Evidence-Based Examination and Treatment of the Sports/Orthopedic Knee and Patellofemoral Joint

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Knee Injuries

• 14–16% of all musculoskeletal injuries at the high school level.
• 9000 knee surgeries performed on high school athletes alone


PFP

• Investigate 2-year prognosis of knee pain among adolescents with and without knee pain.
• 2200 aged 15-19 yrs old.
• 55% of those with knee pain continued to have knee pain after 2 years
• 12% of those without knee pain at baseline had pain after 2 years
• Those with pain more likely to decrease activity


Anatomy and Biomechanics of the Patellofemoral Joint

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Knee Injuries

• General practitioner sees an average of 5-6 new cases per year, actual incidence in general population is unknown.
• Higher incidence in females.
• Incidence rates of 25–43% in military and sports medicine.

Callaghan M, Selfe J. Has the incidence of prevalence of patellofemoral pain in the general population in the UK been properly evaluated. Phys Ther Sport. 2007;8:37-43.

PFP

• Investigate 2-year prognosis of knee pain among adolescents with and without knee pain.
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Patellofemoral Anatomy
The Patella: The “little plate”

Primary role in promoting efficient load transmission

Acts as bony shield to underlying structures

• Embedded within quadriceps
• Largest sesmoid in body
• Inverted triangle with apex directed inferior

Patella

• Anterior Surface
  • Convex all directions
  • Rough superior third
    – Quadriceps tendon
  • V-shaped point
    – Patellar tendon

Patella

• Posterior Surface
  • Central portion of patella has thickest cartilage ~ 5 mm
  • < 1 mm in periphery of surfaces
  • Up to 7 mm mid-patellar
    – Thickest in human body


Patella

• Bone mineral density greater in lateral portion of patella
  – Increased loads
• Inferior pole
  – Non articulating
• Vertical ridge
• Articular cartilage
• Divided equally
• Medial and lateral facets


Patella

• Posterior Surface
  • Facets flat to biconvex sup/inf and med/lat
  • Second vertical ridge
  • Odd facet

**Distal Femur**

- Distal Femur
  - Femoral sulcus
  - Patellar groove
  - Trochlea
- Ridge corresponds to that of posterior patella
- Lateral facet of sulcus higher than medial

**PFJ**

- Attached from quads to tibial tuberosity
- Patellar surface much smaller than femoral surface
- One of the most incongruent joints in body

**PF Medial Side Restraints**

- Dynamic
  - VMO fibers
  - Originates from adductor magnus and adductor longus tendon
  - Inserts on superomedial half of patella
  - Results in oblique pull

- Trochlear displasia

**Four – Quadrant Force Equality**

- VMO fibers do not extend the knee
- VML fibers extend the knee
- VMO fibers provide medial dynamic stability to patella
- VMO dysplasia predisposes the patient to lateral subluxation
- Selective atrophy of VMO post Sx
PF Medial Side Restraints

- VMO
  - “Key to the knee”
  - Normal inserts 1/3 to ½ way down medial border of patella
  - Pathologically may barely reach patella
  - Only medial side dynamic restraint

Quadiceps

- Lieb and Perry
  - VML 15-18° from long axis of femur
  - VMO 50-55° from long axis of femur


PF Medial Side Restraints

- Static
  - Medial Retinaculum
  - Medial capsule
  - Medial PFL

Medial Patellofemoral Ligament

- Primary static restraint to lateral patellar displacement at 20° of knee flexion, contributing 60% of total restraining force.
  - Medial retinaculum and patellotibial ligaments minimal contributions at 11% and 5% respectively


Medial Patellofemoral Ligament

- 55% of passive soft tissue restraint to lateral patellar subluxation


Medial Patellofemoral Ligament

- 20 limbs from 17 cadavers
  - MPFL identified in 66.7%
  - More commonly found than LPFL

**Dynamic Medial Restraints**

- **Dynamic**
  - Vastus lateralis
- **Static**
  - Lateral retinaculum
    - Superficial – IT band to patella
    - Deep
      - ITB
      - TFL

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**PF Lateral Side Restraints**

- Dynamic
- Static

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**Patellofemoral Biomechanics**

- **Patellar Function**
  - Facilitating extension of the knee by increasing the distance of the extensor apparatus
  - Moment arm produces greatest quadriceps torque at 20-60° flexion
  - Neutral position 0°
**Patellar Function**
- Guide for the quadriceps tendon
- Changes direction of quadriceps force – acting as a pulley

**PF Joint Reaction Forces (PFJRF)**
- The measurement of compression of patella against femur
- Greatest force occurs between 60-30°
  - Values approaching 3000 Newtons


**PF Joint Reaction Forces (PFJRF)**
- PFJRF are equal and opposite to R of quadriceps tension and patellar tendon tension

**PFJRF**
- Increase as knee flexion increases
  - Angle becomes more acute
  - Lever arms of femur and tibia increase

**PF Joint Reaction Forces (PFJRF)**
- OKC knee extension requires greater amount of quad force
  - Active insufficiency of quads
  - Full effects of gravity
  - Decreased biomechanical advantage

Forces on the patella

- Walking  0.5-1.5x BW
- Stairs     3.0x BW
- Squatting  7-8x BW

Contact Stress

One part or another of patellar cartilage is loaded throughout the entire flexion-extension cycle

Except the earliest degrees of knee flexion

CKC Exercises

- CKC Exercises
- As knee extends PFJ contact stress decreases despite:
  - decreased contact area
  - May be due to decreased torque of gravity
OCK Exercises

Contact Pressures and PFJ

- OKC Exercises
- As knee extends, PFJ contact stress increases due to:
  - Increased PFJR force and decreased contact area

Contact Pressures and PFJ

- High contact pressure activities
- Loaded OKC knee extension exercise
- CKC knee extension activities in > 50° of knee flexion

Contact Pressures and PFJ

- Low contact pressure activities
- Loaded OKC knee extension exercise from 90°-50° & 20°-0°
- CKC knee extension activities in < 50° of knee flexion

PF Contact Surface Area
**PF Contact Surface Area**

<table>
<thead>
<tr>
<th>Degree of Flexion</th>
<th>Patella Articulation</th>
<th>Femoral Articulation</th>
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<tbody>
<tr>
<td>0°</td>
<td>Femoral Suleus</td>
<td>Min. bony contact</td>
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<tr>
<td>20°-30°</td>
<td>Inf. facets</td>
<td>Mld. fem.sulcus</td>
</tr>
<tr>
<td>60°</td>
<td>mid. facets</td>
<td>Superior femoral notch</td>
</tr>
<tr>
<td>90°</td>
<td>mid/sup lat facets</td>
<td>Sup fem notch</td>
</tr>
<tr>
<td>120°</td>
<td>Lat mid and sup facet</td>
<td>Sup fem notch/ LFC</td>
</tr>
<tr>
<td>135°</td>
<td>Lat mid facet/lat sup facet/ odd</td>
<td>LFC/lat surface of MFC</td>
</tr>
</tbody>
</table>

**Contact Stress**

Distal portion of patella loaded as knee flexes and contact area migrates proximally with progressive flexion.

At 90° the contact area is located proximally, after which contact area moves back toward central aspect of patella.


**Articular Surface Of The Patella**

**Quadriceps Angle**

*THE LAW of VALGUS*


**PF Signs**

- **Increased Q-angle**
  - More significant for females
  - Normal Males: 8°-14°
  - Females: 15°-17°
**Q-Angle**

- Originally described by Brattstrom
- “the angle formed by the resultant vector of the quadriceps force and the patellar tendon with the knee in an “extended, end-rotated” position.”


- Angle formed by the intersection of a line drawn from the anterior superior iliac spine to the midpoint of the patella
- Proximal extension of the line from the tibial tubercle to the midpoint of the patella


**Q-Angle**

- Theory centers around this measurement
- Offset in force vectors from the quadriceps force and force from patellar tendon

**Measuring Q angle**

- Standing

- Dynamically
Measuring Q angle

• With Quadriceps Contracted

Measuring Q angle

• With Standardized Foot Positions

Lack of standardization of a measurement technique still a problem!

Q-Angle

• Relationship between Q-angle and clinical signs and symptoms has not always been consistent

Q-Angle

• May be problematic in subpopulation of those with PFP
• Etiologic factors unrelated to Q-angle may be more dominant in certain individuals
• Remember: Q-Angle is “static” measurement that measures dynamic function!

Femoral Anteversion and Retroversion Effects on Q-Angle
**Q-Angle**

- Can vary significantly when measurement taken standing due to foot position.
- Supine measurement taken as static position
- Standing can be taken as a more “functional” measurement.

**Q-Angle**

- Although and increased Q-angle is traditionally associated with a valgus knee, some of the highest Q angles are found in patients with a combination of genu varus and proximal tibial torsion.


**Patellar Orientation**

**Clinical Assessment of PF Alignment**

**Patellar Position**

- Assess medio-lateral glide and patellar tilt with MRI
- 24 subjects; 16 males; 8 females
- * Examiner -15 years of experience


**Patellar Position**

- Good correlation between findings of clinical test of medio-lateral position and MRI ($r=0.611$, $p=0.002$)

Patellar Position

- If found lateral patellar tilt, patellar tilt angle via MRI was > 5°


- 30 patients with tilt
- 51 patients without tilt
- Found patients with significant tilt on PE can be expected to have >10° tilt on MR


- Any MR angle <10° is associated with the absence of significant tilt on MR
- “This study should not imply abnormal tilt in any given patient automatically implies pathology
- Patients with any tilt on PE can be expected to have an MRI tilt angle that is 10° or >.


Assessment of Patellar Position?
Clinical examination and measurement of patellofemoral alignment with visual examination, using calipers or goniometer’s may be unreliable when performed within or between testers.

Intratester Kappa’s displayed questionable reliability for:
- Mediolateral tilt 0.57
- Superior/inferior tilt 0.50
- Rotation 0.41
- Mediolateral position 0.40


Intertester Kappa’s displayed questionable reliability for:
- Mediolateral tilt 0.18
- Superior/inferior tilt 0.03
- Rotation 0.30
- Mediolateral position 0.03

The low intratester and intertester agreement coefficients were clinically unacceptable and suggest that treatment decisions based on these measurements should not be made!

What passes for PF malalignment at one clinic or with one therapist may not be the deemed the same problem at another clinic because clinicians cannot agree on basic physical examination data.

Reliability of Tests for PF Alignment (Intertester)
- Medial/lateral displacement 0.10
- Medial/lateral tilt 0.21
- Anterior/posterior tilt 0.24
- Medial/lateral rotation 0.36

### Medial/lateral Position

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>Inter-Tester</th>
<th>Intra-Tester</th>
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<tr>
<td>Fitzgerald and McClure, 1995</td>
<td>0.10</td>
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<td>Herrington, 2008</td>
<td>NA</td>
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<td>Herrington, 2002</td>
<td>M-.91; L-.94</td>
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<td>Herrington, 2006</td>
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<td>Tomsich et al, 1996</td>
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<td>Watson et al, 1999</td>
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<td>0.11-0.35</td>
</tr>
</tbody>
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**References**


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**Thank You!**

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