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

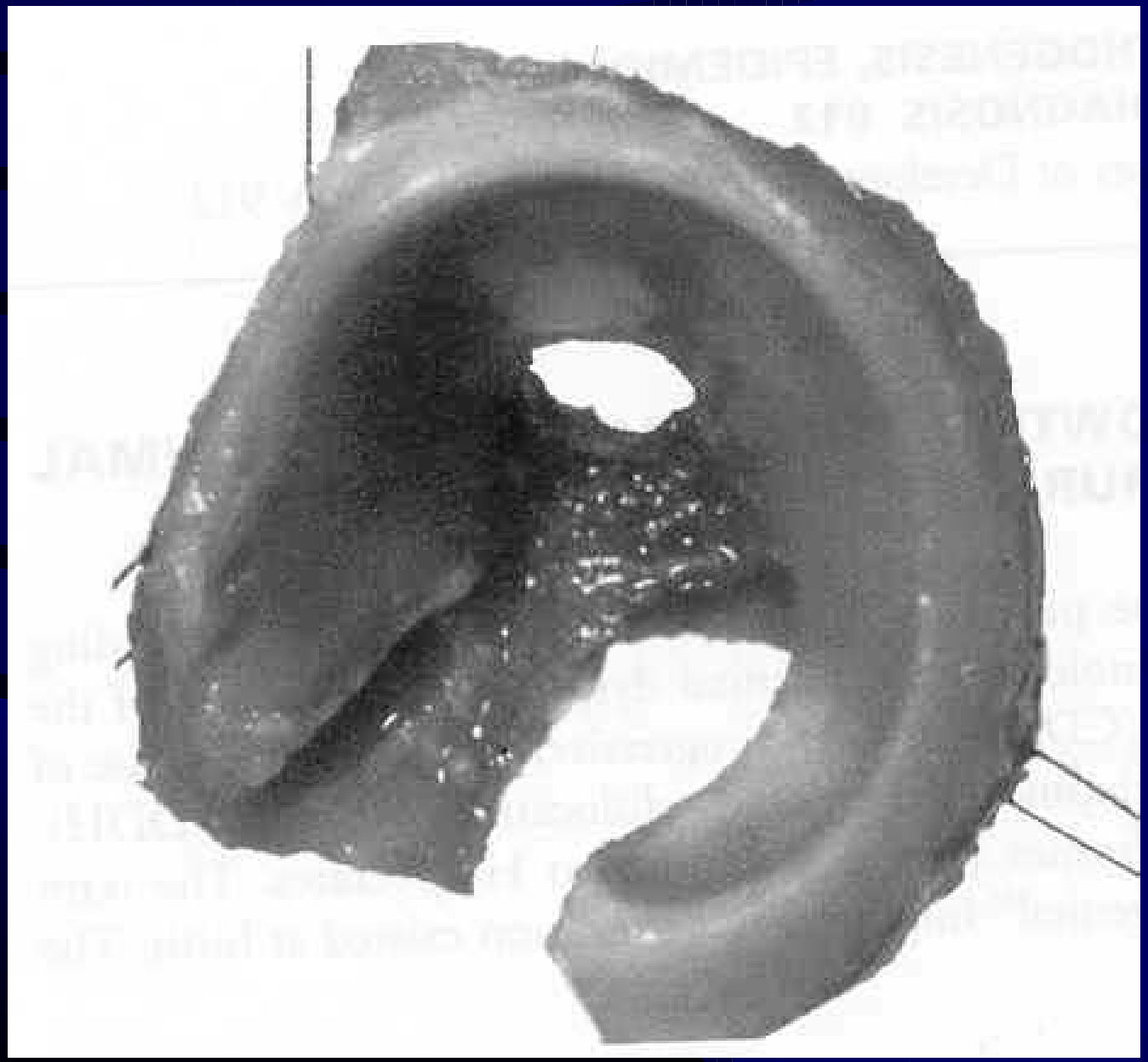
- The cartilage complex is 3D with triradiate medially and cup-shaped laterally
- interposed between ilium above and ischium below and pubis anteriorly
- acetabular cartilage forms outer 2/3 cavity and the non-articular medial wall form by triradiate cartilage which is the common physis of these three bones
- fibrocartilaginous labrum forms at margin of acetabular cartilage and joint capsule inserts just above its rim

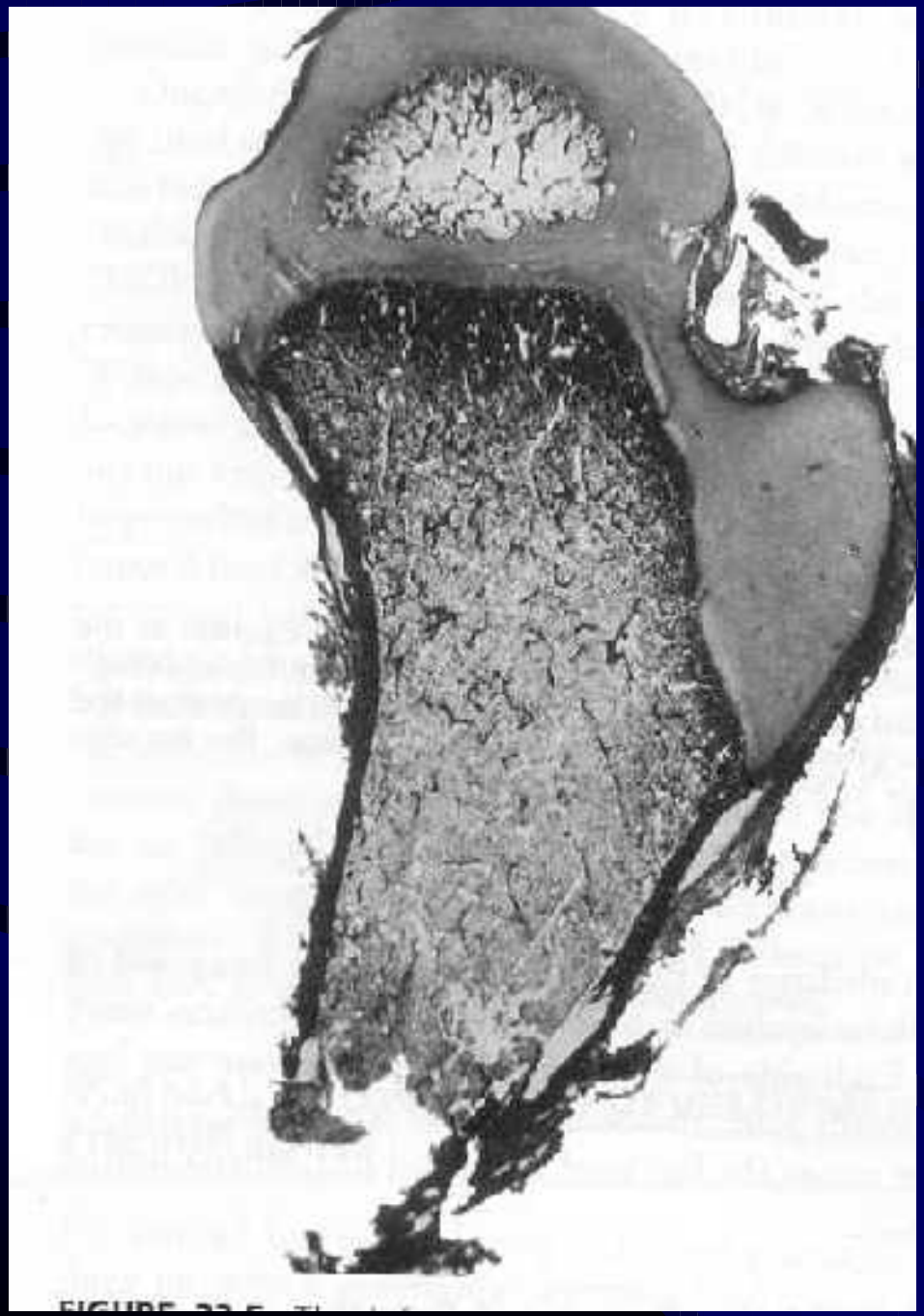
- articular cartilage covers portion articulating with femoral head opposite side is a growth plate with degenerating cells facing towards the pelvic bone it opposes

- 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 cpn'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 grove 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


B
A

- 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

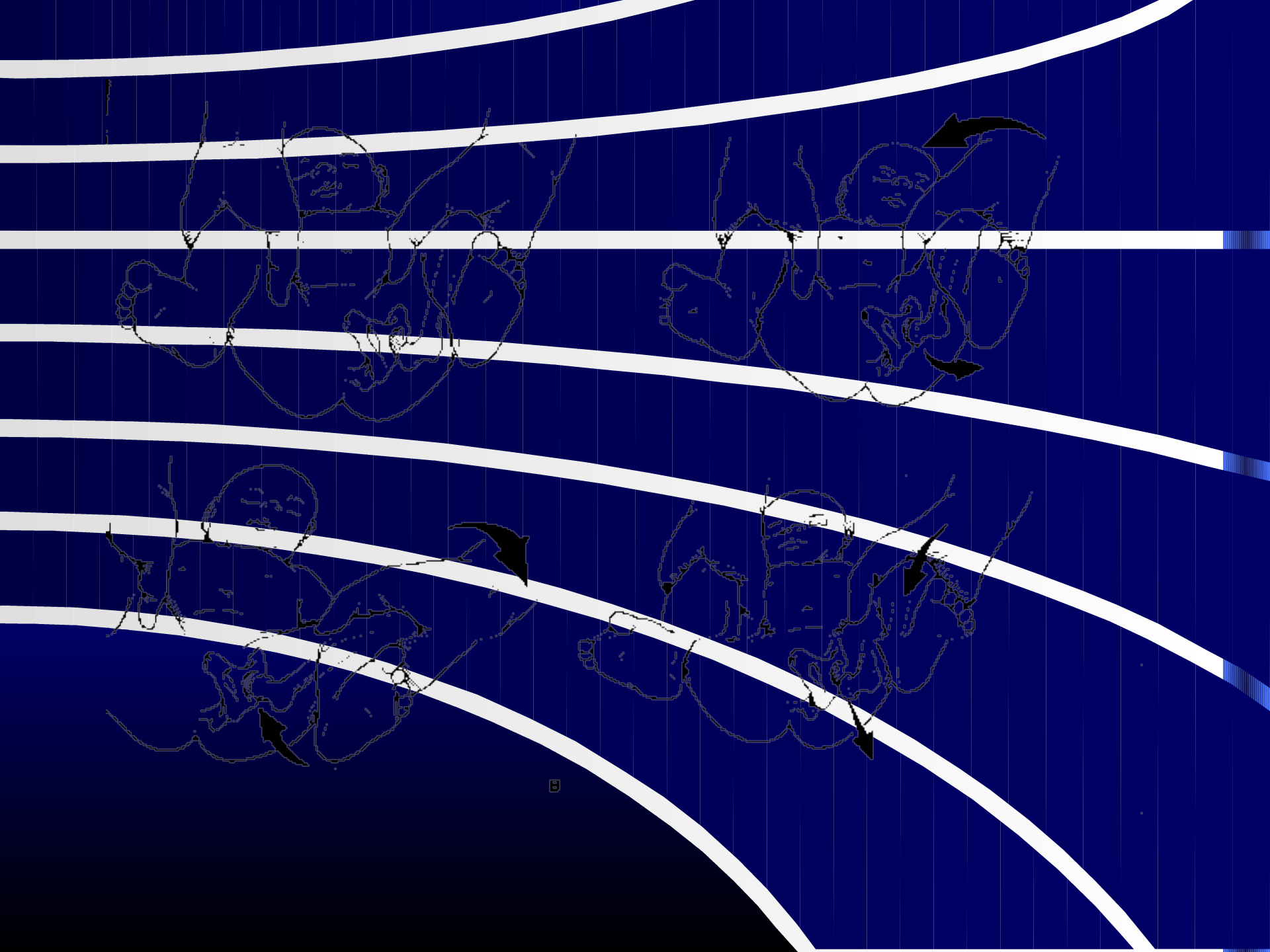
- 1 in 100 newborns examined have evidence of instability (positive Barlow or Ortolani)
- 1 in 1000 live births true dislocation
- most detectable at birth in nursery
- Barlow stated that 60% stabilize in 1st week and 88% stabilize in first 2 months without treatment remaining 12% true dislocations and persist without treatment
- Coleman26% become dislocated, 13% partial contact 39% located but dysplatic 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 disloactions assoc with other conditions like arthrogyposis



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 inequailty
- waddling gait and hyperlordosis in bilateral cases

Radiography

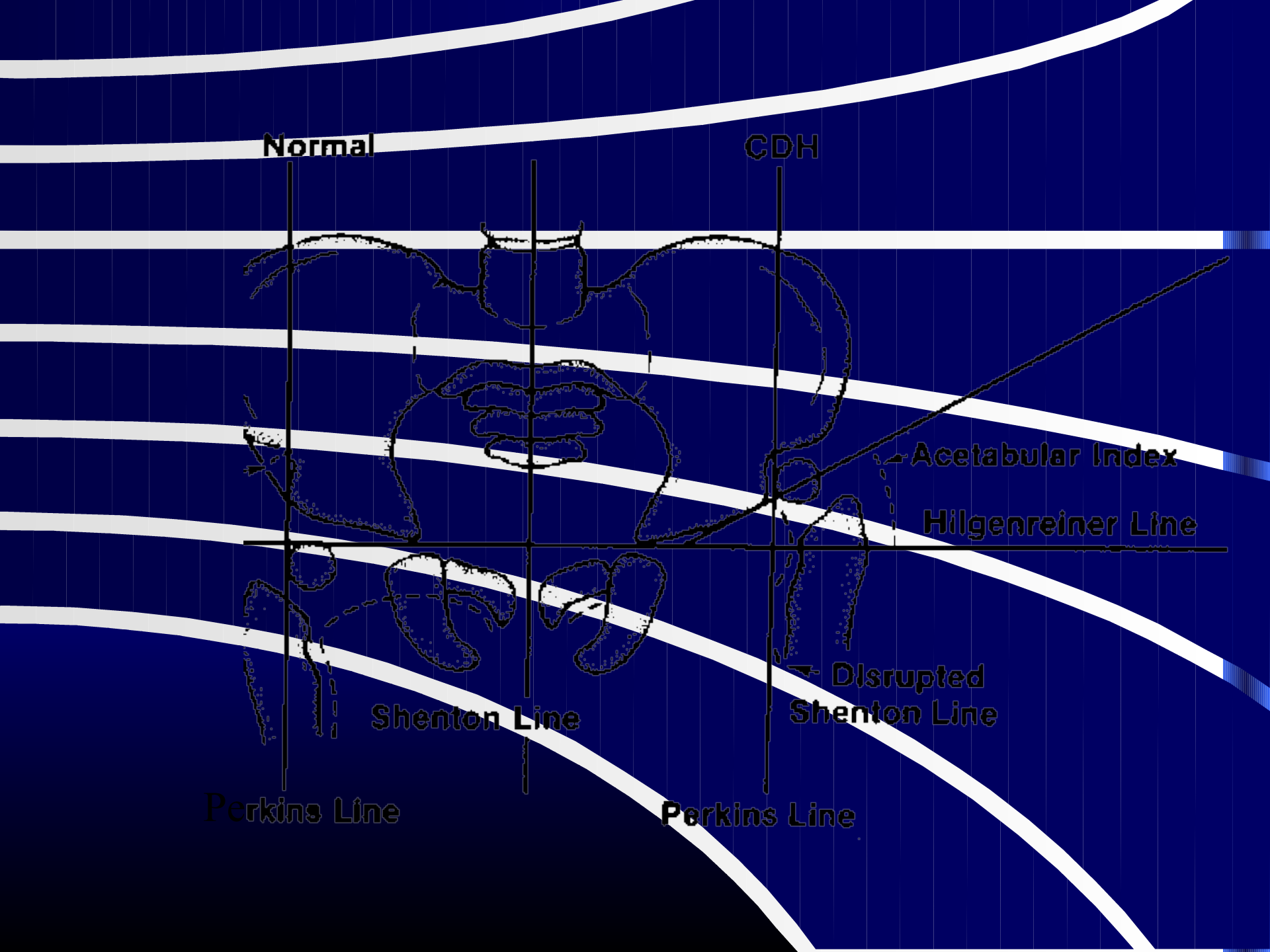
- Ultra sound
- morphologic assessment and dynamic
  - anatomical characteristics
    - alpha angle: slope of superior aspect bony acetabulum
    - beta angle: cartilaginous component (problems with inter and intraobserver error)
  - dynamic
    - observe what occurs with Barlow and ortolani testing
- 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


Normal
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Acetabular Index
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Shenton Line
Shenton Line
Perkins Line
Perkins Line

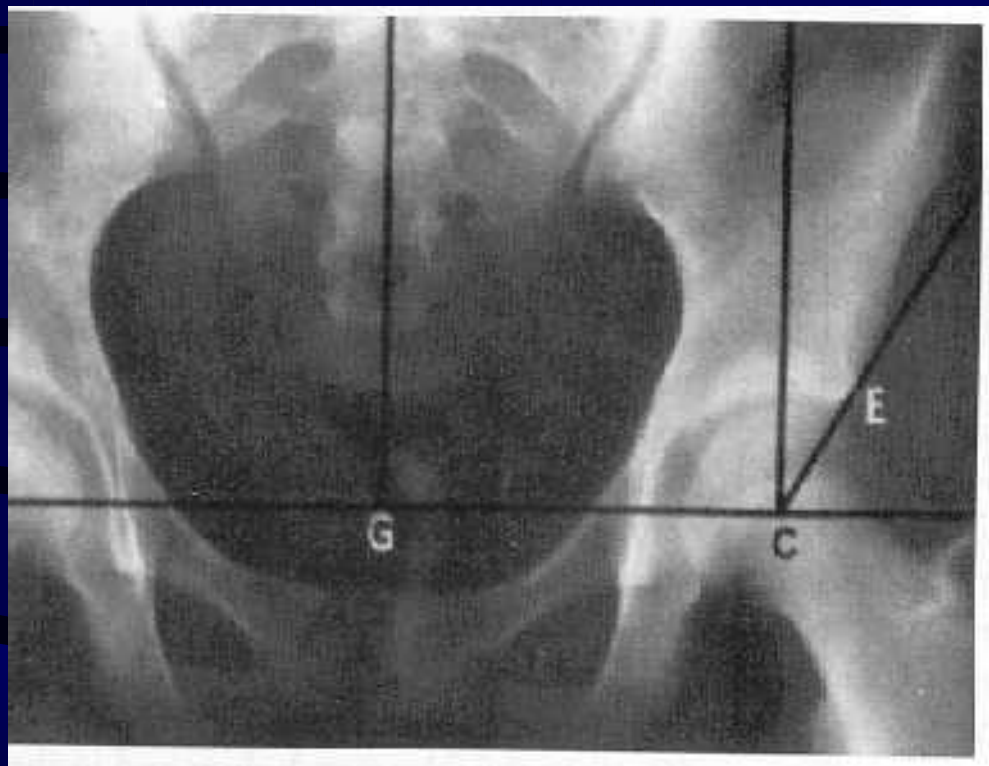

FIGURE 23-18.
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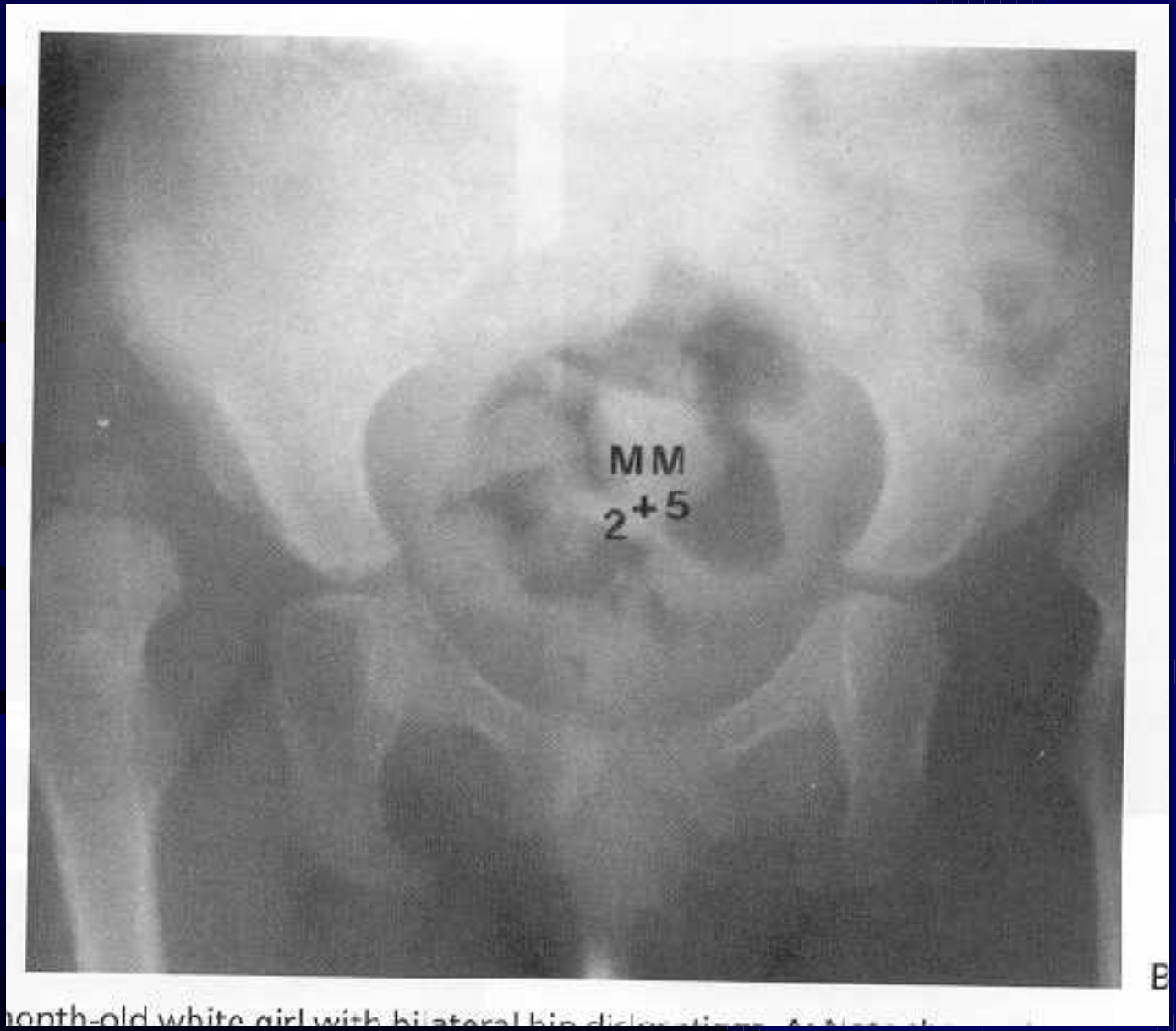
Natural History in Newborns

- 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 fac
the concave shape and the shallowness of the acetabulum.



B

month-old white girl with bilateral hip dislocations. A: Note th

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 ar laterally displaced from the medial wall
  - dysplasia: line is intact

- important because natural history is different


A
B

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 xray changes 46 in female and 69 in males
- Cooperman
  - 32 hips with CE angle < 20 without subluxation
  - 22 years all had xray 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 diagosed 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 xray
- follow weekly intervals by clinical exam and US for two weeks if not reduced other methods pursued
- once successfully reduced harness continued for childs age at stability + 3 months
- worn full time for half interval if stability continues and then weaned off
- end of weaning process xray 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
ction. Note the excellent coverage of the femoral
ied acetabular cartilage.

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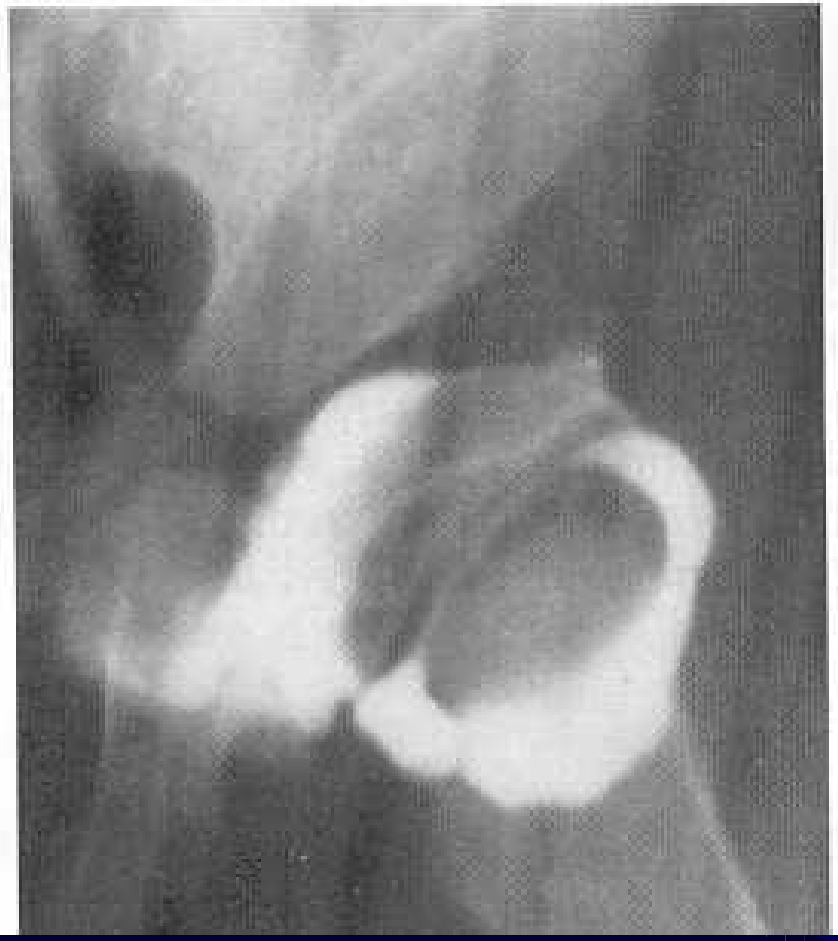

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Failure of Closed Methods

- 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 shoild 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
- occurrs 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 60 degrees) and abduction with internal rotation

- compression on medial circumflex artery as 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 onf 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 reduction2
- 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