The Diagnostic Calendar
Birth congenital dislocation
0-5 Perthes’ disease
10-20 slipped epiphysis
Adult osteoarthritis, AVN, rheumatoid arthritis

The Trendelenberg Sign
A test for postural stability seen by looking for contralateral pelvic droop in the one-legged stance. Caused by:
1. Pain on weight bearing
2. Weakness of the Hip Abductors
3. Shortening of the femoral neck
4. Dislocation or subluxation of the hip

Developmental Dysplasia of the Hip
- 5 to 20 per live 1000 births exhibit instability, but 80-90% resolve spontaneously by 3 weeks
- girls are affected 7 times more than boys; 1 in 5 bilateral (20%)
- left > right perhaps due to normal vaginal delivery being left occiput anterior?
- Genetic factors:
  - Northern & eastern Mediterranean
  - Generalized joint laxity (dominant)
  - Shallow acetabula (polygenic trait)
- Risk factors:
  - High levels of relaxin present in last few weeks of pregnancy
  - Rarer in Chinese & Africans who carry children astride their shoulders
  - Breech presentation
  - Oligohydramnios
  - Other congenital anomalies
- Otolani’s test: the hip is dislocated and there is a loss of smooth abduction of the flexed hip, though pressure beneath the trochanters may allow the head to relocate with a “clunk” and fully abduct.
- Barlow’s test: the hip is dislocatable.
- X-ray signs:
  - Epiphysis should lie medial to a vertical line which defines the outer edge of the acetabulum (Perkins line), and below a horizontal line which passes through the triradiate cartilage (Hilgenreiner’s line)
  - The acetabular roof angle should not be > 30°
  - The femoral shafts should point to the acetabulum with the hips abducted 45° (Von Rosen's lines)
- 0-6 months:
  - screen high risk babies or those with signs of instability
  - if dislocated start abduction splintage immediately, but if simply unstable then nurse in double napkins or abduction pillow
- re-examine at 6 weeks and observe if stable, or else place in abduction splint if unstable, until x-ray evidence of satisfactory position (6 months)
- **6-18 months:**
  - if delayed presentation, then closed reduction is preferable over three weeks using a vertical frame with gradual abduction ± adductor tenotomy
  - splint with plaster spica at 60° flexion, 40° abduction and 20° internal rotation; replace at 6 weeks with a Pavlik harness for 3-6 months.
  - X-ray follow-up to check position, and gradually abandon splint.
  - Open reduction may be needed in which case the psoas is divided and redundant capsule ± thickened ligamentum teres (limbus) is excised. A derotation subtrochanteric osteotomy may be needed if stability can only be achieved by marked internal rotation of the hip.
- **18 months to 4 years:**
  - open reduction ± derotation osteotomy ± excision of segment of femur to reduce pressure on the hip and AVN.
  - For a acetabular dysplasia
    - Pemberton’s capsular reconstruction of acetabular roof
    - Salter osteotomy where an osteotomy is performed through the ischium above the acetabulum. The acetabulum is then tilted inferiorly and anteriorly, with the defect filled with bone graft from the ilium and secured with a K-wire.
  - Splint in plaster spica for 3 months and then a harness for further 1-3 months
- **Over 4 years:**
  - Increasingly difficult to reduce and stabilize, with AVN and stiffness rates as high as 25%
  - Non-intervention in child over 8 is justified as the child often has a mobile hip which is pain free, and only suffers from a waddling gait. In bilateral dislocations the waddling gait is less noticeable, and failure rates greater.
  - AVN is the feared complication for which there is no treatment once established. Mild cases are confined to the ossific nucleus, and supported by NWB while avoiding manipulation until the epiphyses heal. In severe cases the growth plates suffer and there is shortening and deformity of the femoral neck ± coxa vara.
  - Late complications may require THR. Lengthening beyond 3 cm may lead to stretching of sciatic nerve, or damaging the profunda femoris artery.
**Acetabular Dysplasia ± Subluxation**

- May be congenital or follow incomplete reduction of DDH, or maldevelopment of femoral head (e.g. Perthes disease)
- The acetabulum is usually shallow and open, with deficient coverage of the femoral head supero-laterally.
- In children it is usually asymptomatic and picked up radiographically. There may be a limp, groin pain or +ve Trendelenberg following strenuous activity.
- Older adolescents may complain of lateral hip pain from muscle fatigue, while adults are at risk of early secondary osteoarthritis
- On x-ray Wilberg’s Centre Edge Angle should **not** be < 30° (normal 40°)
- Crow Classification is assesses amount of proximal migration of the femoral head, and is based on the ratio distance migrated to the femoral head height
  - 1 = < 50 % subluxation
  - 2 = 50-75% subluxed
  - 3 = 75-100% subluxed
  - 4 = > 100% or superiorly dislocated.
- Treat infants as for DDH with abduction splintage, while older children may simply need muscle strengthening exercises.
- Surgical options for persistent pain:
  - Salter’s innominate osteotomy
  - Chiari’s pelvic osteotomy (step created to increase coverage)
  - Shelf procedure
  - Peri-acetabular osteotomy and 3D-reorientation of entire acetabulum
  - Total hip arthroplasty

**Femoral Anteversion (In-toe Gait)**

- Children usually walk awkwardly and trip over their own feet, and sit in the television position with their knees pointing inwards. There may also be a “squinting” patella on standing.
- < 3 years – due to forefoot adduction or tibial torsion
- >3 years – due to anteversion of the femoral neck (internal rotation of leg)
- femoral anteversion seen with hips and knees extended, but not when both are flexed 90° (tibial torsion or forefoot adduction)
- The condition usually improves with growth with no bar on athletic prowess. Treatment is seldom indicated, but a femoral osteotomy may be considered in children over 8 years with a clumsy gait.

**Protrusion Acetabuli**

- Deep socket which may bulge into the cavity of the pelvis. X-rays show inner wall beyond the iliopectineal line.
- Primary form shows familial tendency, more common in girls developing after puberty.
  - Usually asymptomatic with the exception of reduced ROM
  - May lead to early secondary osteoarthritis
- Secondary forms associated with softening disorder such as osteomalacia, Paget’s disease or chronic rheumatoid arthritis.
**Coxa Vara**

- Congenital form due to a defect in endochondral ossification of medial part of femoral neck. Continues to bend or fracture on crawling/standing
  - Leads to medial collapse with varus ± retroversion
  - Bilateral in one third of cases
  - Leg is often shortened and thigh may bow.
  - Look for a Hilgenreiner's epiphyseal angle > 30°
  - Observe if angle 40 to 60°, but consider subtrochanteric valgus osteotomy if greater.

- Acquired causes:
  - Rickets
  - Perthes’ disease
  - Epiphysiolysis in adolescents
  - Osteomalacia
  - Fibrous dysplasia
  - Pathological fracture of malunited fractures
  - Paget’s disease

**Proximal Femoral Focal Deficiency**

- Rare non-genetic disease, possibly teratogenic origin

- Aitken classification:
  - A – segment of unossified cartilage give appearance of a gap in the femoral neck or sub-trochanteric region. It will eventually ossify but only after proximal femur has developed a varus and shortening.
  - B – gap persists leading to acetabular and femoral dysplasia
  - C – femoral head is missing and acetabulum underdeveloped
  - D – agenesis of entire proximal femur and acetabulum

- Treatment:
  - A & B – joint is mechanically functional and can be treated with sub-trochanteric osteotomy and bone grafting to promote ossification. Limb-lengthening also possible.
  - C & D – Van Ness rotationplasty which is a tibial rotational osteotomy to turn the foot “back to front” to allow fitting of a prosthesis.
The Irritable Hip

- A transient synovitis of the hip which is more common in boys, usually presenting with hip/groin pain and a limp. Resolves within 2 weeks
- A diagnosis of exclusion with a systemically well child with normal blood parameters and x-rays; USS may show a small effusion. Exclude:
  - Perthes
  - SUFE
  - Tuberculous or pyogenic (septic) arthritis
  - Initial presentation of juvenile chronic arthritis and ankylosing spondylitis (uncommon)
- Usually treat with bed rest at home, but for severe effusions traction may be required in slight flexion and external rotation to reduce intra-articular pressure on the femoral head which can otherwise lead to AVN.
  - Sequential USS useful, and continue traction until both effusion and symptoms have resolved.
  - Repeat x-rays if symptoms persist beyond 2 weeks

Perthes’ Disease

- Painful childhood disease characterized by AVN of the femoral head
  - Age group is 4-8
  - 4:1 ratio in boys
  - Incidence is 1 in 10,000 (very rare in black Africans)
  - Genetic link amongst those with an acquired thrombophilia (e.g. hypofibrinolysis, factor V Leiden & protein C&S deficiencies), low birth weight or increased maternal age.
  - 4% associated with a urogenital anomaly

- Blood supply to the femoral neck:
  - Metaphyseal vessels penetrating growth plate
  - Lateral epiphyseal vessels within the retinacula
  - Vessels of the ligamentum teres
  - The metaphyseal vessels gradually decline until virtually absent by age 4, and the vasculature of the ligamentum teres only matures by age 7. Therefore in between the femoral head relies on the retinacula vessels which are susceptible to stretching and venous occlusion by capsular tamponade (e.g. effusions).

- Stages:
  - 1: ischaemia and bone death; cartilaginous part being nourished by synovial fluid thickens (increased joint space on x-ray)
  - 2: revascularisation and repair with alternating zones of new lamellae and fibrous tissue (increased density, but fragmented appearance on x-ray)
  - 3: distortion and remodelling; if repair process is complete before the femoral head loses shape, the bony architecture can be saved. If tardy, the epiphysis collapses (crescentic subarticular fracture on x-ray) and the femoral head becomes mushroom-shaped and displaces laterally in the acetabulum.
Catterall Classification on x-ray:
- **1**: < half the ossific nucleus is sclerotic, and the epiphysis retains its height
- **2**: < half the nucleus is sclerotic, with some central collapse
- **3**: most of the nucleus is involved, with fragmentation and collapse
- **4**: whole head involved, ossific nucleus is flattened & dense, with marked metaphyseal resorption

Herring classification (of the lateral, weight bearing pillar)
- Under 6 years → symptomatic treatment with traction
- Age 6-8 take x-rays of the wrist to estimate bone age:
  - Bone age < 6:
    - **1**: normal height → symptomatic treatment with traction
    - **2**: <50% collapse → symptomatic treatment with traction
    - **3**: >50% collapse → containment with abduction brace
  - Bone age > 6:
    - **1 & 2** → containment with brace or surgery
    - **3** → probably unaffected regardless of treatment, but some would advocate surgery.
- Age over 9 years → except in very mild cases, surgery is recommended.

Management:
- Initially while the hip is still “irritable” it should be kept in **traction** for up to 3 weeks, in a position of slight flexion and external rotation.
- Thereafter either **symptomatic** treatment can be given (analgesia ± further traction followed by gentle physiotherapy) or **Containment** of the head within the acetabulum to prevent dysplasia or loss of shape of the head during the healing & remodelling phase.
  - Held in wide abduction by plaster or ambulation brace (up to 1 year)
  - Surgical option: varus osteotomy of femur, or pelvic osteotomy.
- There is a 10-fold increased risk of secondary osteoarthritis.
Slipped Upper (Capital) Femoral Epiphysis

- “Epiphysiolysis” is usually confined to the pubertal growth spurt, again favouring boys and the left side
  - Unilateral slip through the hypertrophic zone of the cartilaginous growth plate increases the risk of a contralateral slip

- Aetiology:
  - Hormonal due to an imbalance between pituitary stimulated physical growth, and gonadal hormone mediated physeal maturation and epiphyseal fusion. (Seen in cases of juvenile hypothyroidism and craniopharyngioma)
  - Trauma: 30% acute slip, 70% acute-on-chronic slip.

- In a SUFE, the epiphysis slides posteriorly on the femoral neck, which tends to cause the shaft to roll into external rotation. The anterior retinacular vessels are disrupted. Therefore the only blood supply to the femoral head is derived from the posterior vessels which tend to be lifted off the bone with the retinaculum, and hence more prone to damage by surgery or manipulation.

- Physeal disruption usually leads to premature fusion of the epiphysis within 2 years

- Clinical signs:
  - Groin or knee pain
  - Pubertal, overweight, or particularly tall & thin child
  - Prolonged limp
  - Leg is externally rotation, shortened by 1-2 cm (look at patellae)
  - Limitation in abduction, internal rotation (and flexion)
  - An acute slip is accompanied by pain and limitation of all movements (irritable)

- X-rays:
  - Trenthovan’s sign on the AP view shows a line along the superior femoral neck remaining above the head, instead of passing through it.
  - In the lateral view, the angle between the centre of the femoral shaft and the femoral epiphysis is 90°. An angle <90° indicates a posterior slip.

- Treatment goals:
  - Preserve the epiphyseal (posterior retinaculum) vessels
  - Stabilise or fix the physis
  - Correct any residual deformity for improved function and prevention of early 2° osteoarthritis.
  - Mild = < 1/3 width of epiphysis on AP view, and <20° on lateral x-ray.
    - Minimal deformity is accepted
    - Stabilise with threaded pins through femoral neck into the epiphysis
  - Moderate = one to two thirds lateral slip, and posterior tilt 20-40°
    - Accept deformity initially and stabilise with short-threaded pins to protect the posterior retinacular vessels, or a less risky method is fusion using a bone graft epiphyseodesis (Heyman & Herndon)
If deformity still noticeable at 1 year despite remodelling, then proceed with a corrective sub-trochanteric osteotomy.

- **Severe** = > 2/3 lateral slip (AP) and >40° posterior tilt (lateral film)
- Marked deformity and risk of early 2° osteoarthritis
- Open reduction even in specialist centres carries 5-10% risk of AVN
- Staged fixation and corrective osteotomy is a safe option, with the cuts of the osteotomy aiming to restore valgus, internal rotation and flexion, while realigning the femoral head into the acetabulum.

**Complications:**
- 20% risk of contralateral slip (therefore should be radiographically observed)
- Avascular necrosis – actually rarely occurs in the absence of treatment
- Articular chondrolysis results in narrowing of the joint space and stiffness; again usually iatrogenic.
- Coxa vara – apparent as opposed to real, as the actual deformity is femoral retroversion with external rotation & shortening
- Early secondary osteoarthritis – which needs early THR. During a THR the femoral head may be difficult to dislocate, requiring an in-situ femoral neck cut ± reaming of the head if it cannot be levered out.

**Septic (Pyogenic) Arthritis**
- Usually in children < 2 years from distant haematogenous spread, or local spread from osteomyelitis of the femur
- Cartilaginous head (at this age) is at risk of destruction by proteolytic enzymes
- Clinically the child is unwell and in pain – though pain may not be localised to the hip, and the whole leg may be held stiffly.
- X-rays are of little value initially, but may show signs of joint distension or effusion which pushes the ossification centre of the femoral head laterally,

**Treatment:**
- Confirm diagnosis by aspiration under anaesthesia
- If pus found → anterior arthrotomy with washout of the joint
- Local antibiotic instilment with systemic IV antibiotics subsequently tailored to microbiological findings
- Hip kept in traction or splinted in abduction until infection controlled

**Complications** include pathological dislocation or joint destruction.

**Tuberculosis**
- Chronic insidious onset with aching in groin or thigh, and a slight limp. An early sign is apparent lengthening.
- Leg held flexed and mildly abducted, with reduced ROM
- If arthritis supervenes, the joint is more painful and held internally rotated and adducted in spasm
- Untreated the patient is left with a shortened leg and fixed flexion.
- X-rays may show general rarefaction. Later the femoral epiphysis may be enlarged, osteopaenic ± a visible bone abscess.
As the disease progresses there may be signs of acetabular destruction or pathological dislocation

- Healing usually results in calification and fibrous tissue leading to shortening and ankylosis.

- Treatment is along the lines of standard quadruple systemic therapy, with skin traction. Children may have an abduction frame.
- Bone abscesses are best evacuated ± joint debridement.
- In joint destruction, arthrodesis can be considered after age 14 and disease remission.
- Later in older patients, total hip arthroplasty can be considered with antituberculous cover.

**Rheumatoid Arthritis**

- Usually a poly-articular condition that occasionally can remain mono-articular for several years, with persistent synovitis in the weight-bearing hip leading to joint destruction on both sides of the joint without any reactive osteophyte formation.

- Clinical features:
  - Polyarthritis, hand disease and extra-articular features
  - Progressive difficulty getting out of a chair, and then movements in bed
  - Limb held in external rotation and fixed flexion

- Once cartilage and bone eroded, there is no medical treatment to prevent progressive joint destruction, protrusio or perforation of the acetabulum.
- Therefore joint replacement is the only answer.
- If there is ankylosis of the joint, it may be difficult to dislocate, and the femoral cut will have to be made in situ, with the head levered out or simply reamed into the acetabulum creating natural bone graft.
- A supportive cage may be needed
- Infection a problem as they may be immunosuppressed
- Juvenile Chronic Arthritic patient may need custom made prostheses.

**The Loose THR**

- These should be considered infected unless proven otherwise

- In the history:
  - Never right or pain never settled
  - Delayed healing or wound ooze or haematoma after initial surgery
  - Rest pain or night pain
  - Metasynchronous sepsis during primary surgery

- On examination:
  - Scars
  - Regional lymphadenopathy
  - Sinus or discharge
  - Painful ROM or pain on telescoping

- Investigations:
  - ESR peaks at 6 days, but can be elevated up to 1 year after
  - CRP peaks at day 2, and usually returns to normal within 3 weeks
  - Normal ESR & CRP practically excludes infection (specific and sensitive)
Both being raised has a +ve predictive value of 0.84, and aspiration is indicated

Aspiration showing a WCC > 25000/ml or a >25% predominance of polymorphs indicates high risk of infection, in the absence of a positive culture.

However, if bloods and x-ray are suggestive of infection, there is a 20% false negative rate.

*Nuclear imaging is not specific, but is sensitive* – not routinely recommended

During surgery, specimens should be taken using separate instruments into separate containers, avoiding cross-contamination (e.g. using a galley pot)

- The more specimens, the higher the predictive value of infection on histology samples.

Close to 50% of infections are due to *Staphylococcus epidermidis*

**Infections:**

- Early acute – occur in the first 3 months, with symptoms lasting for less than 2 weeks. The joint is acutely inflamed ± pyrexia
- Late Acute – symptoms last less than 2 weeks, but after 1 year after surgery.
- Late Chronic – the symptoms are insidious over 2 weeks in duration, and occur after the 1st year.

**Options:**

- **Antibiotic suppression** – needs well fixed components. For low virulence organisms with 3 to 6 weeks treatment, and has a 81% success rate.
- **Debridement with retention** – for early pos-op infections with a 74% success rate, or for cases from metasynchronous haematogenous spread (50% success rate)
- **1 Stage Revision** – if organism is known in a patient who is unlikely to tolerate two long anaesthesias. Bone stock should be good, and patient should not have other risks for infection.
- **2 Stage Revision** – has a 64 to 96% success rate. Usually 6 weeks IV antibiotics between stages followed by a 2 to 3 week period without antibiotics. If aspiration is then negative, 2nd stage can be performed preferably within 6-8 weeks of stopping antibiotics.
- **3 Stage Revision** – new concept, with extra stage of bone grafting to restore integrity, in between removal of prosthesis and reimplantation.
- **Excision arthroplasty** – if poor bone stock or soft tissues, or persisting organisms, or a very virulent or resistant organism. Alternatively for those with poor medical or social backgrounds.
AVN Causes

- Idiopathic is most common.
  - Male to female ratio of 4:1
  - 50% bilaterality
  - tend to present with sudden onset groin pain – may radiate to buttock or anterior thigh

- Congenital - Perthes

- Acquired
  - Traumatic (e.g. NOF#, scaphoid #, Neer 3 or above proximal humeral #)
  - Infection (septic arthritis or TB)
  - Neoplastic / paraneoplastic during a hypercoaguable state
  - Circulatory – haemoglobinopathies, myeloma, thrombophilia, Caisson’s
  - Autoimmune – vasculitis
  - Pulmonary – COPD, chronic lung disease
  - Metabolic – Gaucher’s disease, Crohn’s
  - Endocrine – Diabetes
  - Drugs – steroids or alcohol
  - Degenerative
  - Iatrogenic – during manipulation of reduction of SUFE or CDH.

- FICAT classification (CORR 1985)
  - 99-Tc bone scan good for showing increase uptake in early necrosis
  - Other investigation is functional exploration of bone (FEB)
    - Intra-osseous pressure measured through a cannula placed in intertrochanteric area (under LA and x-ray control) > 30 mmHg abnormal
    - Stress test by injecting 5 ml saline and looking for a rise in pressure >10 mmHg above baseline at 5 minutes
    - Take intra-osseous blood sample and look for O2-sats < 85%
    - Inject 10ml contrast medium and assess for stasis after 15 minutes
    - Core biopsy for histology analysis.

- Stage 0
  - Pre-clinical and no x-ray changes. Raised intra-osseous pressure
  - FEB may show silent hip on FEB-testing of contra-lateral hip in patients with established AVN. 66% will go onto develop AVN if testing abnormal

- Stage 1
  - Sudden pain in groin. Raised intra-operative pressure
  - Reduction in internal rotation ± abduction
  - X-ray may show blurring of trabecular pattern (subtle)
  - 90% good results with early core decompression

- Stage 2
  - Trabecular pattern changes in femoral head. Shape normal
  - Sclerosis + cysts (from areas of decalcification)
- 80% good results with early core decompression

- **Stage 3**
  - Sequestrum on x-ray
  - Crescentic line from subchondral fracture
  - Segmental flattening of femoral head
  - Increasing pain clinically, and now global reduced ROM

- **Stage 4**
  - Loss of articular cartilage and ischaemic coxopathy
  - Patient age 60-70 with sudden pain at night
  - Narrowing of joint space *without* much osteophytes
  - Bilateral involvement in 50% of idiopathic cases
  - Up to 80% bilaterality in AVN secondary to steroid use.

- Nowadays the acute investigation of choice is MRI. If spotted early, aim for core decompression or vascularised grafts within 1 week. Ensure you target the affected area within the femoral head, based on the MRI findings. Pass cannulated drill over guidewire – can make 2-3 passes. TTWB or PWB for 3 months. Warn of contra-lateral symptoms (similar concept as the “you what” test for SUFEs)

- Another option is to place a trabecular metal peg (Zimmer) after core decompression to support femoral head. If grade 3 or 4, consider THR as a single principle treatment.

- **Rx:**
  - Ficat 0,1,2 – early diagnosis, reduced weight bearing, drill femoral head ± graft/peg
  - Ficat 3,4 – THR / BHR

### Hip Resurfacing

- Useful for younger patients
  - Increased functional demand
  - Not prepared for a compromise in activity level
  - Allows for later surgery
  - Reduced risk of dislocation
  - Preserves bone stock and anatomical neck-shaft angle

- **Contra-indications:**
  - High BMI > 30
  - Inactive
  - Female > 55, as increased risk of neck fracture – consider pre-operative bone densitometry

- **Pre-operative Counselling:**
  - Metallic clunk for up to 1 year post-op
  - More swelling and pain
  - VTE
  - Dislocation < 1%
  - Infection < 0.5% (institute specific)
- Limb length discrepancy
- Femoral Neck fracture (acute or chronic)
- Conversion to THR (intra-operative or later)
- Avoid impact sports and squash for 6 months minimum.
**Osteoarthritis**

- **Pathology:**
  - Softening and fibrillation of the articular cartilage
  - Underlying new bone formation (sclerosis) or cysts
  - Reactive osteophytes
  - Progressive erosion of articular cartilage to reduce joint space, until there is bone on bone contact, with subsequent erosion of the femoral head or acetabulum.

- **Clinical features:**
  - Pain in the goin which may radiate to the knee
  - Patient may think the leg is getting shorter
  - Fixed flexion
  - +ve Trendelenberg

- **Secondary causes**

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- **Non-operative options:**
  - Analgesics and anti-inflammatory drugs
  - Warmth
  - Use of a walking stick
  - Non-weight bearing exercises to preserve movement and stability
  - Physiotherapy

- **Indications for surgery:**
  - Progressive increase in pain (including night pain)
  - Severe restriction of activities
  - Marked deformity
  - Progressive loss of movement
  - Together with x-ray signs of joint destruction

- **Surgical options:**
  - Hip replacement or resurfacing
  - Intertrochanteric realignment osteotomy
  - Arthrodesis can guarantee freedom from pain and good stability, but disadvantages include restricted movement and later problems with backache.
Osteonecrosis

- Common in the femoral head because of its precarious anatomical blood supply leaving it susceptible to:
  - Arterial compromise
  - Venous stasis
  - Intravascular thrombosis
  - Intra-osseous sinusoidal compression from extra-vascular swelling (e.g. steroid and alcohol induced swelling of fat cells)

- Congenital causes: CDH, Perthes’ Disease

- Acquired:
  - Traumatic – displaced NOF#, dislocation
  - Inflammatory – septic arthritis
  - Neoplastic
  - Circulatory – coagulopathies, Sickle-cell, Caisson’s disease (dysbaric ischaemia), haematological malignancy
  - Auto-immune – vasculitic causes, SLE, RA
  - Pulmonary – COPD
  - Metabolic – Gaucher’s disease
  - Endocrine – diabetes
  - Degenerative – primary OA
  - Drugs – steroids, alcohol
  - Iatrogenic – forced reduction of SUFE or dislocated hip in CDH

- Clinical signs:
  - Wasting and limb shortening
  - Positive Trendelenberg test
  - Tendancy for the hip to fall into external rotation on passive flexion
  - Loss of internal rotation and abduction
  - Sectoral sign – full internal rotation when hip extended, but restriction in flexion; this also can also distinguish between muscle pain and septic arthritis in the young (clinical tip from Mr Sadique, Walsall Manor)

- X-ray changes are reported under Perthes’ Disease. Ficat classification:
  - Stage 1 – no changes; dx based on MRI hypodensity change
  - Stage 2 – tangential crack (crescent sign) or reactive change (sclerosis) in subchondral area
  - Stage 3 – structural damage and loss of bone outline
  - Stage 4 – joint destruction and secondary OA

- MRI scans show the changes earlier, as x-ray appearances may only manifest at 6-9 months after bone death occurs, and show reactive changes in surrounding living bone, before destructive changes in the necrotic segment appear even later.
Shimuzu (1994) thereafter looked at location of AVN to grade prognosis:

- **Grade 1** – lesion < ¼ of femoral head in coronal plane, and limited to medial 1/3 of weight bearing surface will rarely collapse.
  - *Symptomatic treatment only, but observe for late changes*
- **Grade 2** – lesion < ½ of coronal femoral head, and < 2/3 medial weight bearing surface have a 30% risk of collapse
  - Conservative treatment by decompression of femoral head to reduce intra-osseous pressure if raised, by drilling out a 7mm core of bone under image intensifier guidance (30-50% long term success)
- **Grade 3** – if >2/3 of weight bearing surface, the risk of collapse is 70%
  - Realignment osteotomy in the younger patient, to move the necrotic area away from the maximal load-bearing trajectory
  - Joint replacement
- The MRI demarcates the reactive zone between living and dead bone, and appears as a reduced intensity band on T1-images (or increased density on a STIR-image).

**Marrow Oedema Syndrome**

- Transient osteoporosis of femoral head and pelvis lasting 6-12 months, and characterised with pain
- No cause found, but MRI shows features of marrow oedema
- Analgesia and observation is one option.
- However symptom relief is rapid with marrow decompression.
- If distinction between Grade 2 osteonecrosis (AVN) is unclear, surgical decompression is indicated

**Other causes of Hip Pain**

- **Trochanteric Bursitis**
  - Pain over lateral aspect locally ± crepitus on flexion-extension
  - Bursa lies deep to tensor fascia lata
  - Exclude gout, rheumatoid hip and infection (incl. TB)
  - Rest and NSAIDs are usual treatments ± steroid injection
- **Gluteus Medius Tendinitis**
  - Pain and local tenderness behind the greater trochanter
  - X-rays may show calcification or shadows within the soft tissue
- **Adductor Longus Tendinitis**
  - Footballers and athletes
  - Pain in the groin close to the pubis
  - Swelling just beneath also suggests a tear of the adductor longus
  - Treatment with rest and heat ± physiotherapy if chronic
- **Iliopsoas Bursitis / Snapping Psoas**
  - Pain in groin and anterior thigh
  - Guarding of muscles around lesser trochanter possible
  - Increase in pain on adduction and internal rotation
  - Test with patient sitting, and ask to lift thigh (flex hip) against resistance
  - Exclude LNs, hernia, fracture of lesser trochanter, SUFE, and infection
Treatment with NSAIDs ± steroid injection under image intensifier → arthroscopic release if good response.

Test Psoas with pain on resisted flexion while supine. Stretch with patient supine on couch with buttock at edge. Flex up other leg to stabilise lumbar spine, and then allow affected leg to hang down (extension of hip).

Snapping Hip
- Complaint of hip jumping or catching while walking
- Caused by a thickened band in the ilio-tibial band (ITB) which moves anteriorly during the swing phase, but is pulled back around the greater trochanter during the stance phase when the gluteus maximus contracts to pull the hip into extension
- Painless “clunking” may also be a psoas tendon
- The audible snap can be painful or painless, but the hip can give way
- Exclude a labral tear or osteocartilaginous flap of femoral head (similar to osteochondritis dissecans) by arthrogram or arthroscopy.
- Ober’s test – lie patient on side with affected hip uppermost. This is then extended and allowed to lie off the couch. If this is painful or cannot be done the ITB is tight.
- General rule: if you can see the hip snapping it is ITB. If you can only hear the hip snapping, it is psoas.
- Treatment with reassurance, or division/lengthening of tendon (z-plasty) if very distressing.
- Can also be caused by tears of the gluteus medius or minimus – presenting with mild weakness in abductor function and a possible Trendelenburg gait. Diagnosed and treated in a similar manner to rotator cuff tears.

Ligamentum Teres pathology
- 15% incidence in patients arthroscoped for investigating young hip pain
- partial rupture, hypertrophy or degenerative changes
- 50% complained of catching, popping or locking
- full traumatic rupture usually caused by dislocation (or occasionally twisting injury)

Synovial Chondromatosis
- Cartilaginous or osteocartilaginous metaplasia within synovial membrane of joints, bursae or tendon sheaths
- Early – metaplasia alone
- Late – metaplasia with loose bodies
- Treated by arthroscopic resection.

Transient Osteoporosis (& Regional Migratory Osteoporosis)
CRESPO E ET AL (2001, ACTA ORTHOPAEDICA BELGICA 67 (4); 330-337)
- Sudden onset of joint pain followed by local osteopaenia after several weeks and then spontaneous healing.
- Risk factors:
- middle-aged men (age 40-60)
- women in 3rd trimester of pregnancy
- osteogenesis imperfecta

- Aetiology largely unknown but believed to involve a transient ischaemic event which produces limited cell death involving only the haematopoietic and fatty elements of bone. Results in intra-trabecular oedema and bone resorption.

- Clinical presentation:
  - Sudden or progressive pain
  - No previous trauma
  - Mechanical symptoms, improves with rest
  - Phase 1 – intense pain (up to 1 month)
  - Phase 2 – symptoms remain unchanged, but marked osteopaenia on x-ray (1-2 months)
  - Phase 3 – regression with gradual increase in bone density (4 months)
  - Joints most affected are the hip, then knee and ankle.
  - Up to 40% will have migratory episodes, with a variable latent period

- Imaging:
  - Bone density normal until 4-8 weeks
  - Then diffuse peri-articular osteopaenia develops
  - Rarely affect the pelvic bones or greater trochanter
  - Increased uptake seen on bone-scan
  - MRI shows increased T2 signal (oedema), and an effusion
  - (In the knee – changes more frequent on lateral condyle)

- A diagnosis of exclusion, with the differential including:
  - Septic joint
  - Osteomyelitis
  - AVN – difficult to distinguish but often have significant rest pain, and the osteopaenia is rarely so diffuse. Look for a cold spot on bone scan in the antero-superior region of the femoral head.
  - TB
  - Malignancy

- Initially treatment was empiric core decompression – but now favour conservative options with pain relief, protected weight bearing and 3 monthly MRI scans to exclude progressive changes (which would suggest an alternate diagnosis)

- Complication – pathological or traumatic femoral neck fracture
  - So important to strictly recommend protected weight bearing in pregnant women, in whom any pathological fracture is usually only treated post-partum.

**Femoro-acetabular impingement:**

- Cam type – prominence head-neck junction abuts on acetabular rim
More common in young men
Old history of SUFE, fracture malunion, perthes common
Labrum usually spared, with delamination of cartilage

- Causes of retroversion
  - Idiopathic (more common in Caucasians and men)
  - DDH
  - Perthes
  - SUFE
  - Over-correction (e.g. after Salter osteotomy)
  - Post-traumatic dysplasia
  - Proximal focal femoral deficiency

- Pincer type – acetabular over-coverage
  - global protrusion or focal osteophyte / retroverted acetabulum
  - commonly affects middle aged women
  - antero-superior impingement with "contra-coup" postero-inferior injury
  - a common pattern
  - common in: acetabular retroversion coxa profunda, protrusio, rim ossification
  - usually results in labral tears

- Symptoms:
  - Groin pain with prolonged sitting or flexion
  - Positive impingement sign – pain on flexion, adduction & int rotation
  - Patients may describe “locking, snapping or giving way”
  - Walking in external rotation and wearing out lateral part of shoe

- X-rays:
  - Assess acetabular depth by the lateral center-edge angle of Wiberg
    - Normal is 20° to 40°
    - Low angles indicate dysplasia, and high angles over-coverage.

- Pistol grip deformity (flattening of lateral head-neck junction) seen in cam impingement.
Treatment options:
- Conservative: pain killers and activity reduction
- Cam impingement – proximal femoral osteoplasty to remove bony prominence (can be performed arthroscopically or mini-open)
- Resection of acetabular rim and re-attachment of labrum performed for pincer lesions.
- Mini-open modified Smith-Peterson approach can only address anterior lesions. Otherwise a Ganz “flip-trochanteric osteotomy” is needed – allows dislocation and a full 360° view, while protecting medial circumflex artery.

Labral Tears
- Present with gradual onset of groin and hip pain, usually activity related.

Causes:
- Femoro-acetabular impingement
- Degenerative
- Dysplasia
- Instability
- Post-traumatic (few)

Simple arthroscopic debridement usually only successful if no other pathology (e.g. impingement, dysplasia or chondral injury / OA)

Recent evidence for more success with labral repair in controlling pain. (Hines 2007)

Special Tests of Hip Examination
- Impingement test – for femoro-acetabular impingement
  - Test with the hip in flexion, adduction and internal rotation
- FABER distance – also for impingement, but may be painful in those with SI joint pathology
  - Place hip and leg in “figure of 4” position and measure vertical distance from lateral joint line of knee to couch.
- Thomas test for fixed flexion deformity
- McCarthy Hip extension sign – painful usually in intra-articular causes
  - Place both hips in flexion and then move to extension first in external and then internal rotation.
- Anterior apprehension sign – painful usually in patients with dysplasia
  - Seated patient asked to externally rotate hip from a position of maximum external rotation
- Log roll test – laxity of anterior capsule or insufficiency if ilio-femoral ligament
Maximum internal passive internal rotation in a supine patient. Release and see if foot naturally returns to external rotation position, and matches contra-lateral side.

Common Surgical Approaches

Posterior
- Incision centred over posterior third of trochanter, and 50% proximal to trochanter at a 45° angle posteriorly
- Identify sciatic nerve and protect; inferior gluteal artery below piriformis
- Gentle internal rotation of leg to visualise short external rotators
- Interval between gluteus minimum and piriformis split with diathermy
- Release short external rotators (piriformis, gamelli, obturator internus & quadratus femoris) off the trochanter from below the trochanteric ridge
- Capsulotomy and internal rotation to dislocate the hip
- Retractors:
  - Over anterior edge of acetabulum (2-3 o’clock)
  - Posteriorly (after a releasing incision in the inferior capsule)
  - Under transverse ligament
- To increase exposure: release Gluteus maximus from femoral shaft ± quadratus femoris. Extension possible down femoral shaft.

<table>
<thead>
<tr>
<th>Posterior approach</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to deal with concomitant pathology, e.g. posterior column acetabular plate.</td>
<td>Sciatic Nerve in operative field.</td>
<td></td>
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<tr>
<td>Preservation of proximal femoral ring.</td>
<td>Perceived increased risk of dislocation, particularly in patients with pre-existing neurological impairment or uncooperative patients.</td>
<td></td>
</tr>
<tr>
<td>Ability to perform subtrochanteric osteotomy.</td>
<td>Trochanter may obscure view of canal at time of revision surgery.</td>
<td></td>
</tr>
<tr>
<td>Preservation of abductor muscles/function.</td>
<td>Ability to extend using an Extended Trochanteric Osteotomy (ETO).</td>
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</table>

Direct Lateral Approach
- Incision lies with its midpoint over the greater trochanter: distally along the anterior border of femoral shaft, and proximally curves gently posterior until at the level of the anterior superior iliac spine.
- Omega shaped incision through upper most end of the ridge of vastus lateralis, around the greater trochanter releasing gluteus medius with a cuff to repair back to, and proximally between fibres of the medius.
  - Stay superficial within medius fibres to avoid injury to the superior gluteal nerve.
- Normally 5 cm proximal to the tip of the Greater Trochanter
- Adduct the leg to help develop the division of medius

- Next release the gluteus minimus and Ligament of Bigelow to allow the leg to be placed in the 90-90 position (flexed and externally rotated)
- T-shaped cut into the capsule

- Acetabular exposure from a Norfolk & Norwich retractor in an east-west direction, and a Hohmann under the TAL.

### Direct lateral approach

**Advantages**
- Noncompliant patient (e.g. elderly or with Parkinson's disease) at risk for posterior dislocation
- Familiarity as commonly trained in this approach for hemi-arthroplasty for fractured neck of femur

**Disadvantages**
- Tendency to insert femoral prosthesis with “Front to Back” alignment.
- Visualization of femoral canal may be poor.
- Risk of gluteus medius dehiscence or damage to superior gluteal nerve, resulting in Trendelenburg gait.

### Anterior Approach

- Used for open reduction of a dislocated hip in DDH
- Supine position
- Incision – anterior half of iliac crest, then curve vertically down pointing towards lateral edge of patella
- Beware: lateral cutaneous nerve of thigh, 2.5 cm below ASIS
- Internervous plane – Sartorius muscle (femoral nerve) and tensor fascia lata (superior gluteal nerve). Then find internervous plane between gluteus medius and rectus femoris.
- Can be extended proximally towards ASIS. Can then split the apophysis and dissect sub-periosteally to expose the inner and outer table – for pelvic osteotomy.

### Medial Approach

- Used again in children with dislocated hip requiring open reduction
- Incision with the thigh abducted and external rotation, longitudinal cut from 3 cm below pubic tubercle, along the line of adductor longus
- Internervous plane between adductor longus and gracilis (divisions of obturator nerve). Deep dissection between adductor magnus (posterior division obturator nerve) and adductor brevis (anterior division of obturator nerve)

- Structures at risk = posterior division of obturator nerve on deep dissection
Anterolateral Approach

- Supine position with greater trochanter at the edge of table, and buttock hanging free
- Incision 2cm posterior and distal to ASIS, curving to greater trochanter and then longitudinally along shaft of femur for 10 cm
- Intermuscular plane = tensor fascia lata & gluteus medius, with incision through fascia lata distally, and muscle bellies separated towards the iliac crest
  ➢ Beware branch of superior gluteal nerve and
- Raise the anterior parts of gluteus medius and minimus from the greater trochanter and retract posteriorly
- Reveals the anterior capsule and reflected head of the rectus femoris (inserts onto superior acetabulum rim).
  ➢ Beneath this lie the ascending branch of the lateral femoral circumflex artery and its vena committantes
- Capsulotomy and external rotation of leg to dislocate hip.
  ➢ May require release of posterior capsule and short external rotators, to avoid excess torsion and fracture of the femur
- Blunt retractors anteriorly and posteriorly and a spiked retractor under the TAL.

<table>
<thead>
<tr>
<th>Antero-lateral approach</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>• Preservation of abductors if minimally invasive technique used.</td>
<td>• Difficult visualization of femoral canal</td>
</tr>
<tr>
<td>• Good visualization of the acetabulum.</td>
<td>• Potential damage to the gluteus medius during femoral canal preparation</td>
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<tr>
<td></td>
<td>• Requires two assistants for THR</td>
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</table>

Trochanteric Osteotomy

- Supine position with the hip at the edge of the table.
- With the hip flexed to 30°, adducted and internally rotated – a longitudinal incision is made just in front of the lateral aspect of the femur with only a gentle curve 3cm posteriorly.
- Fat and fascia split in line to reveal gluteus medius and vastus lateralis
- Excise the trochanteric bursa and feel with a finger for the piriformis fossa and the anterior edge of the gluteus medius.

- Pass forceps orthograde from piriformis fossa and over superior neck, down over the femur and piercing the capsule laterally. Use this to then pass a Gigli saw retrograde.

- A pin or spike is then passed from the centrally on the lateral surface of the greater trochanter, just below the vastus lateralis ridge, at a 45° angle to the femoral shaft.

- The saw is then used and pulled distally to make the osteotomy. It angles over the pin to produce a biplanar cut. (The hip is again flexed, adducted and internally rotated during the sawing)

- Incise the postero-inferior capsule and labrum down to the acetabular margin and the hip is dislocated by adduction only.

- A Charnley pin is placed above the superior margin of the acetabulum, and an east-west retractor placed against the pin and medial femoral neck. A north-south retractor is also placed. A Hohmann can be placed beneath the TAL to complete the acetabulum exposure.

<table>
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<th>Trochanteric osteotomy</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>- Wide exposure of the acetabulum for complex reconstruction.</td>
<td>- Technically challenging for inexperienced surgeon</td>
</tr>
<tr>
<td>- Good visualization of the femoral canal (e.g. for removing cement at revision surgery)</td>
<td>- Potential weakening of proximal femoral ring — may be important if uncemented prosthesis to be used</td>
</tr>
<tr>
<td>- Trochanter advancement possible if femoral shortening is required</td>
<td>- Risk of trochanteric non-union</td>
</tr>
<tr>
<td>- Ankylosed hip — neck can easily be cut in situ</td>
<td>- Requirement for restricted activity until trochanter united</td>
</tr>
<tr>
<td>- Noncompliant patient (e.g. elderly or with Parkinson’s disease) at risk for posterior dislocation</td>
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</table>
Joint Replacement Tribology

- Cartilage does not act as a shock absorber as it does not absorb the energy of impact.
  - Rather it deforms to load, and distributes the force over a wider area and reducing contact stress

- Fluid film lubrication occurs when there is a continuous film of fluid separating the articular surfaces
  - Entrainment – relative motion of articulating surfaces pulls fluid into the area of contact
  - Squeeze film – occurs when two surfaces suddenly move together and trap pools of fluid

- Film thickness is proportional to:
  - Equivalent radius of bearing = product of radii of bearing surfaces divided by the gap / clearance between them. Thus the better conformation (assisted by cartilage deformation) the lower the clearance and the more the fluid thickness
  - Viscosity of lubricant – reduced in arthritis, resulting in loss of fluid film lubrication and direct contact and cartilage degradation
  - Sliding velocity (entrainment only)
  - Inversely proportional to the load
  - Inversely proportional to the material stiffness (less deformation and conformity)

- During gait cycle, the heel strike and stance phase correspond to squeeze film formation, while the swing phase involved high velocity and low load which replenishes fluid film through entrainment.

- Lambda ratio (λ) – predicted fluid film thickness to the combined surface roughness of articulating surfaces
  - If $\lambda > 3 \rightarrow$ fluid thickness is greater than combined roughness, and a complete film layer separates bearing surfaces. Ceramic-on-ceramic bearings are more polished than metal or polyethylene resulting in lower roughness, high wettability and reduced radial clearance (better conformity) – all of which improve fluid thickness to allow for complete fluid film lubrication
  - If $\lambda < 1 \rightarrow$ fluid thickness is less than combined roughness, and interactions exist between asperities (bumps) on the bearing surfaces, resulting in boundary lubrication
  - If $\lambda 1 – 3 \rightarrow$ a mixed lubrication regime is in place. Metal on metal bearings where design features improve lubrication performance.
Wear process

- Abrasive – surface asperities of a harder surface wear away the asperities from the softer surface; smaller wear particles
- Adhesive – asperities on two surfaces stick together when in contact resulting in cyclical shear forces each time movement starts and stops
- Fatigue – cyclical loading to stress greater than the material’s fatigue strength

Wear rate

- Linear = reduction in thickness – steady state linear wear is around 0.1 mm per year for a well functioning acetabular polyethylene cup
- Volumetric = total amount – so for larger bearings, the linear rate may be low, but the volumetric rate high.
- Historically acetabular cups were irradiated in oxygen and not vacuum packed. Thus there was more free radical generation during sterilisation a higher exposure to oxygen in the packaging than in vivo, resulting in a reduction in fatigue strength by up to 80%.

Corrosion – usually from oxidation of surface layer of metal, which may be worn away with motion (e.g. modular junction, or head-neck taper), allowing more oxidation and a continual corrosive wear cycle.

- Alternatively within actual bearing surfaces, the oxidative layer combined with local heat generation and the biological fluid to form a “tribochemical” film which actually protects against further wear.

Bone Defects in Revision Surgery

Acetabular (AAPS classification)

I. Segmental – think about normal cemented prostheses
II. Cavitatory – think about impaction grafting
III. combined
IV. discontinuity – think about cages or augments
V. arthrodesis

Femoral (Papsoky classification)

I. Minimal metaphyseal bone loss – cemented prosthesis ± impaction grafting or cement in cement technique
II. Metaphyseal loss, but diaphysis intact – uncemented with distal fit stem
III. Metaphyseal and diaphyseal damage
   A. Greater than 4cm of isthmus intact – allows uncemented distal fitting cylindrical stem
   B. Less than 4 cm of isthmus – may need to think about long stem prosthesis with distal interlocking screws
IV  Extensive metaphyseal and diaphyseal damage – tumour prostheses?

- Periprosthetic fracture (Vancouver classification)
  A  Proximal fracture (lesser or greater trochanter involvement)
  B  Around the stem
     1  Stem well fixed
     2  Stem loose
     3  Stem loose with severe bone loss
  C  Distal to tip of stem

The Infected Hip Replacement

- Risk factors:
  - Length of procedure
  - Number of previous operative interventions
  - Rheumatoid arthritis
  - Diabetes
  - Sickle cell disease
  - Obesity
  - Poor nutrition
  - Immunosuppressives (e.g. DMARDs or steroids)
  - History of osteomyelitis or septic arthritis
  - Presence of open skin lesion on the affected extremity
  - Perioperative UTI or dental infection
  - Perioperative SSSI

- 85% to 90% infections caused by Staphylococcus aureus or epidermidis
  - Resistance dependent on ability of bacteria to produce a biofilm of glycocalx (polysaccharides) that enable bacteria to adhere to and survive on surface of prosthesis, shielded from antibiotics.

- Vancomycin and aminoglycosides are synergistic. Palacos cement allows higher concentrations of antibiotics to leach than other cements, and when combined with gentamicin is more resistant to fracture.
  - Up to 20-times the MIC recorded in drainage fluid.

- Classification:
  - Positive intra-operative cultures found on undertaking revision → treat with 6 weeks targeted IV antibiotics and no additional surgery
  - Early post-operative (less than 1 month) → debridement and targeted IV antibiotics, with retention of prosthesis. Success rate up to 50%
  - Late chronic infections (more than 1 month) → removal of prosthesis and staged revision. Success rate up to 90%
    - Antibiotic spacers can be used to achieve up to 200-times systemic concentrations. Usually around 20g antibiotic per 40g cement, or 100g amphotericin B per 40g cement (against fungal infection)
  - Acute haematogenous infections → debridement of joint and prosthesis retention if well fixed. Staged revision if loose.
- Raised CRP is sensitive marker, as usually peaks at 48 hours after primary surgery and settles after 2-3 weeks.
  - Persistant CRP > 10 and ESR > 30 is 96% sensitive and 92% specific (Spangehl, JBIB 1999)

- Patients with raised inflammatory markers and a troublesome hip replacement should undergo hip aspiration for microbiological assessment.
  - Sensitivity up to 93%, and specificity up to 97%.

- Salvage options reserved for patients refusing or unfit for revision surgery, or unable to comply with post-operative regime:
  - Antibiotic suppression
  - Girdlestone arthroplasty – warn of up to 3 cm shortening
  - Arthrodesis – for younger patient
  - Amputation