"KNEE PAIN": Evaluation of Knee pain in Adults; Primarily Patellofemoral Pain

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Family Medicine Review
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Learning Objectives

- Discuss knee anatomy and specialized physical exam of the knee
- Describe the overall differential diagnosis and highlight patellofemoral disorders
- Explain the treatment for anterior knee pain

Knee Anatomy

Bony Anatomy

Soft Tissue Anatomy

Knee Examination

- Inspection
- Palpation
- Range of Motion
- Special Tests
Alignment

- Genu valgum (knock-kneed)
- Genu varum (bow-legged)
- Genu recurvatum (hyperextended)

Alignment

- Quadriceps angle
  - 15° for men
  - 20° for women
- >15° is a predisposing factor for Patellar instability
- Concept of dynamic Q-angle

Inspection

- Gait

Inspection

- One-Leg Squat

Palpation

- Patient must be in a relaxed position and comfortable
- Either supine or seated with the knee flexed
- Use fingertips to palpate specific bony landmarks
**Palpation: Anterior**
- Quadriceps tendon, patella, Patellar tendon
- Pre-Patellar and infrapatellar bursa
- Plica
- Tibial tuberosity and plateau
- Infrapatellar fat pad

**Palpation: Medial**
- Medial femoral condyle-
- Medial tibial plateau
- Pes anserine tendons & bursa
  - sartorius
  - gracilis
  - Semitendinosis

**Palpation: Lateral**
- Lateral tibial plateau
  - Attachment of lat. meniscus
- Lateral femoral condyle
  - Attachment of LCL
- IT band - Gerdy's tub.
- Fibular head
  - Attachment of lateral collateral ligament, biceps femoris tendon
- Fibular head fractures

**Active ROM**
- Flexion (full) >135°
- Extension (full) 0°

**Passive ROM**
- Resisted isometric movement

**ROM - Flexion**
- Squatting test – ask patient to perform a squat in a deep knee bend and check for symmetry

**ROM - Extension**
Range of Motion

- Internal/External Rotation
  - Rotate foot medially and laterally
  - Normal motion is 10 degrees in either direction
- Screw-home mechanism
  - Tibia externally rotates in full extension to "lock" knee

Special Tests

Patellar Instability

- Patellar Mobility
  (Girling Test)

- Patellar Grind/Inhibition Test
  (Clarke’s Sign)

- Patellar Tilt Test

- Patellar (Fairbank’s)
  - Apprehension test
<table>
<thead>
<tr>
<th>Joint Stability</th>
<th>Joint Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Lachman Test</td>
<td>- Pivot Shift Test</td>
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<tr>
<td>- Anterior Cruciate Ligament</td>
<td>- ACL</td>
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<tr>
<td>- Anterior and Posterior Drawer Tests</td>
<td>- Posterior Drawer Test</td>
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<tr>
<td>- Posterior Sag Sign (Gravity Drawer Test)</td>
<td>- Varus Stress Test</td>
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<tr>
<td>- PCL</td>
<td>- Lateral Collateral Ligament</td>
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</tbody>
</table>
Joint Stability

Valgus Stress Test
Medial Collateral Ligament

Meniscal Tests

McMurray Test

Meniscal Tests

Bounce-Home Test

Meniscal Tests

Apley’s Compression Test

Case: history

- 24 y/o woman, normal BMI
- C/o diffuse right knee pain
- Gradually worsening over 4 mo
- Noticed during skiing this winter
- Feels “tight”, “searing”, “crunchy”
- Maybe swelling? Not obvious
- Training for ½ marathon, pain aggravated by jogging
- Pain on stairs & after car rides
- No locking, no instability, but occasionally feels like might give way going down stairs

Physical exam

- Normal gait
- Full active ROM
- No effusion
- Mild crepitus
- + J-sign
- + patellar grind
- - patellar apprehension
- Poor hamstring flexibility
- Poor form on single-leg squat
Differential diagnosis

- Patellofemoral pain syndrome
- Patellofemoral arthritis
- Patellar tendonitis
- Patellar subluxation
- IT band syndrome
- Patellar subluxation
- Fat pad syndrome
- Plica syndrome
- Prepatellar neuroma

In skeletally immature:
- Tibial tubercle or distal patellar pole apophyseis (O-S, S-L-J)
- SCFE

Imaging?
**Patellofemoral pain syndrome**

- Retro- or peri-patellar pain resulting from physical & biochemical changes in the patellofemoral joint
- Previously used interchangeably with Chondromalacia Patella
- Etiology appears multifactorial
  - Abnormal joint mechanics
  - Altered lower extremity alignment and / or motion
  - Overuse / training errors

**Epidemiology**

- PFP: one of the most common knee issues
- 15 – 33% of active adults, 21 – 45% teens¹
- 25% of 549 knees seen in a Sports Med clinic²
- In a 7yr US study of athletic patients³
  - PFP dx in 7% of all males seen, 20% of females
  - 18% of male knees (~1/5), 33% of females (1/3)
- In 2000 running-related injuries⁴
  - #1 complaint was PFP (16.5%)
  - Of these: 38% male, 62% female

**Natural history**

- Anterior knee pain traditionally was described as benign and self-limited
- 81% of 47 patients treated non-op for CMP: mild / no pain at 12 yrs¹
- AKP in teens, FU at mean of 16 yrs: 71% “better” (22% no pain), but 25% continued to have significant symptoms²
- 2005 study surveyed pts after PF arthroplasty for isolated PF arthritis vs medial uni-compartmental arthroplasty pts³
  - >75% response rate
  - 22% of PF group reported adolescent / early adulthood AKP vs 6% of medial compartment pts (p<0.001)

**A riddle, wrapped in an enigma...**

- In spite of very high incidence, anterior knee pain pathogenesis still not clearly known
- Why are some affected and others not?
- “Black Hole of Orthopedics”... Why?
  - International PF Study Group suggests this is due to:
    - Complex biomechanics of PF joint
    - Pathology “less clinically interesting” than menisci or cruciates
    - Various causes for anterior knee pain
    - Discrepancies re: normal vs. abnormal
    - Often no correlation btw symptoms, physical & radiologic findings

**So, what DO we know about PFP?**

- “Typical” clinical history of PFP
  - Onset insidious, but may be after trauma
  - May have history of overuse or supraphysiologic loading
  - Typically anterior, but also commonly medial or lateral to patella, or near inferior pole
  - Described as achy, vague, poorly localized, activity-related
  - Sometimes describe “swollen” or “hot”
  - Aggravated by rising out of chair / sitting for prolonged time, going up or down stairs, kneeling, squatting, incline running
  - Noisy knees (common) vs painful crepitus (pathologic)
  - Ask about current & desired activity levels
  - Consider associated psychological conflicts...

1. Lindberg, Linkoping Univ 1986
2. Devereaux & Lachmann, BJSM 1984
3. DeHaven & Linter, AJSM 1986
4. Taunton et al, BJSM 2002

IPSG, Am J Knee Surg 1997

3. Lifting et al, Knee 2005
“Typical” physical exam

- Patellar Grind, or Inhibition Test
  - Displace patella inferiorly into trochlear groove, then have pt contract quad while examiner resists superior movement of patella
  - +ve if produces pain

Physical exam: patella-specific tests

- Lateral tracking or “J-sign”
  - As knee extended from 90° to full extension, patella demonstrates abnormal path, deviating laterally at full extension

Other relevant physical exam findings

- Effusion?
- Alignment
- Knees, feet
- Crepitus
- Location of tenderness
  - Retinaculum, patellar tendon, pes anserine, ITB, fat pad, plica?
- Flexibility
  - Quads, hip flexors, groin, hamstrings, ITB, gastrocs
- Strength
  - Isolated hip abductor strength, single leg squats

Physical exam: patella-specific tests

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  - As knee extended from 90° to full extension, patella demonstrates abnormal path, deviating laterally at full extension

Anatomy of the PF joint
The patella

- Sesamoid bone in quadriceps/patellar tendon
- Undersurface of patella has vertical ridge dividing Medial & Lateral Facets
  - Each has a Superior, Middle & Inferior aspect
  - Odd Facet: most medial

Medial

Odd

Lateral

More than a hinge:
- Patellar translation: cephalad / caudad & medial / lateral
- Patellar rotation
- Patellar tilt

Function of patella:
- Protection & strength
- Patella ➝ mechanical advantage of extensor muscles by transmitting forces at ➝ distance from axis of rotation
  - At 45° flexion, patella ➝ moment arm of extensors by 30%
- Compression forces drive patella into groove
- Thickest articular cartilage in body

Upon flexion, patellar-femoral contact begins around 10-20°
- Contact area moves proximally on patella, posteriorly on condyles
- Lateral Facet remains in contact, Odd Facet only articulates after deep flexion ~135°

Compressive forces

<table>
<thead>
<tr>
<th>Activity</th>
<th>x Body Weight</th>
<th>For 170 lb person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>½ x</td>
<td>85 lbs</td>
</tr>
<tr>
<td>Stairs</td>
<td>3 - 4x</td>
<td>510 - 680 lbs</td>
</tr>
<tr>
<td>Running</td>
<td>6x</td>
<td>1020 lbs</td>
</tr>
<tr>
<td>Squatting</td>
<td>7 - 8x</td>
<td>1190 – 1360 lbs</td>
</tr>
<tr>
<td>Jumping</td>
<td>20x</td>
<td>3400 lbs</td>
</tr>
</tbody>
</table>

Wheeless Online, Biomechanics of the PF joint
Flynn & Soutas-Little, JOSPT 1995
Dye, Clin Ortho & Related Res 2005

Dye, Clin Ortho & Related Res 2005

Goodfellow et al., JBU 81 1976
Patellar types
- Wiberg types
  - Type 1: Roughly equal-sized medial and lateral facets
  - Type 2: Most common; medial is ½ size of lateral facet
  - Type 3: Central ridge barely noticeable, very small medial facet
  - Jagerhut: “Huntsman’s Cap”: no medial facet

![Patellar types diagram]

Patella Alta & Baja
- >20% variation considered to be abnormal
- Associated with PFP, PF arthritis, patellar instability, etc.

![Patella Alta & Baja diagram]

PatelloFEMORAL joint
- Anatomic variation in more than just patella
- Consider the femoral trochlea

![PatelloFEMORAL joint diagram]

patelloFEMORAL joint
- Anatomic variation in more than just patella
- Consider the femoral trochlea

![patelloFEMORAL joint diagram]

The trochlea
- Trochlear dysplasia: irregular morphology & shallow groove
  - Causes abnormal kinematics, excess patellar tilt, impingement & especially patellar instability (96%)
- Characterized on “true lateral” x-ray
  - With posterior aspects of femoral condyles superimposed

![The trochlea diagram]

Normal trochlea
- Floor of trochlea remains dorsal to (does not cross) ventral outlines of femoral condyles

![Normal trochlea diagram]
Trochlear dysplasia

- Trochlear dysplasia found in 16.5% of patients with anterior knee pain vs 2.7% in controls¹
- Incidence ~2% (16 of 983) consecutive knee MRIs²
  - Likely under-identified in clinics due to lack of true lateral films
- Important, but obviously is not the only, or main, cause of PFP

¹ Keser et al, Knee Surg Sports Traumatol Arthrosc 2008
² Pfirrmann et al, Radiology 2000

Other potential contributors to PFP...

Risk factors for PFP

- Anatomic abnormalities
  - Hypoplastic medial patellar facet, trochlear dysplasia, patella alta
  - Mal-alignment & altered biomechanics of lower extremity
    - Q-angle, pes planus, subtalar pronation
- Muscle dysfunction
  - Weak core, weak quads/VMO, improper firing patterns
- Poor flexibility
  - Hamstring, quad, calf
- Patellar hypermobility
- Tight lateral structures
  - Lateral retinaculum, IT band
- Training errors or overloading
- Trauma

Where & how can we intervene?
Review of treatment options

**Therapeutic modalities**
- Ice, US, ioniophoresis, phonophoresis, e-stim, biofeedback, laser
- Systematic review: 12 studies met criteria, most of low-moderate quality
  - Some reported therapeutic modalities, when combined with other tx, may be of some benefit for pain management
  - Did not consistently provide added benefit over conventional PT
  - No consistent evidence of any benefit when modality used alone

  - "None of the therapeutic modalities reviewed has justification for treatment for PFPS when used alone"

Lake & Wofford, Sports Health 2011

**Patellar ("McConnell") taping**
- Developed to improve tracking by medializing patella (glide, tilt, rotational components) to allow decreased pain during rehab
- Systematic review: 16 included studies
  - Study designs mostly weak, had various outcome measures (pain, neuromus control, or patella position), with mixed results

  - "Patellar taping may be a useful tool in treating PFPS, and does not seem to exacerbate symptoms", though "strong evidence is not available"

Aminaka & Gribble, J of Athletic Training 2005

**Arthroscopy**
- 56 pts with PFP (18-40y)
  - Randomized (28 each) into 8-wk HEP or arthroscopy + HEP
  - Scoped pts: nothing, shaving of chondral lesions, inflamed plica resect, shaving inflamed synovium, partial menisc resect
  - Both groups improved Kujala AKPS scores markedly (14.7 for scoped, 13.5 for controls) at 5 yr FU
  - No difference between groups in improvement in AKP scores immediately HEP, 9 mo or 5 yrs

  - "Arthroscopy did not provide any overall additional advantage for chronic PFPS pts than training program"

Kettunen et al, BSJM 2011

**Gait retraining**
- 10 runners with PFP, given real-time kinematic feedback of hip adduction as ran on treadmill x8 sessions, gradually removing feedback by the end
  - After gait-retraining:
    - Significant \( \downarrow \) in hip adduction & contralateral pelvic drop while running
    - Hip IR \( \downarrow 23\% \) (ns), hip adduction in single leg squat \( \uparrow 18\% \) (ns), 20\% \( \uparrow \) in vertical load rates
    - Significant improvements in pain & function
  - Maintained improvements in running mechanics, pain & fxn at 1 mo

  - "Interventions for PFP should focus on underlying mechanics"

Noehren et al, BSJM 2010

**Foot orthotics**
- Study of 20 teenage girls dx’d with PFP and had excessive forefoot varus or calcaneal valgus (>6°)
  - Randomized to exercise (quad/ham strength & stretching) vs exercise + soft orthotics (Spenco insole + medial wedge, $15)
  - At 8 wks, both groups had significant reduction in pain on VAS
  - Significantly greater pain reduction in orthotic group during running, squatting, up/down stairs, but not walking or sitting >1h

  - "In addition to exercise, use of soft foot orthotics is an effective treatment for patients with PFP"
  - ...if they have abnormal feet

Eng & Pierrynowski, Physical Therapy 1993

Lake & Wofford, Sports Health 2011

**Foot orthotics, review**
- Review of 138 studies, only 7 met inclusion criteria
- Some evidence prefabricated foot orthoses may provide greater short-term improvements in symptoms vs flat inserts
  - Combining PT with prefab orthoses seems superior to orthoses alone
  - Further research needed to establish the mechanism behind the efficacy, ID which pts will benefit, and compare prefab to custom orthotics

  - "Limited evidence that prefab orthotics may have some short-term benefits" in PFPS

Barton et al. Sports Med 2010
### Review of treatment options

**Physical therapy**
- 67 pts under age 41y, with PFP for more than 1 month
- Randomized to PT (quad retraining, PF jt mobilization, patellar taping, daily HEP) vs placebo (sham US, non-therapeutic gel, placebo taping) for 6 weekly sessions
- PT group significantly greater reduction in average pain, worst pain, and disability

- "A 6-treatment, weekly PT regimen is efficacious in alleviation of PFP"

Crosley, McConnell et al, AJSM 2002

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**Physical therapy – Core**
- Case series, 19 women (16-40yo) with PFP participated in 8-wk core strengthening rehab program & HEP
- Post rehab improvements compared to pre-rehab
- Significant improvements in pain per VAS, functional ability per AKPS, lateral core endurance, hip abduction, hip ext rotN, & reduction in knee abduction moment during running

- "8-week program focusing on core/hip strength and neuromuscular control improves strength and reduces knee abduction moment associated with PFPS"

Earl & Hock, AJSM 2011

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**"Pre-hab" on core is effective**

**Exercise for prevention – Core**
- Military recruits, RCT during 14-week boot-camp, PT 7x/wk
- Intervention program (n=759), vs control (n=743) usual warm-ups
  - Intervention: 4 strengthening & 4 stretching exercises
  - Hip abduction, Forward lunges, Single leg step downs, Single-leg squat
  - Quadriceps, IT band, Hamstring, and Calf stretches
- 36 (4.8%) new cases AKP in control, vs 10 (1.3%) in intervention
- Risk reduction for AKP of 75%

- "Simple set of lower limb exercises substantially reduced incidence of AKP in young recruits"

Coppack et al. AJSM 2011

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**Core stability & PFP**

- Study of young (12-22 yo) women with PFP vs controls
  - Dynamometer testing showed deficits in PFP pts' peak abduction (26%, p<0.001) and ER forces (36%, p<0.001)
  - Strength deficits may capacify to resist knee adduction & IR (associated with high lateral retro-patellar contact pressures)

- Is knee pain / injury a cause or effect of core deficiencies?
- Core stability is a complex phenomenon
  - Complete evals may require sophisticated EMG & modeling
  - Clinicians need portable, fast, cheap tests
  - For example: Single-leg squat test...?

1. Ireland et al, J Orthop Sports Phys Ther 2003

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**Single leg stance requires lateral core**

- Vertical ground reaction force (F) lies medial to hip joint center during single leg support

- Creates an external abduction moment (M_e) that must be opposed by an equal moment created by lateral core muscles (M_u) to avoid femoral adduction

Wilson et al, JAAOS 2005

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**Single leg squat**

- "Subject demonstrates excessive movement of right femur into adduction and IR..."

- "...both of which are signs of decreased core muscle capacity"

Wilson et al, JAAOS 2005
Does SLS test indicate ms fxn?

- Consensus panel of 5 experienced clinicians developed criteria to rate SLS as “good”, “fair”, “poor” in 34 asymptomatic pts
- 3 other clinicians also rated videos of patients
- Inter & intra-rater reliability both excellent to substantial (73-87%)
- “Good” (n=9) vs “poor” (n=12) performers were tested for core strength and Gluteus Medius EMG activation
  - “Goods” had significantly earlier activation of Glut Med than “Poors”, for both anterior (p=0.01) and post glut med (p= 0.04)
  - “Goods” had significantly greater hip abduction torque (p=0.01) & side-plank force (p=0.01) than “Poors”, but no diff in hip ER torque
- SLS is a reliable tool to ID pts with hip muscle dysfunction

Crossley et al, AJSM 2011

Rating criteria per expert consensus

<table>
<thead>
<tr>
<th>Criterions</th>
<th>To Be Rated “Good”</th>
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<tbody>
<tr>
<td>A</td>
<td>Overall impression across the 5 trials</td>
</tr>
<tr>
<td>B</td>
<td>Ability to maintain balance</td>
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<tr>
<td>C</td>
<td>Perturbations of the aces</td>
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<tr>
<td>D</td>
<td>Depth of the squat</td>
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<tr>
<td>E</td>
<td>Speed of the squat</td>
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<tr>
<td>F</td>
<td>Trunk position</td>
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<tr>
<td>G</td>
<td>Trunk/lower extremity rotation</td>
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<tr>
<td>H</td>
<td>Trunk/lower extremity tilt</td>
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<tr>
<td>I</td>
<td>Pelvis tilt</td>
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<td>J</td>
<td>Pelvis tilt</td>
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<tr>
<td>K</td>
<td>Hip adduction</td>
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<td>L</td>
<td>Hip abduction</td>
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<tr>
<td>M</td>
<td>Hip internal rotation</td>
</tr>
<tr>
<td>N</td>
<td>Knee joint</td>
</tr>
<tr>
<td>O</td>
<td>Ankle position relative to foot</td>
</tr>
<tr>
<td>P</td>
<td>Center of the knee remains over the center of the foot</td>
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</tbody>
</table>

Original PFP case

Single leg squat

- What we see the most:
  - Contralateral pelvic drop
  - Adduction / IR of hip
  - Inward rolling of knee
  - Trunk forward flexion

Examples of performance on SLS

A: Good
B: Poor trunk
C: Poor pelvis & hip
D: Poor hip & knee

Crossley et al, AJSM 2011
Treatments recommendations

- Formal PT & HEP to work on core deficiencies:
  - Strengthening: hip abductors, quads, hip flexors, hip ERs
  - Flexibility: hamstrings, hip adductors, + individualized needs
- Core handout: especially lateral leg lifts & side planks
- Recommend OTC shoe inserts (i.e., Superfeet) IF they demonstrate pes planus or over-pronation on brief treadmill gait analysis
- Avoid deep squats, avoid incline running / hill workouts
- FU after 6 weeks of PT for re-evaluation symptoms & exam
  - If not improving, re-consider other diagnoses, investigations, tx options

Compare case with:
40 yo male with patellofemoral arthritis

Compare with:
25 yo with soft tissue mass