

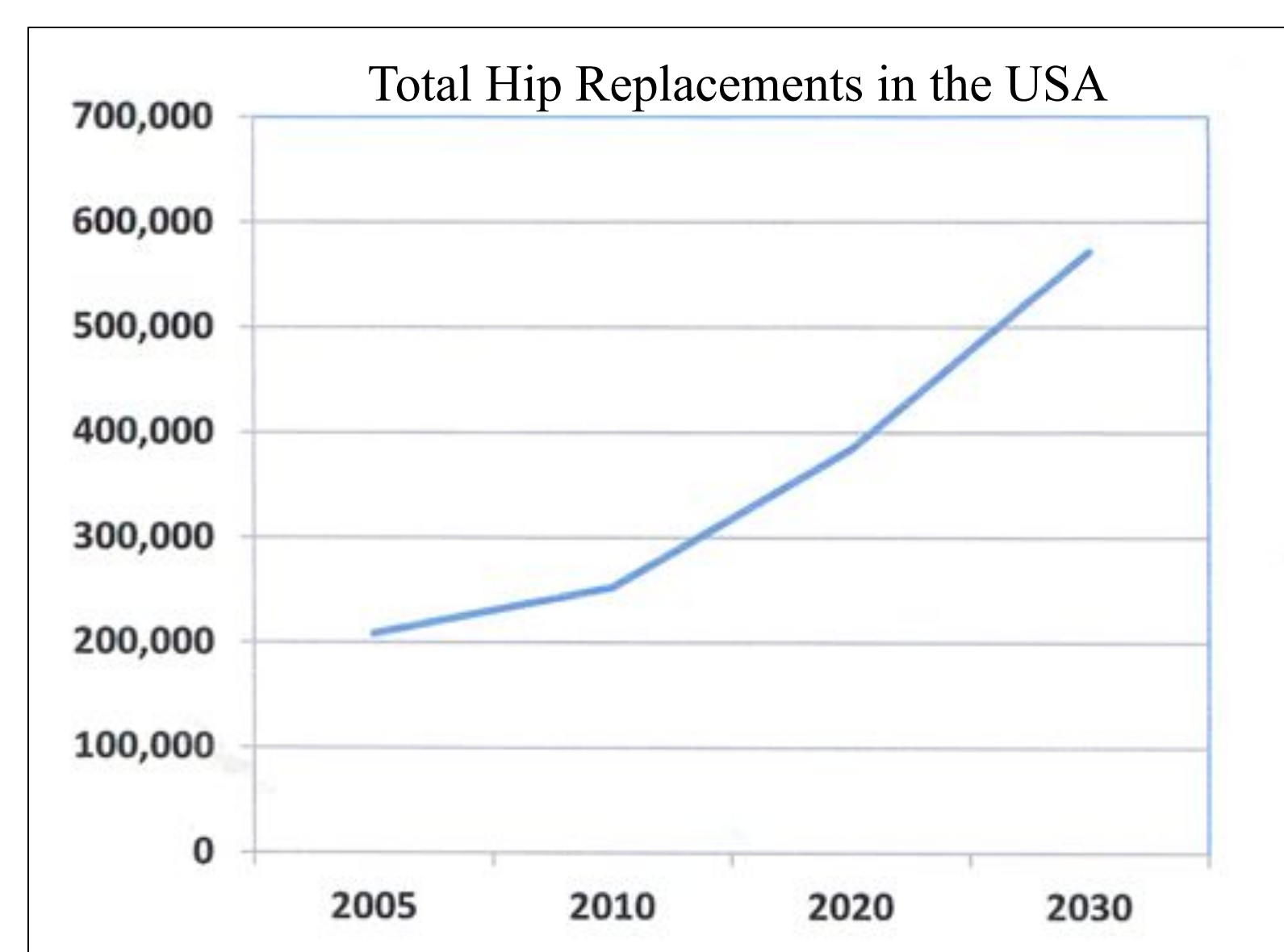
# Infantile DDH

HS Hosalkar, SJ Mubarak, EL Sink, K Mulpuri, CT Price

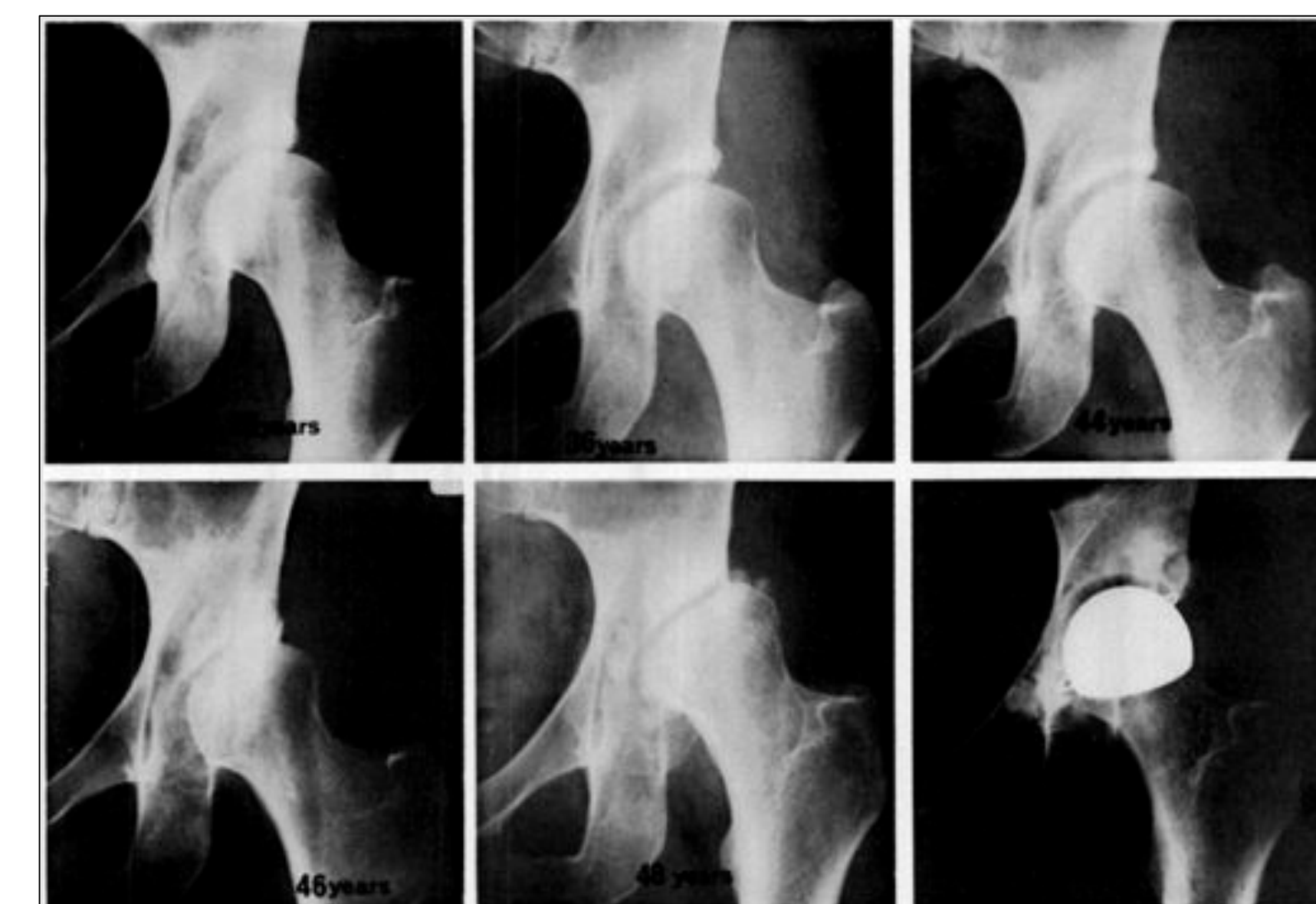
## Prevalence

5-10% of all total hip replacements are due to hip dysplasia

- Most common abnormality in newborn infants  
Clinical hip instability 1-3% of neonates  
Ultrasound hip dysplasia 5-15% of neonates  
~80% mild cases resolve spontaneously
- Neonatal hip instability accounts for <10% of hip dysplasia cases
- >90% of hip dysplasia presents in adolescents or adults



S Kurtz, et al. JBJS-Am 2007;89(4):780-5  
FT Hoaglund, LS Steinbach JAAOS 2001;9:320-7



JW Wedge, MJ Wasylenko, JBJS-Br 1979;61(3):334-8

## Etiology

- Genetics - familial and ethnic factors
- Hormonal  
Ligament laxity for delivery  
Ratio of Girls to Boys is 6 to 1
- Mechanical risk factors  
First Born  
Prolonged labor  
Left hip due to fetal position  
Torticollis  
Breech babies (25% hip instability)  
Swaddling to extend hips and knees



- More common in winter births except for breech infants
- More common in Northern climates

➤ This suggests environmental factors such as wrapping or nutritional insufficiencies

- Bjerkreim, Clin Genetics 1974;5:433
- R Chen, Am J Epidem 1970;92:287
- PJ Charlton, Med J Aust 1966;2:83

## Cultural Differences

### Chinese, Bantu, Nigerian

Rare hip dysplasia, rare hip arthritis in adults. Infants in these cultures are carried with hips abducted.

RB Salter, JBJS-Am 1966;48A:1413-39



FIG. 1. Backslings in Hong Kong Chinese. Hips are flexed and abducted.  
AR Hodgson, Brit Med J 1961;2:647



### Navajo Indians

**Before 1940** - Cradle board  
without diapers: 2.7% had  
hip dislocations  
**After 1960** - diapers introduced:  
0.7% had hip dislocations

DL Rabin, et al, Am J Public Health 1965;55(2):1-44



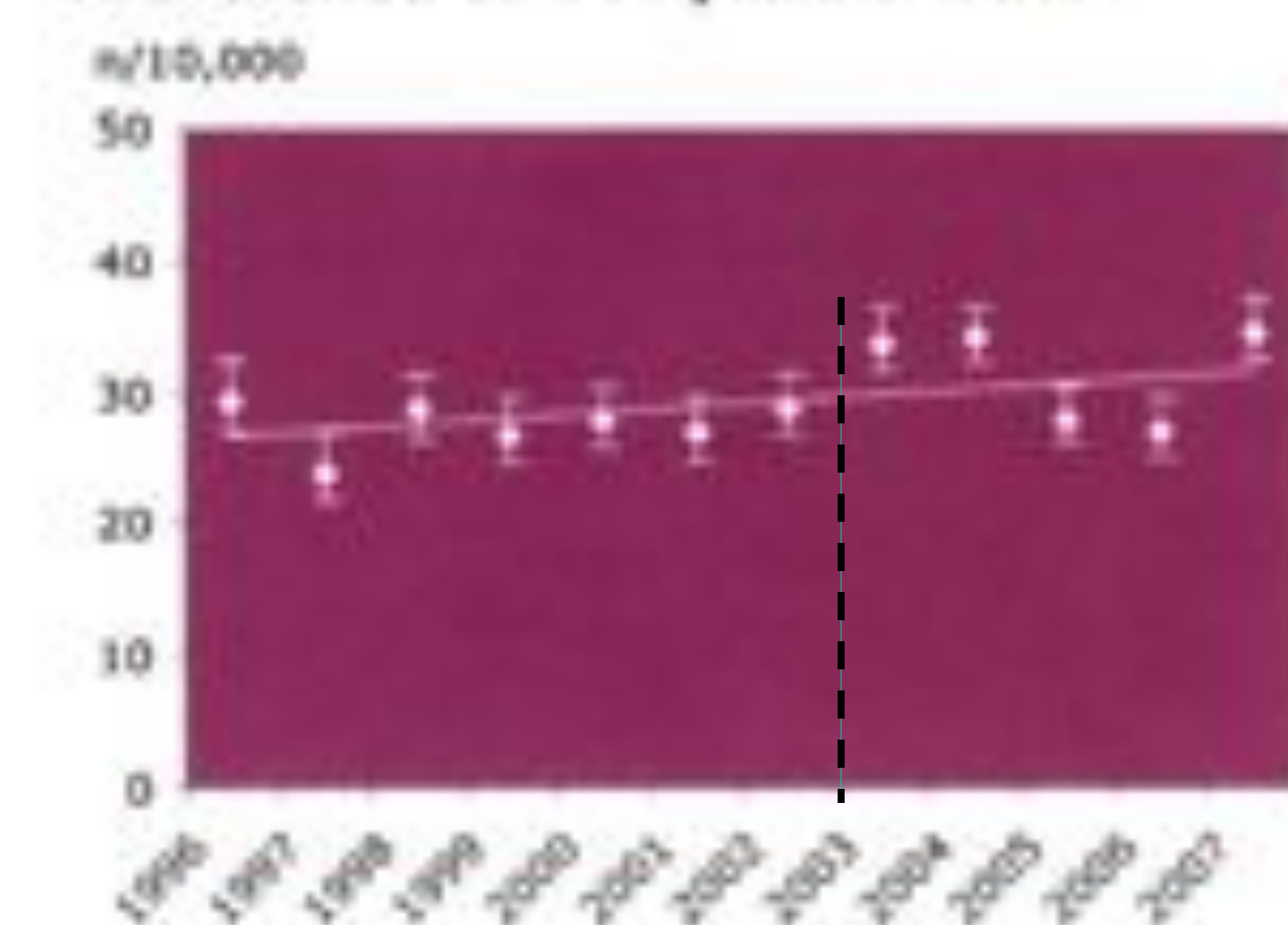
### Australia

**2003:** Increasing popularity of  
baby wrapping (Swaddling)

**After 2003:**  
• National increase in DDH  
• Increase by three fold in one  
region

N Williams, et al, MJA 2012;197(5):272

Prevalence of DDH, 1996-2007



### Japan

**1965:** 3% incidence of hip dislocation  
In spite of screening  
**1975:** National program eliminated swaddling  
**1984:** 0.2% incidence of hip dislocation

Yamamuro, Ishida CORR 1984;184:34-40





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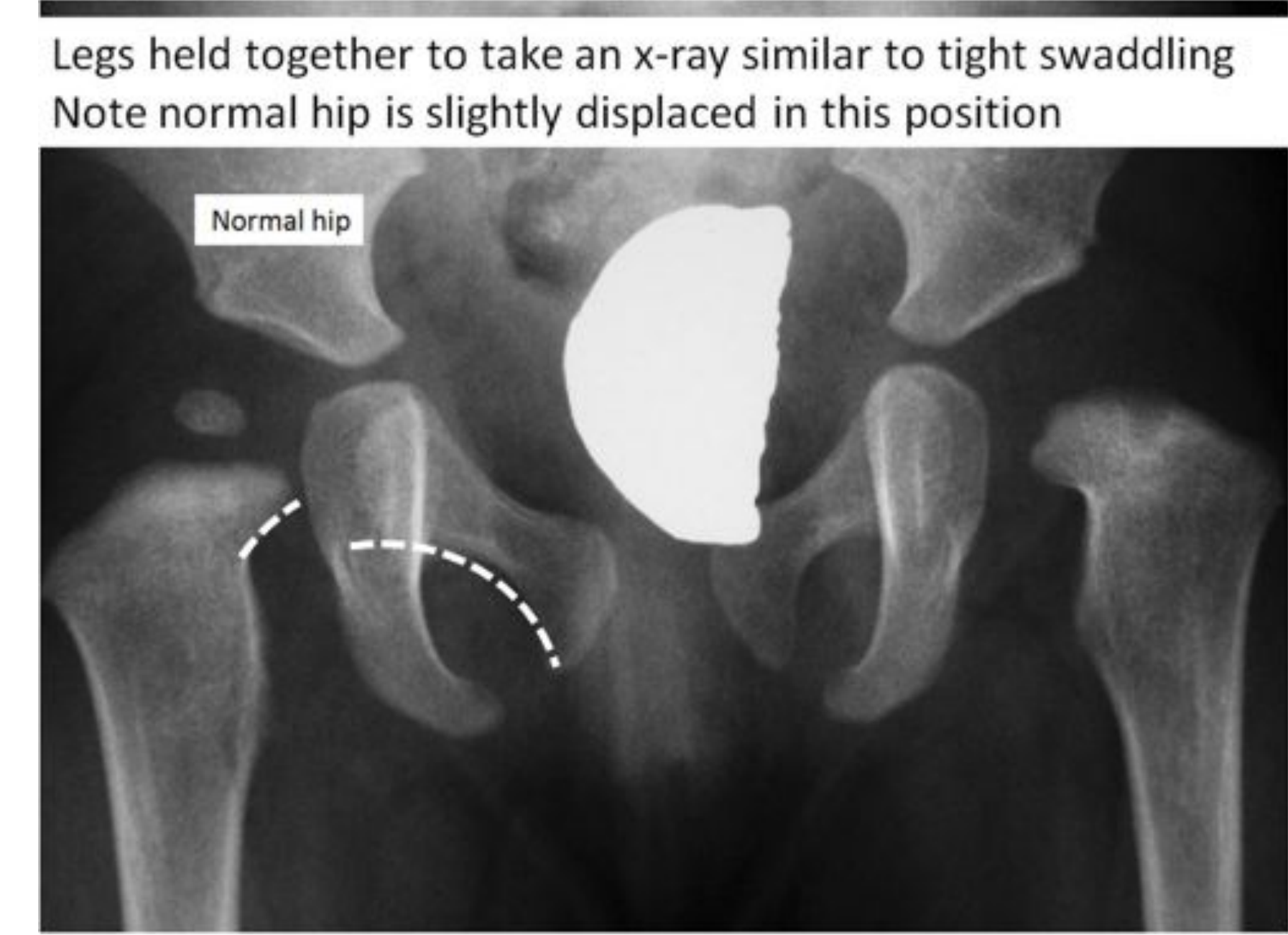
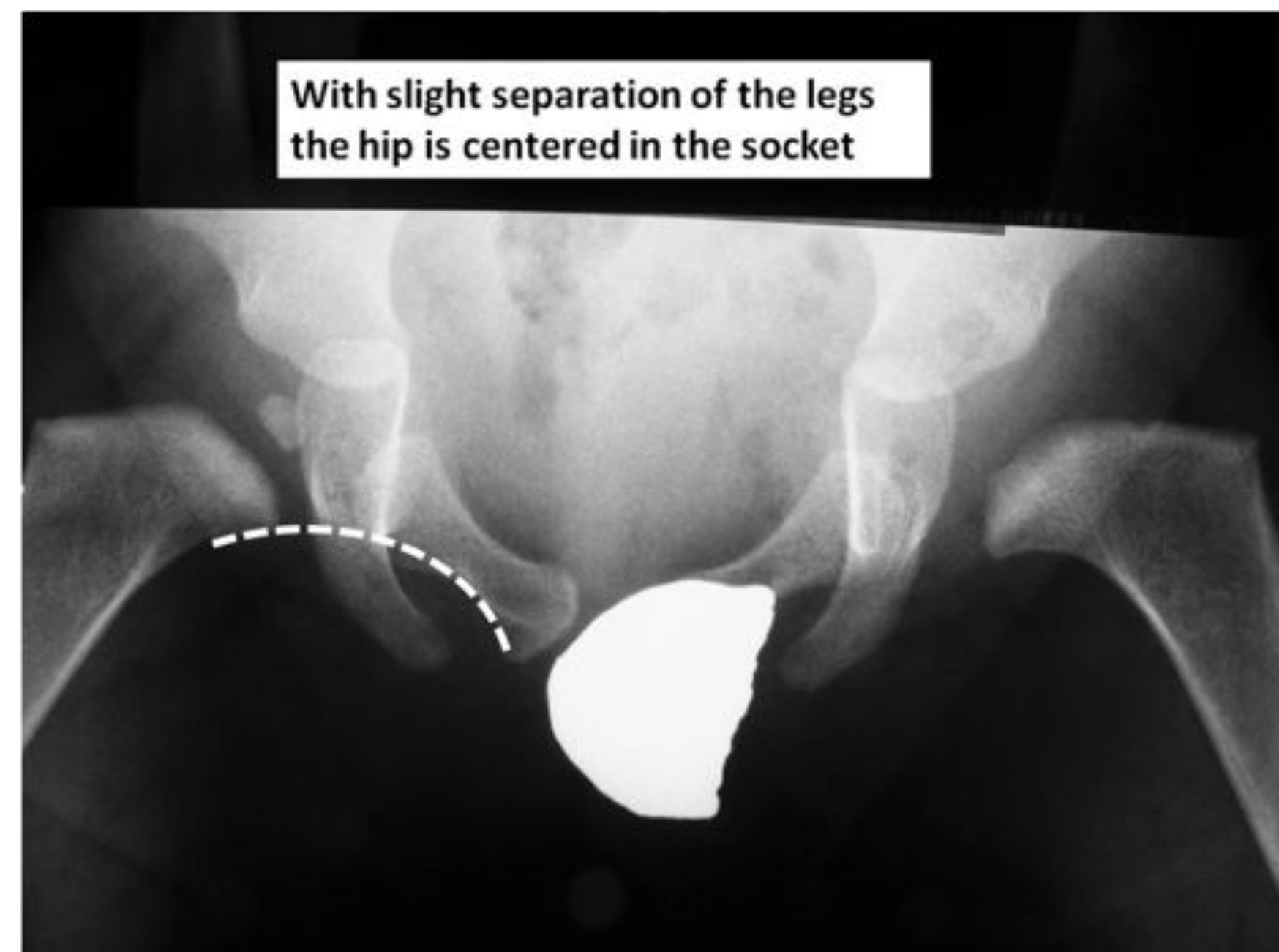
## PREVENTION

### Robert Salter, 1968

*“It is quite possible that if infants' hip joints were never suddenly passively extended either at birth or shortly after birth and if infants' hips were never maintained in extension and adduction for long periods during the early months of postnatal life, the initial dislocation in congenitally unstable or dislocatable hips might never occur”.*

Canadian Med Assoc J 1968;98(20):933-45

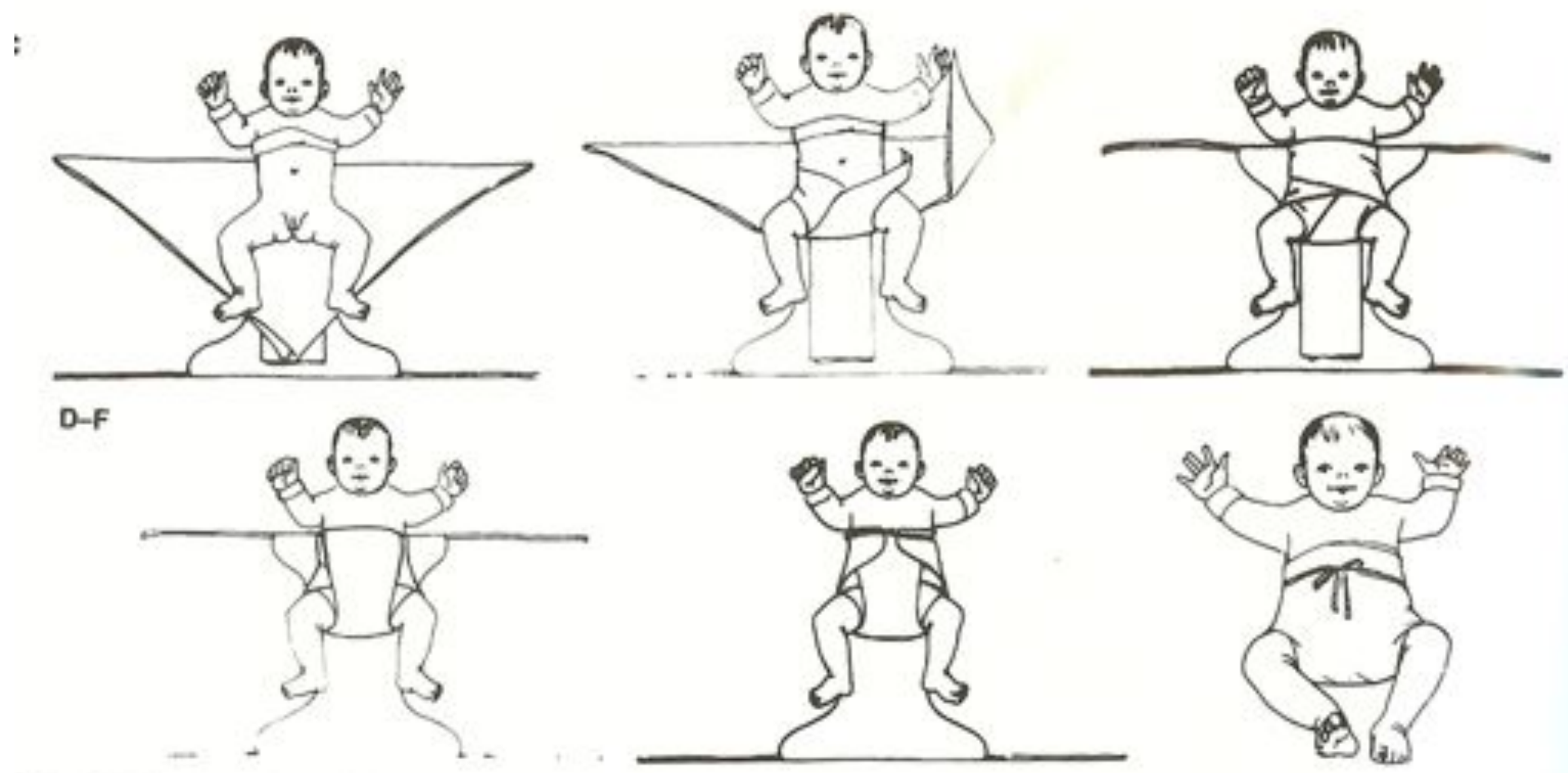
Newborn infants have hip  
and knee flexion contractures



### Klisc Method of Prevention

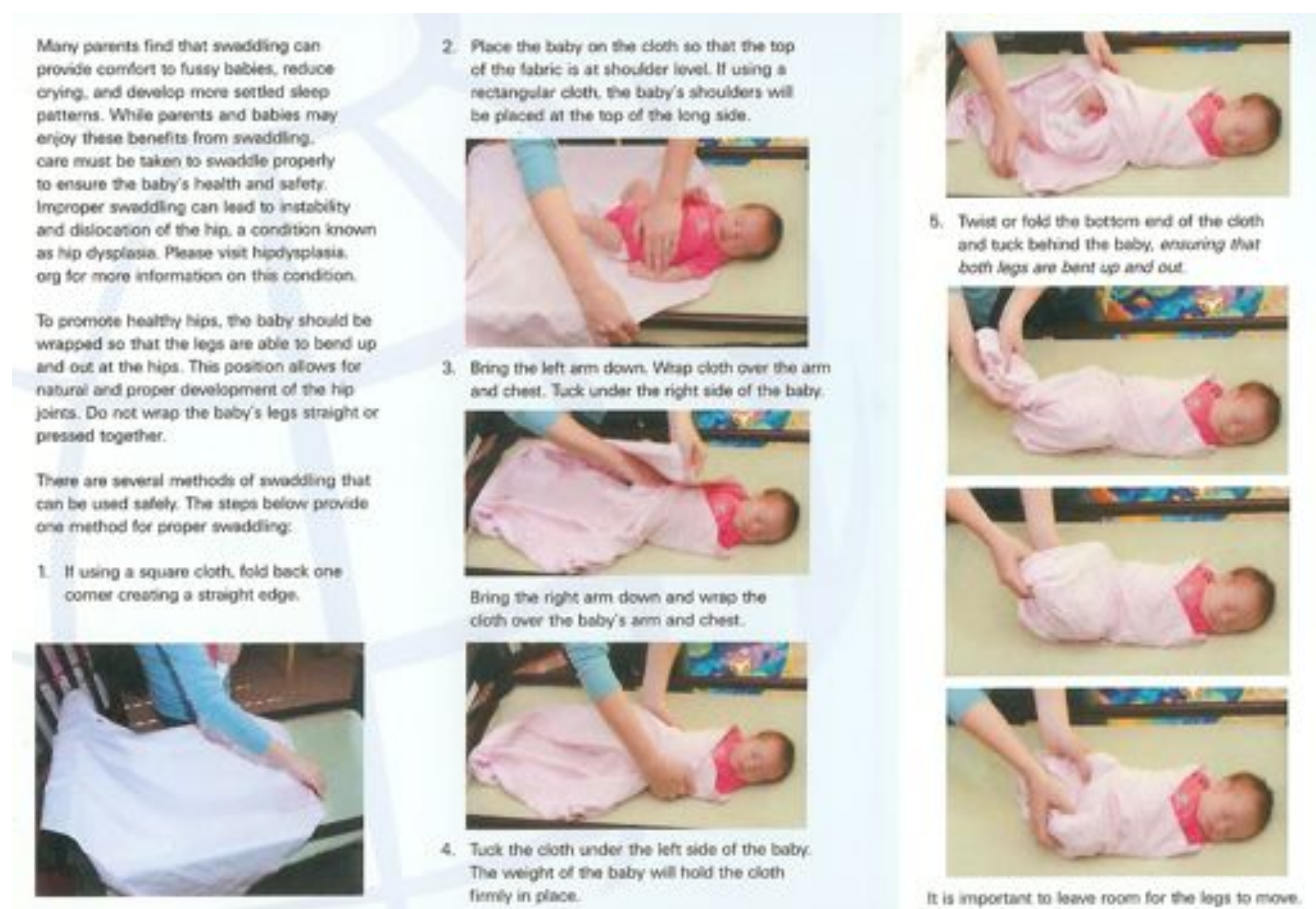
- Use of bulky diaper “Hip Package” for all “normal” infants eliminated missed DDH
- Seven fold decrease in surgery for DDH

J Pediatr Orthop 1988;8(1):9-11



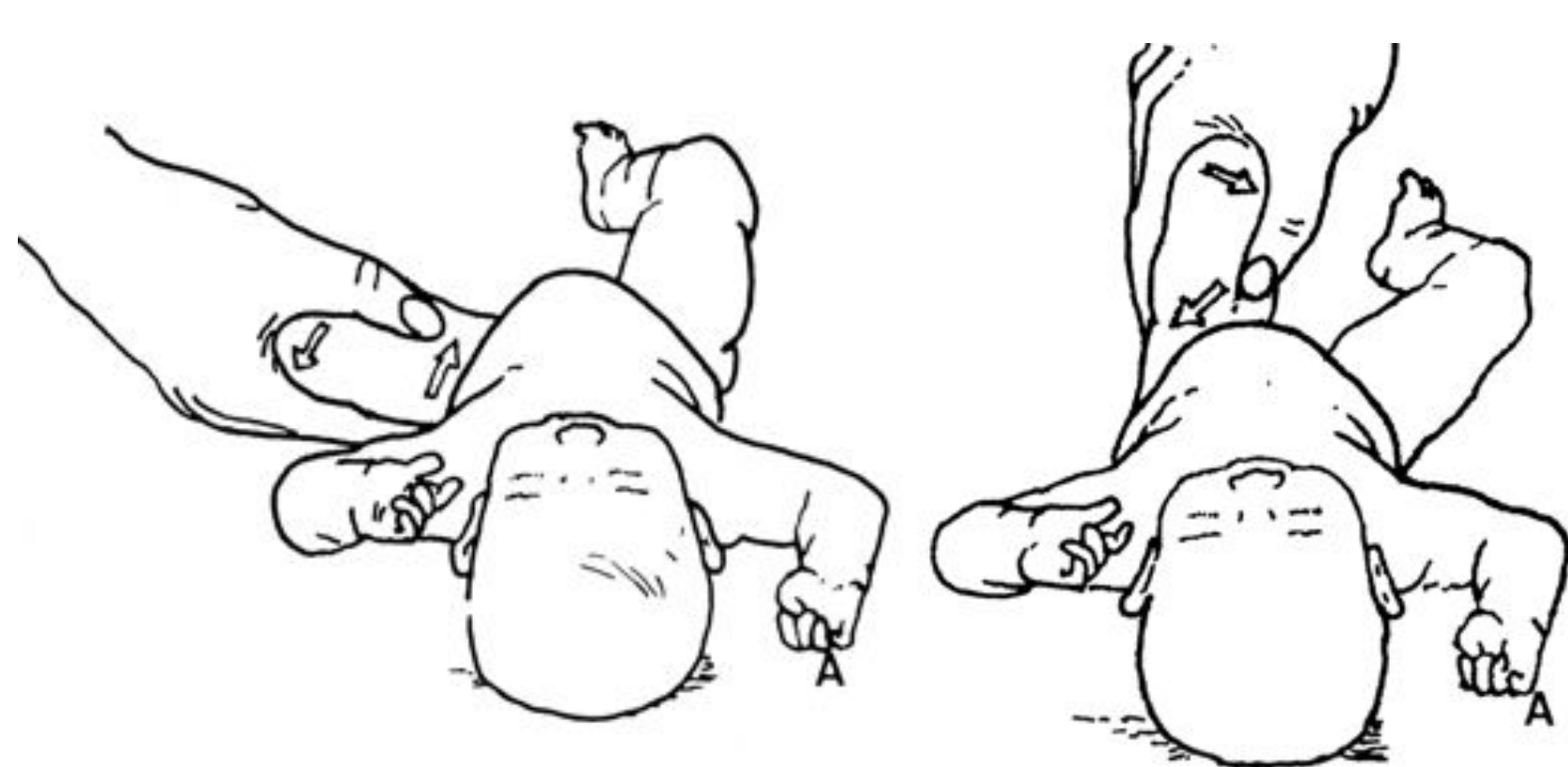
Similar results: Judet, 1959; Mittlemeier, 1998; Tredwell 1989

### Healthy Hip Swaddling

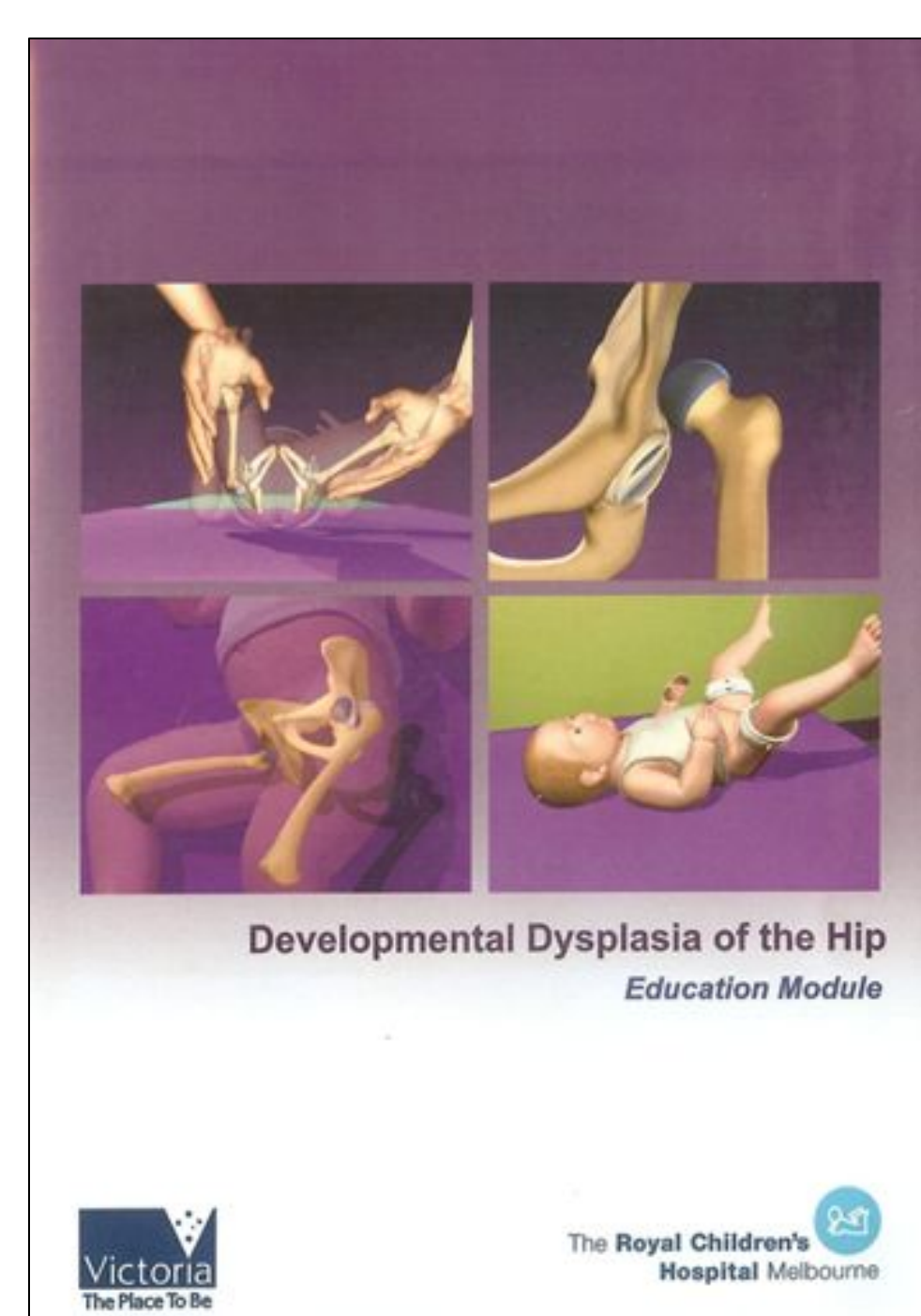


## Screening – Early Detection

- Neonate exam is essential for early detection
- Validated teaching module available online at no cost <http://www.hipdysplasia.org/for-physicians/pediatrician-and-primary-care-providers/lectures-and-video/>



DeRosa GP, Feller N, CORR1987;(225):77-85



- US Preventive Services Task Force and Canadian Task Force on Preventive Health Care recommend against routine screening of infants that do not have a dislocated hip detected at birth
- POSNA and the American Academy of Pediatrics recommend selective screening for infants with a normal neonatal hip examination
- Ultrasound screening at 4-6 weeks may be recommended for infants with normal exam who have risk factors for hip dysplasia:
  - breech presentation
  - positive family history
  - parental concern
  - suspicious exam
  - history of tight lower extremity swaddling

- US Preventive Services Task Force *Pediatrics* 2006;117:898-902
- H Patel, *CMAJ* 2001;164(12):1669-77.
- Am Acad Pediatrics Guideline: *Pediatrics* 2000;105(4):896-905
- Schwend RM, *JPO* 2007 ;27(6):607-10.



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## Diagnosis Pitfalls

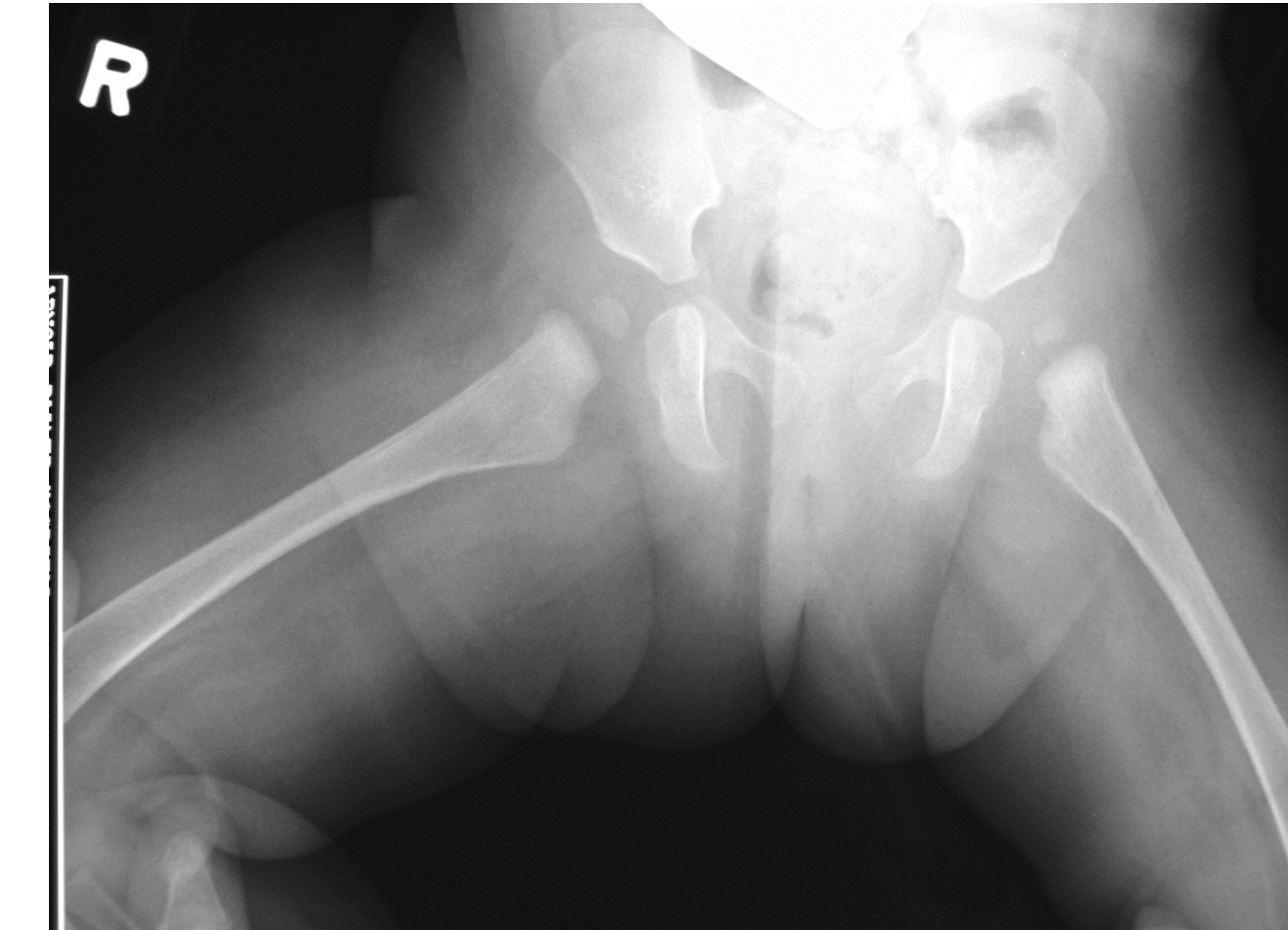
### Torticollis and foot deformities



- Slightly increased risk of DDH
- Questionable value of routine ultrasound screening
- DDH easily overlooked while treating these conditions

KP Minihane, Am J Orthop 2008;37(9):E15508  
von Heideken, JPO 2006;26(6):805-8  
RW Paton, JBJS-Br. 2009;91(5):655-8

### Hip Abduction Contracture



- Asymmetrical gluteal creases with abducted thigh at rest
- Adduction of both hips pulls opposite thigh into excessive adduction with pelvic obliquity
- Apparent limb length discrepancy due to pelvic obliquity
- Opposite hip at risk for dysplasia
- Treat with abduction splinting combined with stretching exercises

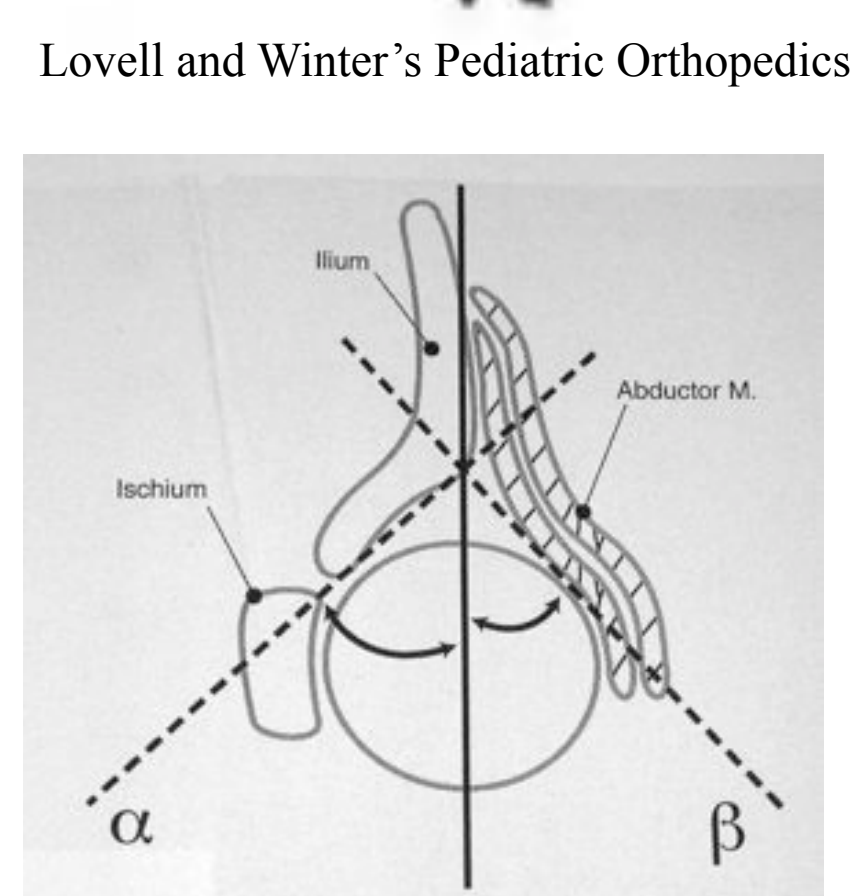
Green NE, Griffin PP. JBJS-Am. 1982;64(9):1273-81

## Ultrasound Diagnosis

### Graf Static Method ----- Larger $\alpha$ -angle is better

Mean  $\alpha$ -angle = 70° at 6 weeks of age  
JP Riad, JPO 2005;25(1):5-9

### Coronal View - Hip flexed

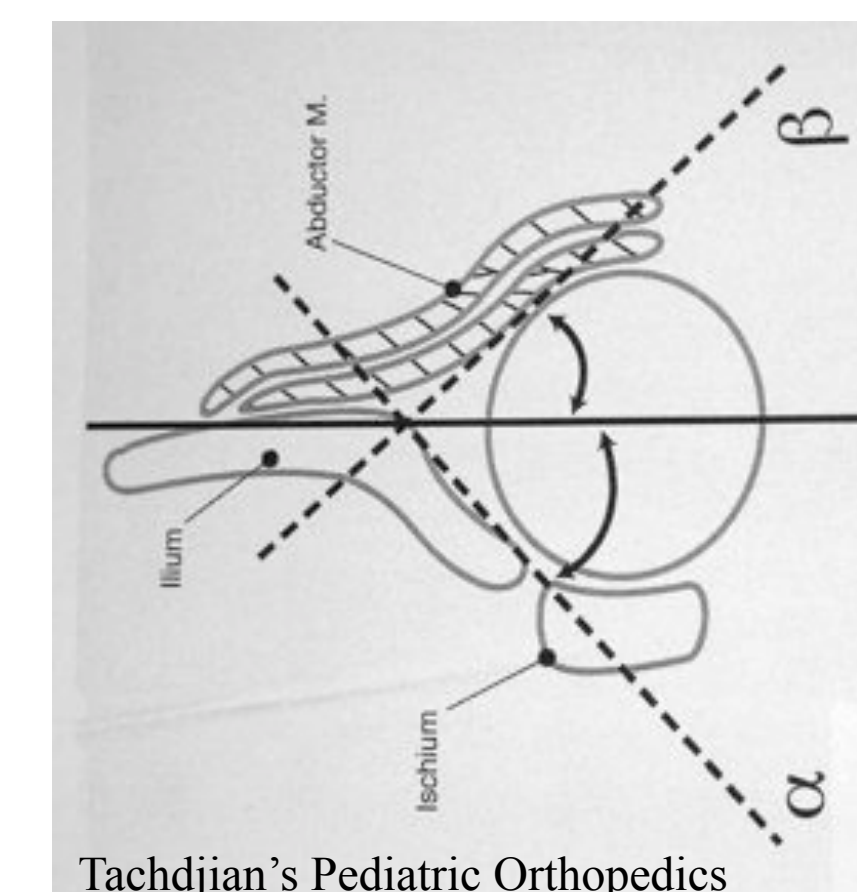


Tachdjian's Pediatric Orthopedics

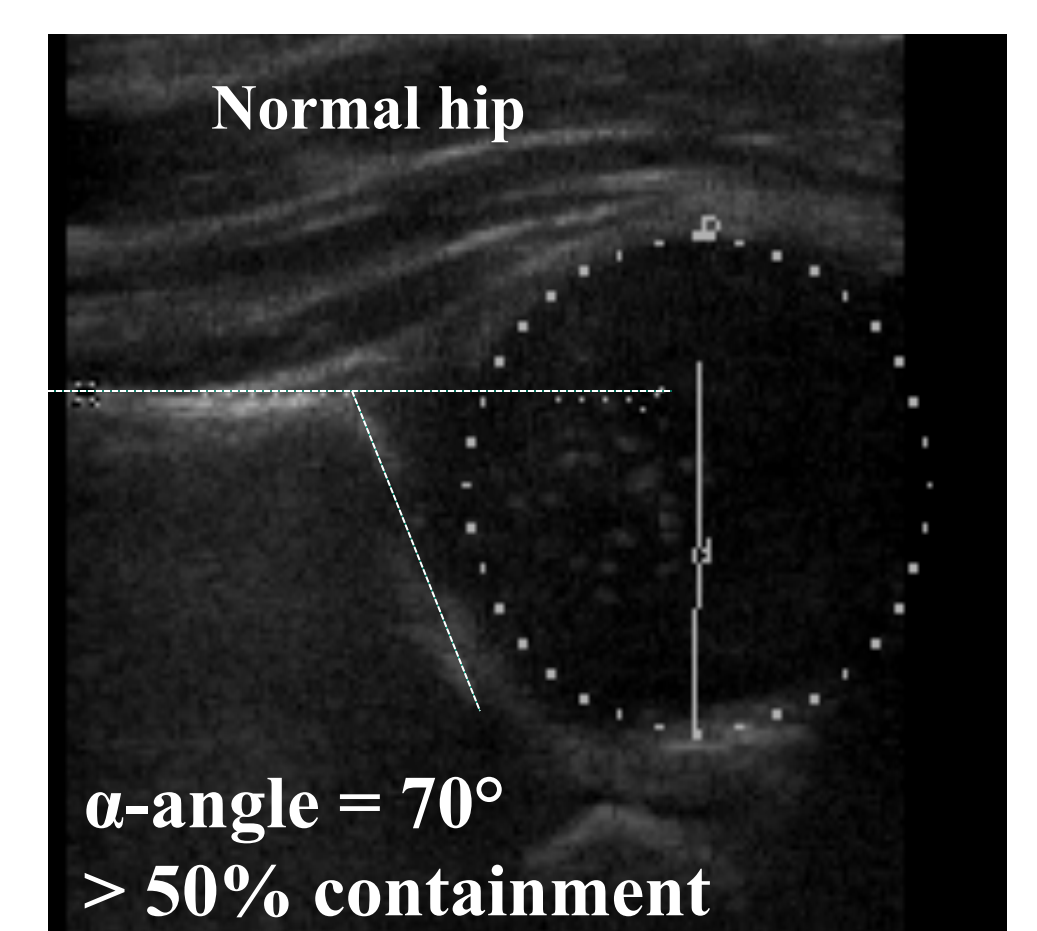
### Simplified Graf Classification of DDH

Class	$\alpha$ -angle	Description	Treatment
Ila	50°-60°	< 3 mo old	Observe
Ilb	50°-60°	> 3 mo old	Pavlik
Ilc-d	43°-59°	Acetabular deficiency	Pavlik
III	< 43°	Everted labrum	Pavlik
IV		Dislocated	Attempt Pavlik, Expect Closed Reduction

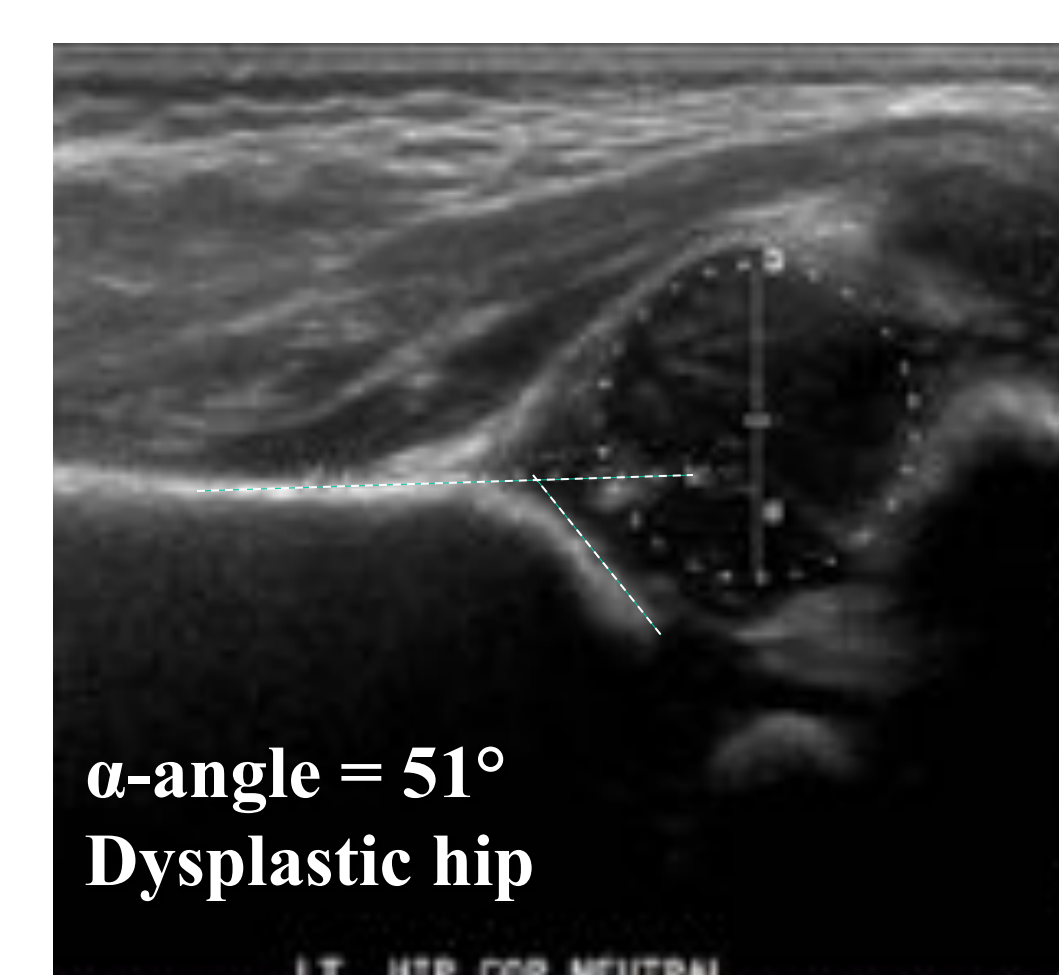
Adapted from Tachdjian's Pediatric Orthopedics, 3<sup>rd</sup> Edition p.529



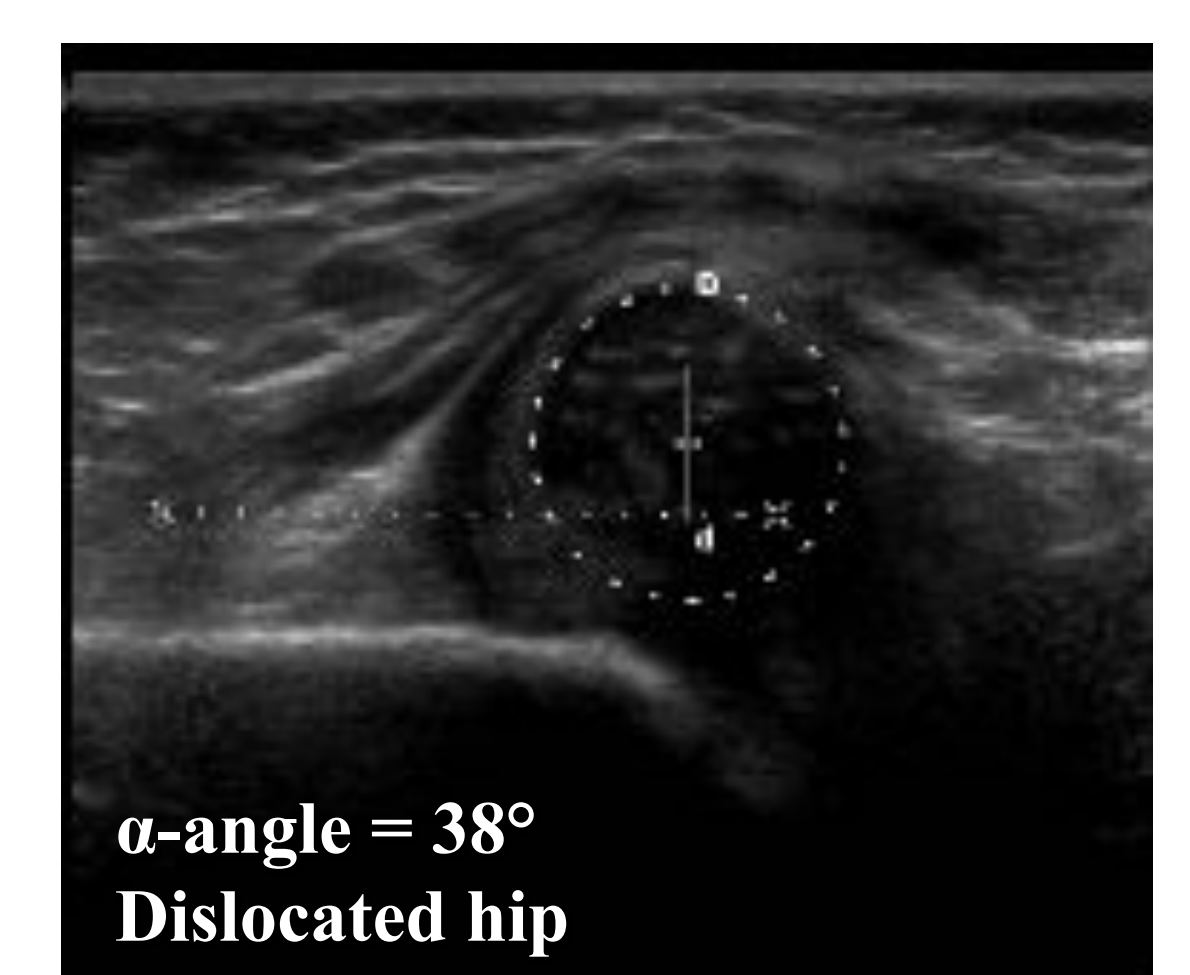
Tachdjian's Pediatric Orthopedics



Normal hip  
 $\alpha$ -angle = 70°  
> 50% containment



$\alpha$ -angle = 51°  
Dysplastic hip



$\alpha$ -angle = 38°  
Dislocated hip

### Harcke Dynamic Method ----- Stability is tested

Pressure similar to Barlow test in coronal and transverse view

### Transverse View - Hip flexed

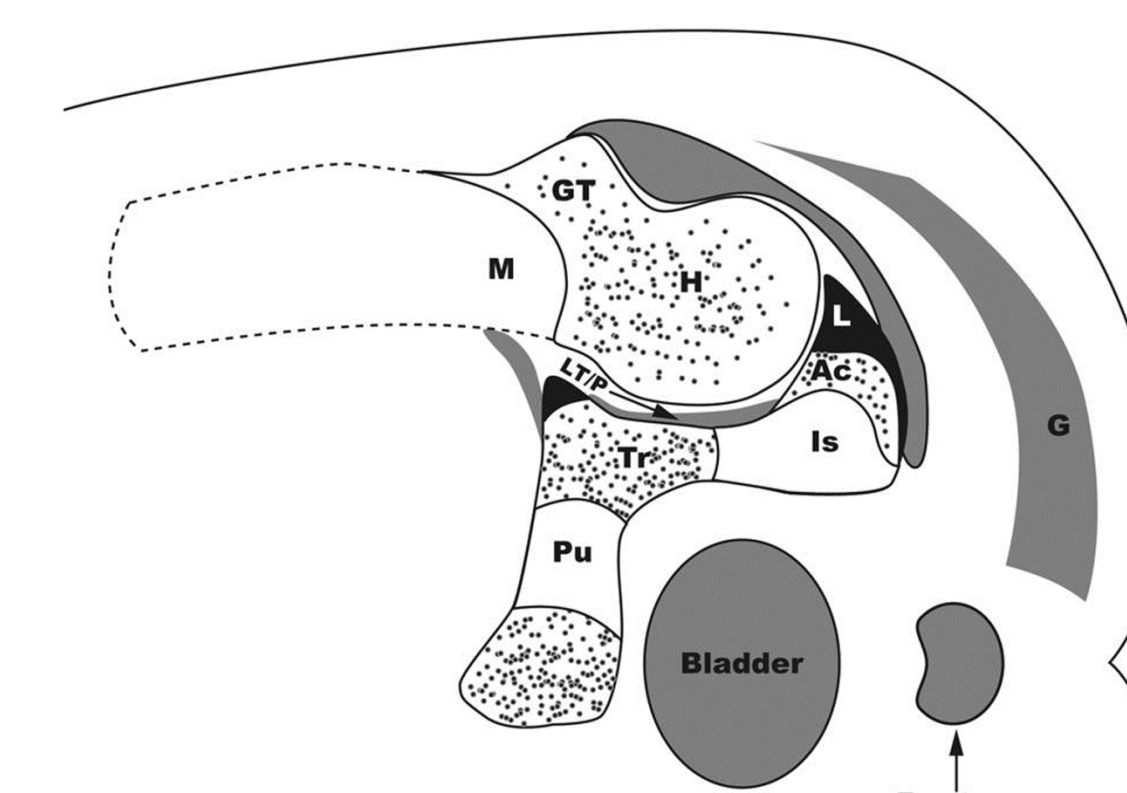


### Evaluation of DDH – Harcke Method

- Subluxation - normal hip has more than 50% containment
- Instability - Newborn may have 4-6 mm instability that resolves
- Advantages
  - Measurements not required
  - Rapid examination
  - Easily performed in Pavlik Harness

### Treatment indications

- Treat at birth for dislocated hips
- Treat at 3 weeks if subluxation present
- Treat at 6 weeks if instability present



Concept by Neil Johnson, MD  
Illustration by Glenn Milano

J Ultrasound Med 2009;28:114-9





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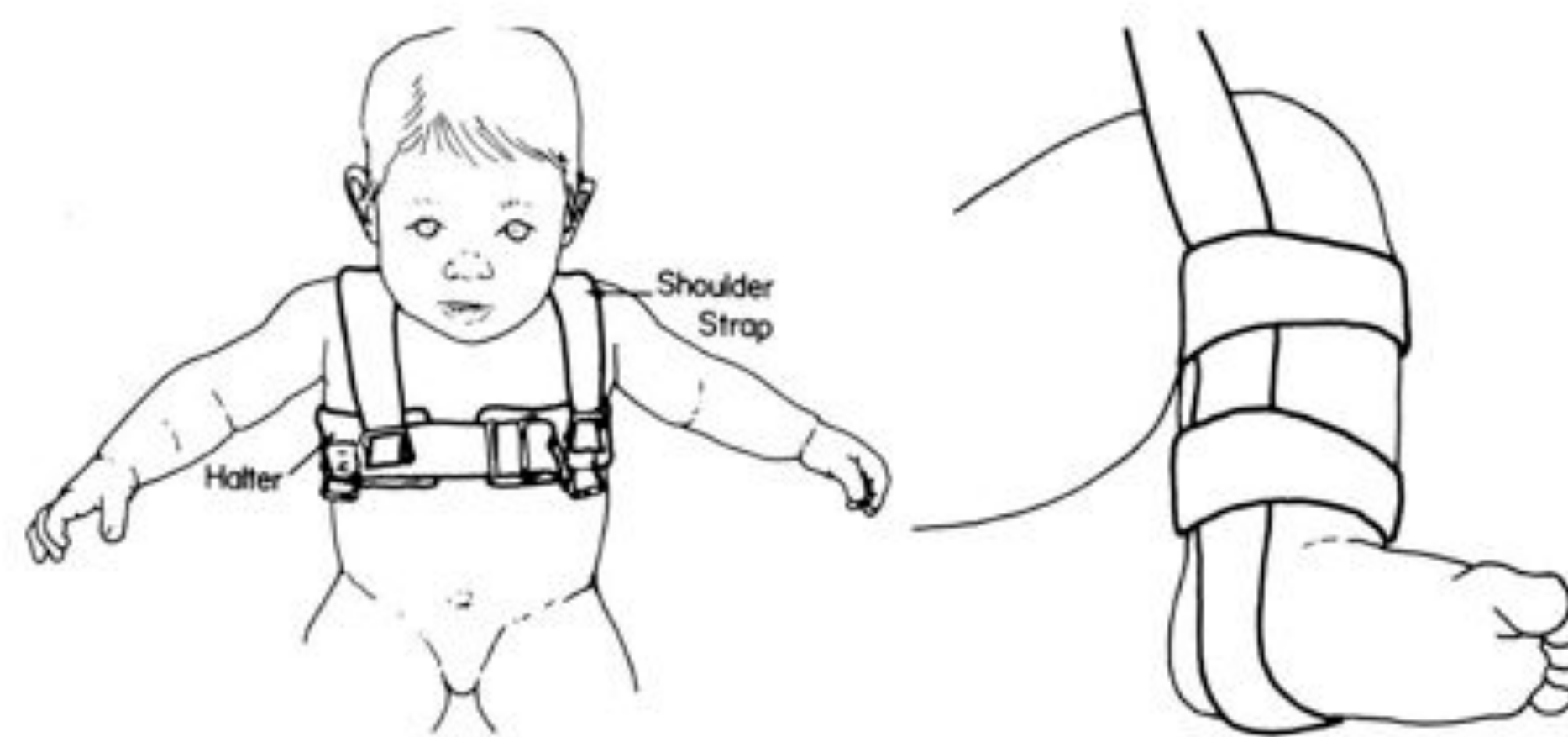
## Treatment - Birth to 6 Months of Age

### Harness Application

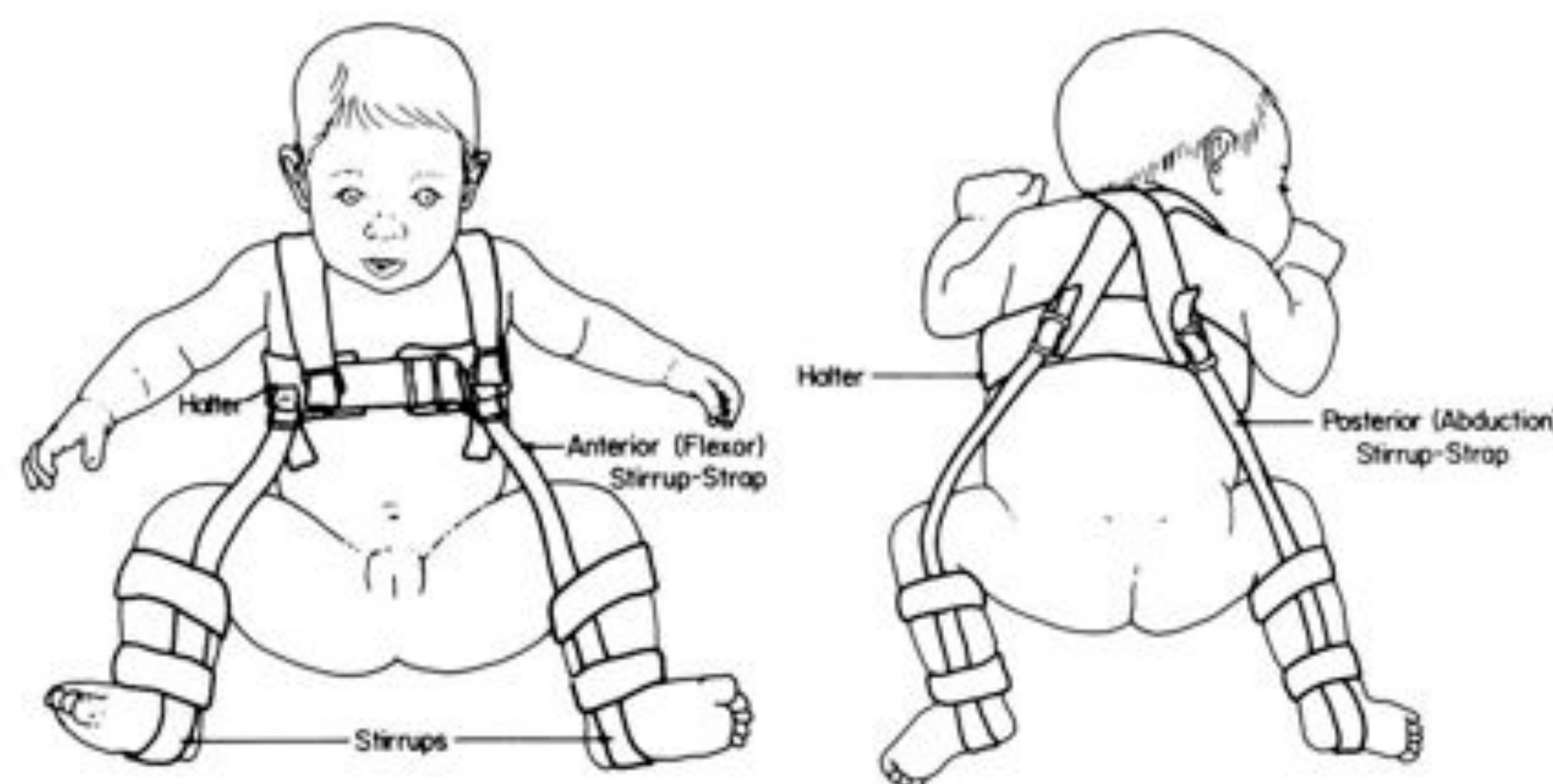
(Mubarak, et al, JBJS -Am 1981;63:1239-48)

#### Pavlik Harness

- Allows diaper change without removal
- Useful for all classes of DDH
- Permits ultrasound imaging in the harness



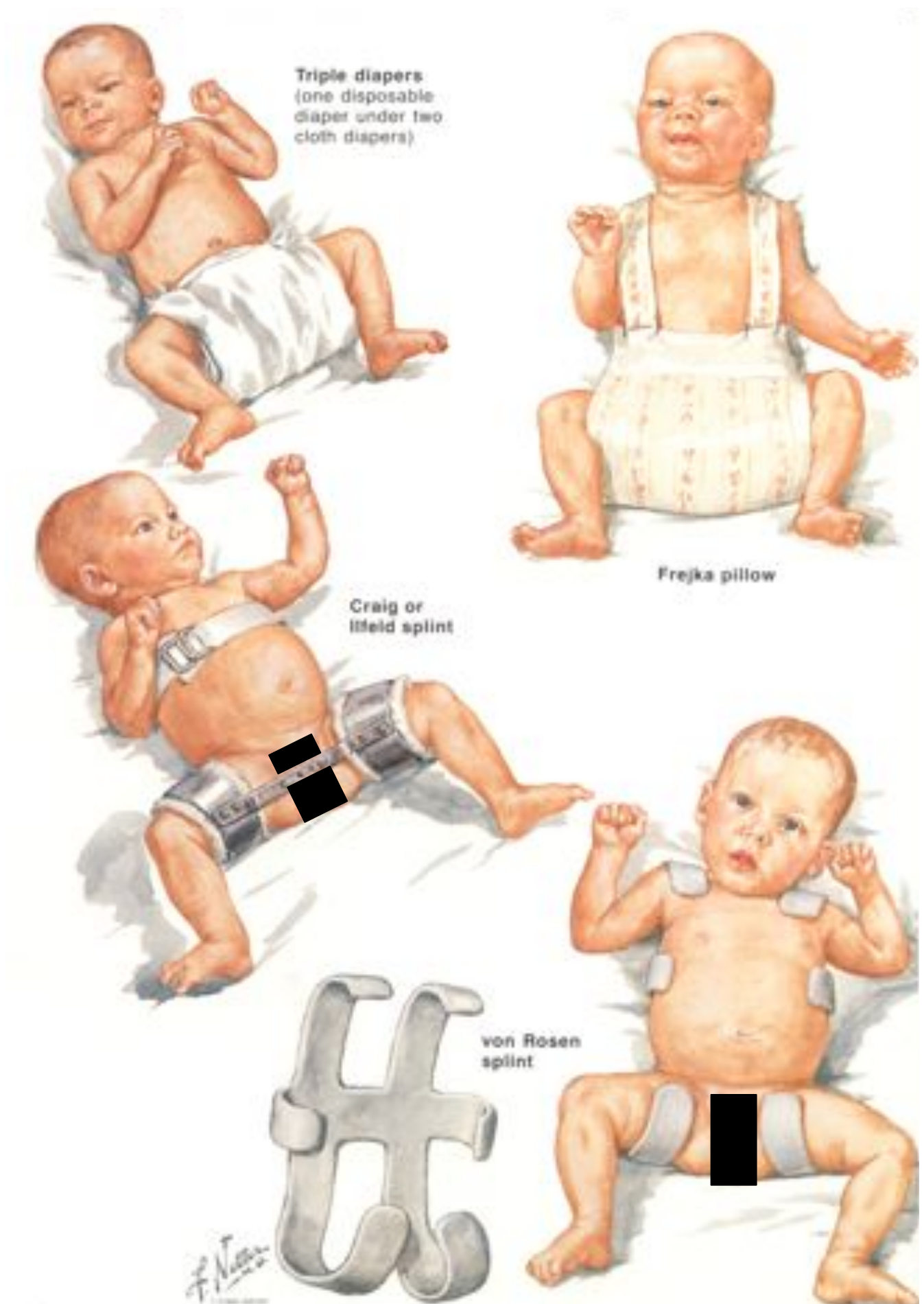
- Chest halter positioned at nipple line.
- Leg should be supported to popliteal crease



- Anterior straps attached at anterior axillary line
- Posterior straps attached over scapula
- Adjust anterior straps so hips are flexed 100°-110°
- Adjust posterior straps to allow the hips to adduct to within 5 cm between the knees

#### Abduction Pillows and Braces

- Intuitive for parents to use
- Useful for hips that are reduced and stable in abduction
- Limited usefulness of ultrasound in the pillow or brace



Netter illustration from [www.netterimages.com](http://www.netterimages.com).  
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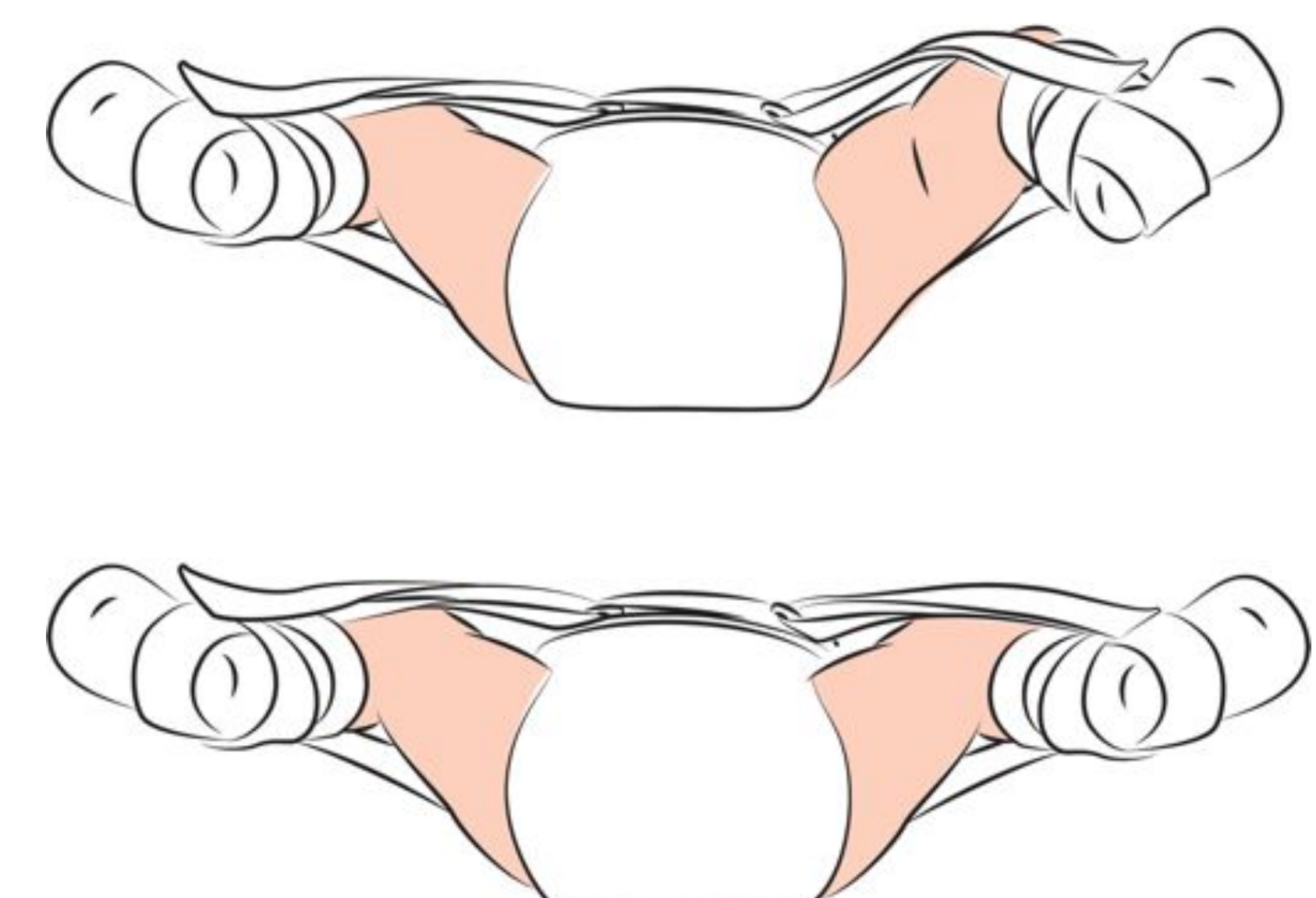
## Pavlik Harness – Tips



#### Treatment protocol

- Full-time wear with hip ultrasound in harness every 7-14 days
- 90% of successful cases are reduced by two weeks
- May require up to four weeks to reduce or stabilize
- Abandon harness if not reduced by 4 weeks in child < 6 months old
- May attempt Pavlik for subluxated hips between 6-12 months old
  - Up to six weeks may be needed in this age group

H Malkawi, JPO 7:144  
S Mubarak, JPO 29:224 and JBJS 63A:1239  
MAJ van de Sande, Intl Orthop 36:1661  
V Pollet, JPO 30:437



- Hip reduces by weight of leg when child relaxes
- Encourage supine sleeping with thighs free
- Adduction contracture resolves when hip reduces

## Pavlik Harness – Pitfalls

- Leg supports too short**
- Incorrect forces on hip



- Femoral nerve palsy – quadriceps paralysis**
- More common in higher grade dislocations
  - Discontinue Harness until recovers
  - 70% success if recovers in ≤ 3 days

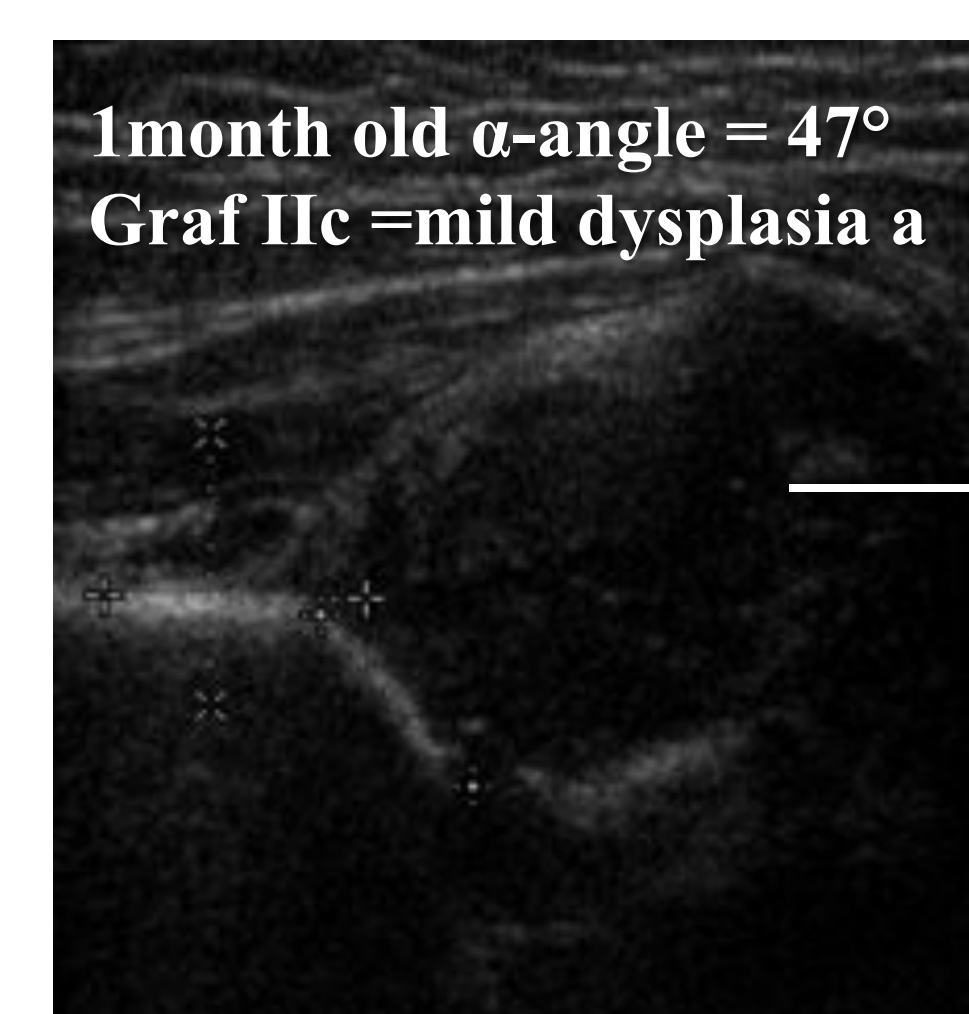


Murnaghan ML, Browne RH, Sucato DJ, Birch J.  
J Bone Joint Surg Am. 2011;93(5):493-9

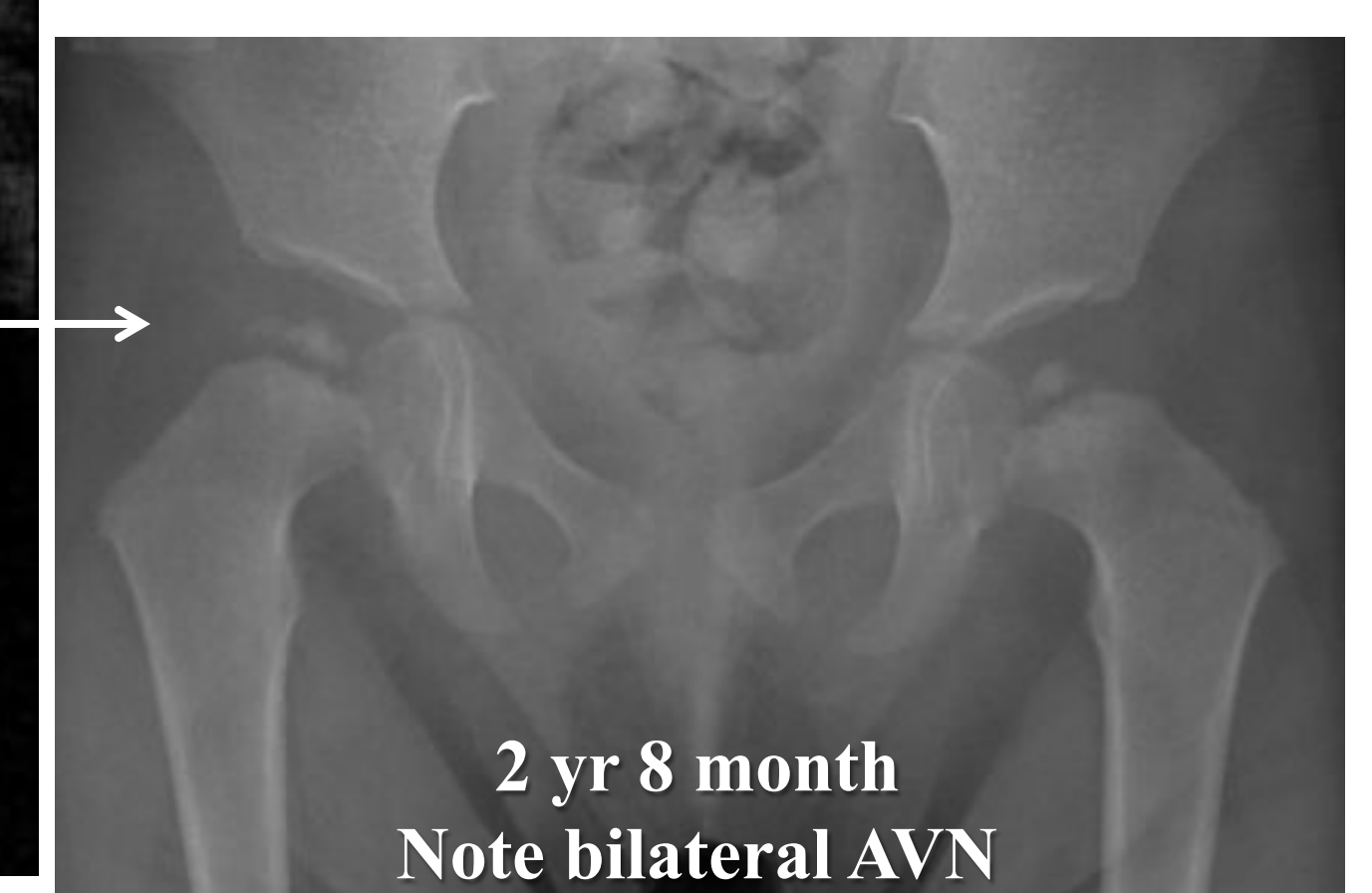
#### Avascular necrosis

- Absent ossification one year after treatment, broadening of femoral neck, or fragmentation
- Decrease risk of AVN by avoiding forced or prolonged abduction

RB Salter, Can J Surg 1969;12(1):44-61



1month old  $\alpha$ -angle = 47°  
Graf IIC = mild dysplasia



2 yr 8 month  
Note bilateral AVN



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## Pavlik Harness – Success

### Success Rates with Pavlik Harness

- High success rates for unstable and subluxated hips
- 65-85% success rates for dislocated hips treated before 6 weeks of age

Harding, Harkke, Bowen JPO 17:189, 1997  
Cashman, Clarke JBJS 84B:418, 2002  
Peled, Bialik, et.al. CORR 466:825, 2008  
Swaroop and Mubarak JPO 29:224, 2009

- 20-60% success rates for dislocated hips treated between 6 weeks and 6 months of age

Lerman, Kasser, et.al. JPO 21:348, 2001  
Viere, Herring, Johnston, et.al. JBJS 72A:238, 1990  
Harding, Harkke, Bowen, et.al. JPO 17:189, 1997  
Atalar, et.al. Intl. Orthop. 31:145, 2006



### Typical Treatment Plan

- Follow with hip ultrasound until reduced and stable
- Infants  $\leq 6$  months at start of treatment
  - Abandon Pavlik harness if unsuccessful in 4 weeks
  - Continue full time bracing 6 weeks after stable for slightly longer after 3 months of age
  - Part-time harness or abduction brace for 6 more weeks
- Infants 6-12 months with subluxated hip
  - Follow with ultrasound or radiographs
  - Abandon harness if unsuccessful in 6 weeks
  - Longer duration of full time and part time treatment for these older infants
    - Total time approximately equal duration to age at time of reduction; example, 6 months of treatment for a 6 month old infant

• Tachdjian's Pediatric Orthopedics, 3<sup>rd</sup> Edition  
• Lovell and Winter's Pediatric Orthopaedics, 6<sup>th</sup> Edition  
• N Clarke and P Castaneda, OCNA 2012;43(3):281-9  
• V Pollet JPO 2010;30(5):437-42

## Pavlik Harness - Failure

### Abduction Brace when Pavlik Harness Unsuccessful



- Indication
  - Hip unstable after 3-4 weeks in Pavlik harness, and
  - Hip reduces in abduction
- Treatment duration
  - Should stabilize in 4-6 weeks
  - Continue full time treatment for 6 weeks after stabilization

D Hedequist, JPO 23:175, 2003  
VT Swaroop, JPO 29:224, 2009



Follow-up until maturity is recommended for more severe degrees of dysplasia

- 3% adolescent dysplasia after successful treatment without AVN using Pavlik Harness prior to age 6 months

J Nakamura, JBJS-Br 2007;89(2):230-5  
K Modaresi, J Child Orthop (2011) 5:261-266

## Options when Pavlik Harness fails?

### Closed reduction and hip spica cast

- Most frequent option after Pavlik harness or abduction brace failure
- Infants  $\leq 18$  months of age
- ? Greater risk of AVN before ossific nucleus appears?
- ? Preliminary traction or no preliminary traction?

### Surgical reduction

#### Medial Open Reduction

- Best results prior to one year of age
- Hip is reduced at a younger age for better development
- Relatively uncommon procedure requires proper training and experience
- High rate of growth disturbances when patients are followed to maturity

#### Anterior open reduction $\pm$ femoral shortening $\pm$ pelvic osteotomy after ossific nucleus appears

- Time interval provides a break for mother to nurture her child
- Allows posterior acetabulum to recover
- May decrease risk of AVN
- Later surgery means shorter time in cast, and may have social advantages.
- Disadvantage of more invasive surgery performed later in development of joint



# Infantile DDH

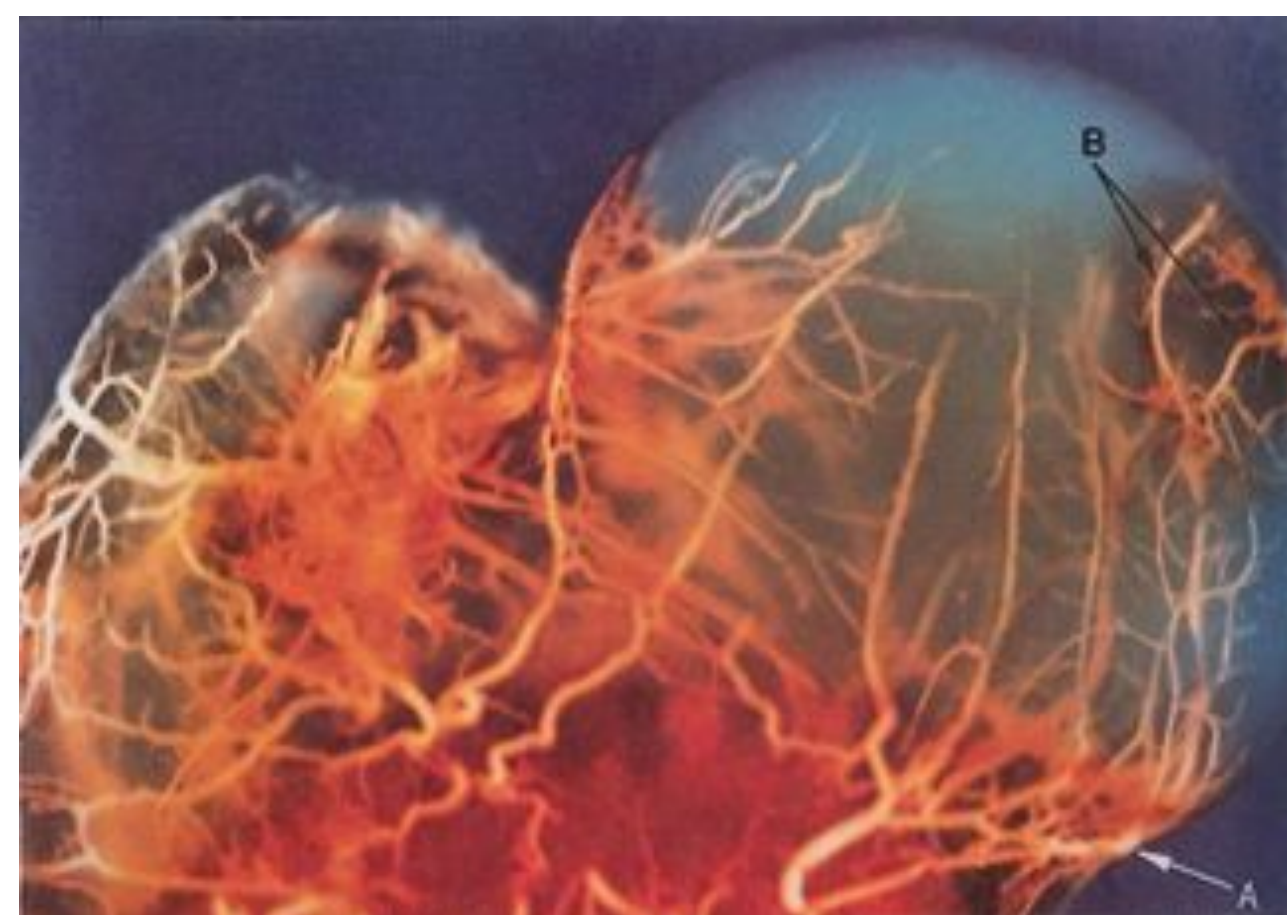
HS Hosalkar, SJ Mubarak, EL Sink, K Mulpuri, CT Price

## Considerations for AVN

### Vascularity

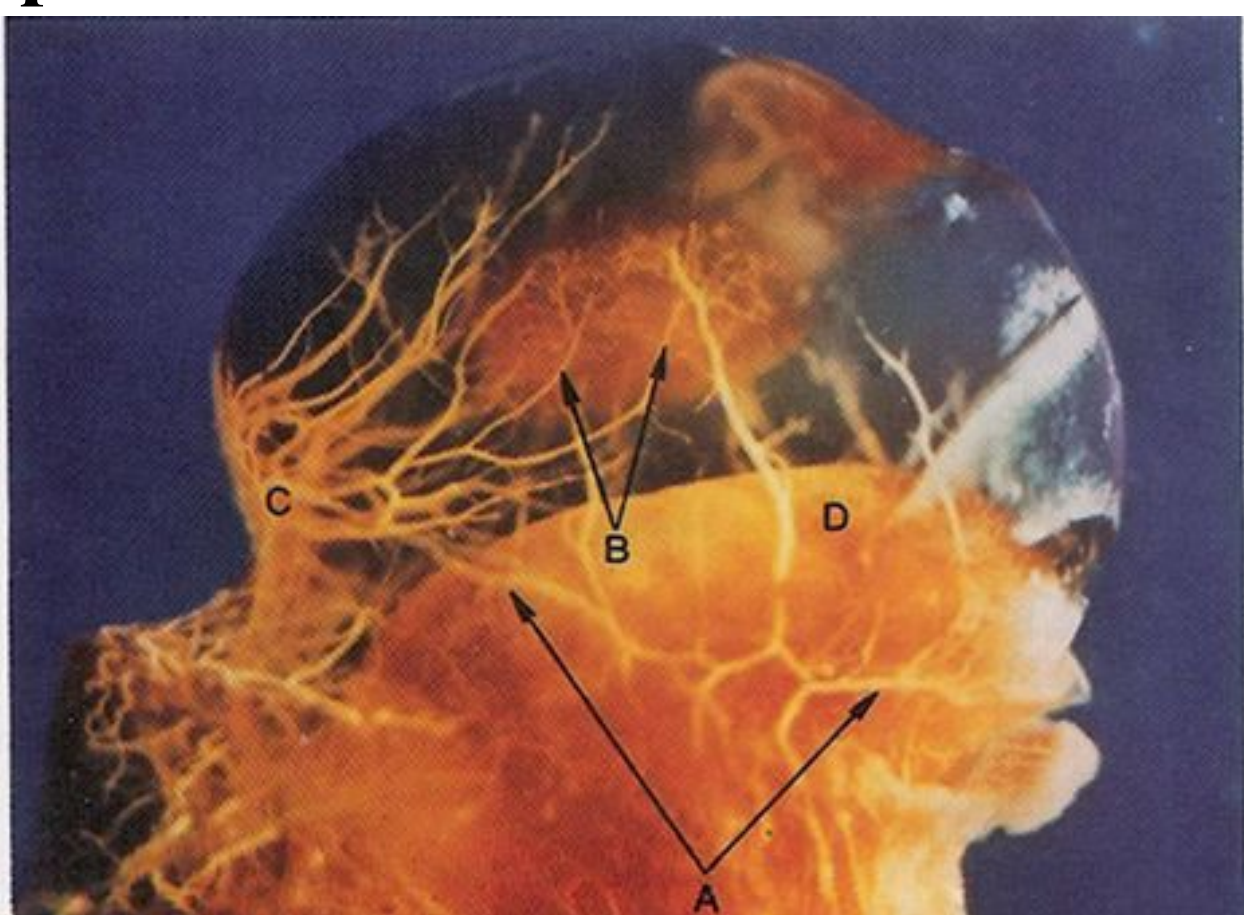
Newborn

Compressible cartilage and vessels  
with poor collateral circulation

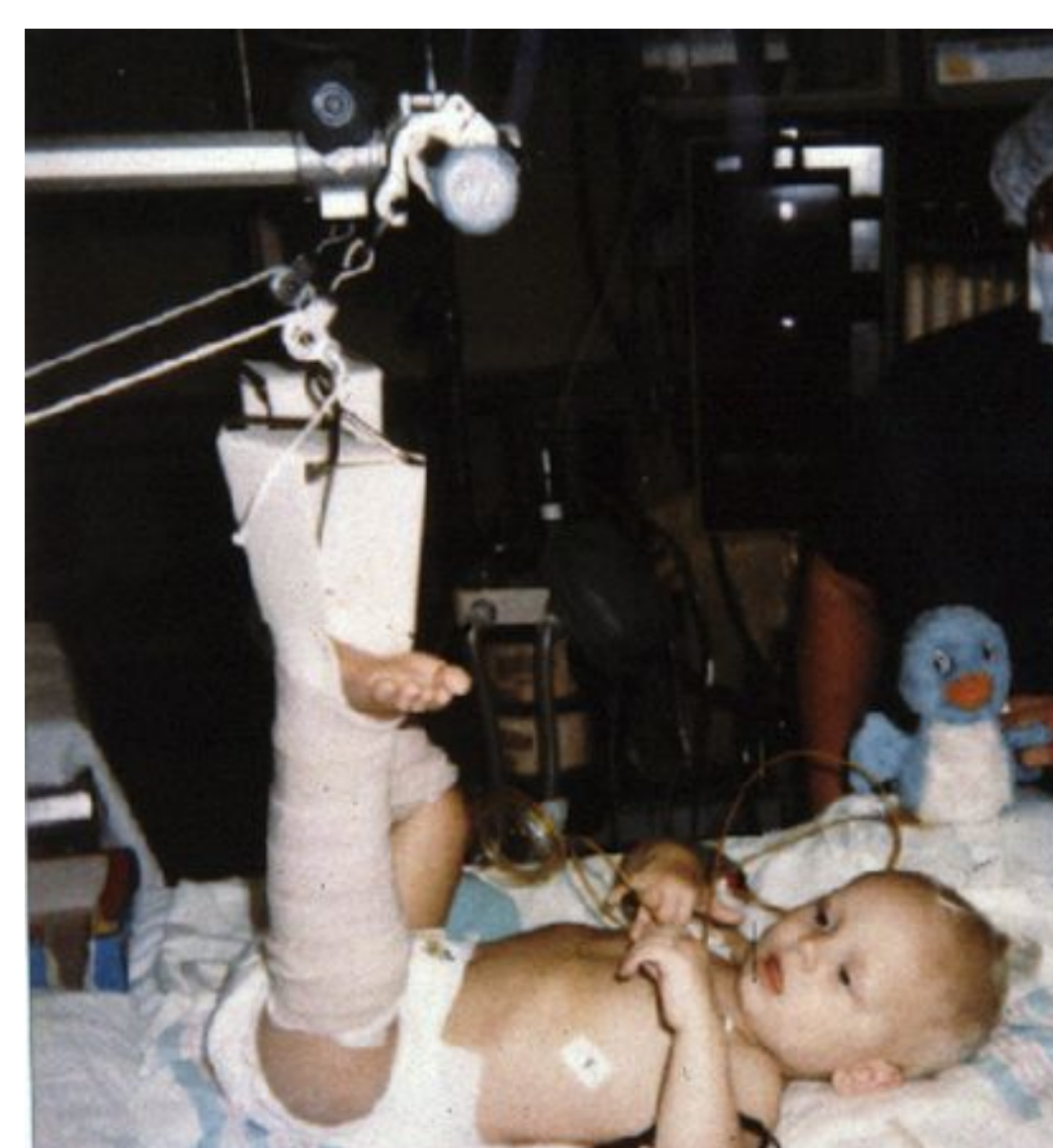


7 months

Ossific nucleus resists compression,  
provides collateral circulation



Guided overhead traction gradually abducts the hips over 5-7 days



Does ossific nucleus protect against AVN?

- Evidence is inconclusive
- Approximately equal risk with or without ossific nucleus
- Severity may be greater in absence of ossific nucleus

A. Roposch (Meta-analysis) JBJS-Am 2009;91(4):911-8

- Avoid compression of femoral head during reduction

Jaramillo D, Villegas-Medina O, Laor T, Shapiro F, Millis MB.  
AJR Am J Roentgenol. 1998;170(6):1633-7.

### Preliminary Traction

- Unlikely to decrease risk of AVN
- May improve rate of successful closed reduction,  
especially for high dislocations
- 60% success without traction

Quinn, Renshaw, et.al. JPO 14:636, 1994

Kahle, Stevens, Coleman et.al. JBJS 72A:1043, 1990

- 70-90% success with guided overhead traction

Tavares, et.al. JPO 14:643, 1994

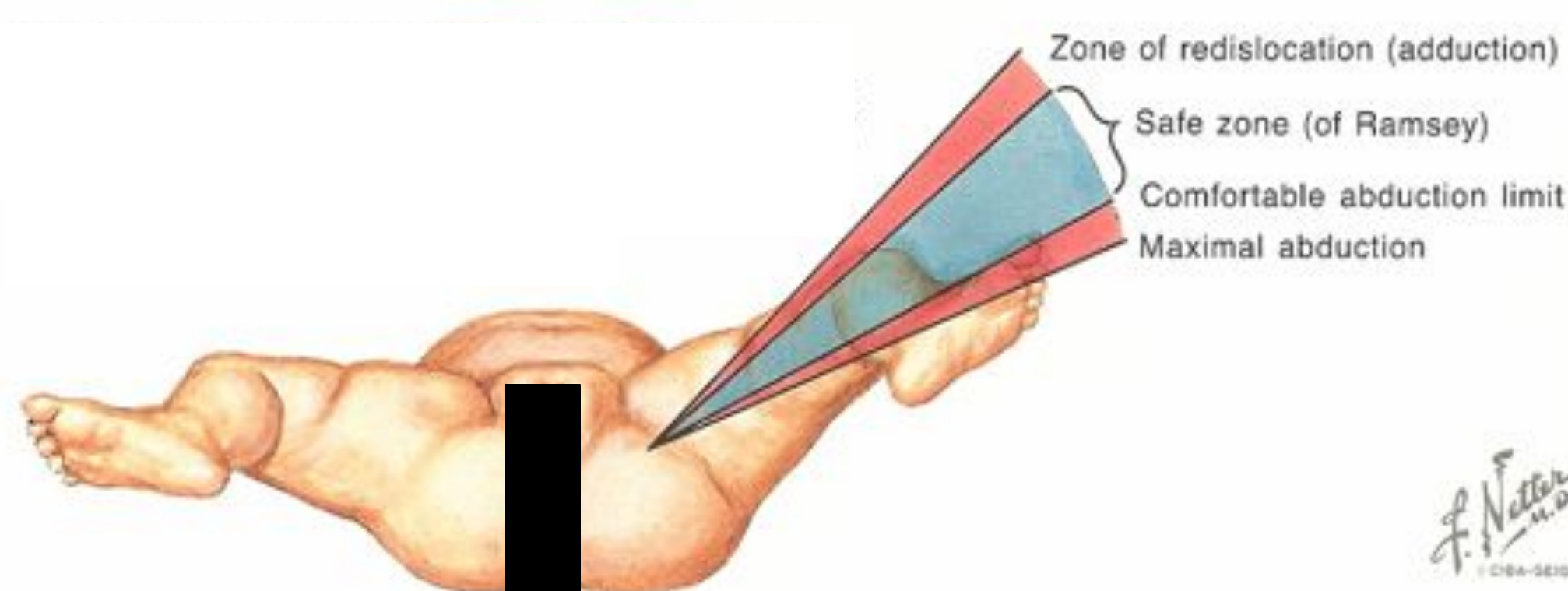
Daoud and Saighi-Bououina, JBJS 78A:30, 1996

Yamada, et.al. JBJS 85B:1173, 2003

Sibinski, et.al. Intl. Orthop. 30:268, 2006

## Closed Reduction

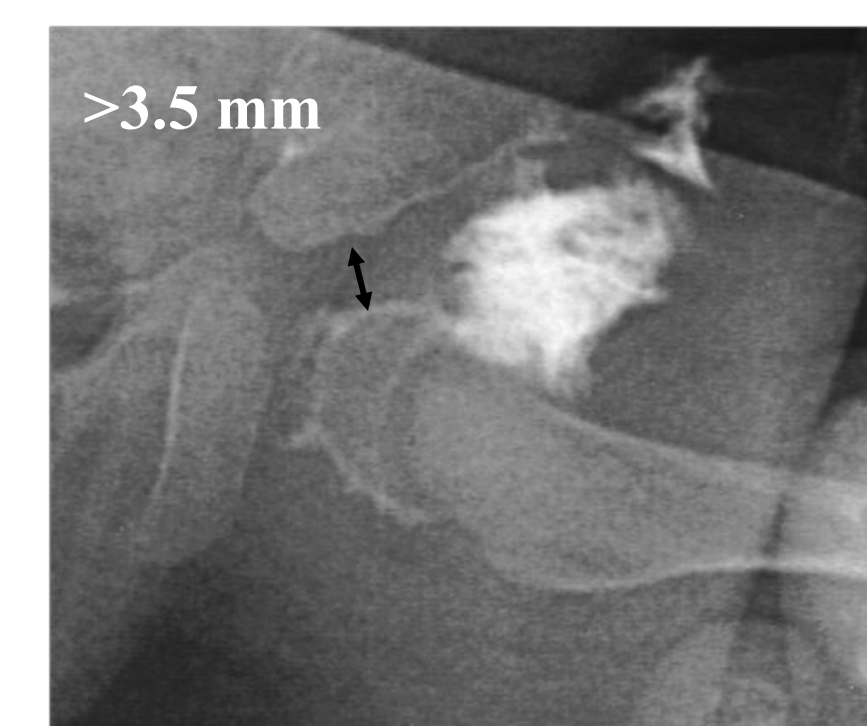
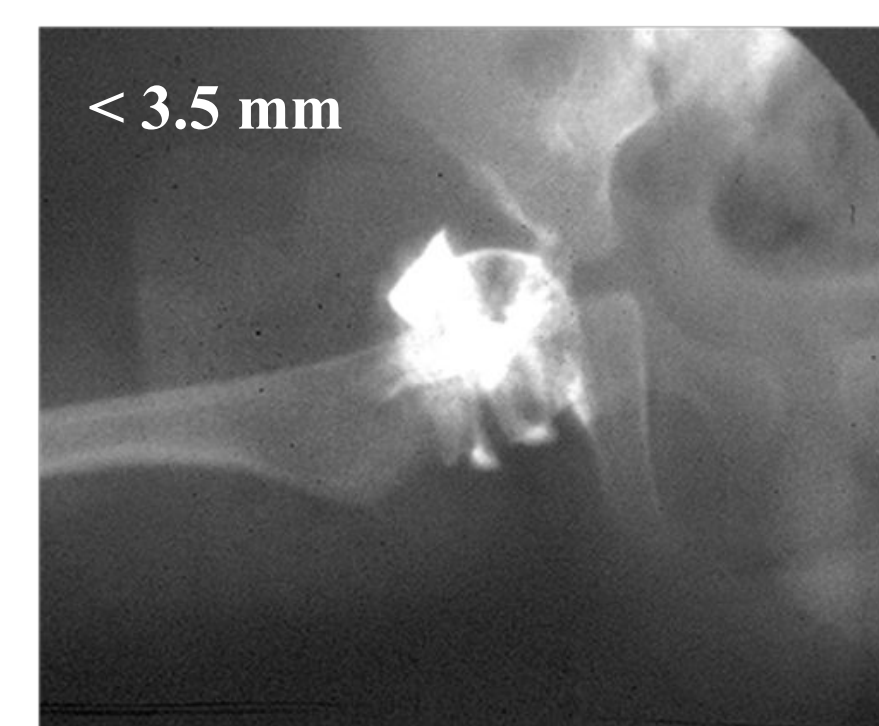
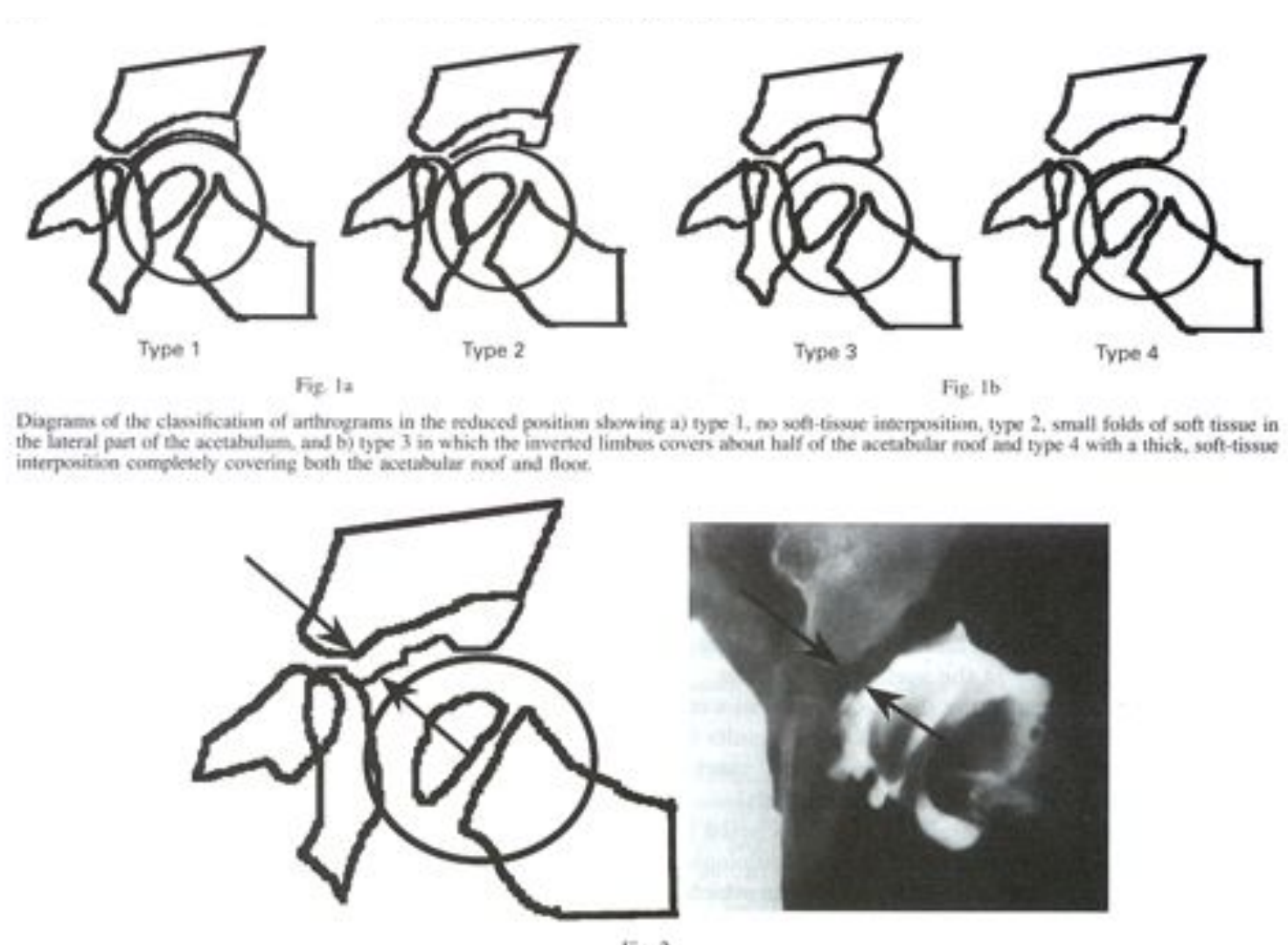
Adductor tenotomy – increases safe zone and  
decreases forces on femoral head in abduction



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### Arthrogram

- Limbus type and soft tissue depth  
influence outcome



- A. <3.5mm initial reduction  
38% secondary surgery
- B. >3.5mm initial, but <3.5mm at second arthrogram  
79% secondary surgery
- C. >3.5mm initial and second arthrogram  
100% secondary surgery

T Hattori, et al JBJS 81B:385, 1999

New methods for intra-operative imaging include ultrasound, color Doppler ultrasound, MRI, 3-D fluoroscopy, arthroscopy

Eberhardt O, J Child Orthop. 2009;3(4):313-8;

Vandevenne JE, Singapore Med J. 2009;50(4):407-11.;

Eberhardt O, J Bone Joint Surg Br. 2012;94(6):842-7;

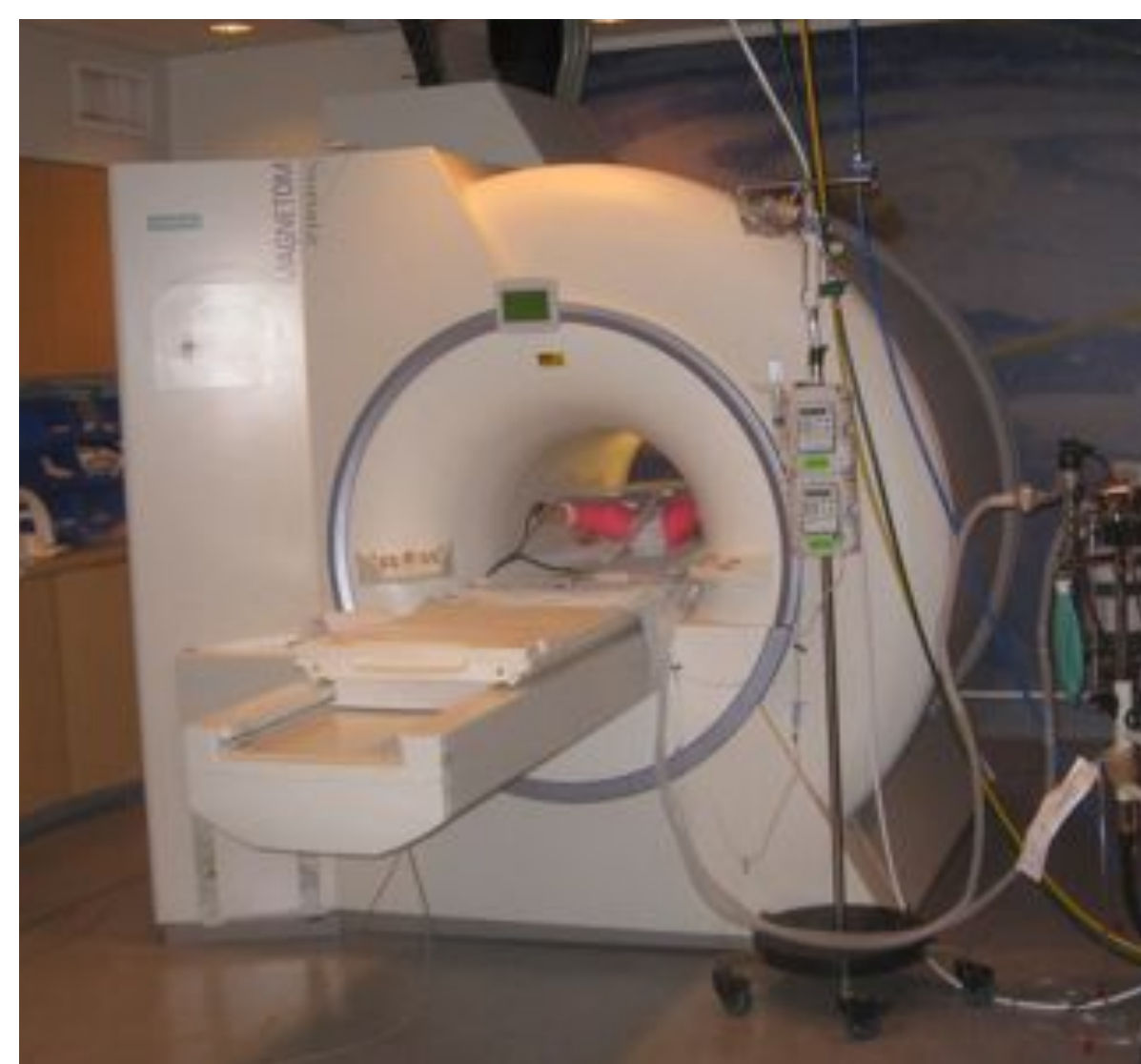
Bearcroft PW, Radiology. 1996;200(1):209-11

## Management after closed reduction

- Hip flexion decreases forces of iliopsoas
- Knee flexion decreases forces of hamstrings
- Limit abduction to safe zone



Post-op MRI is often used to confirm  
reduction in the cast. Limited CT scan,  
and ultrasound have also been used



Gadolinium MRI and Color Doppler  
Ultrasound may assess vascularity

Desai AA, Pediatr Radiol. 2011;41(4):525-9

Conroy E, J Child Orthop. 2009;3(3):223-7

Tiderius C, J Pediatr Orthop. 2009 Jan-Feb;29(1):14-20

Eberhardt O, J Child Orthop. 2009;3(4):313-8

Stanton RP, J Pediatr Orthop. 1992;12(6):727-30.

Jaramillo D, Am J Roentgenol. 1998;170(6):1633-7



MRI at time of initial reduction shows  
reduced hip but poor congruency



Arthrogram 6 weeks later  
shows improved congruency

### Typical Treatment Plan

Change cast after 6 weeks

Repeat arthrogram

Do not test hip mobility or stability

Full-time immobilization period 4½ to 6 months with  
cast plus abduction brace

Part Time bracing for 6 weeks after full time period

Allow contractures to resolve spontaneously



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## Follow-up after closed reduction

### Long-term results may be disappointing

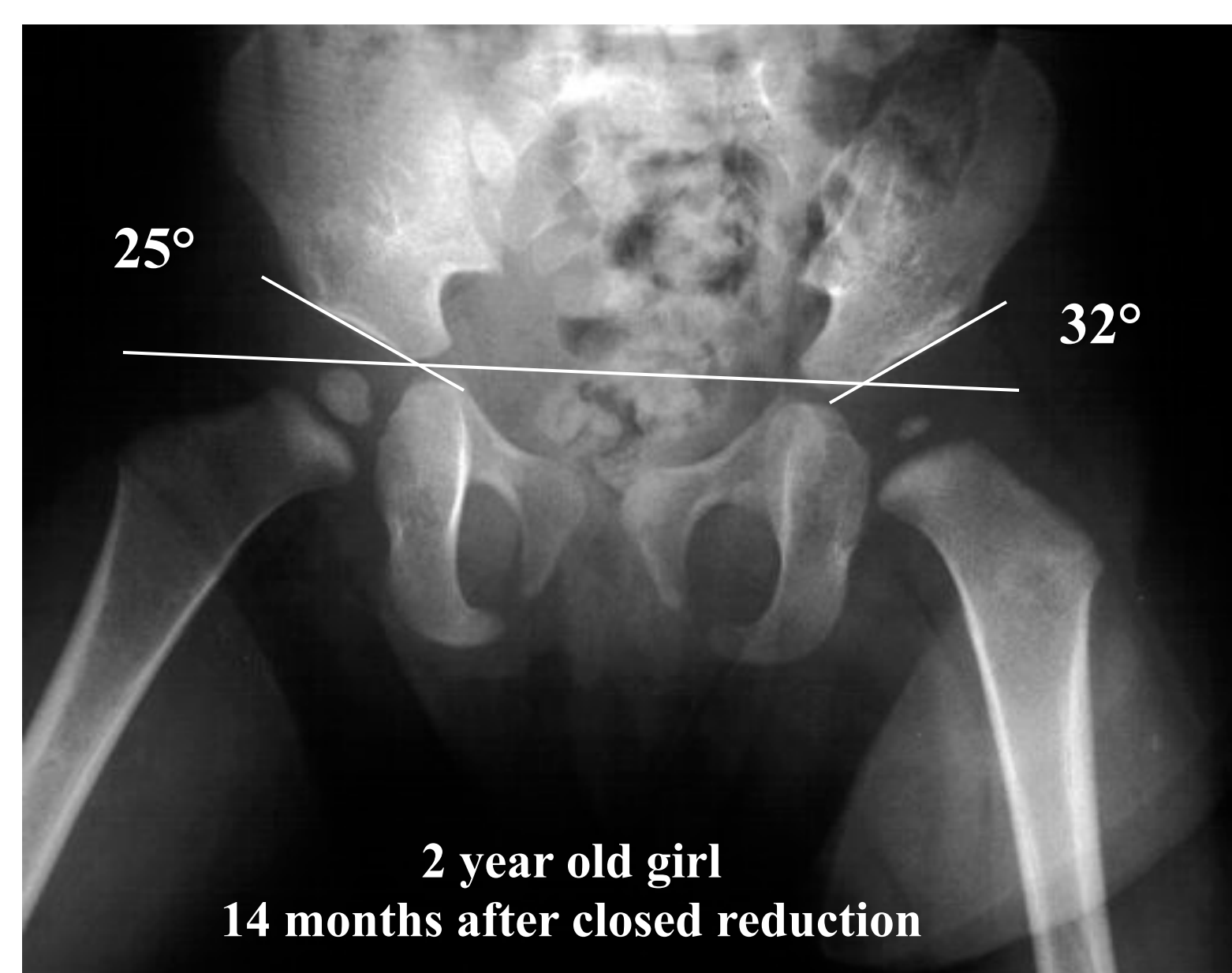
- 30-50% of patients require secondary surgery when followed more than 10 years after successful closed reduction
- Results are better when reduction is performed before age 18 months

TA Malvitz and SL Weinstein JBJS-Am 1994;76:1777  
T Hattori, JBJS-Br 1999;81:385  
HT Kim, JPO 2000;20:701  
T Murray, Am J Orthop 2007;38:82

### Arthrogram at time of cast removal 4.5 months after successful closed reduction



## Residual Dysplasia

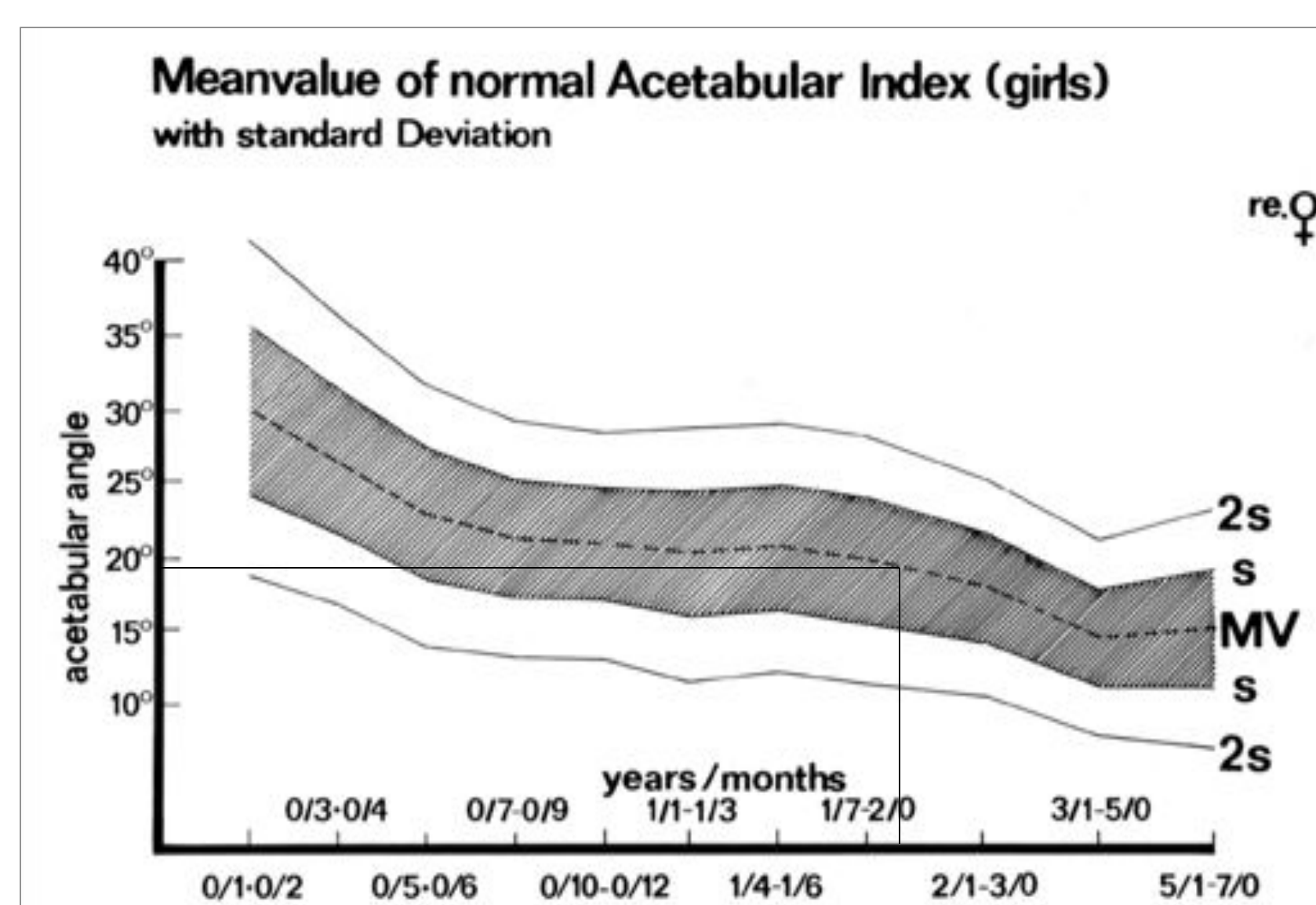


### Follow acetabular index if hip remains reduced

- Consider surgical intervention if Acetabular Index remains abnormal without gradual improvement over 12 months of observation

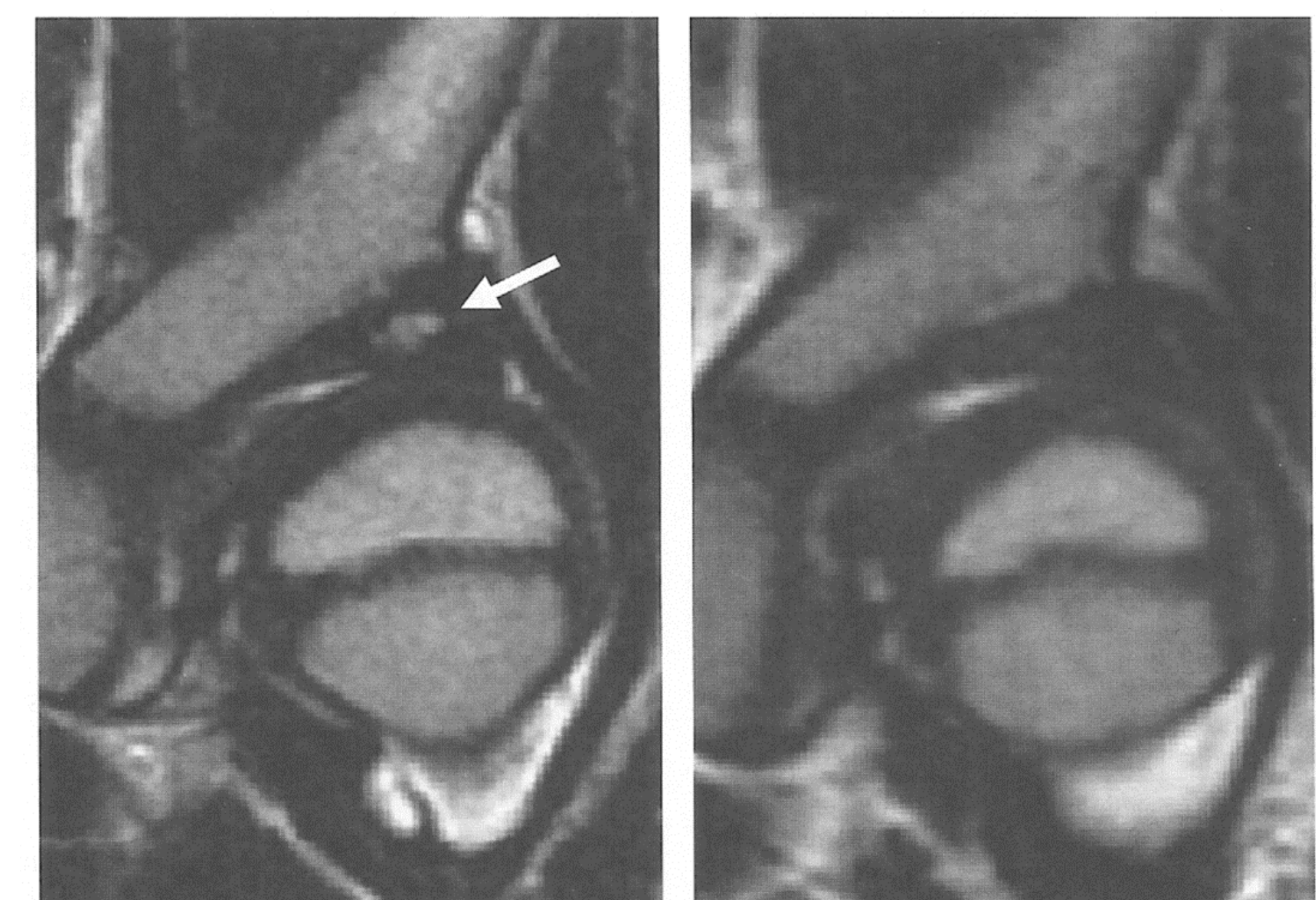
- D Tonniss, *Congenital Dysplasia and Dislocation of the Hip*, Springer-Verlag, Berlin 1984
- JR Bowen, *Developmental Dysplasia of the Hip*, Data Trace Publishing, Brooklandville, Maryland, 2006

Average Acetabular Index for girls age 2 years is 19°



D Tonniss, <http://www.dr-toennis.de/media/downloads/Epidemiology.pdf>  
Also - CORR 1976;119:39-47

### MRI may be useful

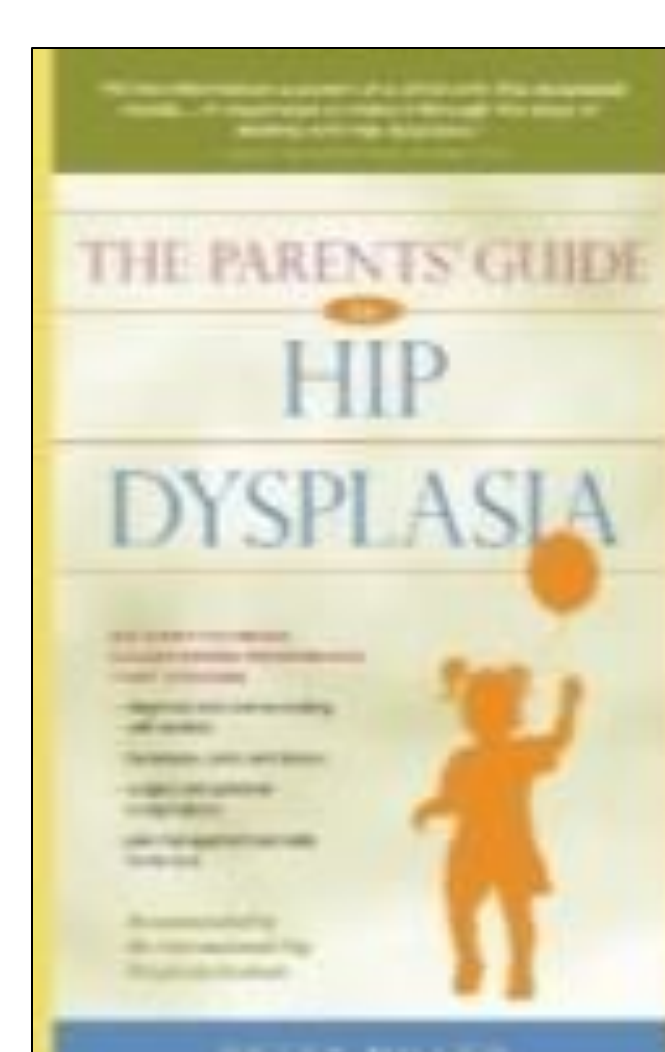
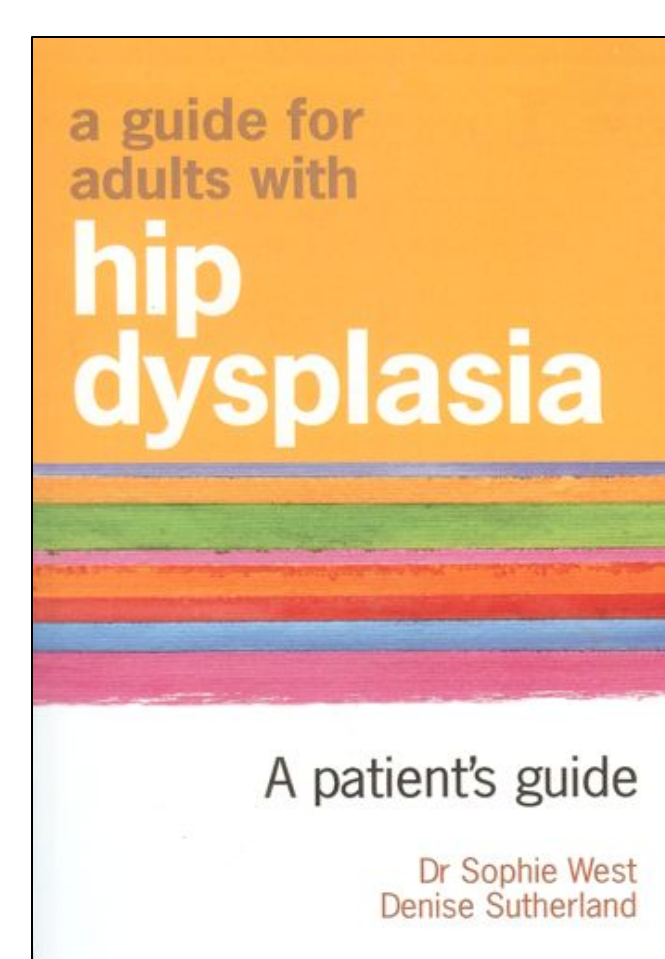
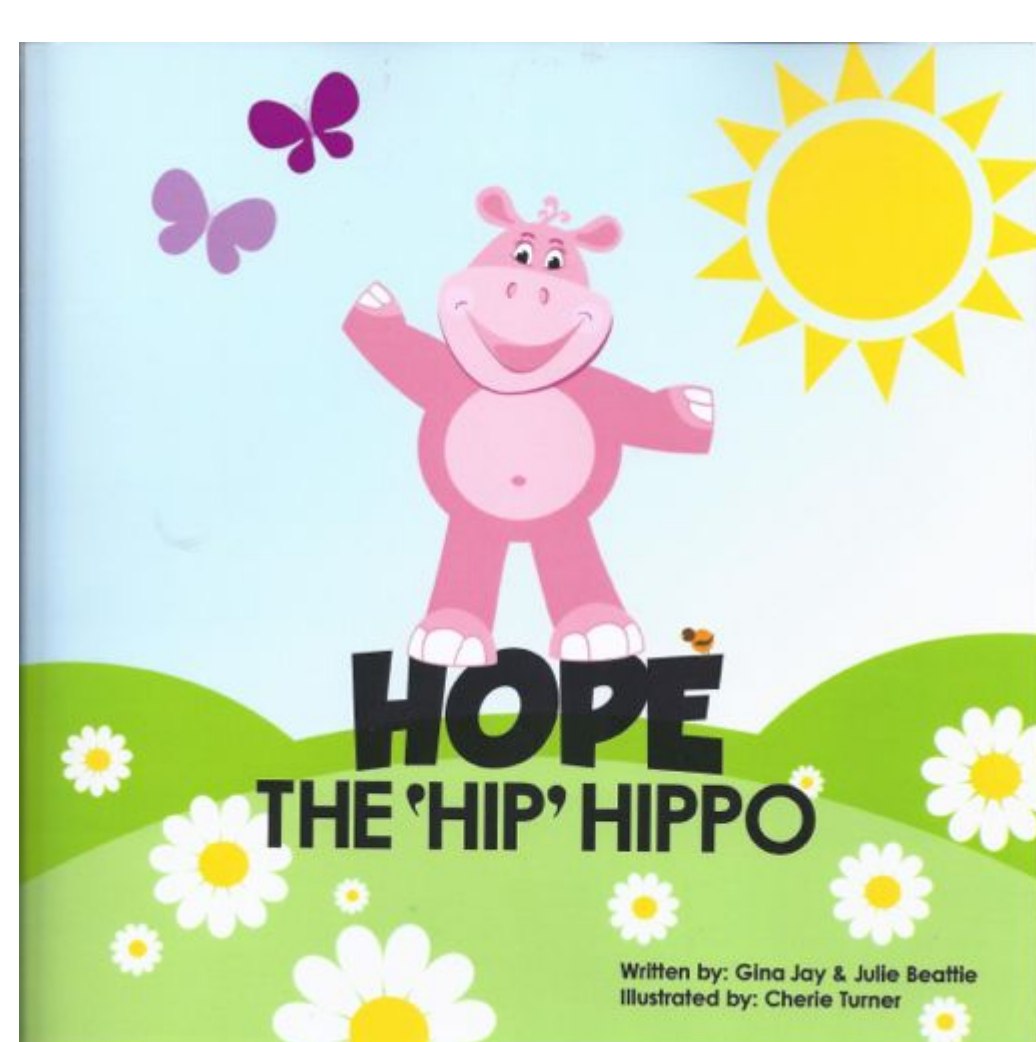


Age 3 years  
High signal intensity area in acetabular cartilage on T2-weighted image predicts poor outcome with observation

K Wakabayashi, JPO 2011;31(4):381-7

## Additional Resources

### For patients and families



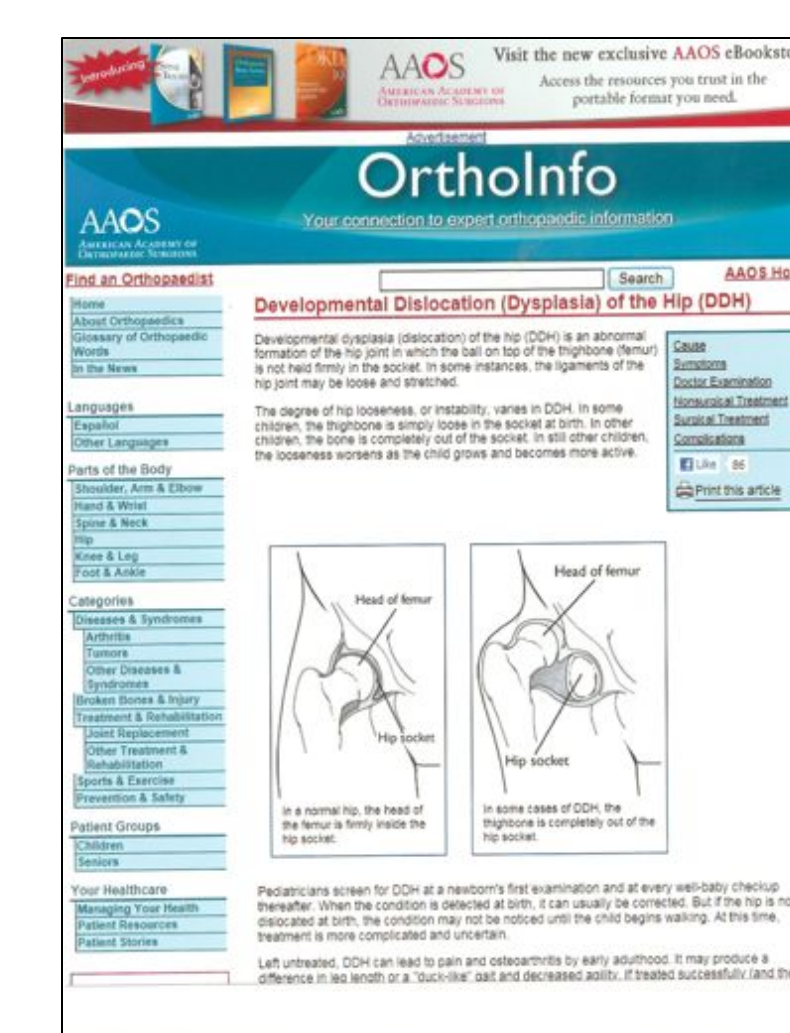
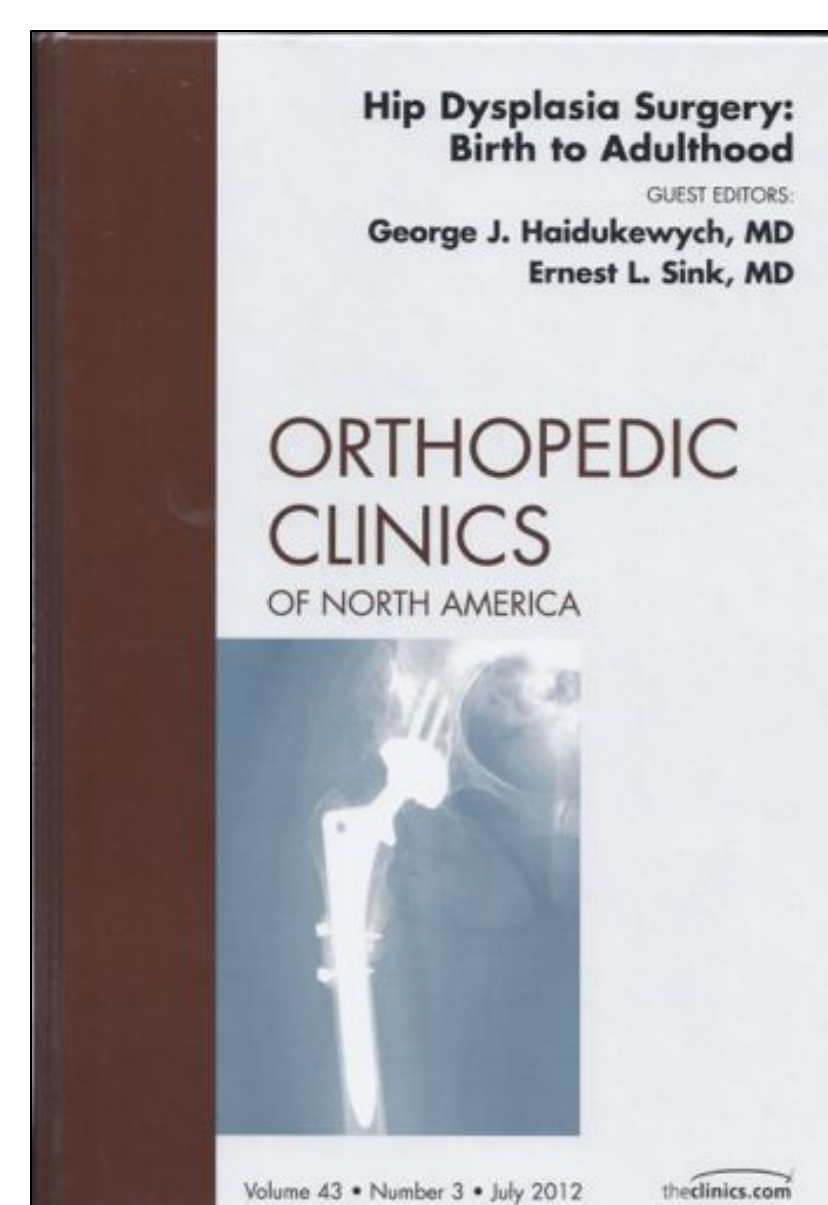
### www.hipdysplasia.org



### International Hip Dysplasia Institute



### For physicians



<http://orthoinfo.aaos.org/topic.cfm?topic=A00347>



[http://orthportal.aaos.org/search/results.aspx?siteChoice=default\\_collection&q=hip+dysplasia&submit=Search](http://orthportal.aaos.org/search/results.aspx?siteChoice=default_collection&q=hip+dysplasia&submit=Search)