ROTATIONAL & ANGULAR VARIATIONS IN CHILDREN:
IN-TOEING, OUT-TOEING, BOWED LEGS, AND KNOCK-KNEES

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MSK Bootcamp
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• I do not intend to discuss an unapproved or investigative use of a commercial product or device in my presentation.
LEARNING OBJECTIVES

ROTATIONAL VARIATIONS ARE THE MOST COMMON REASON FOR REFERRAL TO PEDIATRIC ORTHOPAEDICS.

1. Be able to confidently reassure parents through education about physiologic in-toeing, out-toeing, genu varum (bowed legs), and genu valgum (knock-knees).

2. Recognize red flags: indications for radiographs, laboratory testing, and/or referral to a pediatric orthopedist or other pediatric specialist.
CASES

1. A 2 year-old boy with bowed legs, in-toeing, who is constantly tripping over his own feet.

2. An 18 month-old NICU grad with severe out-toeing.

3. A 10 year-old girl with knock-knees, flat feet, and knee pain who runs funny and would like to be excused from PE due to knee pain and bullying by her peers and her PE teacher.


5. An 11 year old girl with flat feet, and pain in both knees.
CASE #1

A 2 YEAR-OLD BOY WITH BOWED LEGS, IN-TOEING, AND CONSTANTLY TRIPPING OVER HIS OWN FEET.

Family noted bilateral leg bowing during infancy. The bowing seemed worse when he started walking at 16 months. His in-toeing is now so bad that he trips over his own feet and falls constantly. Earlier this week he fell and got a huge knot on his forehead and the parents rushed him to the ED. They are worried that he is going to hurt himself seriously and they are going to be accused of child abuse. Also, father wore braces because of in-toeing and the braces helped him.

1. Are you worried about 2 year olds and falling?
2. Are you worried about in-toeing in a 2 year old? What is the most likely cause?
3. Is bowed legs at age 2 normal? What else do you want to know?
4. What are the most important exam skills to focus on?
5. Likely to need referral? Not likely to need referral?
CASE #1

2 YEAR OLD: BOWED LEGS, IN-TOEING, AND TRIPPING

1st: Do you think the bowing of the legs is improving?
Do you think one side is worse than the other?
Does either knee ever appear to give out or bow out to the side with walking or running?
Was he born at term or premature? Breast or bottle fed? Does he drink milk and eat dairy foods?
What does his growth chart for height look like?
Is he obese?
Is there a family hx of bowed legs and was treatment required?
Is a referral warranted?

UVA ORTHOPAEDICS
# Differential: Bowed Legs

<table>
<thead>
<tr>
<th>Physiologic</th>
<th>Only improvement &gt;18 mos, symmetric. *See q3 mos.</th>
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</thead>
<tbody>
<tr>
<td>Infantile Blount Disease</td>
<td>Pronounced bowing, progression or failure to improve, sometimes asymmetric, obesity is a risk</td>
</tr>
<tr>
<td>Metabolic bone disease X-linked Hypophosphatemic rickets, nutritional rickets</td>
<td>Diet hx, Short stature or plateau in height, AP legs radiograph, CMP and 25 OH-Vit D level, referral to Endocrine &amp; Ortho</td>
</tr>
<tr>
<td>Skeletal Dysplasias Achondroplasia</td>
<td>Short stature &lt;5th percentile, dysmorphic features</td>
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<tr>
<td></td>
<td>Refer: Ortho, Genetics, NSGY...</td>
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CASE #1

A 2 YEAR-OLD BOY WITH BOWED LEGS, IN-TOEING, AND CONSTANTLY TRIPPING OVER HIS OWN FEET.

1. Are you worried about 2 year olds and falling?
2. Are you worried about in-toeing in a 2 year old? What is the most likely cause?
3. What are the possible causes and how will you explain them?
In-toeing: physiologic

**Age at presentation**
- Infant
- Toddler
- School age

**Likely diagnosis**
- Metatarsus adductus
- Internal tibial torsion
- Femoral anteversion (most common)
4-part rotational profile exam*

1. Foot shape

2. TFA = Thigh Foot Angle. Tibial torsion

3. IR/ER
   Internal and External rotation = Femoral version

4. FPA
   Foot Progression Angle
   Sum of the Parts

*record the data for follow up

Quick and powerful way to sort out & explain in-toeing
Thigh-Foot Angle [TFA]

Most are Neutral: by age 7
Not all “outgrow it” by age 2-3

Internal torsion gets better
External torsion can increase

Adult Normal = +5-30°
Exam: IR/ER hip

Prone on firm surface, hips extended pelvis level (use hand on sacrum)

Mild 70-80
Moderate 80-90
Severe 90

While prone:
*Note also if there is
-Internal torsion
-Metatarsus adductus

Remember that FPA is The Sum of the parts
Anatomy

Greater trochanter more posterior with increased anteversion

Greater trochanter in normal position

Greater trochanter
Why do they in-toe?

Intoeing is a natural adaptation provides a
Mechanical advantage during gait
-Lengthens the gluteal muscles
To stabilize the pelvis
**End Case #1**

**Age at presentation**
- Infant
- Toddler
- School age

**Likely diagnosis**
- Metatarsus adductus
- Internal tibial torsion
- Femoral anteversion (most common)

**Our Patient**

To refer, or not to refer...
CASE #1
2 YEAR OLD: BOWED LEGS, IN-TOEING, AND TRIPPING

Tripping and falling?
Normal. Reassure re: normal development and NAT

Bowed legs? Parents think it is improving
Still obvious at 2 but symmetric, improving
1. Measure and see back in 3 mos.  2. AP standing bilateral legs
Advantage of imaging: easily helps sort out the differential dx

In-toeing?
Internal tibial torsion and femoral anteversion are normal variants
Both will improve but it may take several years.

Referral?
Possibly for the bowing, esp. if parent very anxious. OR, schedule a follow up in 3 months for reassurance.
CASE #2

AN 18 MONTH-OLD NICU GRAD WITH SEVERE OUT-TOEING.

18 month-old male presents for his WCC. He has just started walking and his physical therapist is concerned about his degree of out-toeing and suggested that there might be a problem with the hips and bracing might be indicated. Born at 36 weeks, breech, LGA, IDM, transferred to NICU in the first 24 hours of life for respiratory distress, developed pulmonary HTN, treated with ECMO. Other complications include NEC, need for TPN, tracheostomy and G-tube placement, feeding difficulties. After many months, he was finally discharged and has made rapid developmental progress at home - walking, speaking a few words, eating, scheduled for trach and G-tube removal. They feel he is a miracle baby and now they have adjusted their developmental hopes and expectations, but they are worried that he may have hip problem that was missed or that his abnormal walking is a consequence of all that happened to him. They want to know if he will always be slew-footed.
CASE #2

AN 18 MONTH-OLD NICU GRAD WITH SEVERE OUT-TOEING.

During the history you observe him walking independently a few steps at a time - with short steps, a wide-based gait that appears symmetric, but his feet turn out to almost 180 degrees. You think, “It is a wonder he doesn’t fall on his face.”

1. Does he have gross motor delay?
2. Is the out-toeing concerning to you?
3. Would you get radiographs? What would you order?
4. Is this CP? Does he need a brain MRI?
5. Would bracing be helpful? What about special shoes?
6. Will this get better?
7. Is a referral indicated? If so, to which specialty?
CASE #2

THEY ARE WORRIED THAT HE MAY HAVE HIP PROBLEM THAT WAS MISSED OR THAT HIS ABNORMAL WALKING IS A CONSEQUENCE OF ALL THAT HAPPENED TO HIM. THEY WANT TO KNOW IF HE WILL ALWAYS BE SLEW-FOOTED...

Rotational profile:

**Hips IR/ER = 10/80+ bilateral**

TFA R/L = 0/0

Foot shape = straight, normal structure

FPA = variable +60-80 degrees external

All LE joints are supple with FROM, mild hypermobility

Neuro: good eye contact, follows simple commands, no spasticity in legs, down-going toes.

2. Is the out-toeing concerning to you?

3. Would you get radiographs? What would you order?

4. Is this CP? Does he need a brain MRI?

5. Would bracing be helpful? What about special shoes?

6. Will this get better? What is the diagnosis?

7. Is a referral indicated? If so, to which specialty?

**UVA ORTHOPAEDICS**

**EXTERNAL ROTATION CONTRACTURES OF THE HIPS - PHYSIOLOGIC**
CASE #3

A 10 YEAR-OLD GIRL WITH KNOCK-KNEES, FLAT FEET, AND KNEE PAIN WHO RUNS FUNNY AND WOULD LIKE TO BE EXCUSED FROM PE DUE TO KNEE PAIN AND BULLYING BY HER PEERS AND HER PE TEACHER.

Rotational profile:
Hip IR/ER = 85/10
TFA R/L = +45/+35
Foot- straight (but w/ Flexible pes planus)
FPA = near neutral walking
But looks awkward

Normal neurologic exam

Diagnosis?

Malicious Malalignment Syndrome
CASE #3

A 10 YEAR-OLD GIRL WITH KNOCK-KNEES, FLAT FEET, AND KNEE PAIN WHO RUNS FUNNY AND WOULD LIKE TO BE EXCUSED FROM PE DUE TO KNEE PAIN AND BULLYING BY HER PEERS AND HER PE TEACHER.

MALICIOUS MALALIGNMENT SYNDROME

**What can you offer to help with her pain?**
Refer to physical therapy – strength, neuromuscular control
Recommend good supportive shoes, possible cushioned OTC arch supports in shoes that need them for her flexible flat feet.

**What would you advise for PE?**
Needs to stay in PE ...
Write a doctor’s note allowing self-modification of running if there is knee pain.
Talk to principal / guidance counselor / PE teacher.

**Does she need an Orthopaedic referral?**
YES. (If you don’t offer, they will probably ask)
Some risk for patellofemoral arthritis, and the cosmetics are unacceptable to some
May be a candidate for surgery: rotational osteotomy (distal tibia, prox femur, both?)
Outcomes: improved cosmesis, decreased pain.

**UVA ORTHOPAEDICS**
Functional change is variable.
CASE #4

A 21-MONTH OBESE AFRICAN-AMERICAN GIRL WITH SEVERE BOWED LEGS AND FALLING.

Uncomplicated pregnancy and delivery, full-term, SVD. Bottle fed, grew well and gained weight rapidly. Height curve looks normal. Development has been normal. Walked at 10 months. Bowed legs noticed then and the bowing is getting worse. They think it might be more severe on the left. Recently they have noticed her left knee giving out to the side and sometimes this seems to make her fall. She does not complain of pain. Their pediatrician is concerned about her weight but everyone in their family is “big” so they feel her weight is normal. She is drinking a bottle of sweet tea.

What is the differential diagnosis?

Should you get an x ray? What kind?

Should you order any labs?

Is her weight a problem? Advice?

Should you refer to a specialist? What kind?

**Differentia l Diagnosis of Bowed Legs**

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<td>Blount disease</td>
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<td>Metabolic bone disease</td>
</tr>
<tr>
<td>Skeletal dysplasia</td>
</tr>
<tr>
<td>Neoplastic disease</td>
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Lateral thrust of knee Confirmed on exam
Observe gait in hallway
CASE #4- INFANTILE BLOUNT DISEASE

A 21-MONTH OBESE AFRICAN-AMERICAN GIRL WITH SEVERE BOWED LEGS AND FALLING.

Should you get an x ray? What kind?
Should you order any labs?
Is her weight a problem? Advice?
Should you refer to a specialist? What kind?

Bracing - KAFO
Under age 3 years
Stage 1 or 2 disease

Blount- Risk factors
Early walker
Dark skin
obesity
CASE #5
AN 11-YEAR OLD GIRL WITH FLAT FEET, AND PAIN IN BOTH KNEES.

Increasing frequency of complaints of knee pain over the past year. Now that it is summer and she is barefoot, her foster mom noticed she appears to have flat feet. They have tried some arch support shoe inserts but there has been no improvement in the knee pain. Not much of her history is known. They had also noticed she was knock-kneed but the patient remembers being told she would grow out of it.

Is this physiologic knock knee? What could cause this? What is on the differential? What else do you want to ask the patient? What would you do next? Does she need a referral?
CASE #5

AN 11-YEAR OLD GIRL WITH FLAT FEET, AND PAIN IN BOTH KNEES

What could cause this? What is on the differential?
What else do you want to ask the patient?
What would you do next?
Does she need a referral?

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<tr>
<td>Genu valgum past age 8 : &gt;9 cm (3.5”) intermalleolar</td>
</tr>
<tr>
<td>Metabolic bone disease</td>
</tr>
<tr>
<td>Post-traumatic</td>
</tr>
<tr>
<td>Skeletal dysplasias inc. MPS</td>
</tr>
<tr>
<td>Neoplastic- HMO, fibrocartilaginous dysplasia</td>
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Zone 1: no intervention
Zone 2: consider intervention, esp w/pain
Zone 3: surgery indicated
CASE #5

AN 11-YEAR OLD GIRL WITH FLAT FEET, AND PAIN IN BOTH KNEES.

Most flat feet are benign and painless. Think outside the feet...
SUMMARY

WHAT CAN YOU DO TODAY?

1. Use the rotational profile including gait assessment in the hallway, to help sort out and explain in-toeing and out-toeing.

2. Know/review normal physiologic development for LE rotation, genu varum and valgum.

3. Have a lower threshold for imaging (AP standing bilateral legs) bowed legs and knock knees that seem worse than usual.

4. Most of these patients have normal variants and it can be tempting to dismiss them too quickly- remember to ask, “What are you most worried about?” (and make sure you answer that ☺️)
Not Ducks:
- X-linked Hypophosphatemic Rickets
- CP
- Duchenne’s MD
- Post.fossa tumor
- Blount disease
- Skew foot
- CMT
- Leukemia (ALL)
- Hereditary Multiple Osteochondromas
- Multiple Epiphyseal Dysplasia (MED)
- SCFE
- Post-traumatic genu valgum (tibia physeal fx)
- Tethered cord