Blount, Anteversion and Torsion: What’s it all about?

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Disclosures

• Author for Amirsys/Elsevier, receiving royalties
Lower Extremity Alignment in Children

• Lower extremity rotation
  – Femoral version / tibial torsion
  – Normal values & clinical indications
  – Imaging

• Blount disease
  – Physiologic bowing
  – Blount disease
Lower Extremity Rotational Alignment

Primarily determined by:

1. Femoral version
2. Tibial torsion
3. Position of the foot

Rosenfeld SB. Approach to the child with in-toeing. Up-to-date. 2/2014
Lower Extremity Rotational Alignment

Primarily determined by:

1. Femoral version
2. Tibial torsion
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Rosenfeld SB. Approach to the child with in-toeing. Up-to-date. 2/2014
Femoral Version

The rotation of the femoral neck in relation to the long axis of the femur (posterior condylar axis of the distal femur)
Femoral Version

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Femoral Version
Femoral Version
Femoral Version
Femoral Version

Femoral Anteversion

Femoral Retroversion
Tibial Torsion

Rotation of the distal tibia in relation to the proximal tibia
Tibial Torsion

Rotation of the distal tibia in relation to the proximal tibia
Tibial Torsion

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Tibial Torsion
Tibial Torsion
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Tibial Torsion

External Tibial Torsion

Internal Tibial Torsion
Normal Values

• Femoral version (averages)
  – Birth –30 - 40° of anteversion
  – 16 years – 16 ° of anteversion
  – Adults – 8 – 14 ° of anteversion

• Tibial torsion (averages)
  – Birth – neutral to mild external tibial torsion
  – 4yrs – 28° external tibial torsion (range 20 - 37°)
  – Adult - 38° (18 - 47°) external tibial torsion
Clinical Indications for Assessing Lower Extremity Rotation

- In-toeing / Out-toeing
- Associated conditions
  - Cerebral palsy
  - Hemiplegia
- Post-traumatic rotational deformities
  - Normal variability between limbs in an individual
  - Femoral anteversion
    - Left and right differences as high as 15° in normal controls
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:

1. Femoral neck axis
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:

1. Femoral neck axis
2. Distal femoral axis
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:

1. Femoral neck axis
2. Distal femoral axis
3. Proximal tibial axis
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:

1. Femoral neck axis
2. Distal femoral axis
3. Proximal tibial axis
4. Distal tibial axis
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:

1. Femoral neck axis
2. Distal femoral axis
3. Proximal tibial axis
4. Distal tibial axis

CT – most commonly used imaging method
Imaging Lower Extremity Rotation

Rotational alignment of the lower extremity determined by defining four axes:

1. Femoral neck axis
2. Distal femoral axis
3. Proximal tibial axis
4. Distal tibial axis

CT – most commonly used imaging method

NO consensus on how to define these axes on CT or how to measure femoral version/ tibial torsion
16-year-old girl with in-toeing
Scout image from hips -> ankles
Scout image from hips -> ankles

3 Sets of 5 mm thick slices:
Scout image from hips -> ankles

3 Sets of 5 mm thick slices:
1. Femoral heads -> lesser trochanters
Scout image from hips -> ankles

3 Sets of 5 mm thick slices:

1. Femoral heads -> lesser trochanters

2. Femoral condyles -> proximal tibial epiphyses
Scout image from hips -> ankles

3 Sets of 5 mm thick slices:
1. Femoral heads -> lesser trochanters
2. Femoral condyles -> proximal tibial epiphyses
3. Distal tibial epiphyses
1. Place cursor at center of femoral head
1. Place cursor at center of femoral head

2. *Without moving cursor* scroll inferior to the level of the lesser trochanter
1. Place cursor at center of femoral head

2. *Without moving cursor* scroll inferior to the level of the lesser trochanter

3. Mark 2 points on this image:
   i. Center femoral head (obtained from upper image)
   ii. Center of femoral shaft on this image
1. Place cursor at center of femoral head

2. *Without moving cursor* scroll inferior to the level of the lesser trochanter

3. Mark 2 points on this image:
   i. Center femoral head (obtained from upper image)
   ii. Center of femoral shaft on this image

4. Line formed = femoral neck axis
1. Place cursor at center of femoral head

2. *Without moving cursor* scroll inferior to the level of the lesser trochanter

3. Mark 2 points on this image:
   i. Center femoral head (obtained from upper image)
   ii. Center of femoral shaft on this image

4. Line formed = femoral neck axis

5. Obtain femoral neck-horizontal (NH) angle
6. Posterior femoral condylar line
6. Obtain femoral condylar-horizontal (CH) angle
Femoral neck-horizontal (NH) angle is externally rotated 33°

Femoral condylar-horizontal (CH) angle is internally rotated +36°
Femoral neck-horizontal (NH) angle is externally rotated 33°

Femoral condylar-horizontal (CH) angle is internally rotated +36°

Femoral neck-Femoral condylar angle (NC) [NC = NH + CH] 69° Anteversion
Femoral neck-horizontal (NH) angle is externally rotated 33°

Femoral condylar-horizontal (CH) angle is internally rotated +36°

Femoral neck-Femoral condylar angle (NC) [NC = NH + CH] 69°  Anteversion

Average degree of femoral anteversion at 16 years = 16°
1. Proximal posterior tibial condyles
1. Proximal tibial-horizontal angle (PH)
1. Proximal tibial-horizontal angle (PH)

2. Distal bimalleolar line
1. Proximal tibial-horizontal angle (PH)

2. Distal tibial-horizontal angle (DH)
Distal tibial-horizontal angle (DH) is externally rotated 22°

Proximal tibia-horizontal angle (PH) is internally rotated + 12°
Distal tibial-horizontal angle (DH) is externally rotated 22°

Proximal tibia-horizontal angle (PH) is internally rotated +12°

Distal tibial-proximal tibial angle (DH + PH) 34°

External Torsion
Bilateral de-rotational osteotomies of bilateral femurs and tibias/fibulas

Improvement of gait disturbance and cosmetic concerns
NH = Neck
horizontal angle

NH-External
NH = Neck horizontal angle
CH = Condylar horizontal angle
NH = Neck horizontal angle
CH = Condylar horizontal angle
NC = Neck condylar angle

NH-External
CH-neutral
NH = NC
Anteversion
NH-External

NH = Neck horizontal angle

CH = Condylar horizontal angle

NC = Neck condylar angle

NH-External
CH-neutral
NH = NC
Anteversion
NH = Neck horizontal angle
CH = Condylar horizontal angle
NC = Neck condylar angle
NH-External
CH-External
NH-External
CH-neutral
NH = NC
Anteversion
NH-External
CH-Neutral
NH = NC
Anteversion

NH-External
CH-External
NH - CH = NC
Anteversion

NH = Neck horizontal angle
CH = Condylar horizontal angle
NC = Neck condylar angle
NH-External
CH-External
NH – CH = NC
Anteversion

NH-External
CH-neutral
NH = NC
Anteversion

NH External
CH-Internal
NH + CH = NC
Anteversion
More Accurate Measurements of Femoral Anteversion


Axial oblique CT to assess femoral anteversion.

Jarrett DY¹, Oliveira AM, Zou KH, Snyder BD, Kleinman PK.
More Accurate Measurements of Femoral Anteversion


Axial oblique CT to assess femoral anteversion.

Jarrett DY¹, Oliveira AM, Zou KH, Snyder BD, Kleinman PK.


Three-dimensional computed tomography for determination of femoral anteversion in a cerebral palsy model.

Riccio AL¹, Carney CD, Hammel LC, Stanley M, Cassidy J, Davids JR.
Physiologic Bowing and Blount Disease
Bowing / Genu varum

• Bowing of the lower extremities is a common referral to orthopedic clinics

• Differential diagnosis includes:
  – Developmental ‘Physiologic’ bowing
  – Blount disease
  – Physeal disturbance (e.g., trauma, infection)
  – Metabolic bone disease
  – Skeletal dysplasias
Bowing / Genu varum

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  – Skeletal dysplasias
Tibiofemoral angle

Angle between lines parallel to midshafts of the femurs & tibias on a standing AP radiograph
Tibiofemoral angle

Tibiofemoral angle

- 0-1 yr - 10-17° varus

Tibiofemoral angle

- 0-1 yr - 10-17° varus
- 1-2 yrs 0-10° varus

Tibiofemoral angle

- 0-1 yr - 10-17° varus
- 1-2 yrs 0-10° varus
- 2-3 yrs 0-10° valgus

Tibiofemoral angle

- 0-1 yr - 10-17° varus
- 1-2 yrs 0-10° varus
- 2-3 yrs 0-10° valgus
- 3-4 yrs 8-12° valgus

Tibiofemoral angle

- 0-1 yr - 10-17° varus
- 1-2 yrs 0-10° varus
- 2-3 yrs 0-10° valgus
- 3-4 yrs 8-12° valgus
- 4-13 yrs ~6° valgus

Physiologic bowing

1-year-old

3-year-old

13-year-old
Physiologic bowing

1-year-old
Varus

3-year-old

13-year-old
Physiologic bowing

1-year-old

Varus

3-year-old

Valgus

13-year-old
Physiologic bowing

1-year-old
Varus

3-year-old
Valgus

13-year-old
Mild Valgus
Exaggerated Physiologic Bowing

- Radiographs
Exaggerated Physiologic Bowing

• Radiographs
  – Varus angulation

23-month-old
Exaggerated Physiologic Bowing

- Radiographs
  - Varus angulation

20° varus

23-month-old
Exaggerated Physiologic Bowing

- Radiographs
  - Varus angulation

20° varus
1-2 years
nl = 0-10°
varus
23-month-old
Exaggerated Physiologic Bowing

- Radiographs
  - Varus angulation
  - Medial tibial metaphysis
    - Mild enlargement / depression
    - Mild beaking
    - No fragmentation

23-month-old
Exaggerated Physiologic Bowing

- Radiographs
  - Varus angulation
  - Medial tibial metaphysis
    - Mild enlargement / depression
    - Mild beaking
    - No fragmentation
Exaggerated Physiologic Bowing

• Radiographs
  – Varus angulation
  – Medial tibial metaphysis
    • Mild enlargement / depression
    • Mild beaking
    • No fragmentation
  – Mild thickening of the medial tibial cortex
Exaggerated Physiologic Bowing

- Radiographs
  - Varus angulation
  - Medial tibial metaphysis
    - Mild enlargement / depression
    - Mild beaking
    - No fragmentation
  - Mild thickening of the medial tibial cortex
  - Normal metaphyseal-diaphyseal angle
Metaphyseal Diaphyseal Angle

- MDA – the angle between:
Metaphyseal Diaphyseal Angle

• MDA – the angle between:
  – Line drawn along the proximal tibial metaphysis
Metaphyseal Diaphyseal Angle

• MDA – the angle between:
  – Line drawn along the proximal tibial metaphysis
  – Line perpendicular to the long axis of the tibia
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  - Line drawn along the proximal tibial metaphysis
  - Line perpendicular to the long axis of the tibia
Metaphyseal Diaphyseal Angle

- MDA – the angle between:
  - Line drawn along the proximal tibial metaphysis
  - Line perpendicular to the long axis of the tibia

- MDA values
  - Physiologic bowing
    - MDA typically ≤ 11°
  - Blount disease
    - MDA typically > 11°
  - Borderline 8-11°
Exaggerated Physiologic Bowing

Initial

7 months later
Blount Disease
Blount Disease

- Developmental disorder with disrupted endochondral ossification of the medial proximal tibial physis
  - Abnormal development of the proximal, medial tibial epiphysis/metaphysis
- Angular deformities:
  - Genu varum (mostly from tibia)
  - Procurvatum
  - Internal rotation of the tibia
- Limb shortening
  - LLD if asymmetric or unilateral
Blount Disease

- Risk factors:
  - Early ambulation
  - Obesity
  - African or Scandinavian descent
- Etiology: unknown (likely multifactorial)
  - Risk factors of early ambulation & obesity suggest biomechanical component
- Two forms:
  - Infantile or early onset (< 4 years)
  - Late onset >4 yrs
    - Juvenile > 4 yrs
    - Adolescent >10 yrs
Langenskiöld Classification of Early Onset Blount Disease

Radiographic findings
Radiographic findings
Standing AP radiograph
Radiographic findings

Standing AP radiograph

- Genu Varum
Radiographic findings

Standing AP radiograph

- Genu Varum

Tibiofemoral angles
~20°

1-2 years
nl = 0-10° varus

15-month-old
Radiographic findings

- Genu Varum (Standing AP radiograph)
- Increased metaphyseal-diaphyseal angle (MDA)
  - Physiologic bowing
    - MDA typically $\leq 11^\circ$
  - Blount disease
    - MDA typically $> 11^\circ$
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Radiographic findings

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Radiographic findings

• Genu Varum (Standing AP radiograph)
• Increased metaphyseal-diaphyseal angle (MDA)
• Widened medial tibial physis
Radiographic findings

- Genu Varum (Standing AP radiograph)
- Increased metaphyseal-diaphyseal angle (MDA)
- Widened medial tibial physis
- Medial tibial metaphysis
  - Depression
  - “Beaked”
  - Irregular / fragmented
Radiographic findings

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Radiographic findings

• Genu Varum (Standing AP radiograph)
• Increased metaphyseal-diaphyseal angle (MDA)
• Widened medial tibial physis
• Medial tibial metaphysis
  – Depression
  – “Beaked”
  – Irregular / fragmented
• Abnormal/delayed ossification of the medial tibial epiphysis
Radiographic findings

- Angular deformity:
  - Genu varum
  - Lateral subluxation of the tibia
  - Procurvatum
Radiographic findings

• Angular deformity:
  – Genu varum
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  – Procurvatum
Radiographic findings

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Radiographic findings

- Angular deformity:
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  - Lateral subluxation of the tibia
  - Procurvatum
    - Lateral radiograph
Radiographic findings

• Angular deformity:
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Radiographic findings

• Angular deformity:
  – Genu varum
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    • Lateral radiograph
MRI Findings
MRI Findings

Medial Proximal Tibia
MRI Findings

Medial Proximal Tibia

- Physis
  - Widening/downsloping
  - Physeal bar
MRI Findings

Medial Proximal Tibia

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  - Physeal bar
MRI Findings

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MRI Findings

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MRI Findings

Medial Proximal Tibia

- **Physis**
  - Widening/downsloping
  - Physeal bar

- **Metaphysis** – irregularity, downsloping, ↑ T2 SI
MRI Findings

Medial Proximal Tibia

- Physis
  - Widening/downsloping
  - Physeal bar
- Metaphysis – irregularity, downsloping, ↑ T2 SI
- Tibial epiphyseal cartilage
  - Far medial – thick
  - Central Mid-coronal – thin
    - Increased joint space
MRI Findings

Medial Proximal Tibia

- Physis
  - Widening/downsloping
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  - Physeal bar
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  - Central Mid-coronal – thin
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MRI Findings

Medial Proximal Tibia

- Physis
  - Widening/downsloping
  - Physeal bar
- Metaphysis – irregularity, downsloping, ↑ T2 SI
- Tibial epiphyseal cartilage
  - Far medial – thick
  - Central Mid-coronal – thin
    - Increased joint space
- Medial Meniscus
  - Thickened +/- abnormal signal
MRI Findings

Medial Proximal Tibia

- **Physis**
  - Widening/downsloping
  - Physeal bar
- **Metaphysis** – irregularity, downsloping, ↑ T2 SI
- **Tibial epiphyseal cartilage**
  - Far medial – thick
  - Central Mid-coronal – thin
    - Increased joint space
- **Medial Meniscus**
  - Thickened +/- abnormal signal
MRI Findings

Medial Proximal Tibia

- Physis
  - Widening/downsloping
  - Physeal bar
- Metaphysis – irregularity, downsloping, ↑ T2 SI
- Tibial epiphyseal cartilage
  - Far medial – thick
  - Central Mid-coronal – thin
    - Increased joint space
- Medial Meniscus
  - Thickened +/- abnormal signal
MRI Findings

Medial Proximal Tibia

- Physis
  - Widening/downsloping
  - Physeal bar
- Metaphysis – irregularity, downsloping, ↑ T2 SI
- Tibial epiphyseal cartilage
  - Far medial – thick
  - Central Mid-coronal – thin
    - Increased joint space
- Medial Meniscus
  - Thickened +/- abnormal signal
- Angular deformities
  - Medial and posterior downsloping
MRI Findings

Other findings:
MRI Findings

Other findings:

- Lateral proximal tibia
  - Physis - widened/irregular
  - Metaphysis
MRI Findings

Other findings:
• Lateral proximal tibia
  – Physis - widened/irregular
  – Metaphysis
MRI Findings

Other findings:
• Lateral proximal tibia
  – Physis
  – Metaphysis
MRI Findings

Other findings:

• Lateral proximal tibia
  – Physis
  – Metaphysis

• Femur
  – Epiphysis
  – Metaphysis
  – Physis

MRI Findings

Other findings:

- Lateral proximal tibia
  - Physis
  - Metaphysis
- Femur
  - Epiphysis
  - Metaphysis
  - Physis

MRI Findings

Other findings:

- Lateral proximal tibia
  - Physis
  - Metaphysis

- Femur
  - Epiphysis
  - Metaphysis
  - Physis

MRI Findings

Other findings:

- Lateral proximal tibia
  - Physis
  - Metaphysis
- Femur
  - Epiphysis
  - Metaphysis
  - Physis
MRI Findings

Other findings:

- Lateral proximal tibia
  - Physis
  - Metaphysis

- Femur
  - Epiphysis
  - Metaphysis
  - Physis

- Soft tissues
  - Perichondral membrane
    - Thickened
  - ACL - laxity

Treatment of Blount Disease
Treatment

• Conservative
  – Observation
  – Orthosis
Treatment

- Conservative
  - Observation
  - Orthosis

- Surgery
  - Lateral hemiepiphysodeis
  - Resection of a physeal bar
  - Realignment osteotomy
Treatment

• Conservative
  – Observation
  – Orthosis

• Surgery
  – Lateral hemiepiphysodeesis
  – Resection of a physeal bar
  – Realignment osteotomy
Treatment

• Conservative
  – Observation
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• Surgery
  – Lateral hemiepiphysseodesis
  – Resection of a physeal bar
  – Realignment osteotomy
Treatment

• Conservative
  – Observation
  – Orthosis

• Surgery
  – Lateral hemiepiphysodesis
  – Resection of a physeal bar
  – Realignment osteotomy
    • Conventional
    • Ex-fix with gradual correction
    • Medial tibial plateau elevation
Treatment

- Conservative
  - Observation
  - Orthosis
- Surgery
  - Lateral hemiepiphyseodesis
  - Resection of a physeal bar
  - **Realignment osteotomy**
    - Conventional
    - **Ex-fix with gradual correction**
    - Medial tibial plateau elevation
Treatment

- Conservative
  - Observation
  - Orthosis

- Surgery
  - Lateral hemiepiphysseodesis
  - Resection of a physeal bar
  - Realignment osteotomy
    - Conventional
    - Ex-fix with gradual correction
    - Medial tibial plateau elevation

Summary
Summary

• Femoral version
Summary

- Femoral version
- Tibial Torsion
Summary

• Femoral version

• Tibial Torsion

• Physiologic bowing
Summary

- Femoral version
- Tibial Torsion

- Physiologic bowing
- Blount disease
References