Developmental Dysplasia of the Hip
• Previously known as congenital dislocation of the hip implying a condition that existed at birth

• developmental encompasses embryonic, fetal and infantile periods

• includes congenital dislocation and developmental hip problems including subluxation, dislocation and dysplasia
Normal Growth and Development

• Embryologically the acetabulum, femoral head develop from the same primitive mesenchymal cells
• cleft develops in precartilaginous cells at 7th week and this defines both structures
• 11wk hip joint fully formed
• acetabular growth continues throughout intrauterine life with development of labrum
• birth femoral head deeply seated in acetabulum by surface tension of synovial fluid
• in DDH this shape and tension is abnormal in addition to capsular laxity
• The cartilage complex is 3D with triradiate medially and cup-shaped laterally

• interposed between ilium above and ischium below and pubis anteriorly

• acetabular cartilage forms outer 2/3 cavity and the non-articular medial wall form by triradiate cartilage which is the common physis of these three bones

• fibrocartilaginous labrum forms at margin of acetabular cartilage and joint capsule inserts just above its rim
• articular cartilage covers portion articulating with femoral head opposite side is a growth plate with degenerating cells facing towards the pelvic bone it opposes

• triradiate cartilage is triphalanged with each side of each limb having a growth plate which allows interstitial growth within the cartilage causing expansion of hip joint diameter during growth

• In the infant the greater trochanter, proximal femur and intertrochanteric portion is cartilage

• 4-7 months proximal ossification center appears which enlarges along cartilaginous anlage until adult life when only thin layer of articular cartilage persists
Development can’t

• Experimental studies in humans with unreduced hips suggest the main stimulus for concave shape of the acetabulum is presence of spherical head
• For normal depth of acetabulum to increase several factors play a role
  – Spherical femoral head
  – Normal appositional growth within cartilage
  – Periosteal new bone formation in adjacent pelvic bones
  – Development of three secondary ossification centers
• Normal growth and development occur through balanced growth of proximal femur, acetabulum and triradiate cartilages and the adjacent bones
DDH

- Tight fit between head and acetabulum is absent and head can glide in and out of acetabulum

- Hypertrophied ridge of acetabular cartilage in superior, posterior and inferior aspects of acetabulum called “neolimbus”

- Often a trough or groove in this cartilage due to pressure from femoral head or neck

- 98% DDH that occur around or at birth have these changes and are reversible in the newborn

- 2% newborns with teratologic or antenatal dislocations and no syndrome have these changes
Development in treated DDH different from normal hip

- goal is to reduce the femoral head asap to provide the stimulus for acetabular development
- if concentric reduction is maintained potential for recovery and resumption of normal growth
- age at which DDH hip can still return to normal is controversial depends on
  - age at reduction
  - growth potential of acetabulum
  - damage to acetabulum from head or during reduction
- accessory centers seen in 2-3% normal hips however in treated DDH seen up to 60% appearing ages 6 months to 10 years (should look for these on radiographs to indicate continued growth)
Epidemiology

- 1 in 100 newborns examined have evidence of instability (positive Barlow or Ortolani)

- 1 in 1000 live births true dislocation

- Most detectable at birth in nursery

- Barlow stated that 60% stabilize in 1st week and 88% stabilize in first 2 months without treatment remaining 12% true dislocations and persist without treatment

- Coleman: 26% become dislocated, 13% partial contact 39% located but dysplastic features 22% normal
Etiology

• Genetic and ethnic
  • increased native Americans but very low in southern Chinese and Africans
• positive family history 12-33%
• 10x risk if affected parent, 7X if sibling
• intrauterine factors
  – breech position (normal pop’n 2-4%, DDH 17-23%)
  – oligohydroamnios
  – neuromuscular conditions like myelomeningocele
• high association with intrauterine molding abnormalities including metatarsus adductus and torticollis
• first born
• female baby (80% cases)
• left hip more common
Diagnosis

• Clinical risk factors
• Physical exam
  – Ortolani Test
    • hip flexion and abduction, trochanter elevated and femoral head glides into acetabulum
  – Barlow Test
    • provocative test where hip flexed and adducted and head palpated to exit the acetabulum partially or completely over a rim
  – some base there treatment on whether ortolani+ versus Barlow+ feeling Barlow + more stable
  – Lovell and Winter make no distinction
  – 2% extreme complete irreducible teratologic dislocations assoc with other conditions like arthrogryposis
Late Diagnosis

- Secondary adaptive changes occur
- Limitation of abduction due to adductor longus shortening
  - Galleazi sign
    - Flex both hips and one side shows apparent femoral shortening
- Asymmetry gluteal, thigh or labial folds
- Limb-length inequality
- Waddling gait and hyperlordosis in bilateral cases
Radiography

- Ultra sound
- morphologic assessment and dynamic
  - anatomical characteristics
    - alpha angle: slope of superior aspect bony acetabulum
    - beta angle: cartilaginous component (problems with inter and intraobserver error)
  - dynamic
    - observe what occurs with Barlow and ortolani testing
- indications controversial due to high levels of overdiagnosis and not currently recommended as a routine screening tool other than in high risk patients
- best indication is to assess treatment
  - guided reduction of dislocated hip or check reduction and stability during Pavlik harness treatment
Radiography con’t

• newborn period DDH not a radiographic diagnosis and should be made by clinical exam

• after newborn period diagnosis should be confirmed by xray

• several measurements

• treatment decisions should be based on changes in measurements
Radiological Diagnosis

• classic features
  – increased acetabular index (n=27, >30-35 dysplasia)
  – disruption shenton line (after age 3-4 should be intact on all views)
  – absent tear drop sign
  – delayed appearance ossific nucleus and decreased femoral head coverage
  – failure medial metaphyseal beak of proximal femur, secondary ossification center to be located in lower inner quadrant
  – center-edge angle useful after age 5 (< 20) when can see ossific nucleus
Natural History in Newborns

- **Barlow**
  - 1 in 60 infants have instability (positive Barlow)
  - 60% stabilize in 1st week
  - 88% stabilize in 2 months without treatment
  - 12% become true dislocations and persist

- **Coleman**
  - 23 hips < 3 months
  - 26% became dislocated
  - 13% partial contact with acetabulum
  - 39% located but dysplastic feature
  - 22% normal

- because not possible to predict outcome all infants with instability should be treated
Adults

- Variable
- depends on 2 factors
  - well developed false acetabulum (24% chance good result vs 52% if absent)
  - bilaterality
- in absence of false acetabulum patients maintain good ROM with little disability
- femoral head covered with thick elongated capsule
- false acetabulum increases chances degenerative joint disease
- hyperlordosis of lumbar spine assoc with back pain
- unilateral dislocation has problems
  - leg length inequality, knee deformity, scoliosis and gait disturbance
FIGURE 23-6. Untreated dislocation of the hip. Note the lack of the concave shape and the shallowness of the acetabulum.
Dysplasia and Subluxation

- **Dysplasia (anatomic and radiographic def’n)**
  - inadequate dev of acetabulum, femoral head or both
  - all subluxated hips are anatomically dysplastic

- radiologically difference between subluxated and dysplastic hip is disruption of Shenton’s line
  - subluxation: line disrupted, head is superiorly, superolaterally or laterally displaced from the medial wall
  - dysplasia: line is intact

- important because natural history is different
Natural History Con’t

• Subluxation predictably leads to degenerative joint disease and clinical disability
  – mean age symptom onset 36.6 in females and 54 in men
  – severe x-ray changes 46 in female and 69 in males
• Cooperman
  – 32 hips with CE angle < 20 without subluxation
  – 22 years all had x-ray evidence of DJD
  – no correlation between angle and rate of development
  – concluded that radiologically apparent dysplasia leads to DJD but process takes decades
Treatment 0 to 6 months

- Goal is obtain reduction and maintain reduction to provide optimal env’t for femoral head and acetabular development

- Lovell and Winter
  - treatment initiated immediately on diagnosis

- AAOS (July, 2000)
  - subluxation often corrects after 3 weeks and may be observed without treatment
  - if persists on clinical exam or US beyond 3 weeks treatment indicated
  - actual dislocation diagnosed at birth treatment should be immediate
Treatment con’t

• Pavlik Harness preferred
  – prevents hip extension and adduction but allows flexion and abduction which lead to reduction and stabilization
  – success 95% if maintained full time six weeks
  – > 6 months success < 50% as difficult to maintain active child in harness
Pavlik Harness

- Chest strap at nipple line
- Shoulder straps set to hold cross strap at this level
- Anterior strap flexes hip 100-110 degrees
- Posterior strap prevents adduction and allow comfortable abduction
- Safe zone arc of abduction and adduction that is between redislocation and comfortable unforced abduction
Pavlik con’t

- Indications include presence of reducible hip femoral head directed toward triradiate cartilage on x-ray
- follow weekly intervals by clinical exam and US for two weeks if not reduced other methods pursued
- once successfully reduced harness continued for child's age at stability + 3 months
- worn full time for half interval if stability continues and then weaned off
- end of weaning process x-ray pelvis obtained and if normal discontinue harness
Complications

• Failure
  – poor compliance, inaccurate position and persistence of inadequate treatment (> 2-3- weeks)
  – subgroup where failure may be predictable Viere et al
    • absent Ortolani sign
    • bilateral dislocations
    • treatment commenced after age 7 week
  – Treatment closed reduction and Spica Casting
    • Femoral Nerve Compression 2 to hyperflexion
    • Inferior Dislocation
    • Skin breakdown
    • Avascular Necrosis
6 months to 2 years age

- Closed reduction and spica cast immobilization recommended

- Traction controversial with theoretical benefit of gradual stretching of soft tissues impeding reduction and neurovascular bundles to decrease AVN

- Skin traction preferred however vary with surgeon

- Usually 1-2 weeks

- Scientific evidence supporting this is lacking
Treatment con’t

• closed reduction preformed in OR under general anesthetic manipulation includes flexion, traction and abduction

• percutaneous or open adductor tenotomy necessary in most cases to increase safe zone which lessen incidence of proximal femoral growth disturbance

• reduction must be confirmed on arthrogram as large portion of head and acetabulum are cartilaginous

• dynamic arthrography helps with assessing obstacles to reduction and adequacy of reduction
Treatment

• reduction maintained in spica cast well molded to greater trochanter to prevent redislocation

• human position of hyperflexion and limited abduction preferred

• avoid forced abduction with internal rotation as increased incidence of proximal femoral growth disturbance

• cast in place for 6 weeks then repeat Ct scan to confirm reduction

• casting continued for 3 months at which point removed and xray done then placed in abduction orthotic device full time for 2 months then weaned
Arthrogram of a 5-year-old white girl 3 years after reduction. Note the excellent coverage of the femoral head acetabular cartilage.
Failure of Closed Methods

• Open reduction indicated if failure of closed reduction, persistent subluxation, reducible but unstable other than extremes of abduction

• variety of approaches
  – anterior smith peterson most common
    • allows reduction and capsular plication and secondary procedures
    • disadv- > blood loss, damage iliac apophysis and abductors, stiffness
greatest rate of acetabular development occurs in first 18 months after reduction
Open Reduction con’t

- medial approach (between adductor brevis and magnus)
  - approach directly over site of obstacles with minimal soft tissue dissection
  - unable to do capsular plication so depend on cast for post op stability

- anteromedial approach Ludloff (between neurovascular bundle and pectineus)
  - direct exposure to obstacles, minimal muscle dissection
  - no plication or secondary procedures
  - increased incidence of damage to medial femoral circumflex artery and higher AVN risk
Follow-up

- Abduction orthotic braces commonly used until acetabular development caught up to normal side

- In assessing development look for accessory ossification centers to see if cartilage in periphery has potential to ossify

- Secondary acetabular procedure rarely indicated < 2 years as potential for development after closed and open procedures is excellent and continues for 4-8 years

- Most rapid improvement measured by acetabular index, development of teardrop occurs in first 18 months after surgery

- Femoral anteversion and coxa valga also resolve during this time
Obstacles to Reduction

- **Extra-articular**
  - Iliopsoas tendon
  - Adductors

- **Intra-articular**
  - Inverted hypertrophic labrum
  - Tranverse acetabular ligament
  - Pulvinar, ligamentum teres
  - Constricted anteromedial capsule espec in late cases

- Neolimbus is not an obstacle to reduction and represents epiphyseal cartilage that must not be removed as this impairs acetabular development
Age greater than 2 years

- Open reduction usually necessary

- Age > 3 femoral shortening recommended to avoid excess pressure on head with reduction

- 54% AVN and 32% redislocation with use of skeletal traction in ages > 3

- Age > 3 recommend open reduction and femoral shortening and acetabular procedure
Treatment con’t

• 2-3-years gray zone

• potential for acetabular development diminished therefore many surgeons recommend a concomitant acetabular procedure with open reduction or 6-8 weeks after

• JBJS Feb, 2002 Salter Innominate Osteotomy… Bohm,Brzuske incidence of AVN is greater with simultaneous open reduction and acetabular procedure
Treatment con’t

- Lovell and Winter
  - judge stability at time of reduction and if stable observe for period of time for development
  - if not developing properly with decreased acetabular index, teardrop then consider secondary procedure

- most common osteotomy is Salter or Pemberton

- anatomic deficiency is anterior and Salter provides this while Pemberton provides anterior and lateral coverage
Natural Sequelae

• Goal of treatment is to have radiographically normal hip at maturity to prevent DJD

• after reduction achieved potential for development continues until age 4 after which potential decreases

• child < 4 minimal dysplasia may observe but if severe than subluxations and residual dysplasias should be corrected

• when evaluating persistent dysplasia look at femur and acetabulum

• DDH deficiency usually acetabular side
Residual Dysplasia

• plain xray with measurement of CE angle and acetabular index

• young children deficiency anterior and adolescents can be global

• deformities of femoral neck significant if lead to subluxation
  – lateral subluxation with extreme coxa valga or anterior subluxation with excessive anteversion (defined on CT)
  – usually DDH patients have a normal neck shaft angle
• Dysplasia for 2-3-years after reduction proximal femoral derotation or varus osteotomy should be considered if excessive anteversion or valgus

• prior to performing these be sure head can be concentrically reduced on AP view with leg abducted 30 and internally rotated

• varus osteotomy done to redirect head to center of acetabulum to stimulate normal development

• must be done before age 4 as remodeling potential goes down after this
Adolescent or Adult

• Femoral osteotomy should only be used in conjunction with pelvic procedure as no potential for acetabular growth or remodeling but changing orientation of femur shifts the weightbearing portion

• Pelvic osteotomy considerations
  – age
  – congruent reduction
  – range of motion
  – degenerative changes
Pelvic Procedures

- Redirectional
  - Salter ( hinges on symphysis pubis)
  - Sutherland double innominate osteotomy
  - Steel ( Triple osteotomy)
  - Ganz ( rotational)

- Acetabuloplasties ( decrease volume )
  - hinge on triradiate cartilage ( therefore immature patients)
  - Pemberton
  - Dega ( posterior coverage in CP patients )

- Salvage
  - depend on fibrous metaplasia of capsule
  - shelf and Chiari
Complications of Treatment

- Worst complication is disturbance of growth in proximal femur including the epiphysis and physeal plate
  - commonly referred to as AVN however, no pathology to confirm this
  - may be due to vascular insults to epiphysis or physeal plate or pressure injury
  - occurs only in patients that have been treated and may be seen in opposite normal hip
Necrosis of Femoral Head

• Extremes of position in abduction (greater than 60 degrees) and abduction with internal rotation

• Compression on medial circumflex artery as it passes the iliopsoas tendon and compression of the terminal branch between lateral neck and acetabulum

• "Frog leg position" uniformly results in proximal growth disturbance
• extreme position can also cause pressure necrosis on epiphyseal cartilage and physeal plate

• severin method can obtain reduction but very high incidence of necrosis

• multiple classification systems with Salter most popular
Salter Classification

- 1. failure of appearance of ossific nucleus within 1 year of reduction
- 2. failure of growth of an existing nucleus within 1 year
- 3. broadening of femoral neck within 1 year
- 4. increased xray density then fragmentation of head
- 5. residual deformity of head when re-ossification complete including coxa magna, vara and short neck
Kalamachi

• Classified growth disturbances assoc with various degrees of physeal arrest
  • 1 all disturbances not assoc with physis
  • 2 lateral physeal arrest (most common)
  • 3 central physeal arrest
  • 4 medial physeal arrest

• longterm follow up shows that necrosis of femoral head decreases longevity of hip
Treatment

- Femoral and/or acetabular osteotomy to maintain reduction and shift areas of pressure
- trochanteric overgrowth causing an abductor lurch treated with greater trochanter physeal arrest if done before age 8 otherwise distal transfer
- early detection is key with 95% success rate of treatment
- identify growth disturbance lines