 60° and nearly full extension
- Lack of extension affects stance and swing phases
- Lack of flexion affects the swing phase
**Knee Extensors**

- **Quadriceps** (rectus femoris)
  - Active very late stage of swing
    - To prepare for initial contact
  - Major activity - after initial contact
    - Eccentric knee flexion (0-12%)
    - Concentric action (12-30%)
    - Eccentric action (50-60%)
- **Rectus femoris**
  - Active immediately following toe off
    - Acting as a hip flexor (the knee is flexing at that time)

**Knee Flexors**

- **Hamstrings**
  - Active very late stage of swing
    - Eccentric action to slow down knee extension and prepare for initial contact
  - Major activity - after initial contact (0-10%)
    - Assist hip extension
    - Provide stability to the knee
  - Active following toe off
    - Short head of the biceps only
    - Assist with knee flexion (but mostly a passive movement)

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**Kinetics: Joint Torques**

- **Joint Torques**
  - External torques
    - Produced by the GRFs
  - Internal torques
    - Produced by the body
      - Capitae, ligaments, passive tension on tendons and muscle
  - What would the body have to do here??

**Kinetics: Joint Powers**

- Reflects rate of muscle activation
  - Net joint torque x joint angular velocity
    - Reflects the net rate of generating or absorbing energy by all structures
    - Positive: concentric action - power generation
    - Negative: eccentric action - power absorption

**Hip Kinetics**

- Frontal Plane
  - 0-20%
    - Abduction torque
    - Energy absorbed by eccentric glut med
  - 20% and 60%
    - Bursts of abduction
    - Lift contralateral pelvis
    - Adductors assist flex/ext
Knee Kinetics Sagittal Plane

The knee 1
- Early heel contact (0 to 4%)
  - Torque – slight flexion
    - Keep knee bent for shock
  - Power
    - Generated to bend knee

Knee 2
- Stance (4-20%)
  - Torque
    - Extension to control
  - Power
    - Initially absorbed
    - Then generated to straighten leg

Knee 3
- Late stance (20-50%)
  - Torque – Flexion – passive elements
  - Power
    - negligible

Knee 4
- Pre toe off (50-60%)
  - Torque
    - Ext to stop knee flexion
  - Power
    - Absorbed by quads to stop knee flexion

Knee 5
- Swing phase (60-100%)
  - Torque – flexion for foot clearance – plantar flexors
  - Power
    - Absorbed to limit knee extension by hamstrings
Knee Kinetics
Frontal Plane
Small values, lots of variability among subjects

Knee Kinetics
Transverse Plane
Small values, lots of variability among subjects

Gait bottom line
- Appreciate the contributions from
  - GRF
  - Muscle forces
  - Passive tissues
- If GRF cannot be controlled, other tissues will be stressed

Clinical practice guidelines for Meniscal and articular cartilage lesions
- Second most common injury to knee
- High rate of injury concurrent with ACL
- 850,000 surgeries per year
Meniscus outcomes

- Lit review examined outcomes of partial menisectomy from 1990-2004
- Lysholm scores 10 years post 80-99/100
- Another review looked at subjects 4 years post
  - Decreased extensor strength/torque
  - Diminished single limb rise
  - 12-14% decrease in quad strength comp to uninvolved side

Meniscus and the athlete

- 42 athletes/45 meniscus repairs
  - Included bucket-handle, radial, complex
  - 33% lateral, 67% medial meniscus
  - 81% returned to prior competitive levels
  - 8.5 years post, outcomes still good
    - Lysholm 87.4/100
    - IKDC 82.2/100

Meniscus outcomes

- Recovery rate related to
  - Gender (men less recovered)
  - Chronicity of injury

Meniscus injury risk factors

- Time since untreated ACL injury
  - 2.2 times more likely to injury meniscus at 2-5 years post ACL injury
  - 5.9 times more likely after 5 years

Differential diagnosis for meniscus injuries

- Anterior
  - Patellar subluxation
  - Patellar apophysitis/Sinding-Larsen-Johansson
  - Tibial apophysitis/Osgood-Schlatter
  - Patellar tendonitis
  - PFP syndrome

Differential diagnosis for meniscus injuries

- Medial
  - MCL sprain
  - Medial meniscus tear
  - Pes anserine bursitis
  - Medial plica syndrome
  - Medial articular cart lesion

www.eorthopod.com
Differential diagnosis for meniscus injuries

- Lateral knee pain
  - LCL sprain
  - Lateral meniscal tear
  - ITB syndrome
  - Lateral articular cart lesion

Differential diagnosis for meniscus injuries

- Posterior knee pain
  - Baker’s cyst
  - PCL injury
  - PLC injury
  - Distal hamstrings injury
  - Proximal gastroc

Differential diagnosis for meniscus injuries

- Non-specific knee/thigh pain
  - Arthrofibrosis
  - DVT (homan’s sign poor sens/spec)
  - Neurovascular compromise
  - Fracture
  - Radiculopathy
  - Referred from hip
  - OA

MRI with meniscus

- Clinical exam by skilled clinician has been shown to be as accurate as MRI in dx of meniscus lesion
- For cartilage lesion, MRI shows
  - Sensitivity = 83.2%
  - Specificity = 94.3%

Imaging

- Ottawa knee rule – radiograph when (any):
  - Age 55 or older
  - Isolated patellar tenderness
  - Tenderness at head of fibula
  - Unable to flex knee to 90
  - Unable to bear weight 4 steps

Examination of the knee

- Single leg hop
  - Uninvolved vs. involved limb
  - Limb symmetry index (inv/un)*100
- Reliable/repeatable
  - ICC = .92
- Sensitive
  - MDC = 12.78cm in healthy
- LSI 22 weeks post ACL = 88%
Examination of the knee

- Single leg triple hop for distance
  - Involved vs uninvolved
- Reliable/repeatable
  - ICC 0.88 in pts with ACL reconstruction
- Sensitive to change
  - MDC = 10.02% LSI

Examination of the knee

- SL crossover hop for distance
  - 15 cm strip, crossover each hop
- Reliable
  - ICC = 0.84
- Sensitivity
  - MDC of LSI = 12.25%
  - Mean LSI 22 weeks post ACL = 88.3%

Examination – special tests

- McMurray
  - Palpate med/lat joint line
  - Max flex knee
  - ER tibia/varus and extend to test MM
  - IR tibia/valgus and extend to test LM

Examination – Special tests

- McMurray’s
  - Sensitivity = 70.5%
  - Specificity = 71.1%
- Based on meta-analysis with n = 2760
  - +LR = 2 medial, 3 lateral
  - -LR = 0.6 medial, 0.8 lateral

Hegedus et al. JOSPT 2007; 37(9):541-550

Examination – special tests

- Joint line tenderness
  - Sensitivity
    - Medial = 83%
    - Lateral = 68%
  - Specificity
    - Medial = 76%
    - Lateral = 97%

Examination – Special tests

- Joint line tenderness
  - +LR
    - Medial = 3
    - Lateral = 22
  - -LR
    - Medial = 0.2
    - Lateral = 0.3
Examination – special tests

- Joint line tenderness
  - Absent/present
- Positive LR
  - Medial = 3, lateral = 22
- Negative LR
  - Medial = 0.2, Lateral = 0.3

Examination – Special tests

- Thessaly test
  - Patient stands on SL
  - Rotates knee/body int/ext 3 times
  - Do this with knee in 5° and 20° flexion
    - Positive test = sensation of locking/catching/discomfort

Examination – special tests

- Thessaly test
  - At 5° flexion
    - Sensitivity
      - Medial = 41-66%
      - Lateral 16-81%
    - Specificity
      - Medial = 68-86%
      - Lateral = 89-91%

Examination – special tests

- Thessaly test
  - At 20° flexion
    - Sensitivity
      - Medial = 59-89%
      - Lateral 67-92%
    - Specificity
      - Medial = 83-97%
      - Lateral = 95-96%

And the winner is:

- Rule in (Spin)
  - Medial = joint line tender and Thessaly at 20
  - Lateral = Joint line tender and Thessaly at 20
Meniscus – surgical techniques

- Meniscus repair indicated in:
  - Under 50 or active 50-60 y.o.
  - Tear in the peripheral 1/3 – vascularized region
  - If central – should be 8mm of intact meniscal tissue without fragmentation

- Contraindicated in:
  - Tears in inner 1/3 *8+mm
  - Tears with major fragmentation
  - Tears with edges that can’t be reduced/approximated

Meniscus surgery

- Meniscus transplantation indicated in:
  - Prior total meniscectomy
  - Age 50 or less
  - Tib/fem compartment pain
  - Articular cartilage damage
  - 2 mm joint space at 45° squat x-ray
  - Normal alignment
  - Stable joint

Meniscus surgery

- Meniscus transplant contraindicated:
  - Advanced knee arthrosis (less than 2mm space)
  - Knee instability (unless later/concurrent lig reconstruction)
  - Malalignment
  - Prior knee infection
  - Knee arthrofibrosis
  - Muscular atrophy

Meniscus repair

- Placement of sutures depends on tear pattern
- Double stacked vertical suture pattern

Meniscus repair

- Multiple superior and inferior vertical sutures

Meniscus repair

- Radial meniscal tear
- Central sutures first
Meniscus repair

- Flap lesion
- Horizontal component sutured first

Meniscus transplantation

- Lateral meniscus
- Bony bridge

Meniscus transplantation

- Lateral meniscus
- Multiple sutures

Meniscus transplantation

- Medial meniscus
- 2 tunnel technique

<table>
<thead>
<tr>
<th>Postoperative Weeks</th>
<th>Meniscus Repair</th>
<th>Meniscus Transplantation</th>
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<tbody>
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</table>

C = complex tear, T = transplant, P = Peripheral repair
Cup walking to promote step length symmetry

Cartilage injuries

- Present in 60-70% of knee injuries
- 30% are isolated, cartilage only
- 58% due to traumatic/non contact injury
- Common with medial meniscus tear and ACL injury
Cartilage injury

Cartilage treatment
- Arthroscopic lavage and debridement
- Microfracture
- Autologous chondrocyte implantation (ACI)
- Osteochondral implantation (OATS)
- STEM cell implantation

ACI – surgical procedure
- Chondrocytes are harvested
  - Superior edge of lat/med condyle
  - Size of pencil eraser
  - Cultured 3-6 weeks

Autologous Chondrocyte Implantation

ACI
ACI - rehabilitation

Phase I: Protective Phase (Weeks 0–4)
Goals:
Protect healing tissue from load and shear forces
Removal of full passive knee extension
Gradual improvement of knee flexion
Reinforcing quadriceps control
Brace
Locked at 0° during weight bearing activities
Sleep in locked brace for 2–4 weeks
Weight bearing:
Non-weight bearing for 2 weeks, progress to toe touch weight bearing (approximately 20–30 lbs) for 4 weeks
Toe touch weight bearing (approximately 1/4 body weight) at week 5

ACI - rehabilitation

Phase II: Transition Phase (Weeks 6–12)
Goals:
Gradually increase ROM
Gradual improvement in quadriceps strength and endurance
Gradual increase in functional activities

Criteria to Progress to Phase II:
1. Full passive knee extension
2. Knee flexion to 115–120°
3. Minimal pain and swelling
ACI - rehabilitation

Brace:
Discontinue brace at 4–6 weeks
Weight bearing:
Progress weight bearing as tolerated
Hall of body weight bearing at 6 weeks
Progress to full weight bearing 8–9 weeks
Discontinue crutches at 8–9 weeks
Range of motion:
Gradual increase in ROM
Maintain full passive knee flexion
Progress knee flexion to 120–125°
Continue patellar and soft tissue mobilization as needed
Continue stretching program

ACI - Rehabilitation

Phase III: Maturation Phase (Weeks 12–26)
Goals:
Improve muscular strength and endurance
Increase functional activities
Criteria to Progress to Phase III
1. Full range of motion
2. Acceptable strength level
   • Hamstrings within 10% of contralateral leg
   • Quadriceps within 10–20% of contralateral leg
3. Balance testing within 30% of contralateral leg
4. Able to walk 2 miles or bike for 30 minutes
5. 50 lateral step-ups (8" height)

ACI - Rehabilitation

Phase IV: Functional Activities Phase (Weeks 26–52)
Goals:
Gradual return to full unrestricted functional activities
Criteria to Progress to Phase IV
1. Full nonpainful ROM
2. Strength within 90% of contralateral extremity
3. Balance and/or stability within 75% of contralateral extremity
4. No pain, inflammation, or swelling

ACI outcomes

OATS procedure

• Harvesting of “plugs” of cartilage from less WB region of femur
• Lesion cleaned out
• Mosaic transplant

JOSPT 2006;36(10):739-750

Defect at med fem condyle

All ACI info from Gillogly et al, Treatment of articular cartilage defects of the Knee with autologous chondrocyte implantation. JOSPT 28(4):241-251 updated in JOSPT 36(10):751-764
Harvest of graft

Lateral aspect
Of lateral femoral Condyle
Knee is extended

mosaic

3 plugs
6.5 mm diameter

1 year post op

Lateral defect was repaired

MRI 16 weeks post op

OATS findings

- Consistent survival of transplanted cartilage
- Integration of transplanted grafts into host tissue
- Fibrocartilage formation between grafts
- Cancellous bone and fibrocartilage formation in the donor plugs

OATS indications

- Symptomatic knee
  - Pain
  - Swelling
  - defect
OATS contraindications

- Tumor, infection, RA
- Lack of appropriate donor site
- Age 50+
- Defect larger than 8 cm²
- Defect deeper than 10 mm
- Non-compliant patient

Lesion location

OATS rehab protocol

<table>
<thead>
<tr>
<th>Weight-bearing exercises</th>
<th>Immediate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pushing a soft rubber ball with foot</td>
<td>Immediate</td>
</tr>
<tr>
<td>Exercises with full weight bearing</td>
<td>2-3 wk</td>
</tr>
<tr>
<td>Stationary bicycle with resistance (if 90° knee flexion achieved)</td>
<td>2-4 wk</td>
</tr>
<tr>
<td>Stair stepper</td>
<td>6-8 wk</td>
</tr>
</tbody>
</table>

Proprioception

- Balance exercises standing on both feet | 5-6 wk |
- Balance exercises standing on 1 foot (hard ground) | 6-8 wk |
- Balance exercises standing on 1 foot (trampoline or Aerobie) | 8-10 wk |

OATS rehab protocol

- No immobilization
- Ambulation
  - 2-crutch ambulation, non-weight bearing | 0-2 wk |
  - 2-crutch ambulation, partial weight bearing (30-40 kg) | 2-4 wk |
  - Discontinue crutches, full weight bearing | 4-5 wk |
- Functional exercises, gait evaluation, stair climbing | 4-5 wk |
- Step-up | 4-5 wk |
- Skip-down | 5-6 wk |

Range of motion (ROM)

- Early ROM is encouraged
- Constant passive motion device for 2-4 cm² lesions (no painless range)
- Full extension, flexion as tolerated
- Stationary bicycle | 3 wk |

Lesion location
OATS rehab protocol

<table>
<thead>
<tr>
<th>Activity</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jogging</td>
<td>10 wk</td>
<td>3 mo</td>
<td>4-5 mo</td>
<td>5 mo</td>
</tr>
<tr>
<td>Straightline running</td>
<td>3 mo</td>
<td>5 mo</td>
<td>5-6 mo</td>
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<tr>
<td>Directional changes</td>
<td>4-5 mo</td>
<td>5 mo</td>
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<tr>
<td>Shear forces</td>
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<td>5 mo</td>
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<td>Sport-specific adaptations</td>
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<tr>
<td>Sport activity</td>
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</tbody>
</table>

OATS special considerations

- Weight-bearing guidelines based on the location, size, and type of defect:
  - Femur or Tibia Condyle, chondral defect diameter <15 mm
    - Non-weight bearing: 1 wk
  - Femur or Tibia Condyle, chondral defect diameter ≥15 mm
    - Partial weight bearing: 1-3 wk
    - Non-weight bearing: 2 wk
    - Partial weight bearing: 2-4 wk
  - Femur or Tibia Condyle, osteochondral defect
    - Non-weight bearing: 3 wk
    - Partial weight bearing: 3-5 wk
  - Patellar defect diameter <15 mm
    - Partial weight bearing: 2 wk
  - Patellar defect diameter ≥15 mm
    - Partial weight bearing: 3 wk

Cartilage surgery outcomes

- No real difference b/w 4 surgeries
- Microfracture procedure outcomes
  - 6 years post injury
  - 70% had improved pain/swelling and equal SL hop
  - Improved in SF-36 and WOMAC
- OATS outcomes
  - KOOS 81/100

Stem Cells for the treatment of OA

First published 1966
- Often mixed with Fibroblast growth factors
- $4000 per knee
- BMI below 35 (5'8" 230 lbs)
- MSC = Mesenchymal Stem Cell

Where to get the stem cells (MSCs)

<table>
<thead>
<tr>
<th>Tissue type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Marrow</td>
<td>Good potential to become cartilage</td>
<td>Risk of pain/infection with harvesting</td>
</tr>
<tr>
<td>Synovium</td>
<td>Best potential to become cartilage</td>
<td>Very limited studies to date</td>
</tr>
<tr>
<td>Adipose tissue</td>
<td>Easily harvested Plenty available</td>
<td>Lowest potential to become cartilage</td>
</tr>
<tr>
<td>Umbilical cord</td>
<td>No morbidity with collection Large capacity for ex vivo expansion Can differentiate to cartilage, bone</td>
<td>Allergenic source Few studies</td>
</tr>
</tbody>
</table>
Cartilage rehabilitation

- Factors to consider
  - Lesion – size, location, depth, quality of surrounding tissue
  - Patient – age, BMI, health, nutrition, quality of cartilage, sport, goals, motivation
  - Surgery – procedure, concurrent procedures

Rehab after stem cell treatment

- Week 1-2
  - Light ADLs
  - Avoid stairs if possible
  - No NSAIDS
  - Pool walking

Rehab after knee stem cell

- Weeks 3-4
  - Avoid repetitive loaded exercise
  - ROM, stretch, core work
Rehab after stem cell

- Weeks 5-6
  - Initiate light running – no hills
  - Gentle weight lifting
  - Avoid compressive exercises

Rehab

- 3-6 months
  - Gradual return to all activities

Knee Ligament Clinical Practice Guideline

- Risk Factors
- Clinical Course
- Diagnosis
- Examination
- Intervention

Incidence

- ACL
  - 80,000 to 250,000 injuries/year
  - 100,000 reconstructions annually
  - 70% non-contact
  - Females 2.4 to 9.7 times more likely to injure
  - Incidence of meniscus injury in ACL deficient knee
    - 1 year = 40%
    - 5 years = 60%
    - 10 years = 80%

Incidence

- ACL female: male risk ratios
  - Wrestling 4.05:1
  - Basketball 3.5:1
  - Indoor soccer 2.7:1
  - Soccer 2.67:1
  - Rugby 1.94:1
  - Alpine skiing 1:1

Ligaments - MCL

- Incidence
  - 7.9% of all athletic injuries
  - Most common in NFL, alpine skiing
Ligaments - LCL
- Least common knee ligament injury
- 4% incidence
- Common with PLC injury
- Avulsion fracture

Ligaments - multiple
- 0.8/100,000 persons/year
- Complete MCL lesions = 80% chance of other ligament damage

Ligaments - ACL
- Clinical course
  - 1/3 will return to unrestricted activities without surgery
  - 1/3 could return to recreational activities with rehab/bracing/modification
  - 1/3 need surgery

Ligaments - ACL
- Risk factors
  - Shoe-surface interaction
    - Higher friction increases risk
    - Varying cleat height
  - Anatomical features
    - Increased BMI
    - Wide femoral notch
    - Joint laxity (KT-2000)
  - Females – pre-ovulation phase
  - Varus/valgus position

Ligaments - ACL
- Diagnosis
  - Classification system
    - One + “Giving way” episodes
    - SL 6m timed test less than 80%
    - KOS-ADLs greater than 80%
    - GRS greater than 60%
  - Meet all these = coper
    - 79% returned to sport w/o surgery
  - Miss one = non coper
Ligament - ACL

- Special tests
  - Lachman
    - Reliability = 76% agreement
      - Same for PT vs. ortho surgeon
    - Sensitivity = 85%
    - Specificity = 94%
    - +LR = 10.2
    - -LR = 0.2

Ligaments - ACL

- Special testing
  - Pivot shift test
    - Sensitivity = 24%
    - Specificity = 98%
    - -LR = 0.9
    - +LR = 8.5

Ligaments - PCL

- Special testing
  - Posterior drawer test
    - Sensitivity = 90%
    - Specificity = 99%
    - -LR = 0.1
    - +LR = 90
Ligaments - PCL

- Special testing
  - Posterior sag
  - Sensitivity = 79%
  - Specificity = 100%
  - LR = 0.21
  - +LR = 34.1

Interventions - ligaments

- Continuous passive motion
  - Level “C” evidence
  - Insufficient data for benefits in
    - Functional outcomes
    - Post-op complications
    - ROM
    - Blood loss
    - Pain

Interventions - ligaments

- Early weight bearing
  - Force in MCL with gait = 20N (3 times higher in ACL deficient knee)
  - No deleterious changes in outcomes, pain, stability post ACL reconstruction
  - MCL no data
  - PCL no data

Interventions - bracing

- ACL deficient knee
  - 180 professional skiers ACL deficient
  - 101 braced / 79 non-braced
    - Unbraced 8x more likely to be injured
- Post ACL reconstruction
  - D grade conflicting evidence
- Other ligaments
  - F grade conflicting evidence

Interventions – early mobilization

- Measured 2 weeks of immobilization vs. early ROM
  - No differences in ROM, stability, strength
  - Appears to benefit pain, fewer articular cartilage complications, fewer scar complications

Interventions - cryotherapy

- Marginally significant
  - Less pain
  - Same amount of post surgical drainage
  - Same ROM
Other interventions post ligament injury

- Therapeutic ex – GRADE A
- NMES – Grade B
- Neuromuscular re-education – B
  - Joint stabilization, accel, decel, kinesthesia

Lower extremity – knee scope

- Wilk et al 2010, Cartilage 1(2):96-107
Some NMES quad activities

- Squats using switch
- Gait using switch or heel switch
- TENS during ther ex and ADLs
  – Pietrosimone et al, JOSPT 2011; 41(1):4-12

Next – Patellofemoral pain

- Proximal, distal, and local factors
- What have we learned?
- 5 years post rehab
  - 80% still pain
  - 74% reduced activity
\[
\sin \beta/2 = \text{Quad}/\text{Quad} \\
\text{Quad} \times \sin \beta/2 = \text{Quad,}
\]

### Comparison

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Quad Force (kg)</th>
<th>PPFJCF (kg)</th>
<th>PTFJ Stress (MPa)</th>
<th>TFJCF (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>194.18</td>
<td>50.69</td>
<td>1.99</td>
<td>157.84</td>
</tr>
<tr>
<td>Theraband (90)</td>
<td>18.03</td>
<td>25.49</td>
<td>0.59</td>
<td>18.03</td>
</tr>
<tr>
<td>Theraband (45)</td>
<td>68.23</td>
<td>1.48</td>
<td>52.35</td>
<td></td>
</tr>
<tr>
<td>Lunge</td>
<td>668.70</td>
<td>688.70</td>
<td>13.40</td>
<td></td>
</tr>
<tr>
<td>Cybex (90)</td>
<td>842.90</td>
<td>1272.30</td>
<td>30.40</td>
<td>842.90</td>
</tr>
<tr>
<td>Cybex (45)</td>
<td>676.50</td>
<td>462.80</td>
<td>13.04</td>
<td>625.10</td>
</tr>
<tr>
<td>Cybex (8)</td>
<td>802.00</td>
<td>167.70</td>
<td>13.04</td>
<td>790.04</td>
</tr>
</tbody>
</table>

### PFP – local factors

- Can arise from various structures
  - Subchondral bone
  - Infrapatellar fat pad
  - Quad tendon
  - Patellar ligament
  - Synovium
  - Retinaculum
PFP – local factors

- Onset of PFP likely has some mechanical factors, but mechanics is a poor predictor
- Patellar maltracking found in some studies
- Large variability in PF kinematics
- PF loads
  - 0.5x BW in walking
  - 7x BW squatting

PFP – Local factors

- PF contact area increases with flexion
  - Not as fast as PF contact force
- PF stress (force/area) is greater during walking in patients with PFP
- PF bracing has been shown to increase contact area
- Impaired VMO function not consistent across studies

PFP – local factors

- Patellar tracking is mainly influenced by bony geometry
- Abnormal femur motion may contribute to abnormal PF kinematics

PFP – distal factors

- Foot orthotics have been shown to be effective, mechanism not clear
- ER foot in relaxed stance is common
- Increased rearfoot eversion at heel strike

PFP – proximal factors

- Hip
  - Patients with PFP display altered hip kinematics in frontal and transverse plane
  - Prevalent in SL squat, hop, landing
  - Excessive femoral IR increases PF stress

PFP – proximal factors

- Healthy females demo weakness in hip abductors and ER compared to males
  - Even worse in females with PFP
- Healthy females demo increased hip adduction with many tasks
  - Worse in females with PFP
- Same in runners with PFP
PFP – proximal factors

- Patients with PFP show delayed hip abd activation relative to vasti muscles in stairs
- 2-D motion analysis correlates well to 3-D to analyze these factors

Stride to stride variability pre and post hip abductor strengthening program

PFP – interventions

- High quality evidence supporting:
  - Exercise therapy
  - Patellar taping
  - Foot orthoses
  - Multi-modal approaches

Patellar taping effect on proprioceptive task
  Move knee from 40º to 20º
  Increased activity on fMRI in SMA, Sensorimotor cortex, cerebellum

PFP – interventions

- Multi-modal approach

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (y)</th>
<th>Sex</th>
<th>BMI (kg/m²)</th>
<th>Immune/Reflux</th>
<th>Symptoms Duration (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>F</td>
<td>22.1</td>
<td>Bladder</td>
<td>24.0</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>M</td>
<td>34.3</td>
<td>Bladder</td>
<td>3.5</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>M</td>
<td>23.4</td>
<td>Right</td>
<td>8.0</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>M</td>
<td>20.1</td>
<td>Bladder</td>
<td>18.0</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>F</td>
<td>44.9</td>
<td>Left</td>
<td>3.0</td>
</tr>
</tbody>
</table>

JOSPT 2008;38(11):691-702
SB toward, rotated away from painful side (or both)
High velocity, low amplitude thrust at ASIS
If no cavitation, repeated

Inferior and superior patellar nonthrust manipulations
15 degrees knee flexion
Moved until restriction, then hold or oscillate

Caudal hip nonthrust manipulation
Hip and knee at 90°
Caudal directed force

Proximal tibiofibular nonthrust manipulation
Knee and hip to 90
Posterior counterforce at fibular head
Knee flexed to 120

PFP - interventions
- Limited evidence on hip strengthening
- No evidence supporting biofeedback or NMES
- Limited evidence that faulty gait can be retrained, with improvements in pain/function
Lab break #1

- Technique practice
TABLE 3

**DEMOGRAPHIC CHARACTERISTICS OF THE CONTROL, EXERCISE, AND KNEE AND HIP EXERCISE GROUPS
**

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 25)</th>
<th>Knee Exercise (n = 25)</th>
<th>Knee and Hip Exercise (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>260 ± 30</td>
<td>250 ± 40</td>
<td>250 ± 30</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>52.6 ± 6.2</td>
<td>57.2 ± 7.3</td>
<td>63.8 ± 8.1</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.64 ± 0.05</td>
<td>1.84 ± 0.05</td>
<td>1.60 ± 0.06</td>
</tr>
</tbody>
</table>

*Values are means ± SD. Only those subjects remaining at the end of the study are included. There were no differences among groups (P > 0.05).
Figure 4: The lateral rotation retraction test. With the patient supine, the examiner stabilizes the patient's lateral femur with 1 hand and lifts the patient's great toe with the other hand. To observe the amount of genu retraction.

Figure 5: The same structure with the patient seated. The right figure demonstrates the same table, while the upper panels illustrate the joint. The lower one illustrates the fibular collateral ligament. The fibula is a small bone located on the lateral side of the lower leg. It helps maintain stability of the lateral knee structures.

Figure 6: Varus stress radiographs. Bilateral varus stress radiographs demonstrating a 1.7 mm increased opening at the medial joint line of the injured knee (E). This represents a complete tear of the posterior cruciate ligament and medial collateral ligament.

Figure 7: The posterior stabilized knee reconstruction procedure. A: Lateral view, right knee, AP posterior view, right knee. Arthroscopies. FCL, fibular collateral ligament; PCL, posterior cruciate ligament; PLC, popliteus tendon. Reprinted with permission from the American Journal of Sports Medicine.
Other pathologies – snapping at lateral knee

- 21 y.o. female with 7 year h/o snapping knee
  - Dx: snapping ITB
  - Multiple courses of PT, injection, NSAIDS
  - Negative ITB tests (Ober, Noble compression)

Snapping knee

- Posterior mob to fibula alleviated noise and sx
- Taping gave partial relief
  - Tol 2 hours
- 2 weeks of extension immobilizer
  - ineffective
Surgery selected

- Arthroscopy – normal meniscus, ligaments
- Lateral incision
- Prominent lat fem condyle
- Snap at 20-30 degrees
- Shaved

Snapping knee

- Gradually advanced ROM and strength
- 6 weeks return to sport
- Pain and snap free

Case Report

Patella Fracture During Rehabilitation After Bone-Patellar Tendon-Bone Anterior Cruciate Ligament Reconstruction: 2 Case Reports

Sara R. Pitt, John D. Childs, Brian M. Klauer, Teresa J. Ogilvie, Grainne J. M. O'Neill, G. Kelly Fitzgerald

23 y.o. males
- 7 weeks post op, ecc Quad work
- 10 weeks post op, Strength testing of quads
Using burst superimposition
Cross friction massage

- JOSPT 2009;39(7):506-514
- MCL injury to 51 rodents
- Instrument assisted CFM (IACFM) one minute per day, 3/week
Intact untreated treated 12 weeks

**TABLE 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>TEA Group (n = 24)</th>
<th>Healthy Adults (n = 27)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>65.0 ± 8.4</td>
<td>65.8 ± 6.0</td>
<td>-0.8 (95% CI)</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>11/13</td>
<td>17/10</td>
<td>-6 (95% CI)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>30.7 ± 4.1</td>
<td>29.2 ± 3.9</td>
<td>-1.5 (95% CI)</td>
</tr>
</tbody>
</table>

**TABLE 2**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>TEA Group (n = 24)</th>
<th>Healthy Adults (n = 27)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>5.0 ± 2.6</td>
<td>4.3 ± 2.1</td>
<td>0.7 (95% CI)</td>
</tr>
<tr>
<td>Activity</td>
<td>5.5 ± 2.8</td>
<td>5.0 ± 2.5</td>
<td>0.5 (95% CI)</td>
</tr>
</tbody>
</table>

Research Report

Outcomes Before and After Total Knee Arthroplasty Compared to Healthy Adults

Michael T. Bohl, Wendy M. Esher, Jennifer F. Strewe-Leopold

42
Conclusion

- Proximal factors
- New surgical treatments are coming
- Don’t throw away your NMES units
- Hip focus
  - Strength
  - Mobilizations