Where to Draw the Line: Anatomical Measurements Used to Evaluate Patellofemoral Instability

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Objectives

1. Clinical Considerations

2. Anatomical Factors
   - Patellar height
   - Patellar tilt and displacement
   - Patellar congruence angle
   - Trochlear dysplasia

3. Translational forces
   - Q angle
   - Tibial tubercle-trochlear groove distance

4. Checklist for patellofemoral instability
Patellar Instability: Clinical Considerations

• Presentation
  ✓ Isolated anterior knee pain
  ✓ Overt dislocation

• Progression
  ✓ Articular cartilage injuries
  ✓ Osteochondral fractures
  ✓ Patellofemoral osteoarthritis

• Etiology
  ✓ Acute: traumatic dislocation
  ✓ Chronic: recurrent dislocation

• Surgical Treatment: Trochleoplasty
  ✓ Elevation of lateral trochlear facet
  ✓ Deepening trochleoplasty
    ➢ Recreation of trochlear sulcus
  ✓ Recession wedge trochleoplasty
    ➢ Prominent trochlear groove recessed to level of anterior femoral cortex
# Imaging Evaluation of Patellofemoral Instability

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Patellar Height: Insall-Salvati Ratio

- Applicable to lateral film, ideally with knee in 30° flexion
- Measure the greatest diagonal length of the patella (B, yellow line)
- Measure the length of patellar tendon (A, red line) from the lower pole of the patella to the insertion into the tibial tubercle
- Normal ratio of A:B = 1.0 ± 0.2

Normal:
A:B = 1.0 ± 0.2
Patellar Height: Insall-Salvati Ratio

Patella alta: $A:B > 1.2$
Patella baja: $A:B < 0.8$
Patellar Height: Caton-Deschamps Index

- Applicable to lateral film, ideally with knee in 30° flexion
- Measure the articular facet length of the patella (B, blue line)
- Measure the distance between the inferior edge of the patellar articular surface and the anterosuperior angle of the tibia (A, green line)
- Normal ratio $A:B = 1.0 \pm 0.2$

**Normal**

Inferior patellar edge to anterosuperior tibial angle length (A)

Patellar cartilage length (B)

Normal: $A:B = 1.0 \pm 0.2$
Patellar Height: Caton-Deschamps Index

Clinical

Anatomic Factors

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Checklist

Patella alta: A:B > 1.2

Patella baja: A:B < 0.8

Patellar cartilage length (C)

Inferior edge of the patellar articular surface and antero-superior angle of the tibia (D)
Patellar Tilt And Displacement: Laurin Method

Axial radiograph technique

- **Patellar tilt**
  - ✔ Draw Line A: line tangent to the summits of the femoral condyles
  - ✔ Draw Line B: line tangent to the lateral patellar facet
  - ✔ Normal: Angle (∠AB) between Line A and Line B is open laterally

- **Lateral displacement**
  - ✔ Draw Line C: line perpendicular to Line A and 1 mm lateral to summit of medial femoral condyle
  - ✔ Normal: Line C intersects patella

Normal: ∠AB = open laterally
Normal: Line C intersects patella
Patellar Tilt And Displacement: Laurin Method

Lateral Tilt & Displacement

Lateral patellar tilt:

\[ \angle AB = \text{open medially} \]

Lateral patellar displacement:

Patella lies lateral to Line C

Clinical | Anatomic Factors | Translational Forces | Checklist
CT technique

- Patellar tilt
  - Axial image at level of mid pole of the patella
  - Draw Line A: line tangent to posterior femoral condyles
  - Draw Line B: line through transverse axis of patella
  - Normal: $\angle AB < 20^\circ$
  - Lateral tilt: $\angle AB > 20^\circ$

Normal patellar tilt: $\angle AB < 20^\circ$
Patellar Congruence Angle: Merchant Method

Axial radiograph technique
✓ Draw Line DB: line from apex of lateral femoral condyle (D) to trochlear groove (B)
✓ Draw Line BE: line from trochlear groove (B) to apex of medial femoral condyle (E)
✓ Draw Line BC: line bisecting Line DB & Line BE
✓ Draw Line AB: line from trochlear groove (B) to lowest point on the articular surface of the patella (A)
✓ Convention:
  ➢ $\angle ABC$: (+) if A is lateral to line BC
  ➢ $\angle ABC$: (-) if A is medial to line BC

Normal Congruence angle: $-28^\circ < \angle ABC < +16^\circ$
Patellar Congruence Angle: Merchant Method

Lateral Tilt

Lateral patellar tilt:
\[ \angle ABC > +16^\circ \]
Trochlear Dysplasia: Crossing Sign

Lateral radiograph
- Draw outline of the trochlear groove = trochlear floor
- Draw outline of the ventral surface of lateral femoral condyle

Normal: trochlear floor outline never crosses lateral condyle outline
Trochlear dysplasia: trochlear floor outline crosses lateral condyle outline
Trochlear Dysplasia: Lateral Trochlear Inclination

Axial MRI/CT technique
- Axial image at most proximal level cartilaginous trochlea is demonstrated
- Draw Line A: line tangent to posterior femoral condyles
- Draw Line B: line tangent to lateral trochlear facet
- Measure lateral trochlear inclination angle ($\angle AB$)

Normal: $\angle AB > 11^\circ$
Trochlear Dysplasia: Lateral Trochlear Inclination

Trochlear Dysplasia

∠AB < 11°

Clinical  Anatomic Factors  Translational Forces  Checklist
Trochlear Dysplasia: Facet Asymmetry

Axial MRI/CT technique
- Axial image 3 cm above the femorotibial joint space
- Measure length of medial trochlear facet (Line A)
- Measure length of lateral trochlear facet (Line B)
- Measure ratio (A:B) of medial facet length (A) to lateral facet length (B)

Normal ratio: A:B > 40%
Trochlear Dysplasia: Facet Asymmetry

Trochlea Dysplasia

Trochlear Dysplasia: A:B < 40%

Clinical  Anatomic Factors  Translational Forces  Checklist
Trochlear Dysplasia: Depth

Axial MRI/CT technique
- Axial image 3 cm above the femorotibial joint space
- Draw reference Line D tangent to posterior femoral condyles
- Measure the maximal anteroposterior distance of the:
  - Medial femoral condyle (Line A)
  - Lateral femoral condyle (Line B)
- Measure the anteroposterior distance (Line C) between the deepest point of the trochlear groove and Line D
- Calculate the trochlear depth:

\[
\text{Trochlear Depth} = \left( \frac{A+B}{2} \right) - C
\]

Normal: trochlear depth > 3 mm

Clinical | Anatomic Factors | Translational Forces | Checklist
Trochlear Dysplasia: Depth

Trochlear dysplasia:
Trochlear depth < 3 mm

Trochlear Depth = \left( \frac{A+B}{2} \right) - C

Clinical | Anatomic Factors | Translational Forces | Checklist
Quadriceps (Q) angle

Radiograph technique
- Draw Line A: line from the anterior superior iliac spine to the center of the patella
- Draw Line B: line from the center of the patella to the tibial tuberosity
- Measure the Q angle ($\angle AB$)

Normal Q angle:
- Males: $\angle AB < 15^\circ$
- Females: $\angle AB < 20^\circ$

Abnormal Q angle:
- Males: $\angle AB > 15^\circ$
- Females: $\angle AB > 20^\circ$
Tibial Tubercle-Trochlear Groove Distance

Single image technique

• On axial image through deepest portion of trochlear groove, draw:
  ✓ Line tangent to posterior condyles (posterior condyle line)
  ✓ Line perpendicular to posterior condyle line that passes through deepest point of trochlear groove (trochlear groove line)

• Transpose:
  ✓ Posterior condyle and trochlear groove lines onto axial image through tibial tuberosity

• On axial image through tibial tuberosity, draw:
  ✓ Line perpendicular to posterior condyle line that passes through tibial tubercle (tibial tubercle line)

• Measure:
  ✓ Shortest distance between tibial tubercle and trochlear groove lines (TT-TG distance)

Normal TT-TG distance: < 20 mm
Abnormal TT-TG distance: > 20 mm
  • Associated with pathologic patellar instability
Tibial Tubercle-Trochlear Groove Distance

Double image technique
- Superimpose axial images through (1) deepest portion of trochlear groove and (2) tibial tuberosity, then draw:
  - Line tangent to posterior condyles (posterior condyle line)
  - Line perpendicular to posterior condyle line that passes through deepest point of trochlear groove (trochlear groove line)
  - Line perpendicular to posterior condyle line that passes through tibial tubercle (tibial tubercle line)

- Measure:
  - Shortest distance between tibial tubercle and trochlear groove lines (TT-TG distance)

Normal TT-TG distance: < 20 mm
Abnormal TT-TG distance: > 20 mm
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# Checklist for Patellofemoral Instability

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