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Orthopedic Conditions in Pediatrics: A Primer for Physical Therapy Professionals

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Disclosure

- The content of this presentation is partly based on a book chapter co-authored by the speaker.

Tovin M, Fernandez-Fernandez A, Guardo F. *Chapter 7: The Pediatric and Adolescent Hip*. In: Cheatham SW, Kolber MJ (eds). *Orthopedic Management of the Hip and Pelvis*. (2016). St Louis, MO: Elsevier. ISBN 978-0-323-29438-6

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Learning Outcomes

- Explain developmental considerations of the musculoskeletal system in the pediatric patient
- Accurately identify the five components of a pediatric rotational profile, and explain the clinical relevance of each component.
- Describe presentation and management of diverse pediatric orthopedic conditions, such as developmental hip dysplasia, Legg-Calve-Perthes disease, and slipped capital femoral epiphysis.
- Accurately identify situations in pediatric orthopedics that would require referral to a physician

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Why care about orthopedics?

- My client population is not primarily orthopedic-related. Why do I care to learn about this?
 1. You probably address secondary orthopedic problems as part of your interventions, right? Think: cerebral palsy
 2. As the musculoskeletal system grows and develops, new orthopedic issues may arise in patients whose primary diagnosis may not be orthopedic-related
 - These problems may affect your patients' functional abilities and quality of life!
 3. A solid foundation of orthopedics is fundamental in order to address orthopedic problems, optimize patient outcomes, and perhaps refer patients who may require care out of our scope of practice.

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Musculoskeletal development

- The child's musculoskeletal system changes due to
 - Growth
 - Adaptation
 - Therapeutic intervention
 - Clinical condition
 - Environment and opportunity

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Some facts about growth and change in motor units

- Early motor units are innervated by more than one axon
 - Fetal movement
- Process of synaptic elimination completed several months post-term
 - Until unique axon for neuromuscular junction
 - Occurs also at CNS level

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Muscle-tendon unit development

- Infants born prematurely have different muscles than term babies
 - Fewer and smaller fibers
 - Higher interstitial fluid content
- Development continues in childhood
 - Muscles increase in length and cross-sectional area
 - Ability to repair – satellite cells

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Pathologies that affect developing muscles and tendons

- Malnourishment
- Cerebral palsy
- Genetic disorders, dystrophies and myopathies
- Possible effects: atrophy or hypertrophy, decreased cross-sectional area, changes in muscle thickness, sarcomere length, or proportion of fibers (type I vs II)

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Length adaptations

- Sarcomere length and number changes in response to prolonged shortening or lengthening of the muscle
 - Immobilization
 - Spasticity
 - Postural changes
 - Muscular imbalances
- Research: Changes occur more readily in young growing animals than adults
- Rationale for casting to increase ROM

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Example: Changes with CP

- Decreased cross-sectional area
- Decreased muscle thickness
- Changes in sarcomere length/number
- Higher proportion of type I fibers
- Fiber hypotrophy
- Greater variability in fiber size

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Food for thought

- How does spasticity affect the developing muscle?
- What do these changes mean for a child's ability to participate in their environment?
- Is there a way to prevent these changes? Can we promote more "typical" development by controlling spasticity?
- How can our treatment address fiber predominance?
- How do musculo-tendon changes affect the developing skeleton, and vv.?

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Skeletal development

- Basic structures of joints develop in the first few weeks of gestation
- BUT final shape determined during childhood: effect of movement and forces
 - Wolff's law
- Muscular imbalances and pathologies (primary or secondary) of the muscle-tendon unit affect joint development

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Example: hip joint development

- At birth, shallow acetabulum
 - Dislocation risk
- Remodeling forces mold the growing acetabulum until around 8 years of age
 - Femoral coverage adult-like at that age
 - Relationship hip stability / ambulation
- Atypical development of the hip:
 - Obesity, CP, spina bifida
- Evidence: intermittent weight-bearing with movement is most beneficial to hip joint modeling
- Evidence: WB improves bone density and temporarily reduces spasticity

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Skeletal adaptations

- Skeletal growth affected by:
 - Genetics
 - Nutrition
 - Growth spurts
 - Effect of mechanical forces
 - Asymmetrical forces = asymmetrical growth
 - Intermittent compression stimulates bone growth better than tensional forces
 - Excessive static load detrimental to bone development

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Example: angular changes at the knee during child development

- Repeated loading on curved bone wall tends to remodel bone in a “straightening” direction
- Newborn – genu varum (bow-legged)
- Decreases until alignment is neutral (around 1-2 years of age)
- Starts to show physiological genu valgum (2-4 years of age)
- Genu valgum decreases with age
- Final alignment depends on ethnicity, gender (commonly females valgum, males varum)
- Genu varum atypical in Caucasian children age 2-11, but may be physiological in other ethnicities

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Example: Child with CP and hip joint development

- Hip development in CP affected by:
 - ROM limitations
 - Delayed walking
 - Reduced loading affects acetabular depth development
 - Reduced loading affects natural history of hip anteversion
 - Muscle imbalances
 - Loss of hip abduction
 - Hip flexion contractures
 - These two factors add to hip instability

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Effects of intervention on the musculoskeletal system

- Use it or lose it
 - Strength training
- How we stretch matters
- Function, function, function
 - Doing it “right” or doing it “my way”?
- More is not always better

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Musculoskeletal Assessment

- History & observation
 - Birth history
 - Developmental milestones
 - Family history
 - Sleeping and seating positions
- Postural screen
 - Leg lengths – WB & NWB
 - Spine – include forward bend test
- ROM & muscle length tests
- Strength (MMT, dynamometry)
- Muscle tone
- Sensation

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Musculoskeletal Assessment cont

- LE alignment
 - Rotational profile:
 - Hip rotation
 - Thigh-foot angle
 - Transmalleolar axis/angle
 - Heel bisector line
 - Foot progression angle
- Developmental skill level
- Gait pattern
- And everything else you would do in a musculoskeletal assessment for other populations...What's a big thing we haven't mentioned?

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Some Topics in Pediatric Orthopedics

1. Developmental Dysplasia of the Hip
2. Torsional and Angular Conditions
3. Differential Diagnosis: Causes of Limping in Children
4. Other conditions: focus on clubfoot and flat foot

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1. Developmental dysplasia of the hip

- Dysplasia = abnormal development or growth
- Normal hip development requires:
 - Balance of muscle forces
 - Femoral head that is congruent, concentric and seated deep within the acetabulum
 - Acetabulum develops in response to a spherical femoral head (increased depth)
- High incidence of association with other congenital problems such as torticollis and metatarsus adductus

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Developmental Dysplasia of the Hip (DDH)

- Spectrum of hip disorders
 - Mildly dysplastic but stable, to severely dysplastic and dislocated
 - Pre-natal or postnatal atypical development of the hip causes an abnormal relationship between the femoral head and acetabulum, and can result in both subluxation and dislocation of the joint

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Etiology of DDH

- Multifactorial:
 - Malposition and mechanical factors in utero
 - Hormone-induced ligamentous laxity
 - Genetics
 - Cultural or environmental factors
 - Concurrent pathology

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Typical DDH in Infancy

- Most common abnormality in the neonate
 - \approx 1/20 full-term with some instability
 - 2-3/1,000 need Tx
- Several risk factors associated with DDH in otherwise healthy infants:
 - Pre and perinatal (Oligohydramnios, intrauterine position, breech, higher birth weight)
 - Genetics (parent, sibling)
 - Race (non-black)
 - Sex (female)
 - Maternal age (>35 y/o)
 - Postural deformities (torticollis, lower extremity deformities)
 - Clicking hips on clinical exam
- Female sex, positive family history, race and intrauterine position are the most critical risk factors

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CONTINUED[®] Early diagnosis & treatment

- Hip abduction positioning devices can improve long-term outcomes
- Screening begins immediately following birth
 - Identification of risk factors
 - Physical examination of the newborn
 - Clinical provocative tests
 - May also include static and dynamic ultrasound examination to detect skeletal abnormalities and instability of the hip joint
 - Advantages over CT and MRI
 - Minimal evidence
- Neonatal screening
 - Combination of clinical examination and selected ultrasonic examination
 - American Academy of Pediatrics (AAP) recommendations.

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American Academy of Pediatrics Guidelines for DDH Early Detection in Newborns

Risk Factor Stratification	Recommendation
All infants	Physical Examination by a properly trained healthcare provider (e.g., physician, pediatric nurse practitioner, physician assistant, or physical therapist)
Positive <u>Ortolani</u> or Barlow sign	Referral to Orthopedist
Female and breech delivery	Hip imaging <ul style="list-style-type: none"> a. ultrasound at 6 weeks of age OR b. radiographs at 4 months of age
Males born in the breech position	Hip imaging is optional
Females with a positive family history of DDH	Hip imaging is optional

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- Physical examination
 - Check for conditions associated with DDH
 - (e.g. torticollis)
 - Observe B LE's in supine without diaper
 - Femoral shortening (Galeazzi sign)
 - Skinfold asymmetry
 - Limited hip abduction
 - There is a higher incidence L hip DDH (60%) than R (20%), or B(20%).
 - Ortolani and Barlow tests- performed on each hip separately (up to age 3 months)

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- Physical and sonographic screenings may result in false positives.
- Unless examination reveals actual dislocation, the infant can be observed for 3-6 weeks before treatment is initiated.
- DDH may go undiagnosed until the child is 18 months or older.
 - Physical assessment after age 9 months
 - Restricted abduction
 - Leg length discrepancy
 - Trendelenburg limp
 - What would you see if bilateral?

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Prevention and Treatment during Infancy

- Parent education: proper positioning and carrying, swaddling

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- Early treatment during infancy
 - Abduction positioning device
 - Pavlik harness
 - Gold standard for infants <6 mos
 - 80.2% to 100% success rate
 - If unsuccessful, alternative treatment is generally closed reduction under anesthesia with spica casting
 - Treatment of choice for children > 6 mos
 - If unsuccessful → open reduction

Images of Pavlik harnesses:
<https://goo.gl/PkPgAU>

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Childhood and adolescent DDH

- Infants with DDH are routinely monitored for residual dysplasia into adolescence
- May not show signs and symptoms of DDH until adolescence.
- Adolescent DDH is distinct from infantile DDH
 - Males>females, bilateral, family history of total hip arthroplasty before age 65
 - Often not detected until symptoms develop

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- Most common symptom: insidious onset of hip pain.
 - Medical and family history can identify factors associated with DDH and rule out other causes of hip instability.
 - Differential diagnosis: provocative tests
 - Impingement test
 - Apprehension test
 - Bicycle test
 - Confirmation positive findings through imaging
 - MRI is preferable to radiographs or CT

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Treatment

- Untreated → Early degenerative hip arthritis
- Moderate or severe hip dysplasia in adolescents or young adults
 - Surgical to restore joint stability and mechanics and delay onset of osteoarthritis.
 - Several surgical osteotomy approaches
- Severe arthritis and cartilage damage
 - Nonsteroidal anti-inflammatory medication and physical therapy until total hip replacement is necessary
- Post-surgical Rehabilitation

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Neuromuscular Hip Dysplasia

- Occurs in the presence of neuromuscular disorders
- Diagnosis and management differs from that of typical DDH
- Muscular imbalances, abnormal muscle tone, impaired motor control → bony deformity, instability and contractures
 - Posterolateral, and even global, acetabular deficiency
 - In contrast to anterosuperior acetabular deficiency seen in typical DDH.
- Assessment and surveillance
- Prevention, conservative, Surgical

Surgical Management

- Tenotomy
- Osteotomies (pelvic and femoral)
 - Address the acetabular deficiency
 - Optimize coverage of the femoral head
- Femoral derotation
- Arthrodesis
- Arthroplasty

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Conservative Management

- Physical Therapy
 - May delay or prevent the need for surgery
 - Address and maintain proper hip position
 - Identify flexibility and strength imbalances
 - Stretching (effectiveness questionable)
 - Standing programs
 - Positioning and orthoses

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- Standing in Abduction Programs → EBP
 - Macias-Merlo (2015); Macias Merlo (2016), Martinsson (2011), Hagglund (2016)
- Lying and sitting abduction
 - Hankinson (2002); Pountney (2002); Picciolini (2016)
- Alignment during weight bearing and gait
 - Walking- beneficial in hip development in children with cerebral palsy

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- Positioning devices and orthoses
 - SWASH (<https://goo.gl/CbsTTe>)
 - Car seats with swing away abductors (<https://goo.gl/yzjxuJ>)
 - Hip spica chairs (<https://goo.gl/tdXqEh>)
 - Gazelle stander (<https://goo.gl/G9xk7N>) .

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- http://www.childdevelopment.ca/libraries/hip_health/sunnyhill_clinical_tool_hip_health_full_final.sflb.as_hx
 - Tool for positioning in prevention and management of hip displacement/dislocation in children with CP- available for download

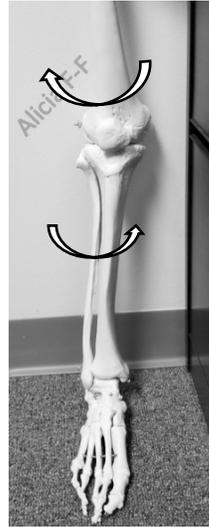
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Long-term effects of DDH

- Unresolved DDH
 - Degenerative arthritis
 - Gait impairments
 - Hip pain
 - Poor candidates for hip arthroplasty
 - High failure rates

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2. Torsional and angular deformities



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Torsional deformities

- Internal tibial torsion
- External tibial torsion
- Internal femoral torsion
 - Etiology of excessive internal femoral torsion is controversial:
 - Congenital risk factors which result in persistent infantile femoral anteversion?
 - Acquired by positional influence (eg abnormal sitting habits)?
- External femoral torsion



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Rotational deformities

- Clinical: in-toeing or out-toeing (less common) gait
- Assessment: measure **rotational profile**
 1. Hip rotation (to assess femoral torsion)
 2. Thigh-foot angle (to assess tibial torsion)
 3. Transmalleolar angle (alternative way to assess tibial torsion)
 4. Heel bisector line (to assess foot deviations)
 5. Foot progression angle (combined assessment of all LE deviations)

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Natural history

Femoral anteversion progression with age

Decreasing from about 40 degrees to about 12 degrees femoral anteversion

Tibial torsion progression with age

Increasing from about -5 or 0 degrees to about 15 degrees external tibial torsion

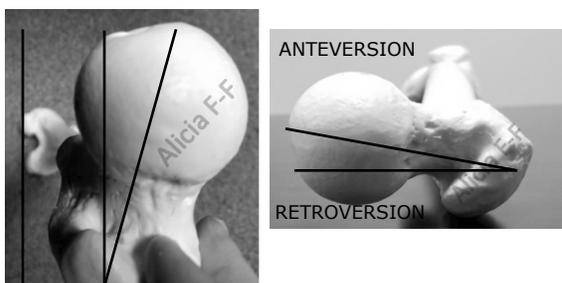
Infants & young children have greater femoral anteversion (=internal or medial femoral shaft torsion) & more internal tibial torsion, so in-toeing is common as children learn to walk

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Hip rotation – an indicator of femoral anteversion

- IR + ER = approx. 100-110 degrees, more in infants
- ER > IR in infants (tightness of soft tissues from intrauterine positioning), but in older children IR similar to ER
- Increased internal rotation compared to the norm is indicative of excessive femoral anteversion.
- NOTE: the terms anteversion and internal/medial femoral torsion are often used interchangeably in the clinic (BUT torsion and version are different concepts...)



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Trochanteric prominence angle test (TPAT or Craig's)



- The examiner rotates the femur internally, moving the greater trochanter anteriorly until it protrudes laterally to the largest extent palpable. In this position, the goniometric measurement of hip internal rotation reflects the degree of femoral anteversion.

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Hip rotation tests and norms

https://www.researchgate.net/publication/259240990_Normal_Variants_of_the_Lower_Limbs_in_Pediatric_Orthopedics/figures?lo=1

This figure, uploaded by the article author, describes norms for IR hip, ER hip, thigh-foot angle, transmalleolar axis/angle, and foot progression angle (AKA Staheli's rotational profile)



Eagle eye! Spot something you would want to correct or further investigate in these 2 pictures.

Also, in order to actually take that measurement, what's important to consider about pelvic position?

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Thigh-foot angle

This angle measures the rotation of the tibia and hindfoot in relation to the longitudinal axis of the thigh and indicates the **amount of tibial torsion** present. By convention, external rotation values +, and internal rotation values -.

Progression of negative angle to positive angle in childhood (progression of internal to external torsion, i.e., medial to lateral)

- Newborns 4° internal, vs adults 23° external tibial torsion average



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Another way to measure tibial torsion: Transmalleolar angle

- Angle between midline of the thigh and the line perpendicular to the axis joining the lateral and medial malleolus (AKA transmalleolar axis).
- Best way to determine tibial rotation when there is foot deformity (versus thigh-foot angle)
- Can also measure angle between line through the malleoli and line through femoral condyles (less practical)



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continued Heel bisector line



- Line drawn through the midline axis of the hindfoot and the forefoot.
- Helpful in evaluating forefoot adduction and abduction.
- In a neutral foot, the heel-bisector line passes through the second web space.

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Foot progression angle

- Angle of the foot relative to an imaginary straight line in the patient's path.
- "Summation" of rotational alignments
- In-toeing = negative angle
- Out-toeing = positive angle

-5° to 20° can be normal; depends on age

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I completed a rotational profile. Now what?

- Determine whether presentation is consistent with age
 - Remember natural progression!
 - Also gives hint of major source:
 - Infant: typically metatarsus adductus
 - Toddler: typically internal tibial torsion
 - Child: typically femoral anteversion
- Determine which component(s) of the LE is causing the torsional condition and intervene at that level
 - Where is the problem based on the measurements?
- Don't just think of the numbers.
 - Look at performance during functional activities
 - Combine functional info with number info
 - Consider other existing diagnoses

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- In children with spasticity, muscle forces are an important contributing factor
 - Example: Child with CP with foot progression angle of -40 degrees
 - Femoral anteversion?
 - Internal tibial torsion?
 - Metatarsus adductus?
 - Spasticity of hip adductors, medial hamstrings, post. tibialis?

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Rotational Deformities

- Interventions
 - When cosmetically unappealing and deformity interferes with function
- Treatment
 - Exercises, bracing, shoe modifications, taping
 - Orthotics: Denis Browne bar, frame orthoses
 - Inconsistent effectiveness; secondary knee stress
 - Orthopedic surgery
 - Femoral or tibial osteotomy
 - Only if severe and affects function!!

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Management of Excessive Femoral Anteversion

- Braces, twister cables, shoes
 - Ineffective
- Encourage tailor seating in max ER
- At age 10-14 years, with cosmetically unappealing in-toeing
 - Femoral derotation osteotomy
 - Is it worth it? Probably only if associated with patellofemoral pathology

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Management of excessive internal tibial torsion

- Should it be treated? Controversial
 - Could predispose to complications at the knee, BUT
 - Gradually improves (natural history)
- Some recommend orthotics after 18 months of age (Dennis-Browne Bar)
- After age 8, external rotational osteotomy of tibia and fibula
 - Significant or functional deformity
 - TFA > 3 standard deviations beyond mean

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Congenital Metatarsus Adductus

- Adducted forefoot as per heel bisector line
- Etiology: intrauterine positioning or congenital abnormality
- Mild – spontaneous correction by 4-6 months, taping
- Moderate – stretching exercises, tickle to strengthen, corrective shoes (straight-lace or reverse-lace shoes), align in non-weight & weight bearing positions, taping
- Moderate to severe, age > 4 years – manipulation & serial casting above knee to control tibial rotation, corrective shoes

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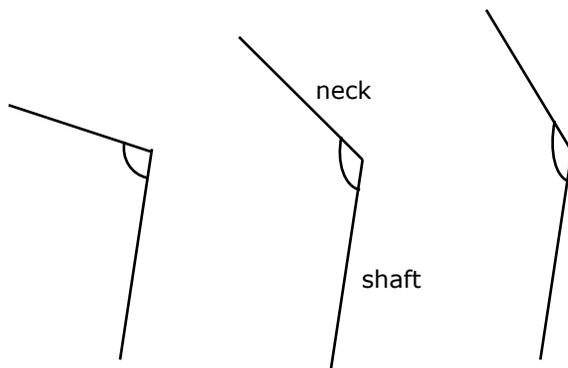
2.2 Angular deformities

- Coxa valga/vara
- Genu varum/valgum

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Coxa vara/valga



Coxa vara – overcoverage

Normal

Coxa valga – instability

Treatment: in severe cases, osteotomy

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Deformities commonly associated with coxa vara/ valga

- Coxa Vara: hip adduction; genu valgum; pronated foot
 - Coxa Valga: hip abduction; genu varum; supinated foot
- (note: these deformities may not occur concurrently)

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Genu varum

- Normal in infants
- Diff. diagnosis:
 - Systemic disorders (OI, achondroplasia, etc)
 - Idiopathic tibia vara (Blount's disease)
- Treat only if persisting beyond age 2 and is worsening
 - HKAFOs or KAFOs with locked knee joint
 - Surgical correction rare

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Differential diagnosis: Tibia Vara (Blount's Disease)

- Growth disorder of medial proximal tibia (epiphysis, epiphyseal plate, metaphysis) in infants, children & adolescents
- Unilateral or bilateral
- Etiology:
 - asymmetric excessive compression & shear forces across proximal tibial growth plate (infants)
 - infection/trauma of proximal medial tibial growth plate (older children)

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Tibia vara

- Radiographic findings: medial epiphysis break & varus angulation
- Clinical:
 - bow-legged stance; obese toddlers who are early walkers, lateral thrust of knee during stance; increases in severity
 - Distinguish from normal physiologic genu varum that decreases by 2.5 to 3 years of age (vs. tibia vara which increases)

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Management for Tibia Vara

- R/O skeletal dysplasias, rickets or vitamin D deficiency, fracture proximal medial tibial growth plate
- Intervention (orthosis or surgery) depends on age & stage of disease
- Treatment:
 - Ages 2-3: Progressive valgus correcting KAFO or HKAFO 23 hours/day
 - Donning/doffing orthosis, wearing schedule, skin inspection, gait training w/without assistive device
 - Ages 4-5: Surgery
 - Tibial osteotomy
 - After 5 years old:
 - Tibial osteotomy & lateral epiphysiodesis or removal of medial bony bridge

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Genu valgum

- Physiological genu valgum is present between ages 2-4; then decreases as child ages.
- Persistent genu valgum typically associated with
 - Obesity
 - Out-toeing foot progression angle
 - Flat feet
- May result in knee pain, patellofemoral instability and difficulty running in teenage years
- If severe:
 - Osteotomy
 - Stapling of the medial femoral growth plate

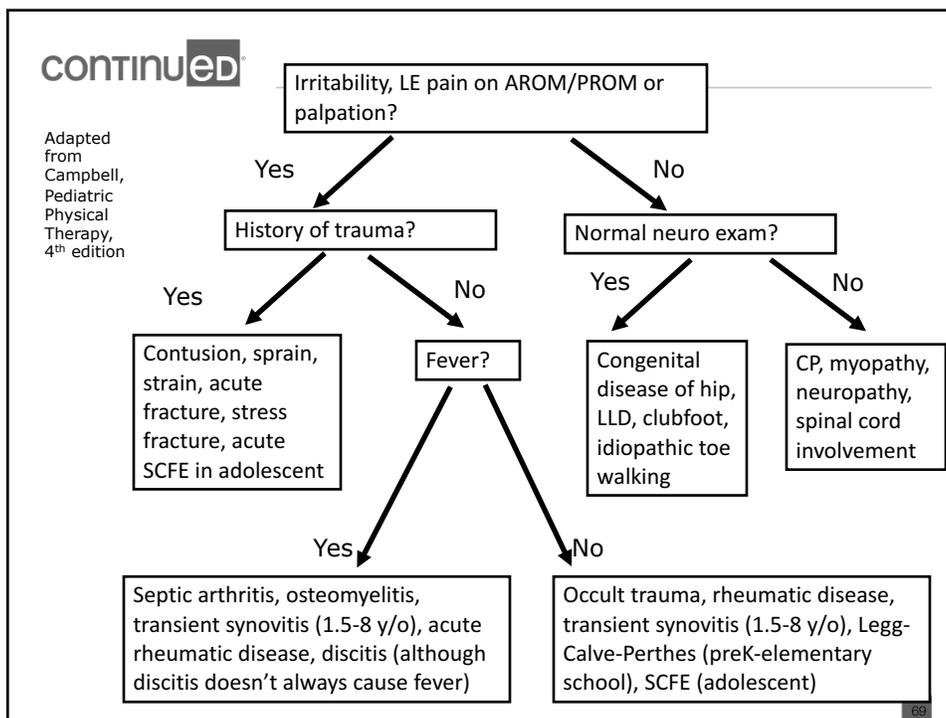
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3. Limping in children

- Assessment:
 - History
 - Falls
 - Systemic signs and symptoms
 - Gait analysis
 - Assessment of spine and LEs (bilateral)
 - ROM, strength, integumentary, sensation
 - Observation during functional activities
- Age can give important hints as to possible causes

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continued

Limping in children: 0-5 years

- Possible causes:
 - Osteomyelitis (bone infection)
 - Septic arthritis (joint infection)
 - Transient synovitis
 - Occult fractures
 - Kohler syndrome
 - Other causes

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Limping in children: 0-5 years

- Osteomyelitis (bone infection)
 - Sudden onset, localized bone tenderness, swelling, pain over the metaphysis, high fever, chills
 - Requires immediate referral! Could be fatal if left untreated! Antibiotic treatment
- Septic arthritis (joint infection)
 - Acute onset of irritability, high fever, anorexia, painful passive ROM, joint swelling signs
 - Requires immediate referral! Joint can be destroyed in 48 hours! Antibiotic treatment

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Limping in children: 0-5 years

- Transient synovitis
 - Acute onset, may seem similar to septic arthritis
 - Clues: typically in hip, often after upper respiratory infection
 - Needs to be referred for differential diagnosis
 - Treatment: limitation of activity, typically resolves in 7 days but may recur.

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Limping in children: 0-5 years

- Occult fractures
 - Common in tibia, femur and fibula
 - No signs of infection
 - Refuses to walk, or walks with limp
- Kohler syndrome
 - Osteochondrosis of the navicular bone
 - Due to temporary loss of blood supply
 - Localized pain at navicular, limp
 - Self-resolves

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Limping in children: 0-5 years

- Other causes
 - Juvenile rheumatoid arthritis
 - Non-accidental trauma
 - Be aware of your state requirements for child abuse reporting
 - Hemophilia
 - Bone tumors
 - Etc

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Limping in children: 5-10 years

- Legg-Calve-Perthes disease (LCPD)
- Discoid lateral meniscus
- Sever disease
- “Growing pains”

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Legg-Calvé- Perthes Disease (LCPD)

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Legg-Calvé-Perthes Disease

- Idiopathic osteonecrosis of capital femoral epiphysis
 - Can lead to permanent deformity.
- Incidence (US): 4-15.6/100,000 children.
- Bilateral presentation ~ 10-20%
- Age-related risk
 - Ages 2-14, average Dx at 5-7 y/o
 - Younger patients (<6 y/o): better prognosis, fewer long-term complications
 - Patients >15 y/o: adolescent AVN of femoral head.
- Gender and ethnicity-related risk:
 - More frequent in Caucasian males (5 males:1 female)

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Mechanisms

- Interruption of flow to femoral head epiphysis
 - Superior and inf. retinacular arteries
- Etiology not always known
- Contributing factors:

<ul style="list-style-type: none"> ▪ Repetitive mechanical trauma ▪ Hx of synovitis/increased intracapsular pressure ▪ Coagulopathies or disorders with increased blood viscosity (sickle cell) ▪ Congenital vascular deformities 	<ul style="list-style-type: none"> ▪ Hx of low birth weight ▪ Steroid use ▪ Leukemia ▪ Graft-versus-host disease ▪ Stickler syndrome ▪ Other hip disorders: dysplasia, slipped capital femoral epiphysis, etc ▪ Etc?
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- Marked growth spurts

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Patient profile and differential diagnosis

*Elementary school age
* Hip, groin, thigh or knee pain

*Hip contracture: flex/add
*May have obligatory ER in hip flexion (Drehmann sign)
*Decreased ROM: hip ext/abd/IR.

LCPD

*Antalgic gait, + Trendelenburg
*Muscle spasms: iliopsoas, hip adductors

*Differential dx: fractures, SCFE, septic arthritis, osteomyelitis, ischial bursitis, muscle strain, etc.

- Refer to orthopedic specialist. Early Dx crucial!
- Even with successful treatment, > risk of hip osteoarthritis as adults.

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Disease process

Blood flow interruption

- Symptoms may not appear for months!

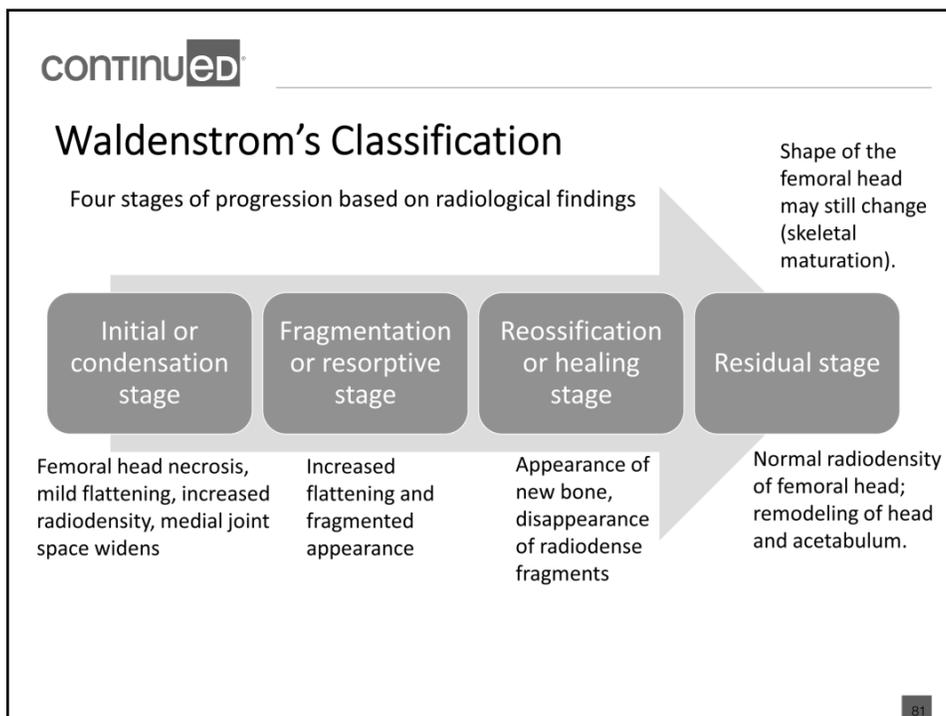
Osteonecrosis

- Reduced load-bearing ability
- Subchondral fractures and deformation of femoral head

Self-limiting process

- Revascularization and reabsorption of necrotic bone
- Repair contributes to further deformity!
- Bone formation/resorption imbalance

CONTINUED



Diagnosis and prognostic factors

- Dx: Based on clinical presentation and medical tests
 - Radiography/imaging, ultrasound, blood tests.
- Long-term outcomes:
 - Determined by remodeling of femoral head and acetabulum
 - Remodeling process may take up to 5 years
 - Also affected by skeletal maturation
- But decision needs to be made early... Prognostic classification systems
 - Salter-Thompson classification
 - Crescent sign (subchondral fracture). Classified as group A (<50% involvement, best suited for non-invasive treatment) or group B (>50%)
 - Catterall classification
 - Lateral pillar classification

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Lateral pillar classification:
group A (no loss of height),
B (<50% height loss),
or C (>50% height loss)

Catterall classification:
Groups I through IV =
up to 25%, 50%,
75%, and complete
head involvement.

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Management considerations

- Watchful waiting or direct intervention?
 - Risk factors for poor outcome: age ≥ 6 y/o at Dx, high degree of femoral head necrosis, lateral pillar height < 50%, femoral head coverage <80%
 - Strong prognostic factors: Lateral pillar classification (odds ratio, 3.6) and hip abduction range (odds ratio, 4.0)
- Approaches:
 - Treat EARLY
 - Key approaches: ROM, WB restrictions, and containment or distraction.
 - Appropriate ROM (PT, short-term traction, or casting) is prerequisite for successful containment.
 - Novel approaches:
 - Core decompression, trans-head-neck tunneling (THNT) or transphyseal neck-head drilling
 - Pharmaceutical and biological interventions: combos of bone morphogenetic proteins and bisphosphonates; sclerostin antibody; Tumor necrosis factor alpha.

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Containment

- Goal: maintain appropriate contact/load distribution, reduce stresses
- Places femur in abd/ IR or abd and flexion: orthoses or surgery
 - Surgery – clearly superior in children > 8 y/o
 - Varus osteotomies, pelvic osteotomies, etc.
 - May need extensive reconstruction and soft tissue release.
- PT important adjuvant to both orthotic and surgical containment.
 - *Pre-intervention period*: focus on ROM – iliopsoas, adductor contractures.
 - *Post-containment period*: progressive gait training/WB activities, pain reduction, ROM, strengthening (gluteus medius, hip stabilizers, core), functional training.
 - Good resource with detailed guidelines (US Dept of Health and Human Services, Cincinnati Children's Hospital Medical Center):
<https://www.guideline.gov/summaries/summary/39444/evidencebased-care-guideline-for-postoperative-management-of-leggcalveperthes-disease-in-children-aged-3-to-12-years>

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Distraction

- If surgery not possible due to restricted ROM
- Evidence shows increased range of motion (93%), reduced pain (86%)
- After insertion of external fixator:
 - Partial WB day 2
 - Distraction starts day 3, rate 1 mm/day
- PT during distraction process (daily)
 - Key to maintaining mobility and supporting tissue lengthening
- Complications: pin infections, breakage, or subluxation

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Limping in children: 5-10 years

- Discoid lateral meniscus
 - Abnormally-shaped meniscus
 - Presentation:
 - Snapping knee joint
 - Pain
 - Clicking or locking
 - Can have atrophied quadriceps
 - Can have effusion
 - Many children do not require treatment, however, should be referred in case surgery is indicated

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Limping in children: 5-10 years

- Sever disease
 - Calcaneal apophysitis
 - Typically due to mechanical overuse
 - Avulsion of cartilage at Achilles insertion
 - Generally 7-10 years of age, but could occur later
 - Main complaint: heel pain, esp. after activity; development of a limp; tenderness of the calcaneus; reproduction of pain with PF in standing
 - Conservative treatment: rest, ice, reduced activity, Achilles stretching, heel cups

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Limping in children: 5-10 years

- “Growing pains”
 - Episodic musculoskeletal pain
 - Pain is non-articular
 - Pain appears late in the day
 - Pain duration: minutes-hours
 - No signs of inflammation
 - Possibly related to rapid growth and joint hypermobility
 - Massage, NSAIDs, muscle stretching
 - Should still recommend that parents discuss with pediatrician to r/o other causes

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Limping in children: 10-15 years

- Slipped capital femoral epiphysis
- Osgood-Schlatter syndrome
- Osteochondritis dissecans
- Other causes

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Slipped Capital Femoral Epiphysis (SCFE)

Slipped capital femoral epiphysis

- Separation or slippage of femoral head from neck
 - Loss of integrity at growth plate
- Incidence: 10.8 cases/100,000
 - Most common hip disorder in adolescents.
- Age-related risk
 - Growth spurts, 10-15 y/o
 - Mean 12.0 boys, 11.2 girls.
- Gender-related risk
 - Males double than females
- Ethnicity-related risk
 - Higher in Asians, Pacific Islanders, and African Americans.

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Mechanisms

- Localized weakness or excessive stress
 - Eventually: plate instability and slippage.
- Left hip > right hip; bilateral as high as 50-60%.
- Contributing factors:
 - Obesity
 - Hormones
 - Torsional or misalignment issues at hip
 - Trauma
 - Radio/chemotherapy

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CONTINUED

Patient profile and differential diagnosis

- Obese adolescent male
- Intermittent hip or knee pain
- Limping or avoidance of weight bearing
- Hip in ER, obligatory ER in hip flexion (Drehmann sign)
- Decreased ROM of hip IR ROM
- Differential diagnosis: fractures, AVN in older adolescents, Legg-Calve-Perthes Disease in younger children, osteomyelitis, septic arthritis, ischial bursitis, muscle strain, etc
- Refer to orthopedic specialist. Early Dx crucial!
Damage is cumulative and irreversible

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Clinical and radiological classification schemes for SCFE

Classification scheme	Source	Levels	Prognostic value
Stability	Clinical	Stable (can bear weight), unstable	Yes, unstable classification associated with osteonecrosis
Timeline	Clinical	Acute (<3 weeks), chronic, acute-on-chronic	No association with prognostic factors
Amount of epiphyseal displacement	Radiological	Grade I (mild, <1/3), Grade II (moderate) or Grade III (severe, >1/2)	Yes, grade I displacements associated with improved prognosis and fewer complications
Angle between epiphysis and shaft (Southwick angle)	Radiological	Mild (<30°), moderate, or severe (>50°)	Yes, mild displacements associated with improved prognosis and fewer complications

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Line of Klein should intersect the lateral part of the superior femoral epiphysis. If not, called Trethowan sign, indicates a slip

Southwick angle:
 A= mild (<30°),
 B = moderate (30-50°), and
 C = severe (>50°)

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Management considerations

- Conservative approaches
 - Traction, rest, casting, orthoses?
 - Little evidence
- Surgical approaches
 - Preferred, asap
 - Goals: stabilize epiphysis, prevent further slippage, avoid complications
 - Simplest approach: screw fixation or pinning
 - Revision surgeries
 - Prophylactic fixation of asymptomatic femur?
 - Complex cases: osteotomies, arthroplasty
 - Emerging techniques:
 - Computer-assisted fixation, arthroscopic-assisted osteoplasty

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Rehab considerations: post-surgery

- Progressive gait training
- Pain reduction
- Weight-bearing activities
- Core and lower extremity strengthening
- Range of motion
- Proprioception
- Endurance training
- Return to functional activities

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CONTINUED **Key focus areas**

- Progressive, balanced hip, knee, ankle ROM and strengthening
 - Hip ROM: emphasize hip flexion, internal rotation, abduction
- Trunk and core strengthening
- Gait training
 - Within precautions; avoid improper alignment
- Functional training – focus on function and participation
- Final period:
 - Advanced coordination, balance, and agility training
 - Address overall conditioning - >50% of children with SCFE exceed 95th percentile for weight!

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How fast can we progress the patient s/p surgery?

- Cautious! Allow for healing
- Avoid aggressive range of motion and strengthening initially
 - Depends on: pt tolerance, severity of the injury and surgical procedure
- Appropriate level of activity/ weight-bearing is controversial
 - May depend on slip severity
 - Mild stable SCFE – 17% no WB restriction
 - Most common guideline: toe-touch WB with crutches for 6-8 wks, may return to full WB around 8-10 wks post-op (x-ray proof of healing)

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Limping in children: 10-15 years

- Osgood-Schlatter syndrome
 - Activity-related pain and swelling at patellar tendon insertion
 - Etiology? Trauma, local chondral alterations, mechanical overpull by knee extensors
 - May be acute, or develop over months
 - Treatment: ice, rest, reduce activity, avoid squatting and jumping. Self-resolves
 - Some cases may need bracing

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Limping in children: 10-15 years

- Osteochondritis dissecans
 - Separation of subchondral bone from articular surface
 - Common in femoral condyles, talus, humerus
 - Typically in children active in sports
 - Primary complaint is joint pain, may have locking if there is complete detachment
 - Antalgic gait
 - Yoshida et al – 81% resolved with rest from sports activities

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CONTINUED

Limping in children: 10-15 years

- Other causes:
 - Tarsal coalition
 - Fusion of tarsal bones
 - Subtalar ROM limitation, rigid flat foot
 - Freiberg disease
 - Avascular necrosis of metatarsal head
 - Forefoot pain, localized swelling in MTP joint
 - Typically in adolescent girls who train as runners

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CONTINUED

Limping in children: 10-15 years

- Other causes:
 - Accessory navicular
 - Presentation: planovalgus foot
 - Patellofemoral problems
 - Monoarticular inflammatory arthritis
 - Neoplasms
 - Limp, pain, constitutional symptoms, pathological fracture

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CONTINUED

4. Other orthopedic conditions

- Clubfoot
- Flat foot

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4.1. Congenital Clubfoot: Talipes Equinovarus

- Ankle PF, hindfoot varus, forefoot adduction
- Etiology: intrauterine positioning, primary neuromuscular impairment (myelomeningocele, arthrogryposis), genetics
- Goal: restore alignment to provide mobile foot for normal function & weight bearing

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Options for Management of Clubfoot

- Splinting, manipulation & serial casting to achieve plantigrade foot, rigid taping to maintain
- Surgery if talocalcaneonavicular joint dislocated & post-op use of night splint

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Current gold standard: Ponseti approach to treatment of clubfoot

- Approximately 4-6 weekly foot manipulations and castings
- May require percutaneous tenotomy
- Followed by bracing for 3 months, then night-time splinting 2-4 years.
- <http://www.ponseti.info/>
- <http://www.ponseti.info/clubfoot-and-the-ponseti-method/resources/reference-material.html>
- <https://www.youtube.com/watch?v=nxG6mR1EIXA>

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4.2. Flat foot

- Incidence: 7-22%
- Critical age for arch development: 6-years old
- Parents may be concerned before this age and consult with the therapist
- Current consensus is that a flexible flat foot before age 6, in the absence of concurrent pathology, is best left alone!

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Flat foot

- In children less than 6 years old with a flexible flat foot, provide education about:
 - Natural history of arch development
 - Nutrition and physical activity – flat foot has been linked to obesity
 - Questionable: shoe education
 - Common recommendation is to use lightweight running shoes
 - Shoes with arch support will not correct, but will wear less and require fewer replacements
 - Incidence is actually higher in children who wear closed-shoes (13.2%) vs sandals (6.0%) or those who often walk on bare feet (2.8%)

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When is a flat foot cause for concern?

- Secondary flat foot
 - Cerebral palsy
 - Muscular dystrophy
 - Accessory navicular
 - Does not become symptomatic until late childhood
 - Flat foot is rigid
 - Tarsal coalition
 - Flat foot is rigid

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CONTINUED

How about later on?

- A low arch is less of a problem than a high arch
- Flat foot has not been found to cause higher incidence of injuries in runners
- Flat foot has not been found to cause higher incidence of low back pain or knee pain
- Treatment of the flexible flat foot is generally not needed
- Some adults may benefit from shoe inserts for comfort

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2

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Done!

Questions?