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

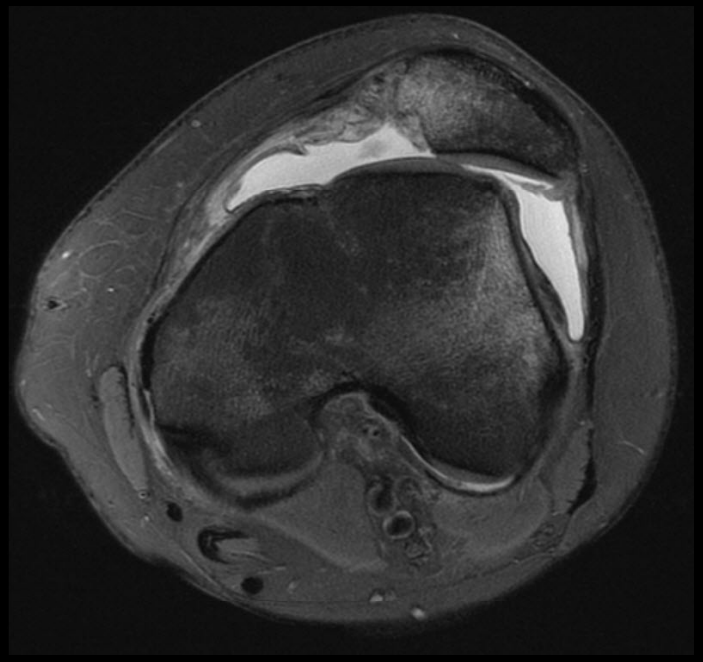
Patellar Instability: Clinical Considerations

- 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

Anatomical Factors	
Measurement	**Normal**
Patellar Height	Insall-Salvati & Caton-Deschamps ratios = 1.0 ± 0.2
Patellar Tilt - radiograph	Index ∠ open laterally
Patellar Tilt - CT	Index ∠ < 20°
Patellar Displacement	Patella intersects reference line
Patellar Congruence	-28 ° < index ∠ < +16°
Crossing sign	Trochlear floor outline never crosses lateral femoral condyle outline
Trochlear Inclination	Index ∠ > 11°
Trochlear Facet Asymmetry	medial to lateral facet ratio > 40%
Trochlear Depth	> 3 mm

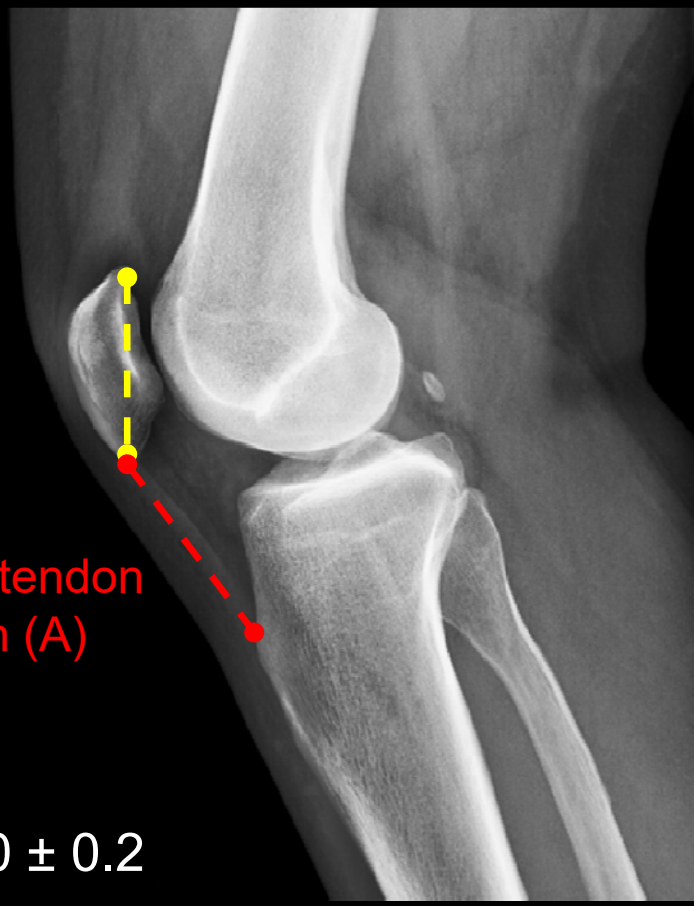
Translational Forces	
Measurement	**Normal**
Quadriceps Angle	Males: < 15° Females: > 20°
Tibial Tubercle-Trochlear Groove Distance	< 2 cm



Patellar Height: Insall-Salvati Ratio

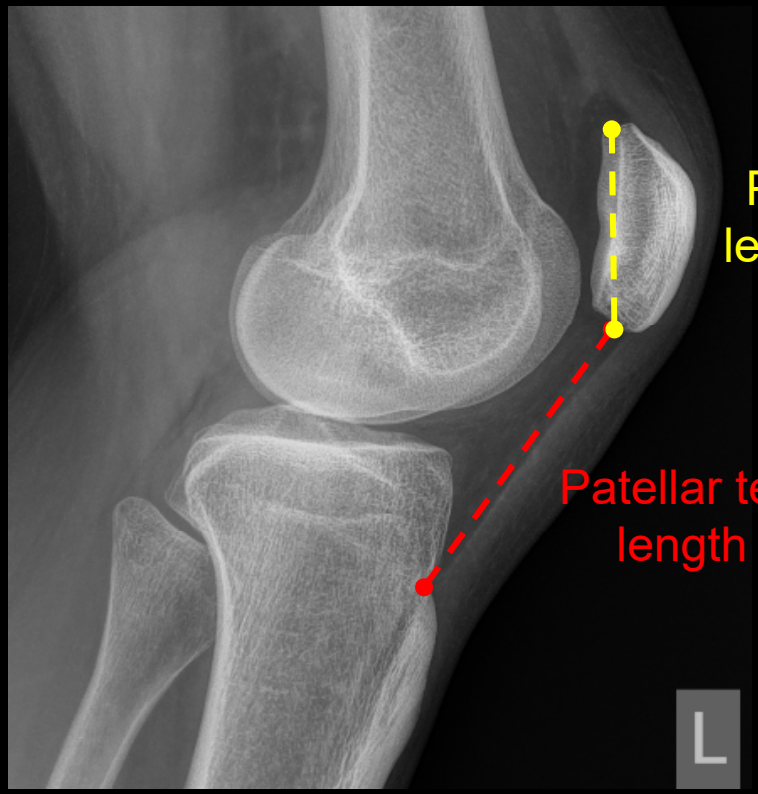
- Applicable to lateral film, ideally with knee in 30° flexion
- Measure the greatest diagonal length of the patella (B, yellow line)
- Measure the length of patellar tendon (A, red line) from the lower pole of the patella to the insertion into the tibial tubercle
- Normal ratio of A:B = 1.0 ± 0.2

Normal

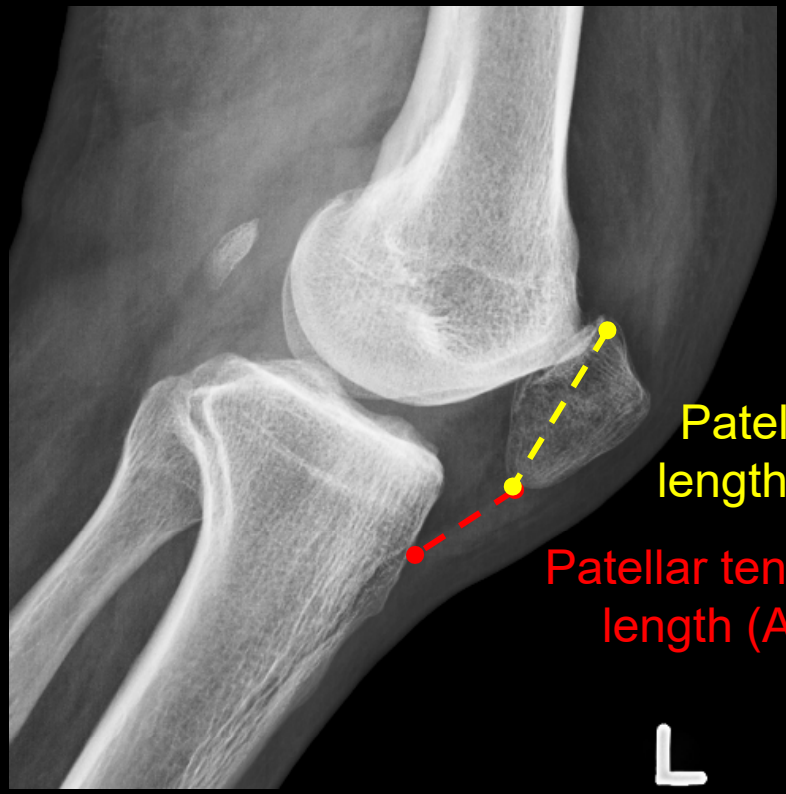


Normal:
A:B = 1.0 ± 0.2

Patellar Height: Insall-Salvati Ratio



Patella alta: A:B > 1.2

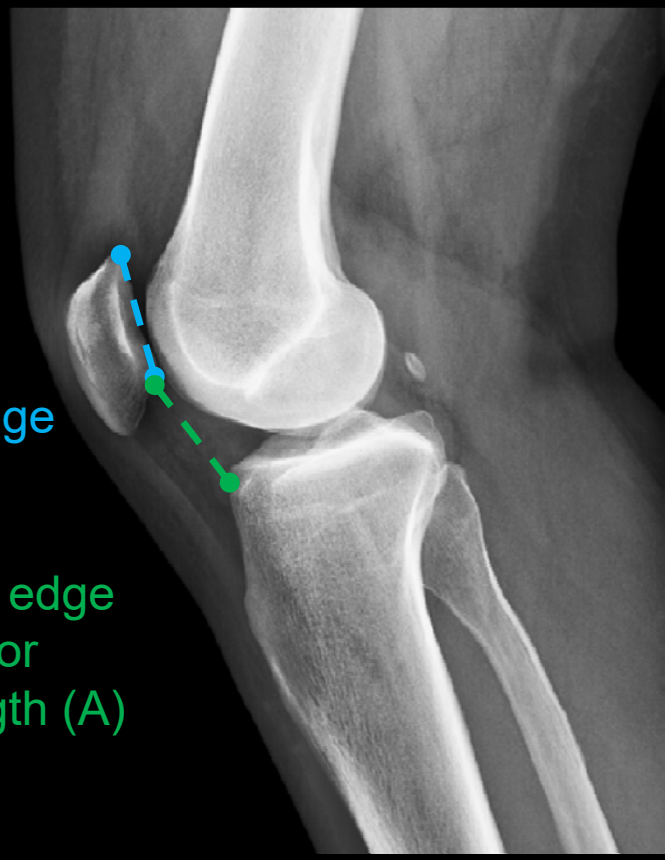


Patella baja: A:B < 0.8

Patellar Height: Caton-Deschamps Index

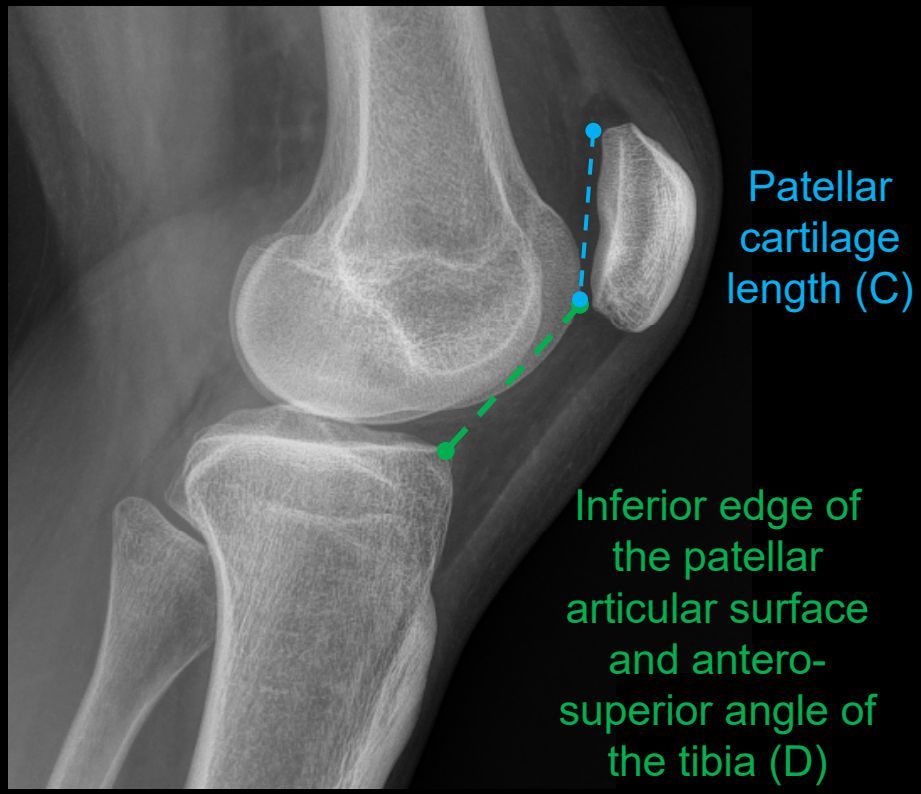
- Applicable to lateral film, ideally with knee in 30° flexion
- Measure the articular facet length of the patella (B, blue line)
- Measure the distance between the inferior edge of the patellar articular surface and the antero-superior angle of the tibia (A, green line)
- Normal ratio A:B = 1.0 ± 0.2

Normal

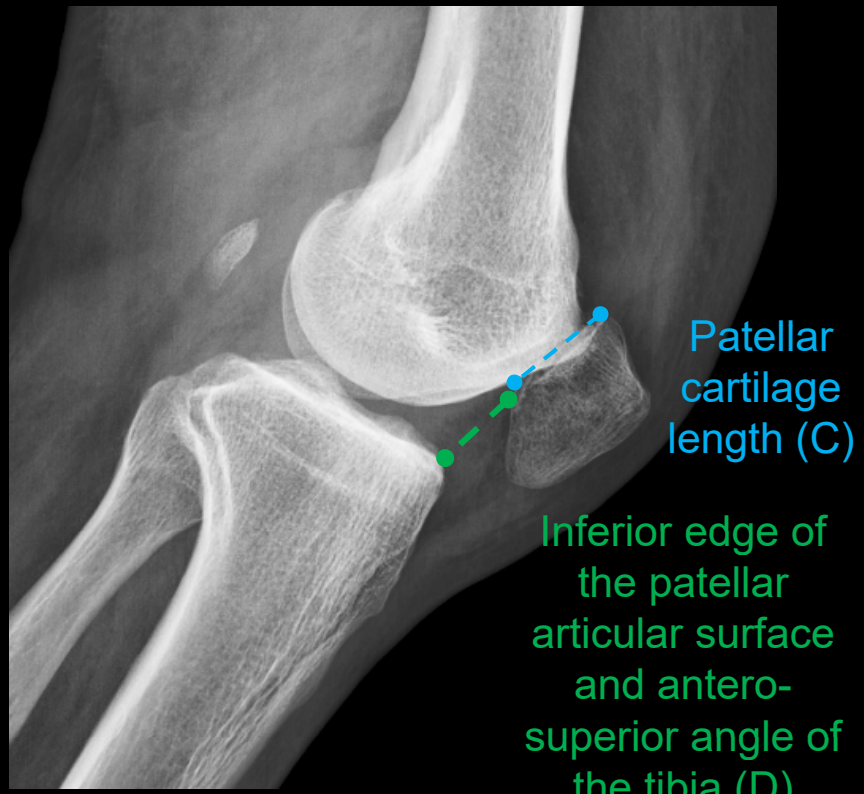


Normal:
A:B = 1.0 ± 0.2

Patellar Height: Caton-Deschamps Index



Patella alta: A:B > 1.2



Patella baja: A:B < 0.8

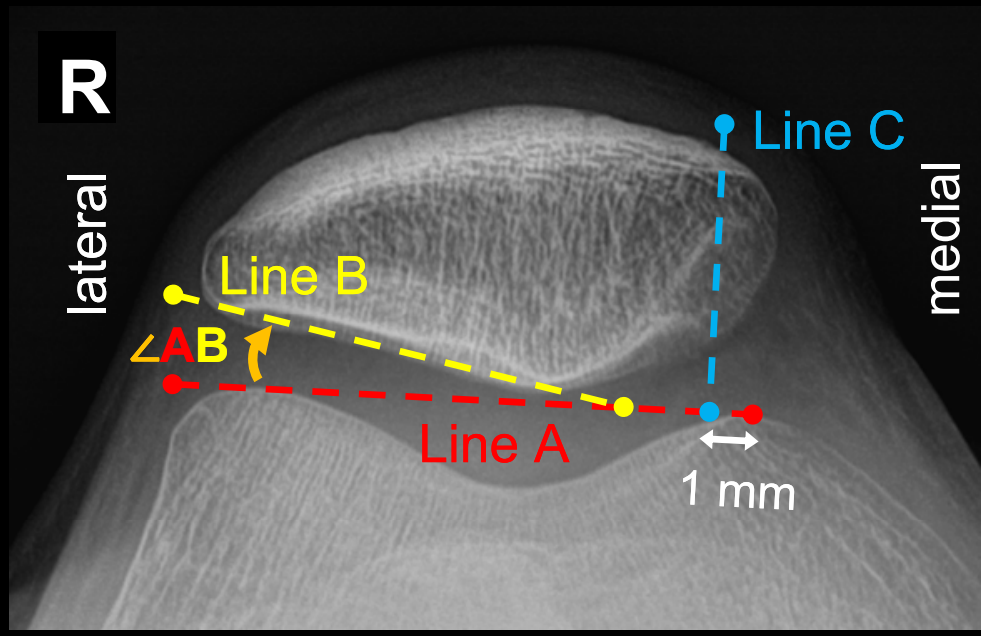
Patellar Tilt And Displacement: Laurin Method

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

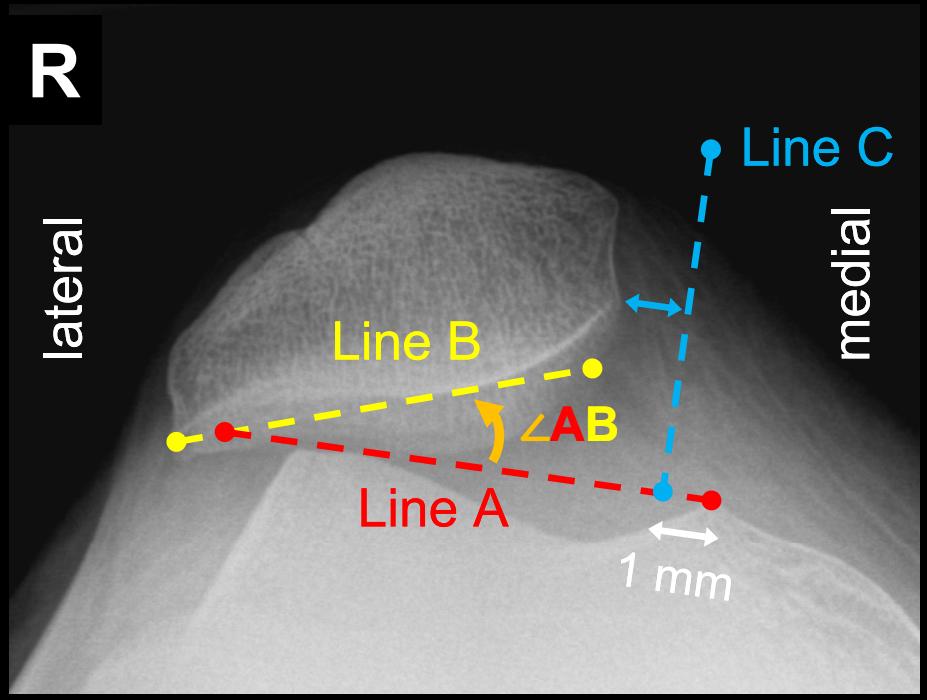


Normal:
∠AB = open laterally

Normal:
Line C intersects patella

Patellar Tilt And Displacement: Laurin Method

Lateral Tilt & Displacement



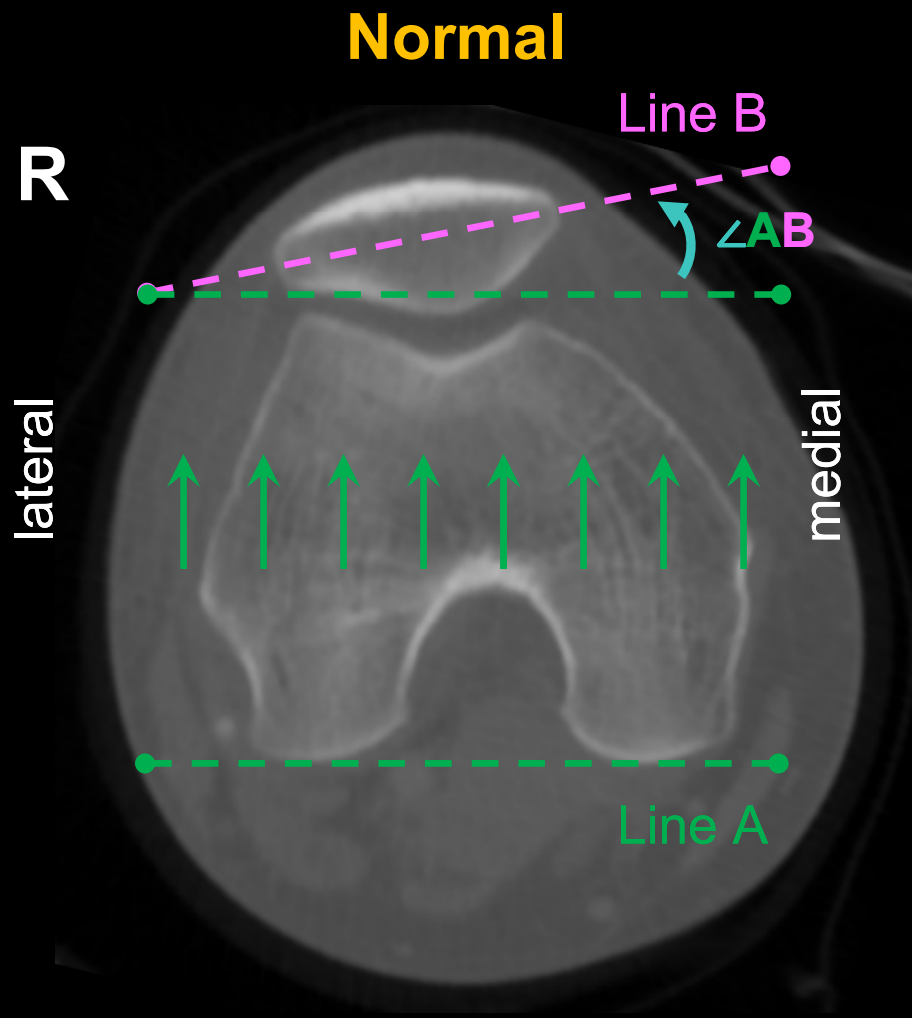
Lateral patellar tilt:
∠AB = open medially

Lateral patellar displacement:
Patella lies lateral to Line C

Patellar Tilt: Dejour Method

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: ∠AB < 20°
  - ✓ Lateral tilt: ∠AB > 20°



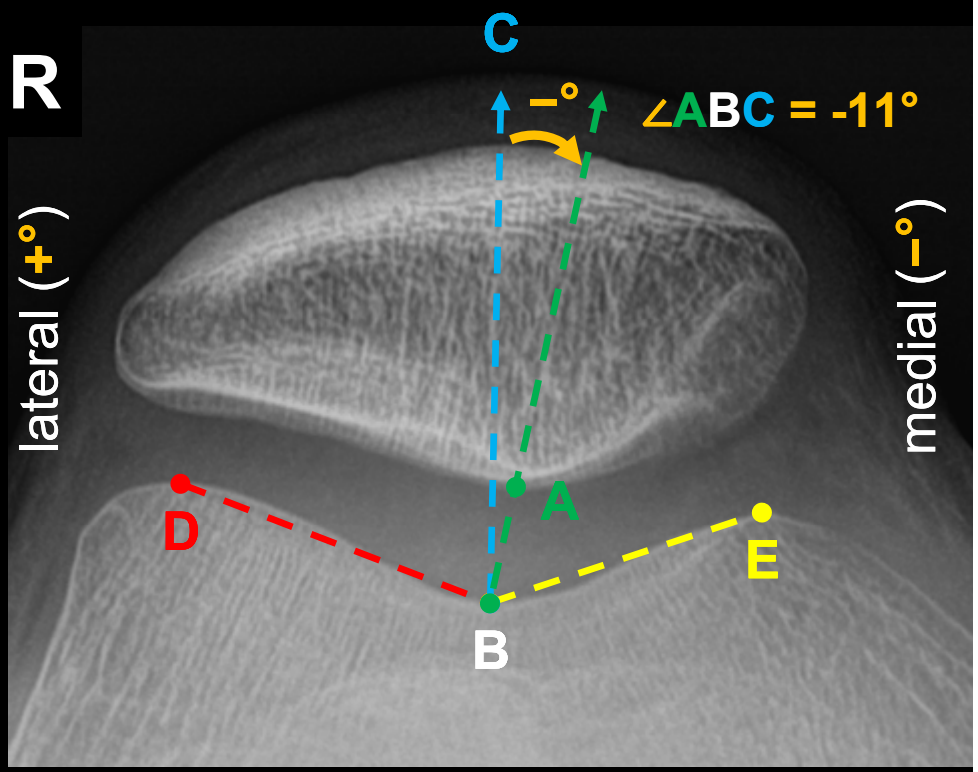
Normal patellar tilt: ∠AB < 20°

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:
  - ➢ ∠ABC: (+) if A is lateral to line BC
  - ➢ ∠ABC: (-) if A is medial to line BC

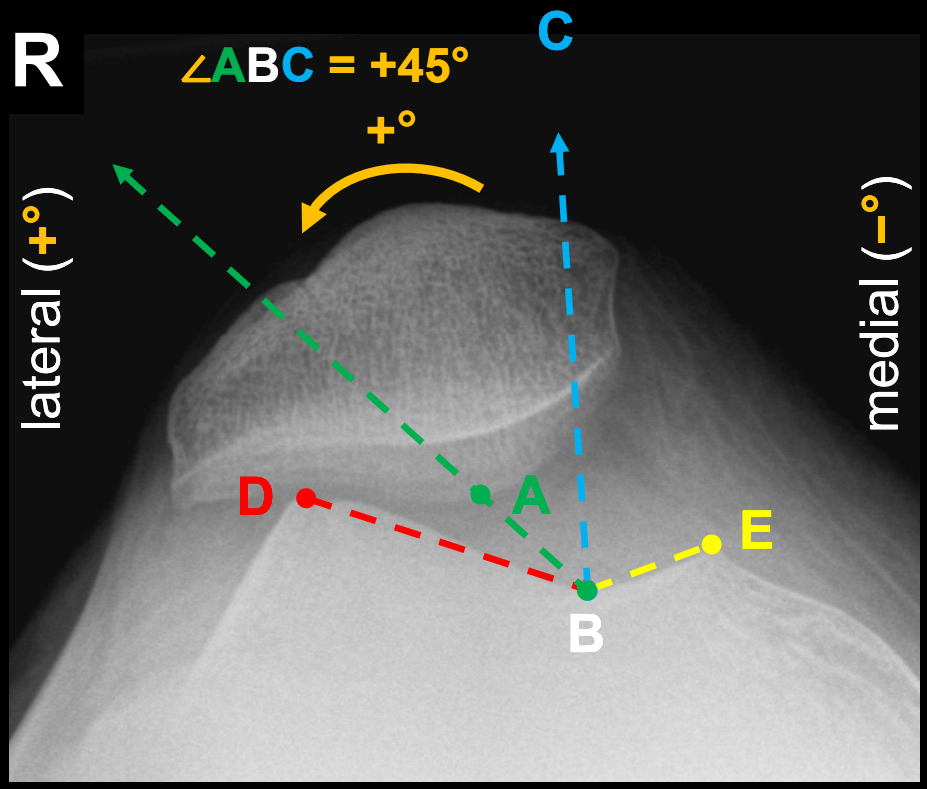
Normal



Normal Congruence angle:
-28 ° < ∠ABC < +16°

Patellar Congruence Angle: Merchant Method

Lateral Tilt

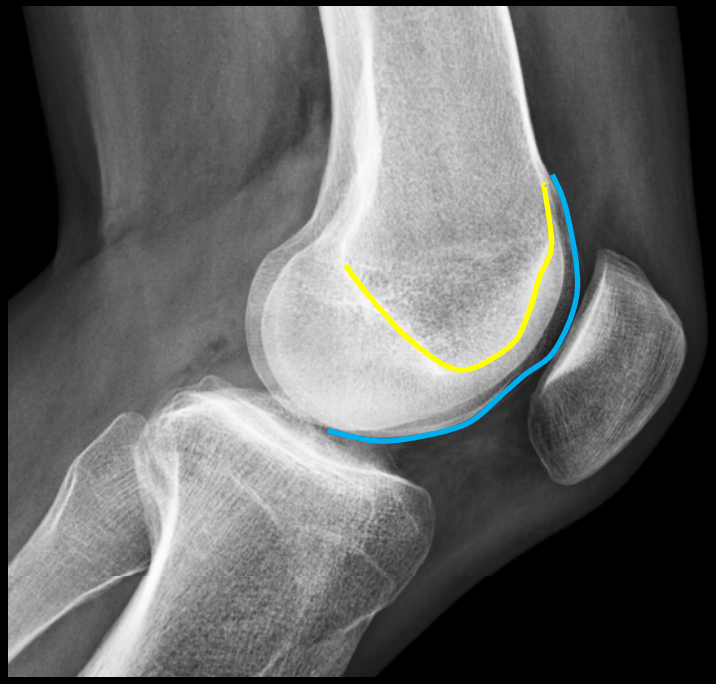


Lateral patellar tilt:
∠ABC > +16°

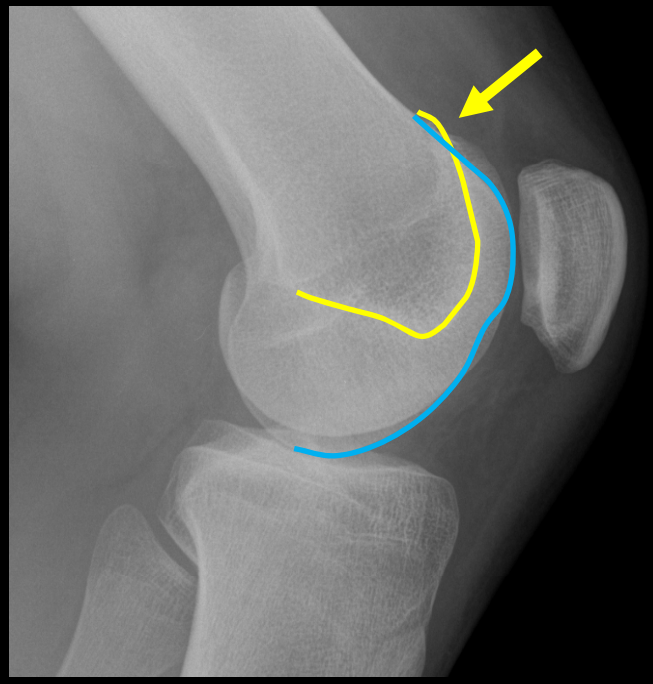
Trochlear Dysplasia: Crossing Sign

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

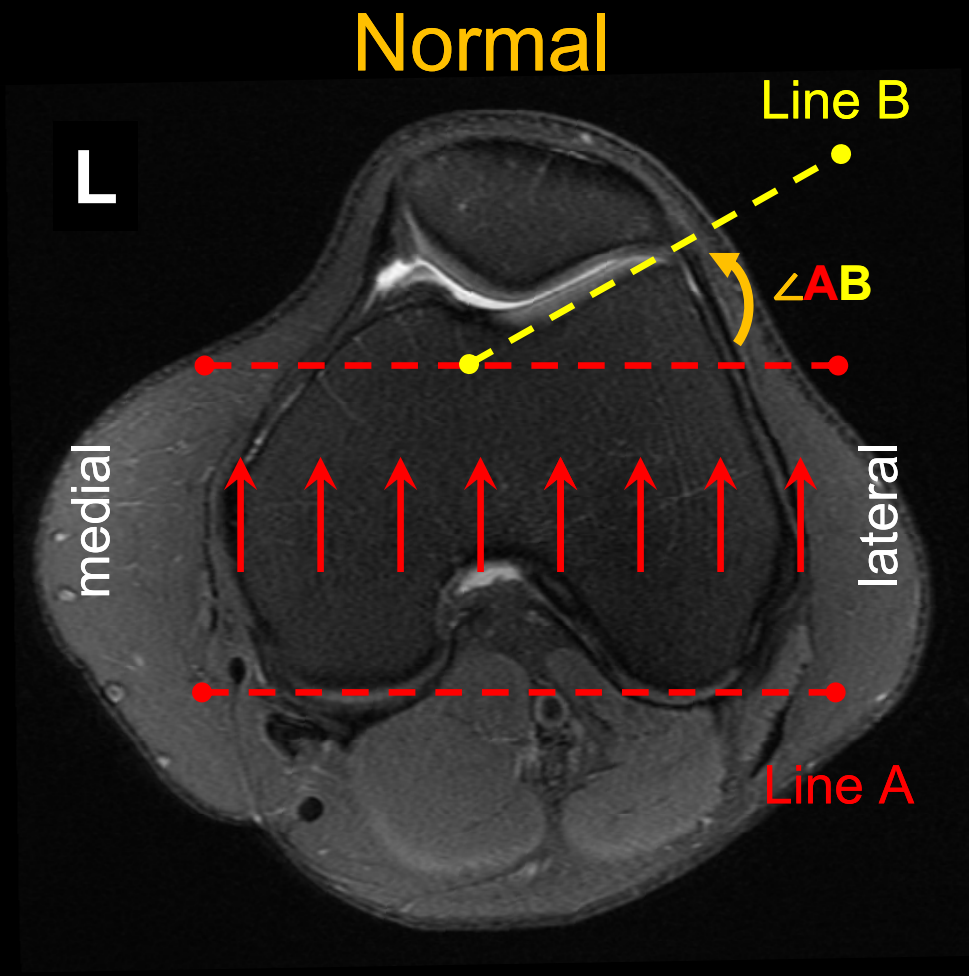


Trochlear dysplasia: trochlear floor outline crosses lateral condyle outline

Trochlear Dysplasia: Lateral Trochlear Inclination

Axial MRI/CT technique

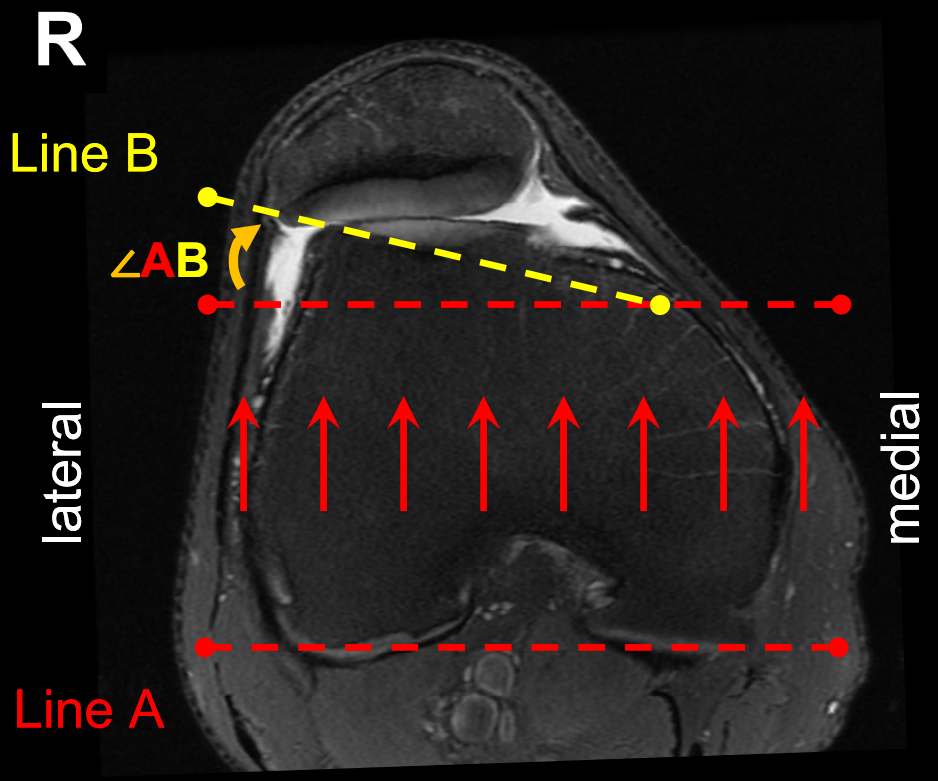
- Axial image at most proximal level cartilaginous trochlea is demonstrated
- Draw Line A: line tangent to posterior femoral condyles
- Draw Line B: line tangent to lateral trochlear facet
- Measure lateral trochlear inclination angle (∠AB)



Normal: ∠AB > 11°

Trochlear Dysplasia: Lateral Trochlear Inclination

Trochlear Dysplasia

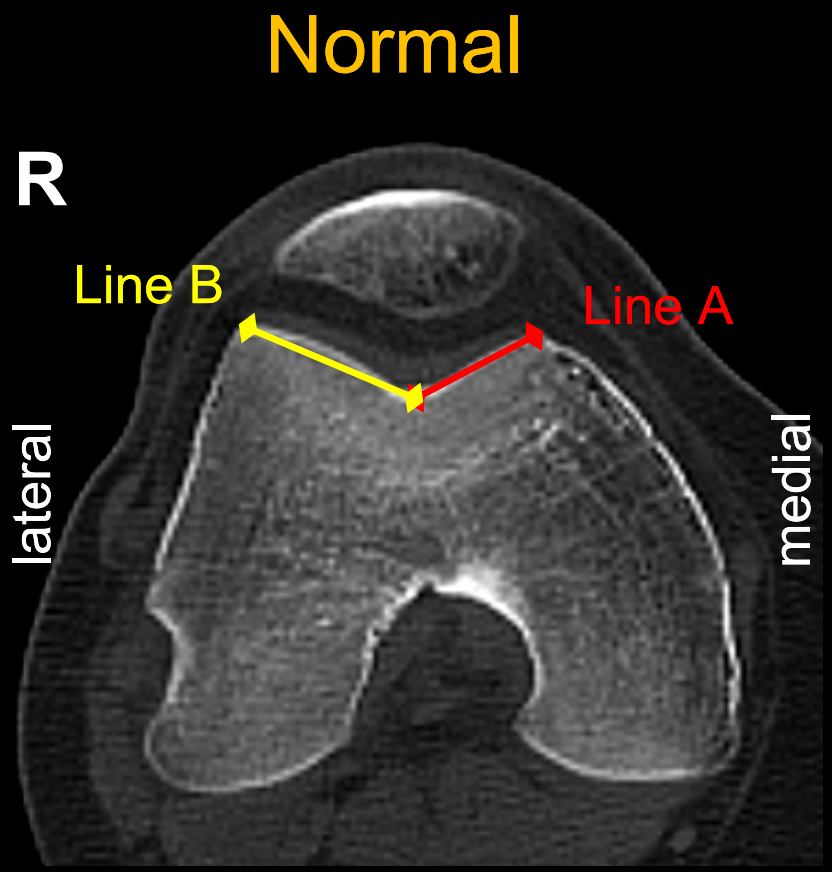


Trochlear Dysplasia:
∠AB < 11°

Trochlear Dysplasia: Facet Asymmetry

Axial MRI/CT technique

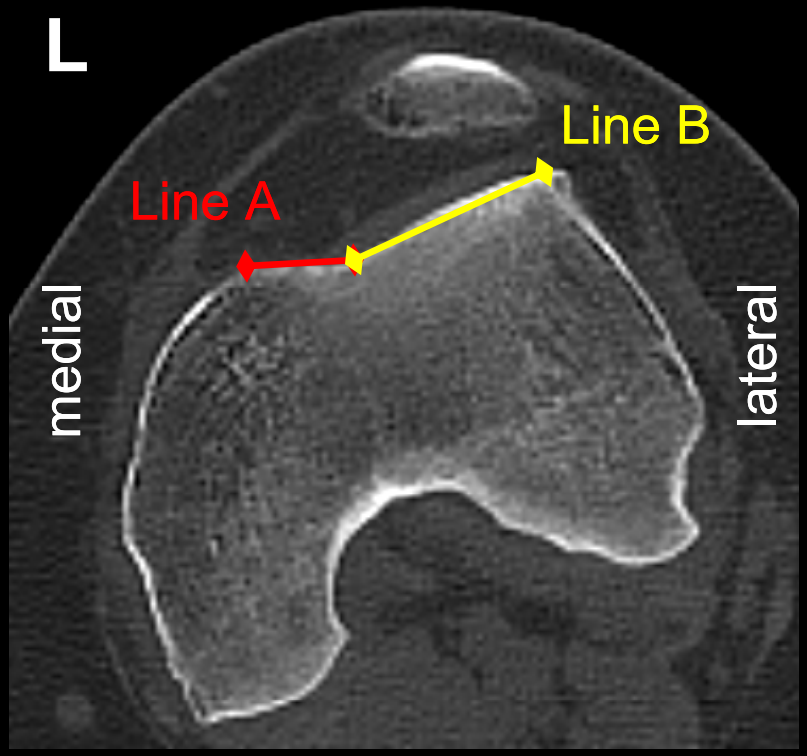
- Axial image 3 cm above the femorotibial joint space
- Measure length of medial trochlear facet (Line A)
- Measure length of lateral trochlear facet (Line B)
- Measure ratio (A:B) of medial facet length (A) to lateral facet length (B)



Normal ratio: A:B > 40%

Trochlear Dysplasia: Facet Asymmetry

Trochlea Dysplasia



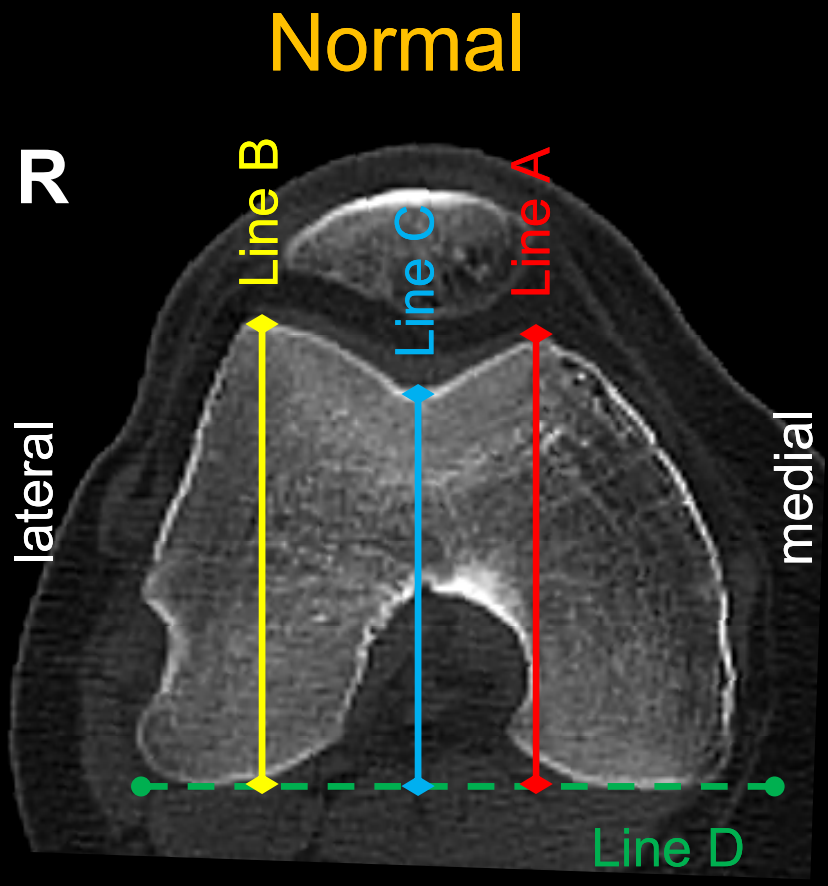
Trochlear Dysplasia: A:B < 40%

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:

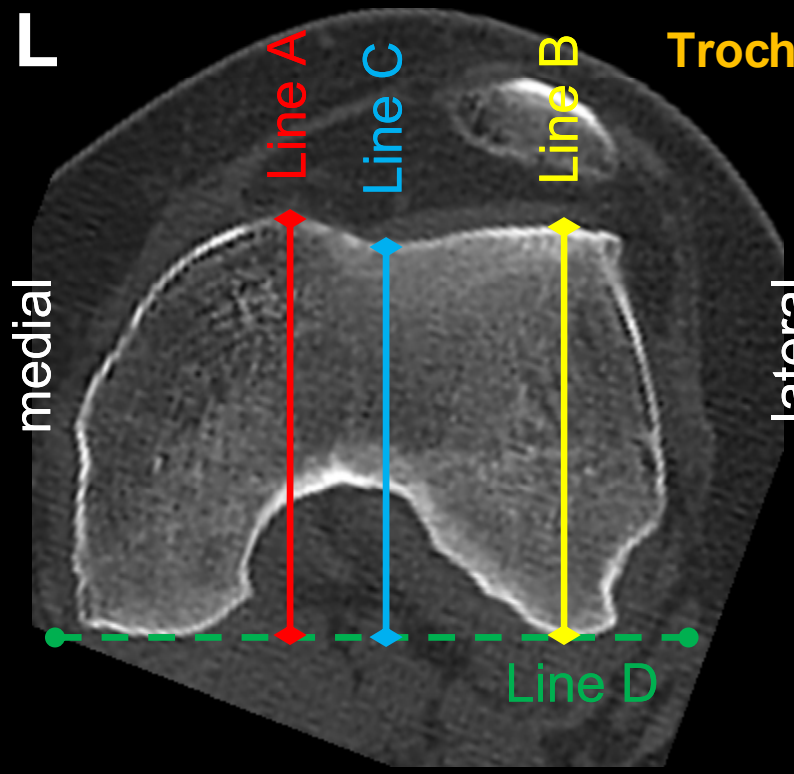
$$\textbf{Trochlear Depth} = \left(\frac{A+B}{2}\right) - C$$



Normal: trochlear depth > 3 mm

Trochlear Dysplasia: Depth

Trochlea Dysplasia



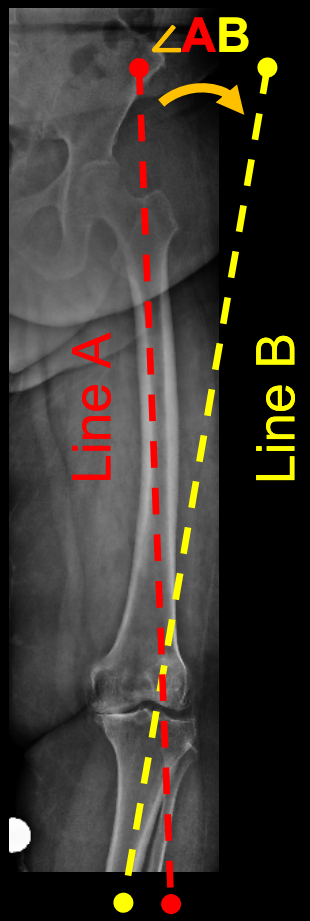
$$\text{Trochlear Depth} = \left(\frac{A+B}{2}\right) - C$$

Trochlear dysplasia:
Trochlear depth < 3 mm

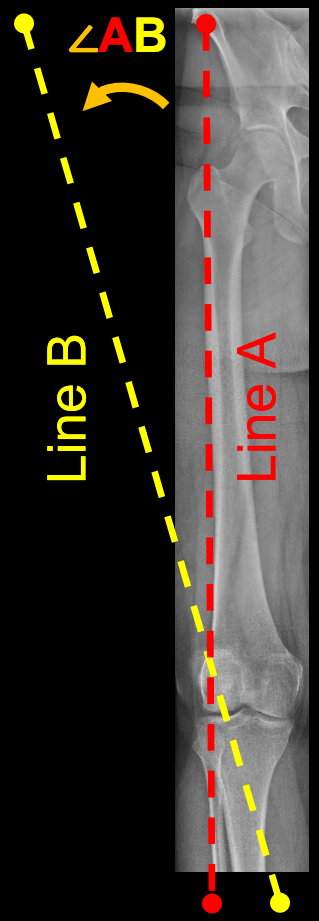
Quadriceps (Q) angle

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 (∠AB)



Normal Q angle:
Males: ∠AB < 15°
Females: ∠AB < 20°

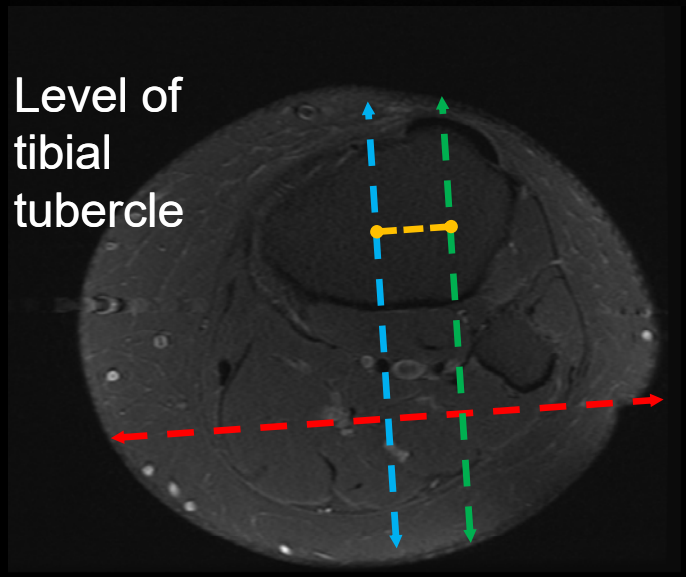


Abnormal Q angle:
Males: ∠AB > 15°
Females: ∠AB > 20°

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

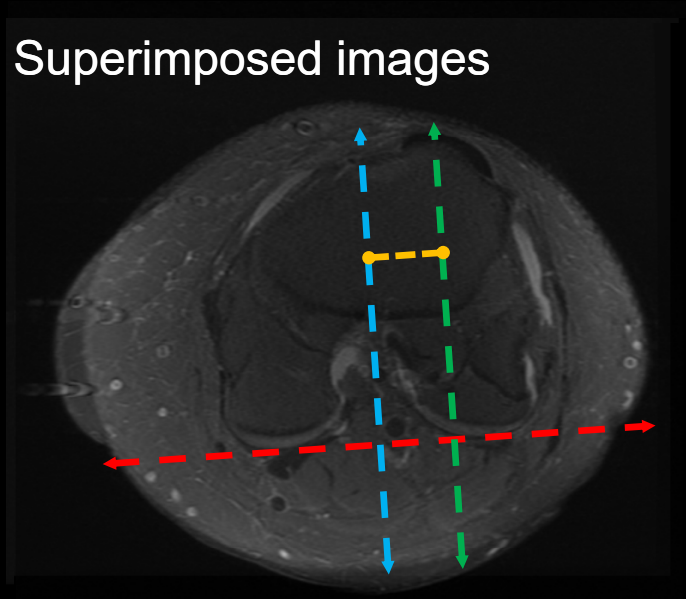
Abnormal TT-TG distance: > 20 mm

- 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
- Associated with pathologic patellar instability

Checklist for Patellofemoral Instability

Anatomical Factors		Translational Forces	
Measurement	**Normal**	**Measurement**	**Normal**
Patellar Height	Insall-Salvati & Caton-Deschamps ratios = 1.0 ± 0.2	Quadriceps Angle	Males: < 15° Females: > 20°
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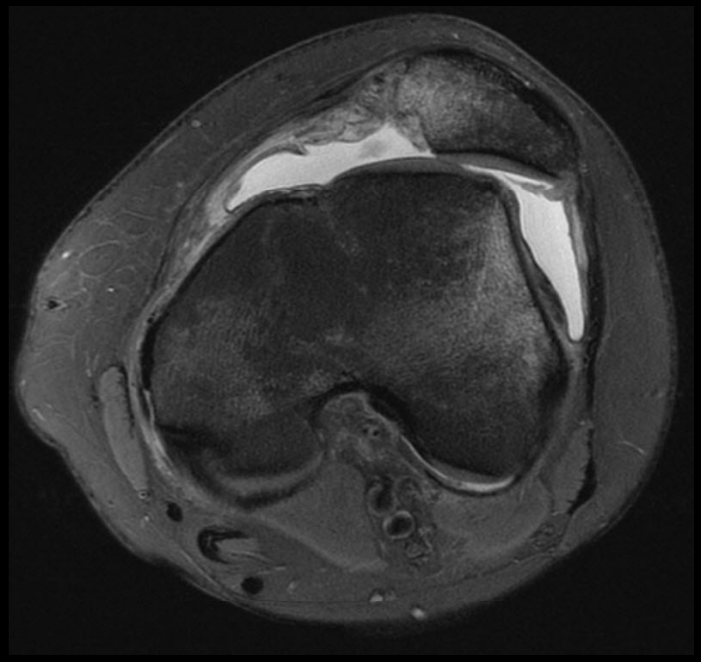

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