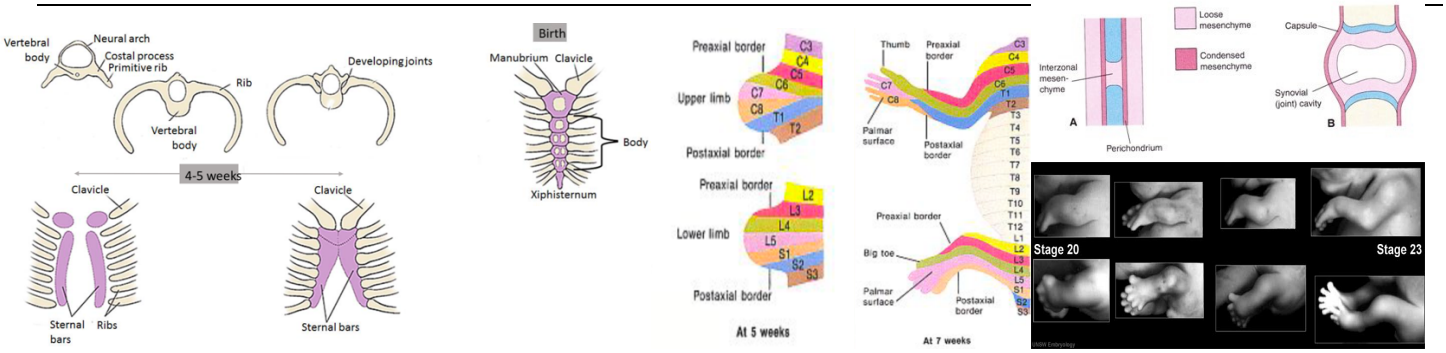
PAEDIATRIC ORTHOPAEDICS

SPINE EMBYROLOGY



Development of the spine	
Week 2:	spine derived from notocord (from ectoderm) ➔ notocord secretes Shh (sonic hedgehog) to stimulate ectoderm to produce neural tube, somite and subsequent sclerotome
Week 3:	**Paraxial mesoderm develops into segments of somite** ➔ divides into sclerotome (vertebra/ribs), dermatome (skin) and myotome (muscle) • Myotome → SKM of neck, trunk and limbs • Dermatome → CT, dermis of skin • Scleroteome → vertebra, thoracic ribs and **Cartilage (brown) derived from sclerotome surrounds neural tube**
Week 4:	spinous process and vertebral body develops as well as nucleus pulposus (formed from notocord) • **Upper limbs buds** develop 1st (2 days before lower limbs) ➔ digit formmation o **Incomplete apoptosis = syndactylyl or polydactyly** • **Closure of neural tube to protect spinal cord** ➔ *failure = spina bifidia occulta* ➔ *hunched back, lower limb paralysis*
Week 4-5:	• **RIBS: develop from transverse processes** of thoracic vertebrae a. Fibrous septa between body wall muscle ➔ becomes cartilaginous ➔ start to ossify by week 8. • STERNUM: Parallel fibrous sternal bars ➔ become cartilaginous ➔ start to ossify by week 8. • 2 manubrium and 2 left/right sternum fuse by birth (BUT ossification not completed as xiphisternum ossifies later in life)
Week 6	**Synovial joints develop** → peripherally forms joint capsule and centrally disappears to form joint cavity
Week 5-7	**Motor axons from spinal cord enter the limb buds** • *Sensory axons enter* the limb after the motor axons
Week 8	• **Upper limbs rotate dorsally** • **Lower limbs rotate ventrally – extensors anteriorly and flexors posteriorly**

(a)What induces the neural tube to form? (b) what vitamin is essential? (c) name a neural tube defect.

(a) Notocord

(b) Neural Tube Defects ➔ linked to **insufficient maternal intake of folate acid (vitamin B9)**

(c) Spinal bifida occulta, meningocoele (i.e. meninges + CSF bulging out), anencephaly

What problem can a cervical rib cause?

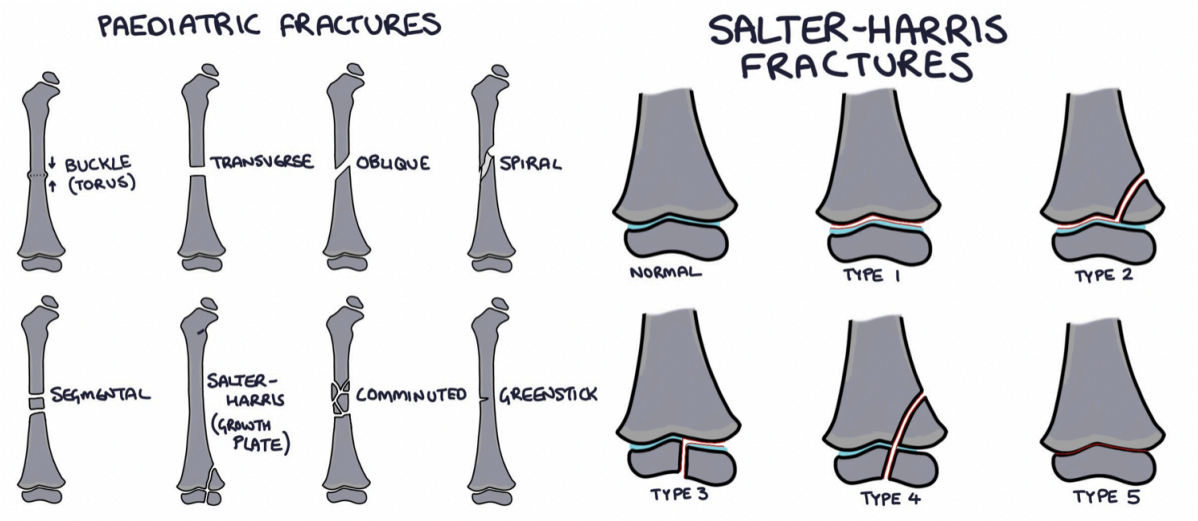
- if cervical transverse process develops a **cervical rib** ➔ thoracic outlet syndrome ➔ occupies space in thoracic outlet and **compress neurovascular structures**

Have the left and right sternal bars fused by birth?

Yes, but no ossification

- o if no fusion ➔sternal cleft ➔ gap between ribs ➔ abnormal respiration and no protection of heart and lungs
- o if incomplete fusion ➔ sternal foramina (holes in sternum)

FRACTURES



What type of fracture is more common in children

- **greenstick fractures** – *where only one side of the bone breaks and other side intact (since children have more cancellous bone than cortical bone making their bones more flexible but weaker)*
- **buckle fractures** → *as less strength against compression*

Principles of Fracture management

- **Safeguarding** → always check history correlated to clinical findings?
- **1ST principle** → closed reduction (joint manipulation) or open reduction (surgery)
- **2nd principle (relative stability)** → temporary period to allow bone healing
  - *E.g. K-wires, external casts, IM wires/nails, plates and screws*
- **Pain Mx [specificed WHO pain ladder for children – 2x steps ONLY]**
  - **1ST = Panadol/NSAIDs → 2ND = morphine (needs to be admitted)**
  - Avoid aspirin (Reye's syndrome)
  - Avoid codeine/tramadol (unpredictable drug metabolism – PD)

Salter-Harris classification of growth plate #

- Type 1: **S**traight across
- Type 2: **A**bove - from growth plate to metaphysis
- Type 3: Be**L**ow - from growth plate to epiphysis
- Type 4: **T**hrough - both metaphysis and epiphysis
- Type 5: **C**rush → *premature closure of growth plate*

HIP PAIN

Age group	0-4 years	5-10 years	10-16 years
Causes	• Septic arthritis • Transient synovitis • DDH	• Septic arthritis • Transient synovitis • Perthes disease	• Septic arthritis • SUFE • JIA

Red flags	General Ix	General Mx
• Child under 3yo • Child over 9yo with restricted ROM • Fever, UWL NS, chills • Nocturnal or persistent pain • Unable to weight bear • Swollen or red joint • Early AM stiffness • Suspicion of abuse • Signs of neurovascular compromise	• FBC, EUC, LFT (baseline) • CRP - ?JIA or septic arthritis • USS - ?joint effusion • XR - ?fractures, SUFE • MRI - ?osteomyelitis • Joint aspiration - ?septic arthritis	Refer to peadiatrics team or orthopaedics team ➢ Admit ➢ Ix Work up ➢ ABx coverage (if septic)

RICKETS

PP	Sx	Ix	Mx
Vit D def. OR calcium def. causes ➢ defective bone mineralisation known as **soft or deformed bones (osteomalacia)** *DDx:* ➢ **Lack of sunlight exposure** ➢ **Reduced dietary intake** (no eggs, fish, cereals, supplements) ➢ **HyperPTH** (1st, 2nd, 3rd) ➢ **Hereditary hypoPO4 rickets** (X-linked dominant – mainly males)	**General:** ➢ **Lethargy** ➢ **Muscle weakness** ➢ **Recurrent pathological #** **Bone deformities:** ➢ **Bowed knees** (legs curve outwards) ➢ **Knock knees** (curve inwards) ➢ **Delayed teeth growth** (under-developed enamel) ➢ **Rachitic rosary (**ends of ribs expand at costochondral junctions causing lumps around chest) ➢ **Craniotabes (**soft skull, delayed suture closure and frontal bossing)	• FBC, EUC, LFT **(high ALP)** • CMP, PTH **(low Ca, PO4) (HIGH PTH)** • **Serum 25-OH vit D** • **XR bones** – radiolucent bones *Other:* • TFT • Coeliac or IBD screen (malabsorption) • Autoimmune and rheumatoid tests	*Prevention key* ➢ Add formula feeds fortified with vit D to EBM ➢ Vit D supp. for BF women and child (400IU daily) *Active ricket sx* ➢ **Paeds referral** ➢ **Vit D supp (ergocalciferol)** → 6000IU /daily for 8-12 weeks for children between 6/12 and 12 years

HIP PAIN DDX – RED FLAGS

	SEPTIC ARTHRITIS	OSTEOMYELITIS	OSTEOSARCOMA
PP	**Infection within joint** ➢ S. aureus (MSSA vs MRSA) ➢ N. Gonorrhea (sexually active teens) ➢ GAS (Strep. Pyogenes) ➢ HiB ➢ E. Coli	**Infection within the bone and bone marrow** ➢ **Esp. in metaphysis of long bones** **Most common bacteria:** ➢ **S. aureus (MRSA vs MSSA)**	Type of bone cancer ➢ Mainly affects femur ➢ Also affects tibia and humerus
RF	• Post-op joint replacement	• Open fracture • Post-op orthopaedic surgery • Open wounds, gums or skin • Sickle cell anaemia • Immunocompromised (HIV, TB, chemo)	Adolescents and young adults (10-20 years)
Sx	• Hot, swollen, red painful joint • non-weight bearing - Antalgic gait • Fever • Open wound	Acutely unwell child ➢ Cannot weight bear ➢ **High grade fever** (if acute), chills, UWL ➢ Painful red swollen	• **Persistent bone pain** – nocturnal bone pain • Fever, UWL, rigors, chills • Palpable mass and bony swelling • Restricted ROM
Comp.	➢ Septic shock →DIC, MOF → death	Septic shock →DIC, MOF → death	➢ Metastasis ➢ Pathological bone fractures
Ix	➢ FBC, EUC, LFT, CRP, ABG ➢ Joint aspirate – M/C/S + cytology	➢ FBC, EUC, LFT, CRP, BSL, ABG ➢ XR (may be normal) ➢ MRI (gold standard) ➢ Bone marrow aspirate → M/C/S	**Urgent direct XR within 48 hrs** ➢ Periosteal reaction (irriration of bone lining) ➢ "sun-burst" appearance **Bloods →** raised ALP (osteopenia) **Stage cancer via** ➢ CT → CT-PET → MRI → Bone biopsy
Mx	➢ ABCDE -**refer to orthopaedics** ➢ IV empirical ABx – for 3-6 weeks ➢ Surgical drainage and washout to clear infection	➢ ABCDE -**refer to orthopaedics** ➢ IV empirical ABx – for 3-6 weeks ➢ Surgical drainage and debride to clear infection	MDT approach = Paediatric specialists + surgeons ➢ **Surgical resection (limb amputation) + adjuvant chemo** ➢ *PT, OT, Dietician, psychologist, social worker, prosthetics, orthotics, specialist nurses +doctors*

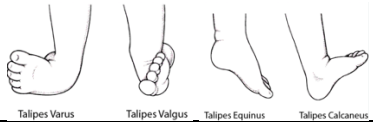
DDx (see below PLUS)

1) Still's disease (JIA) → non-weight bear
2) AML/ALL → bone pain, pallor, easy bruise, LN → FBC + blood film → ALL (chemo), AML (BMT,RT)
3) Haem → SCD, heamophilia, VWF
4) Growing pains and fibromyalgia

HIP PAIN DDX - CHRONOLOGY

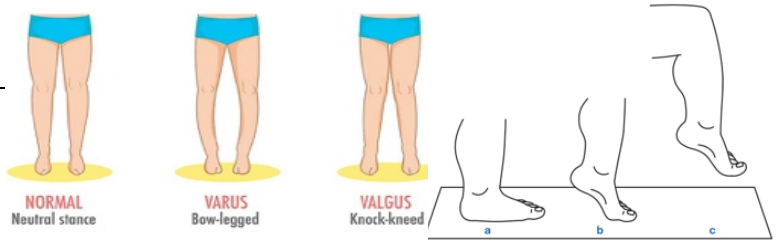
	Developmental dysplasia of hip (DDH)	Transient synovitis	Legg-Calve-Perthes (child OA)	Osgood-Schlatter's Disease	Slipped Capital Femoral Epiphysis
AGE group	**1st few mths of life**	**3-10yo**	**4-12 yo**	**Adolescent (10-15 yo)**	**Adolescent (10-15 yo)**
PP	Structurally abnormal hip jt development causing mechanical instability ➢ Subluxation and dislocation	Irritable hip – transient irritation and inflammation in synovial joint	**Disrupted blood flow to femoral head →** avascular necrosis of bone affecting epiphyses of femur ➢ Idiopathic cause	Inflamed tibial tuberosity (epiphyseal plate) where patella ligament inserts Small avulsion fractures when patella ligament pulls away tiny bone	• **Head of femur** slips along growth plate metaphysis
RF	• **Fhx (1st deg family)** • **Breech (after 36/40)** • Multiple pregnanncy • **female,** • **firstborn**	• POST-viral URTI prodrome	• Male/boys	➢ Male ➢ Puberty ➢ XS activity - *repeated loading*	Obese Males
Sx	• **Barlow and Ortolani manoeuvres –** *clicky hips* • **LLD** • **Restricted hip ROM** (poor hip flexion and abduction)	• **Viral prodrome** (coryza, cough) • **Groin/hip pain** • **Cannot wt bear** • Mild/low fever * *exclude septic arthritis*	• **Hip/groin Pain worse on activity** (better w/ rest) • Gradual onset limp • **Limited hip ROM** • Referred pain to knee • Limp	• **Anterior knee** pain (unilateral mainly) → worse on activity • **Visible or palpable hard lump** (initially tender but heals to become hard)	• **Growth spurt in male** • **Hx of minor trauma** • Hip, groin, thigh pain **disproportionate to injury** • **Painful limp** • Restricted hip ROM - esp. IR (like to keep hip in ER)
Comp.	➢ Asymmetrical gait ➢ Higher risk of early onset OA	Nil		**Avulsion fracture** (tibial tuberosity becomes separated from rest of tibia) ➢ Surgery required	
Ix	**Newborn Exam detected** ➢ Hip USS if < 6/12 old ➢ Hip X-ray if > 6/12 old	Clinical Dx	• **XR (1st line) –** usu. normal • **Bloods** = exclude CRP (myelitis) • **Tc-99M** • **MRI** - Osteosarcoma	Clinical Dx	Pelvic X-ray ➢ Bloods = exc. septic ➢ Tc-99M bone scan ➢ CT ➢ MRI
Mx	Early ambulation + analgesia (NSAID) If < 6 /12 old: ➢ **Pavlik harness** (for 6-8 wks) – hold femoral head and keeps hips flexed and abducted in correct position to allow acetabulum to develop normal shape If harness fails or > 6/12 old: ➢ **Surgery correction → spica/plaster cast →** maintain femoral head in acetabulum	Supportive (rest , NSAID) ➢ Avoid strenuous activity ➢ **Reassure – resolves within 1-2 wks** ➢ **F/U** at 48 hrs and 1 week to ensure Sx improve ➢ **Safety net –** if fever, return immediately	Management depends on severity *Conservative* 1) Bed rest 2) Traction 3) Crutches 4) Analgesia 5) PT referral - + ROM 6) Regular XR to assess healing *Surgery* ➢ Older children ➢ Not healing ➢ Improve alignment and function of femoral head	1) Reduction in PA 2) Ice 3) NSAIDs 4) **Refer to PT** – strengthen joint and improve function	**Surgical fixation** – stabilise head of femur w/ screws prevent lifelong problems

CONGENITAL MSK ISSUES

	OSTEOGENESIS IMPERFECTA	ACHONDROPLASIA	TALIPES (CLUBFOOT)
PP	Autosomal dominant inheritance interfering with collagen production leading to brittle bones	• Autosomal dominant inheritance OR sporadic - FGFR3 gene mutation • **Abnormal function of** epiphyseal plates – **restricts** bone growth (**endochondral ossification**) in length leading to short bones/stature • MOST COMMON cause of **disproportionate short statue (dwarfism)**	Fixed abnormal ankle position ➢ Occurs spontaneously OR part of syndrome  Talipes Varus Talipes Valgus Talipes Equinus Talipes Calcaneus
Sx	• Recurrent unexplained fractures • **Hypermobility** +/- joint/bone pain • **Blue / grey discolouration of sclera** (whites of eyes) • Triangular face • Short stature • Deafness from early adulthood (**hyperacusis)** • Bone deformities e.g. bowed legs, scoliosis	• **Disproportionate short statue (dwarfism)** → *affects proximal limbs (i..e femur and humerus more)* • **short digits** • bow legs (genu varum) • disproportionate skull *achondroplasia affects ***endochondral ossification*** leading to flattened mid face and nasal bridge and foramen magnum stenosis	Types: 1) **Talipes equinovarus** = **FIXED** ankle PF and supination 2) **Talipes calcaneovalgus** = **FIXED** ankle DF and pronation 3) **Positional talipes** = resting ankle position is PF and supination **BUT not fixed and no structural boney issues** a. Resolves w/ time b. PT referral
Comp.	➢ Pathological fractures	• RECURRENT AOM • Kyphoscoliosis OR spinal stenosis • OSA • Obesity → psychosocial problems • foramen magnum stenosis → cervical cord compression and hydrocephalus	
Ix	Clinical diagnosis ➢ XR – diagnose fractures and bony deformities	Clinical Dx ➢ Genetic test	Clinical Dx
Mx	***MDT approach*** ➢ PT and OT = max strength and function ➢ Paediatrician – med treatment and follow-up ➢ Orthopaedics – manage fractures ➢ Specialist nurses ➢ Social workers → social and financial support ***Medications*** ➢ Vit D supplementation – prevent def. ➢ Bisphosphonates – increase bone density	**MDT approach – no cure** ➢ PT and OT = max strength and function ➢ Paediatrician – med treatment and follow-up ➢ Dieticians ➢ Orthopaedics – manage fractures ➢ Specialist nurses ➢ Social workers → social and financial support Last resort (surgery) ➢ **Leg lengthening surgery (***osteotomies – cut bone to create gap/distraction to allow bone to form between 2 parts)*	**PONSETI METHOD (non-surgical)** ➢ Rx talipes without surgery ➢ Therapist list – Rx begins immediately after birth ➢ Serial cast manipulation with brace until age of 3

Types of intoeing + weird legs

- *Check length/ height*
- *Assess gait + Observe running*
- *Measure leg length and symmetry*
- *Assess foot/knee/hip movements (while prone) → hip rotation,*



	VARUS (bowing)	VALGUS (knock knees)	PES PLANUS "flat feet"
Pathological clues Normal progression: • @ birth = varus • 18-24mths = neutral • 24 mth – 4 yr = valgus • > 4 yo = some valgus	• **Severe bowing** (>6cm between medial femoral condyles) **Red flags:** • > 3yo • Unilateral or asymmetric bowing • Short stature	• **Severe knock knees** (> 8cm between MM) **Red flags:** • Age <2 or >7 • Unilateral or asymmetric • Short stature	• **NO medial longitudinal** arch on weightbearing • BUT Presence of arch on **tip-toeing** • Posteromedial ***Footwear*** (not posterolateral) • Reassure = most develop arch by age 6
Risk factors	• **Hx of metabolic disease, infection** • **PMHx: tumour** • Post-traumatic, Rickets, Skeletal dysplasia, neoplasms		• Congenital • Rheumatoid arthritis • Ageing + Obesity • Injury to foot or ankle
Referral indications	• **Rotate legs so patella faces forward** • (>6cm between medial femoral condyles)	• **Rotate legs so patella faces forward and femoral condyles touching** • (> 8cm between MM)	• *Rigid non bendable foot with no tarsal ROM* • *Flexible BUT painful, tender or unilateral*

	Metatarsus Adductus	Internal Tibial Torsion	Increased femoral anteversion
Who	< 1 year	1-3 years (resolved by age 5)	3-6yo
What	• **Kidney bean foot**, • Metatarsals point towards the midline relative to the hindfoot (crosses heel bisector line) • flexible vs semiflexible vs rigid	• MM posterior with LM • Medial rotation of tibia → foot points inwards and patella FACES outward • Internal Thigh foot angle 10-15°	• **Hip rotation** = Increased IR >90 and reduced ER of hip (neutral) • Patella faces medially when standing • Toes and patella point medially while walking
Gait observation	• Internal Foot Progression Angle, • Neutral or External Patella Progression Angle		• Egg beater/windmill running pattern
Rx	• Most resolve alone • Anything unilateral = abnormal → height imbalance issues • Activity limitation		
Referral indications	• Semiflexible > 6/12 • Rigid metatarsus (any age) • Underlying neurological issue	• Child > 8yo = sig. disrupted ADL • Underlying neurological issue	• Child > 11yo = sig. disrupted ADL • Underlying neurological issue