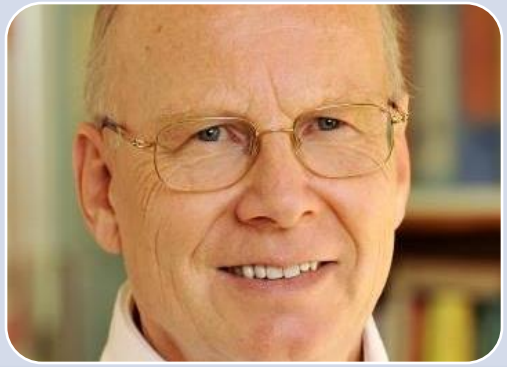
Different ultrasound techniques

Comparative literature review

What do we want from these methods

- Reproducible scans
  - High specificity
- Reliable scans
  - Very high sensitivity

3 main methods, how do they compare?



Graf (1980) : based on a static coronal image of the hip

Harcke (1984) : concept of femoral head coverage (FHC)

Terjensen (1989) : FHC with dynamic hip screening

Graf R. The diagnosis of congenital hip joint dislocation by ultrasound compound treatment. Arch Orthop Trauma Surg 1980; 97:117-33
Morin C, Harcke HT, MacEwen GD. The infant hip: real time US assessment of acetabular development. *Radiology* 1985:157:673-7
Terjesen T, Bredland T, Berg V. Ultrasound for hip assessment in the newborn. J Bone Joint Surg [Br] 1989; 71-B:767-73.

HARCKE METHOD (1984)

Patient in the supine position

Static and dynamic scanning in the frontal and transverse planes are performed

Qualitative description with numeric measurements as well

Use of femoral head cover (FHC) > 57% (patients < 9-12 months) is optional

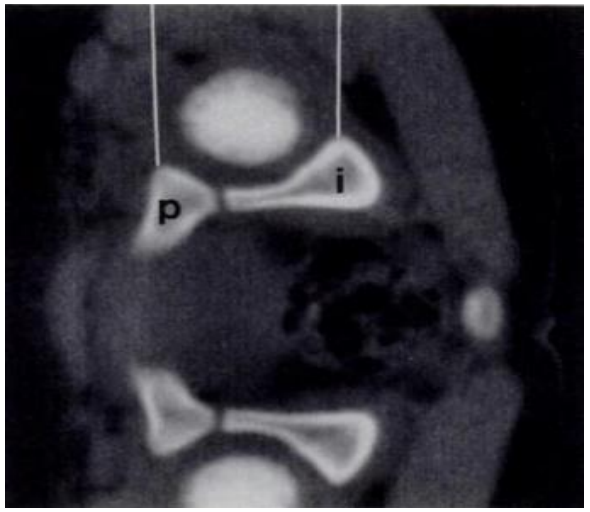
6 views

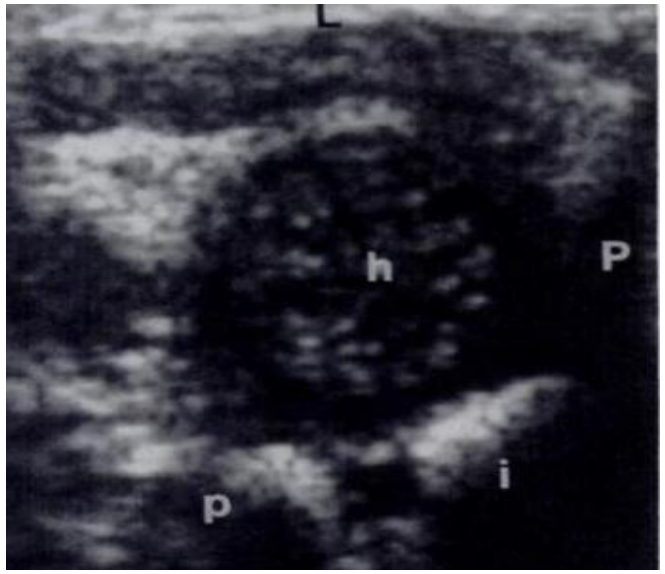
- **Transverse Neutral View**
- **Transverse Flexion/Abduction View**
- **Transverse Flexion/Adduction View**
- **Coronal Neutral View**
- **Coronal Posterior Lip**
- **Coronal Posterio Lip/Mid-acetabulum under stress**

Examination of the infant hip with real-time ultrasonography. *Harcke HT, Clarke NM, Lee MS, Borns PF, MacEwen GD J Ultrasound Med. 1984 Mar; 3(3):131-7.*

HARCKE METHOD (1984)

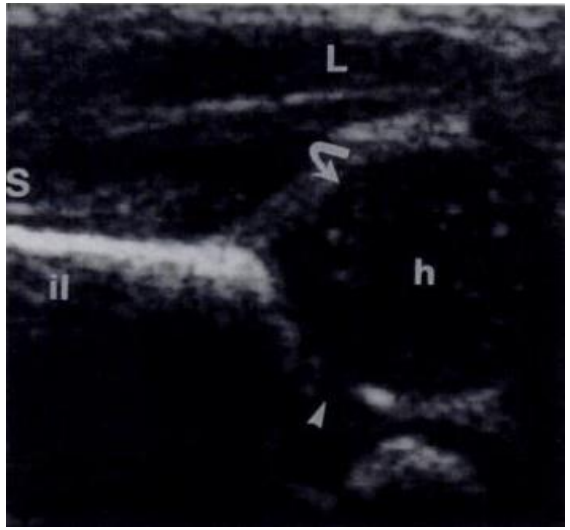
Transverse View

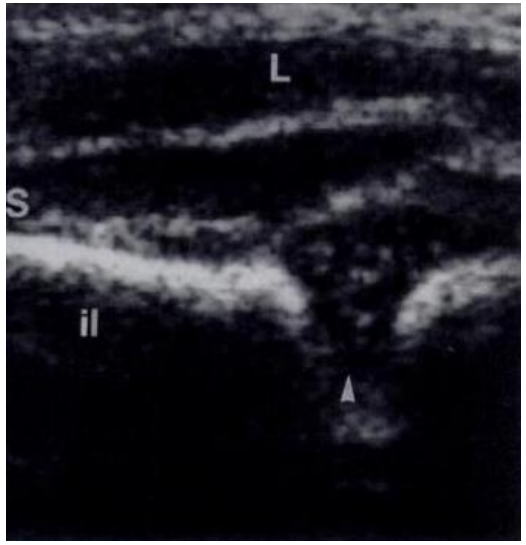




L = lateral
P = posterior
h = head
p =pubis
i = ischium
il = ilium

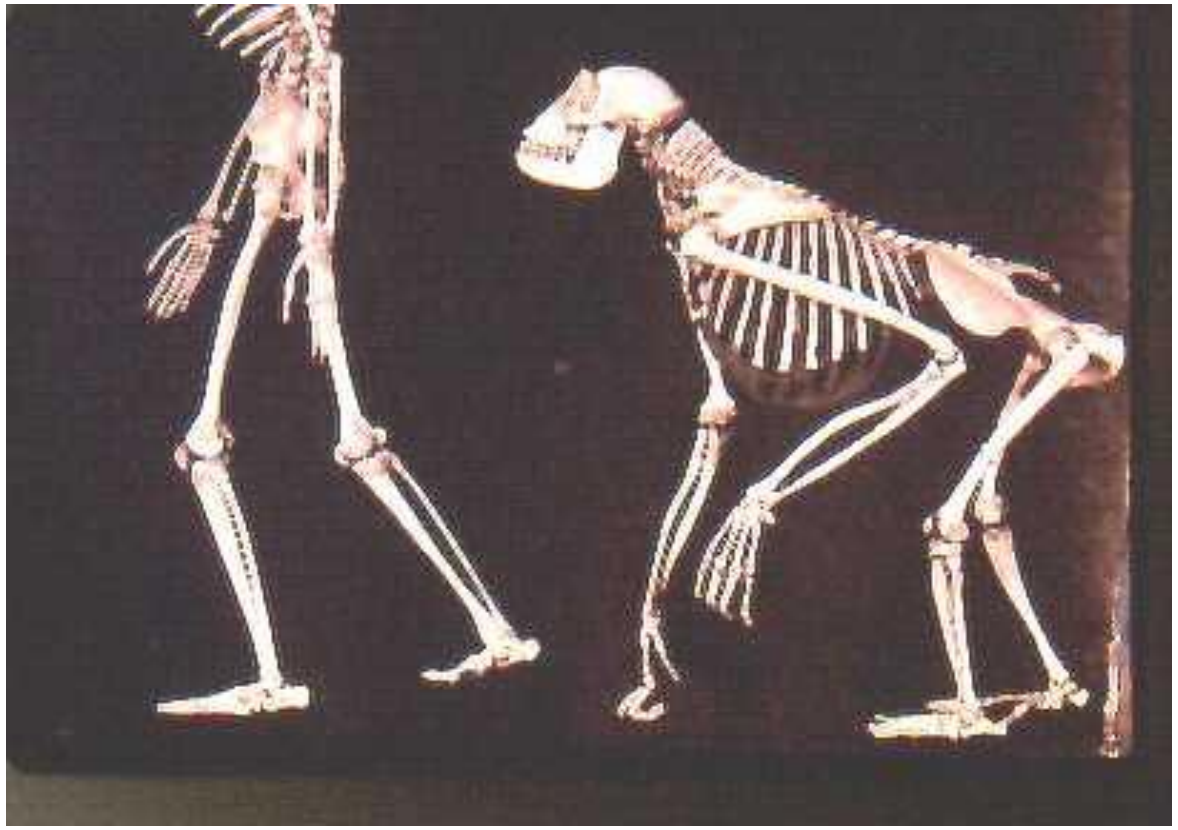
Coronal View

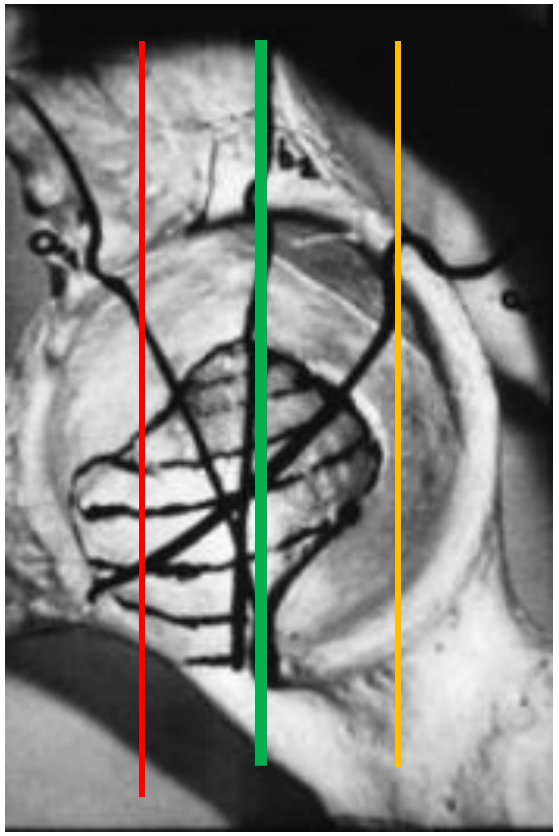




L = lateral
S = superior
h = head
il = ilium
Curved arrow = labrum
Arrowhead = triradiate

Evolution





HARCKE METHOD (1994) Delaware,USA

AJR Am J Roentgenol. 1994 Feb;162(2):395-7.

Screening newborns for developmental dysplasia of the hip: the role of sonography.

Harcke HT[1].

TABLE 2: Sonography of the Hip: Dynamic Standard Minimum Examination

Principles
1. The hip should be examined at rest and when stressed.
2. Assessment should include views in orthogonal planes.
3. Assessment includes description of both stability and morphology.

Methods
1. Examination is performed with a real-time linear-array transducer.
2. The examination may be done with the infant in a supine or lateral position.

Components
1. Either A or B
   A. Coronal neutral view in standard plane at rest. Additional stress view optional. Validation by line/angle measurement optional.
   B. Coronal flexion view in standard plane at rest. Additional stress view optional. Validation by line/angle measurement optional.
2. Transverse flexion view with stress.

Revised to 2 views as the standard minimum technique,

"…quantitative measurements such as Graf's α angle is optional in the Harcke method, but encouraged to use α angle "

TERJESEN METHOD (1989) Oslo

- There is a Grey zone from 45% to 54%.

Lateral approach

Patient in the supine position

Bony Rim Percentage or Femoral Head Coverage %

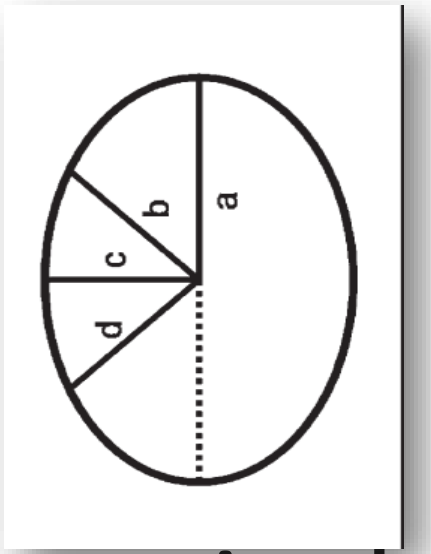
FHC should be > 50%

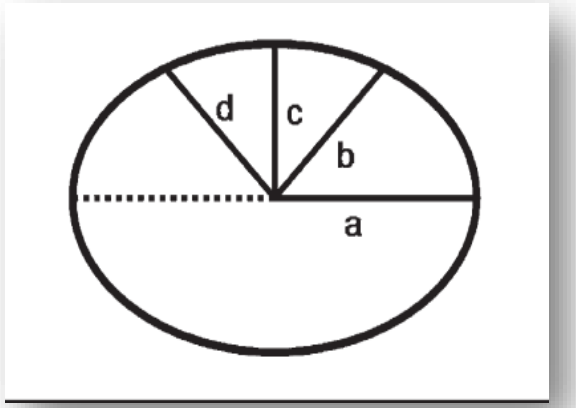
Figure 1. The neonate is lying supine, with slight, physiological flexion but otherwise neutral position of the hips. The baby is supported by the mother. The examiner uses one hand to hold the transducer and the other to hold the infant's leg. The linear transducer is applied longitudinally at the lateral aspect of the hip. Thus, a coronal section of the hip joint is obtained.

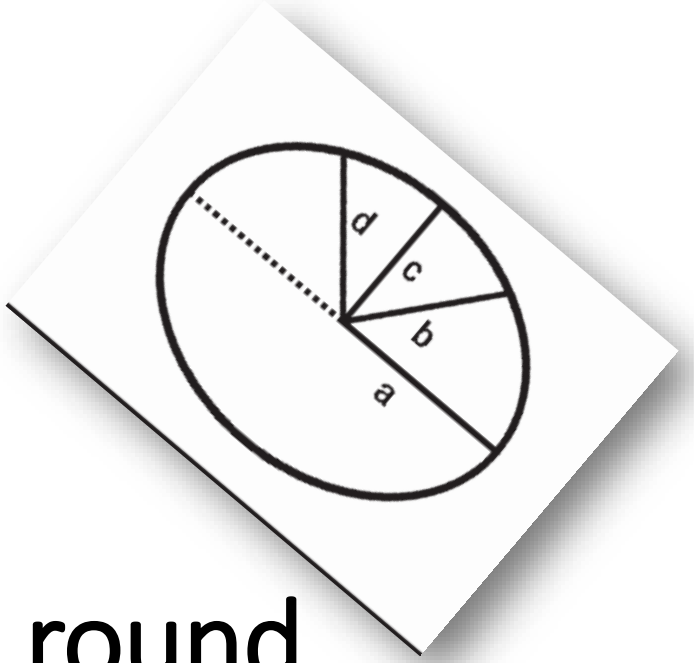
Terje Terjesen (1998) Ultrasonography for evaluation of hip dysplasia: Methods and policy in neonates, infants, and older children, Acta Orthopaedica Scandinavica, 69:6, 653-662,

"Mean normal hips had 54% and in boys 56% FHC .
The lower limit of normal range is approximately 45% (44% in girls and 47% in boys)."

It is difficult to find the centre
of a non-spherical object.







As the Femoral Head is not round…
with rotation each section of the head will
have different sizes !

So % of femoral head coverage will change with rotation
System NOT reproducible

TERJESEN METHOD (1989)

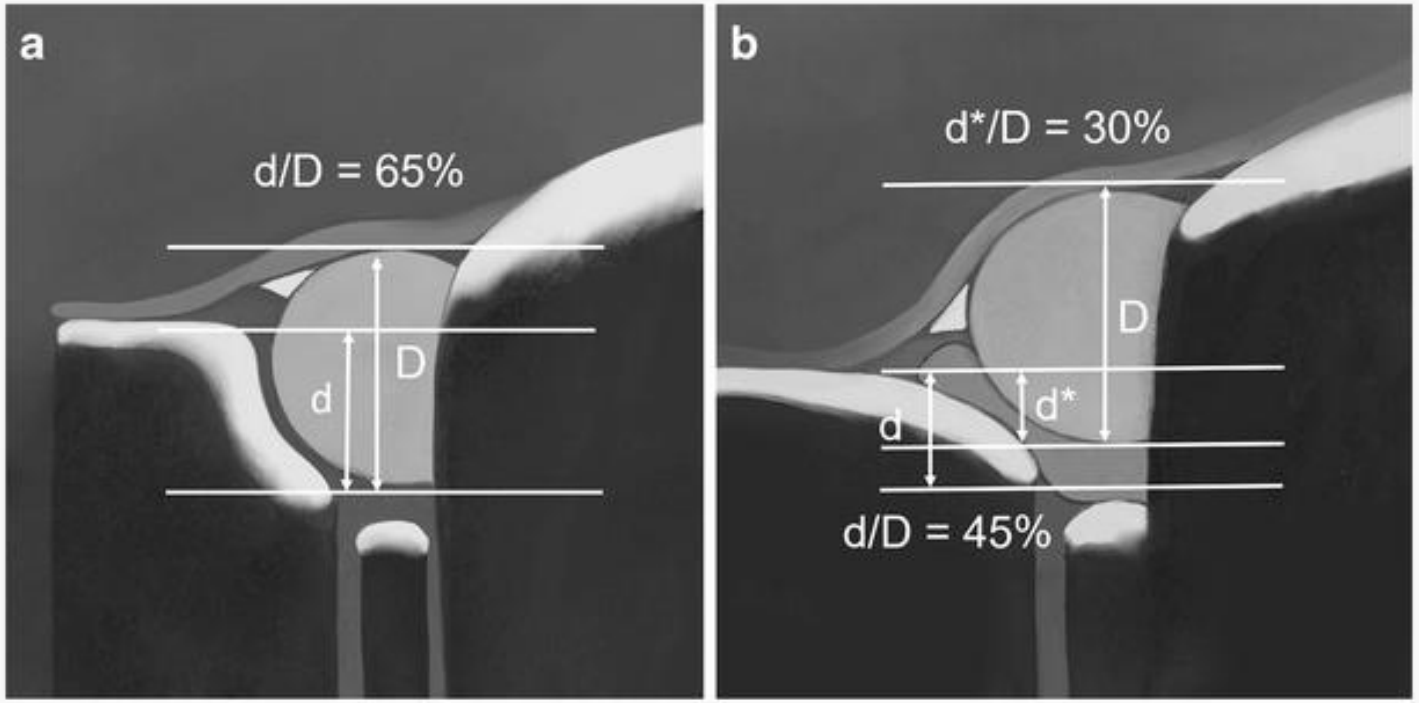


Fig. 1
Coronal neutral view ultrasound schematic. **a** Normally seated hip and normal acetabulum with d/D measurement. **b** Subluxated hip and dysplastic acetabulum with d/D and d*/D measurements. *d/D* the ratio of acetabular depth to diameter of the femoral head [7, 9], *d*/D* ratio of femoral head coverage to diameter of the femoral head

d/D (%) can be measured in normal hips only

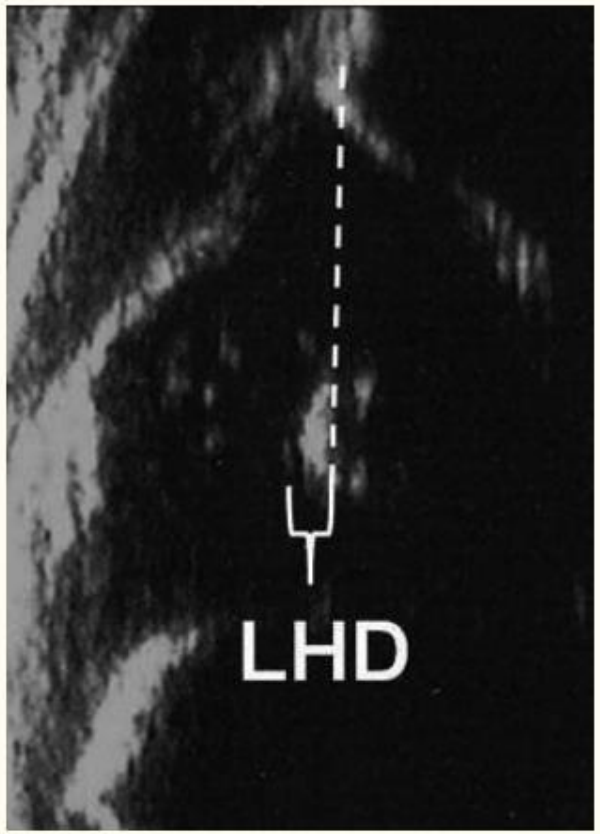
d*/D (%) should be measured in subluxed hips

d/D can be > 50% in subluxed hips!!!

50%, normal
49-40% possible dysplasia,
39-10% subluxation
below 10% dislocation

TERJESEN METHOD (1989)

Lateral head distance (LHD)



"...an expression of the uncovered part of the ossific nucleus, is measured and it can have a minus sign in normal hips."

"In newborns with instability the FHC can be 35%, which means that FH subluxes rather than dislocates. In stress (Flex/adduct/stress) it can be checked if the FH moves lateraly >3mm."

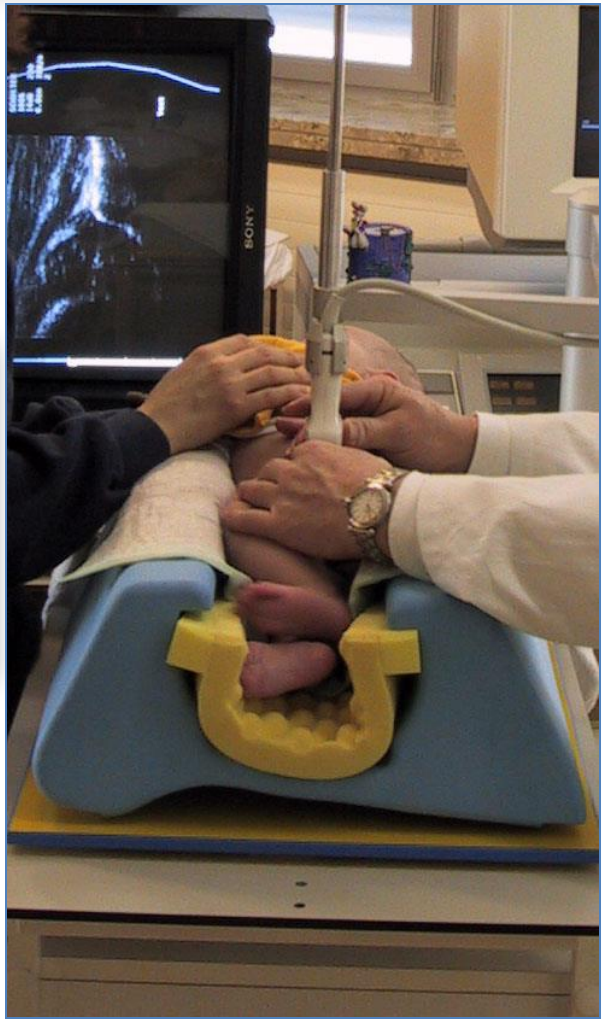
Ossific nucleus in not always in the center!!!

Stress view is difficult to interpret, as there is physiological laxity in newborns

GRAF'S METHOD

Preparation essential

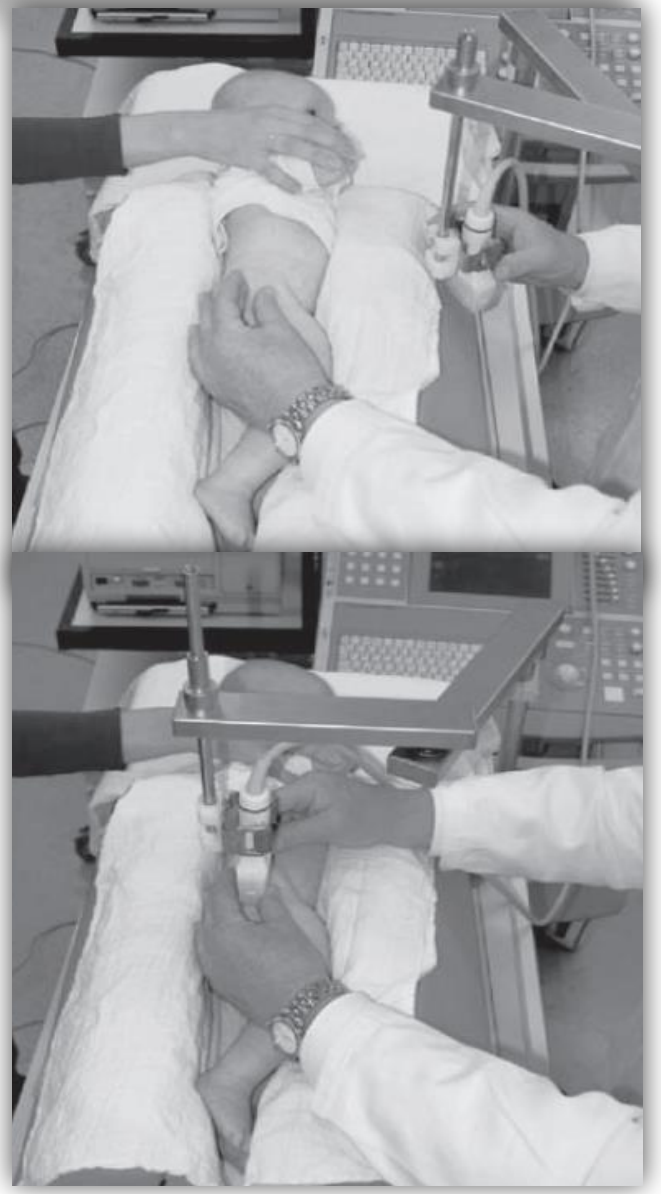
- Warm place
- Changing Table
- **The cradle**
- **Sonoguide**
- **Linear probe**
- Instructions to mother
- Examination should last less than 1 min



GRAF'S METHOD

Positioning standardised

- **Fingers** positioned on trochanter
- **Transducer** position (placed between thumb and fingers parallel to the bolsters of the cradle)

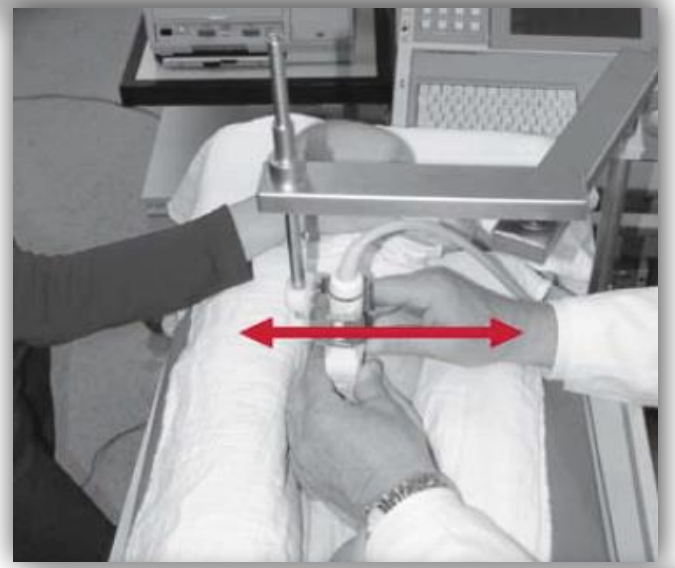


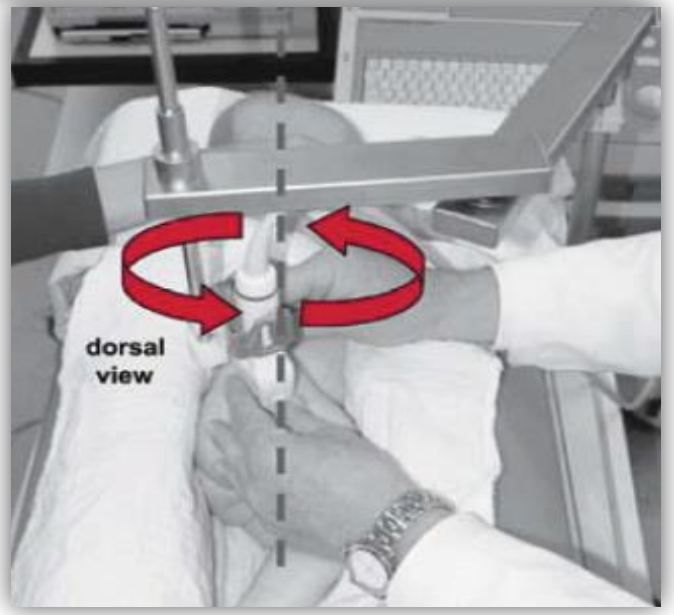
GRAF'S METHOD

Scanning technique

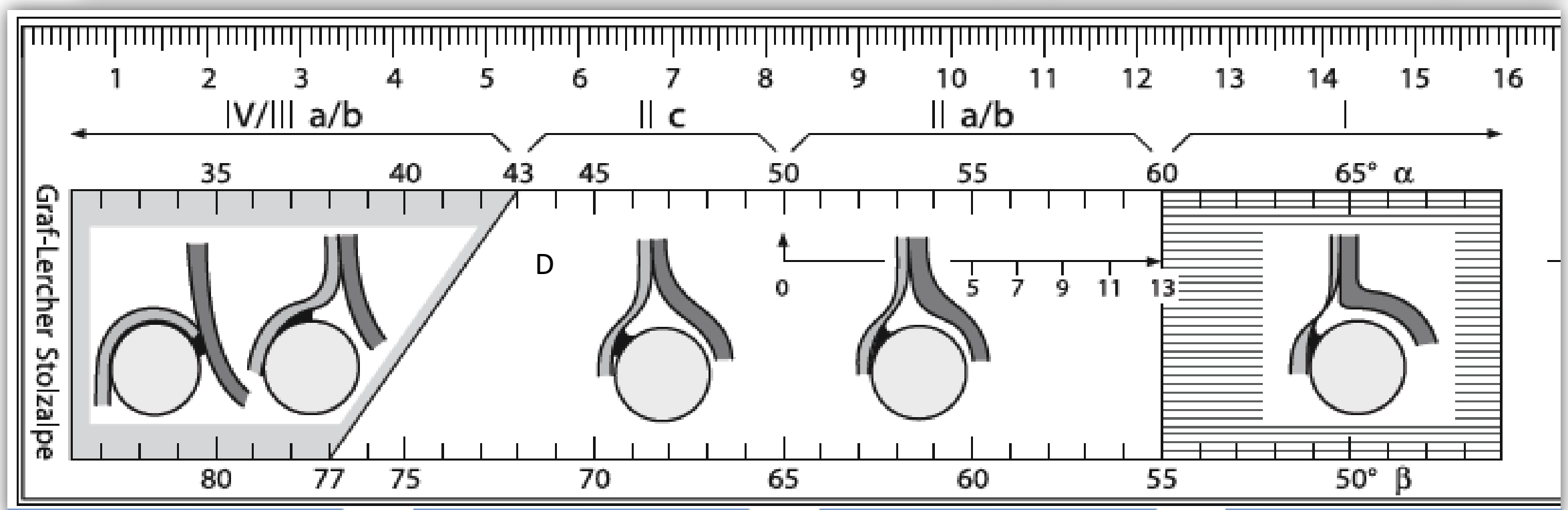
simple

- The transducer is moved backwards and forwards from the position on the greater trochanter
- Concentrate on the lower limb of the os ilium
- Correction of the sectional plane is then carried out





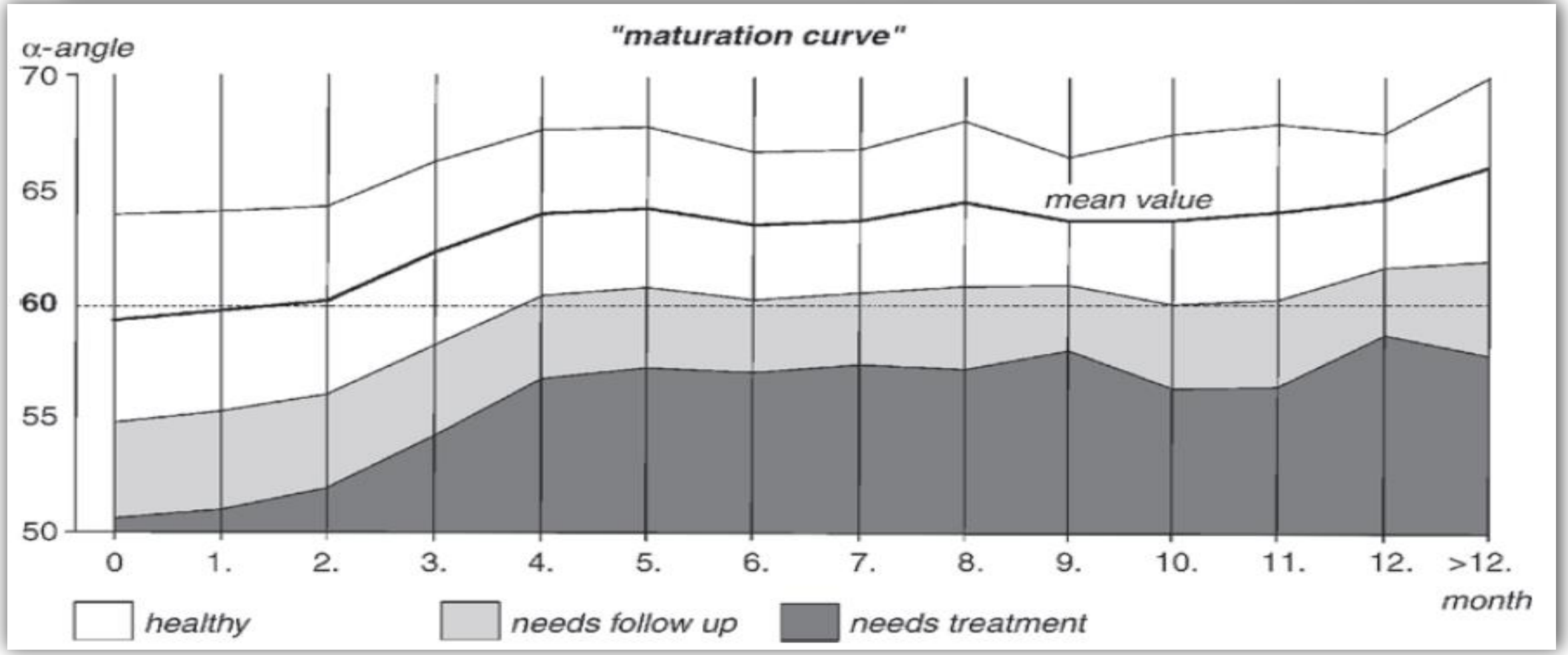
ULTRASOUND MEASUREMENT (alpha and beta angles)



Decentered (III,IV, D)	Unstable (IIc)	Immature II a Dysplastic IIb	Normal type I

!!!NO GREY ZONES!!!

MATURATION CURVE (alpha and beta angle)



Takes into account the normal physiological laxity (elastic wipping)that resolves spontaneously by 6 weeks of age

- Literature
- Comparing the different techniques
- can we set a gold standard ?

COMPARISON BETWEEN METHODS (1994) Spain

Journal of Pediatric Orthopaedics Part B
3:185–189 © 1994 Raven Press, Ltd., New York

Simultaneous Ultrasound Studies of Developmental Dysplasia of the Hip Using the Graf, Harcke, and Suzuki Approaches

A. Diaz, M.D., M. Cuervo, M.D., and T. Epeldegui, M.D.

Servicio de Cirugia Ortopédica y Traumatologia, Hospital del Nino Jesus, Madrid, Spain

- ✓ 208 babies (clinical indic.), 416 Hips
- ✓ examined with Graf/Harcke/Suzuki

Summary: The aim of this study was to evaluate the systematic use of three approaches for ultrasound exploration of developmental dysplasia of the hip (DDH) in 208 children. Graf's procedure was found to be the best and most reliable method. When coupled with the Harcke and Suzuki techniques, the diagnosis of DDH cannot be missed. **Key Words:** Developmental dysplasia of the hip—Ultrasound—Diagnosis.

Simultaneous Ultrasound Studies of Developmental Dysplasia of the Hip Using the Graf, Harcke, and Suzuki Approaches. Diaz A. M.D. et al. Journal of Pediatric Orthopaedics B: 1994

COMPARISON BETWEEN METHODS (1994)

TABLE 1. *Ultrasound diagnostic classification of the hip in 208 infants*[a]

Number of hips	Graf's type	Approach after Suzuki	Approach after Harke
210 (50.48%)	Type I = 210 (50.48%)	Normal findings = 210 (50.48%)	Normal findings = 210 (50.48%)
108 (25.96%)	Type IIa + = 61 (14.66%)	Normal findings = 108 (25.96%)	Slight dislocation = 11 (2.64%)
	Type IIa − = 47 (11.3%)	Normal findings = 108 (25.96%)	Normal findings = 97 (23.32%)
30 (7.21%)	Type IIb = 30 (7.21%)	Normal findings = 19 (4.57%)	Normal findings = 30 (7.21%)
		Slight dislocation = 11 (2.64%)	
18 (4.33%)	Type IIc = 18 (4.33%)	Slight dislocation = 12 (2.88%)	Subluxation = 18 (4.32%)
		Dislocation = 6 (1.44%)	
30 (7.21%)	Type D = 30 (7.21%)	Dislocation = 30 (7.21%)	Subluxation = 25 (6.0%)
			Dislocation = 5 (1.2%)
13 (3.12%)	Type III = 13 (3.12%)	Dislocation = 13 (3.12%)	Subluxation = 10 (2.4%)
			Dislocation = 3 (0.72%)
7 (1.68%)	Type IV = 7 (1.68%)	Dislocation = 7 (1.68%)	Dislocation = 7 (1.68%)

- From 30 IIb Graf hips, all were normal based on Harcke
  - no further follow up

Simultaneous Ultrasound Studies of Developmental Dysplasia of the Hip Using the Graf, Harcke, and Suzuki Approaches. Diaz A. M.D. et al. Journal of Pediatric Orthopaedics B: 1994

COMPARISON BETWEEN METHODS (1998)

Acta Orthop Scand 1998; 69 (1): 21–24

Ultrasound measurements of the newborn hip

Comparison of two methods in 657 newborns

…rt Skrzypek

We conclude that both the Graf and Terjesen method give similar results. A good interobserver agreement, better specificity and a simple classification are in favor of the Terjesen method. We fou… good interobserver agreement as that … Holen et al. (1994) and previously by T… (1989). The Graf method is, however, th… monly used and gives an adequate eval… hip, if the method of examination and r… cated classification are followed carefull…

- ✓ Graf vs Terjesen
- ✓ 656 (1312 hips) newborns
- ✓ Mean age 23 days
- ✓ Treatment based on both technique's results

Table 4. Ultrasound results according to both methods at the primary examination (number of hips evaluated with both classifications)

	α angle				
FHC	I	IIa	IIc	III	Total
Normal	**830**	248	7	2	1087
Possible dysplasia	53	**125**	6	3	187
Subluxation	5	9	**13**	9	36
Dislocation	0	0	0	**2**	2
Total	888	382	26	16	1312

- **Dislocated hips: 2 (Terjensen) vs 16 (Graf)**
- **2 dislocated hips (Graf) appeared normal in Terjensen**
- **No dislocated hip (Terjensen) appeared normal in Graf**

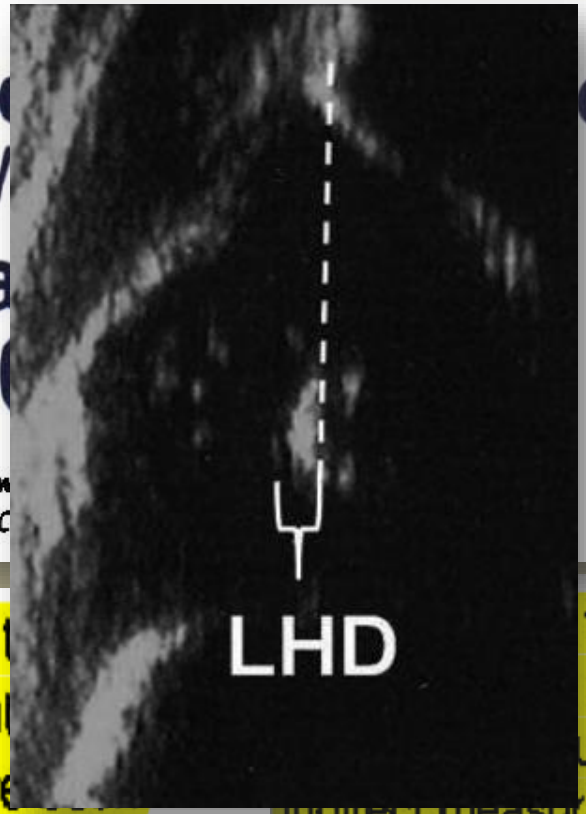
Jaroslaw Czubak et.al. (1998) Ultrasound measurements of the newborn hip Comparison of two methods in 657 newborns, Acta Orthopaedica Scandinavica, 69:1, 21-24

COMPARISON BETWEEN METHODS (2001)

BMUS BULLETIN • August 2001

Comparison of two te in the assessment/ of Developmenta of the Hip (

Sarah-Jane Langford, Susan New
Great Ormond Street Hospital for C



Mini-review article
Graf
vs
Terjensen

The Graf technique is technically complicated for t inexperienced, and for an accurate and consistent needs to be performed by sonographers that have trained in the method. The Terjesen technique is technically

femoral head has ossified (and thus obscures of the iliac margin) this prevents making an urement using Graf. The Terjesen LDH is an rement to assess femoral head coverage when the ossification centre has appeared.

Ossific nucleus in not always in the center!!!

Comparison of Two Techniques Used in the Assessment/Measurement of Developmental Dysplasia of the Hip (DDH). Sarah-Jane Langford, Susan New, and Kalpana Pate. Ultrasound, Vol 9, Issue 3, pp. 26 – 30.Published August 1, 2001

COMPARISON BETWEEN METHODS (2006)

Comparing ultrasound measurements of neonatal hips using the methods of Graf and Terjesen

A. Falliner,
D. Schwinzer,
H.-J. Hahne,
J. Hedderich,
J. Hassenpflug

From University Hospital Schleswig Holstein, Kiel, Germany

232 neonates (<4 days)
Graf vs Terjesen
- Reproducibility
- Inter-observer reliability
- Intra-observer reliability

Correlation between Graf and Terjesen. The plot of α angles against femoral head cover values shows the correlation between these values, which are differently scaled (Fig. 2). Spearman's correlation coefficient is 0.55, with a 95% CI from 0.48 to 0.62.

Inter-observer reliability. The Bland-Altman approach indicates no obvious difference between the physicians and the medical students. The intra-class correlation coefficient (α) was 0.72 for the physicians and 0.74 for the students and the intra-class correlation coefficient (femoral head cover) was 0.61 for the physicians and 0.77 for the students.

Reproducibility in experienced hands. The Bland-Altman approach of double measurement of the α angles and femoral head cover values by the two experienced investigators shows a larger variability for femoral head cover (CR_a 10.25) than for α angle (CR_a 6.15).

Intra-observer reliability. An author's (DS) measurements of 24 hips show better repeatability for Graf (CR_b 5.96) than Terjesen (CR_b 8.22; Table II).

Comparing ultrasound measurements of neonatal hips using the methods of Graf and Terjesen. JBJS (Br). A. Falliner,D. Schwinzer, H.-J. Hahne, J. Hedderich, J. Hassenpflug. Published Online:1 Jan 2006

COMPARISON BETWEEN METHODS (2010)

Peterlein *et al. BMC Pediatrics* 2010, **10**:98
http://www.biomedcentral.com/1471-2431/10/98

BMC Pediatrics

RESEARCH ARTICLE **Open Access**

Reproducibility of different screening classifications in ultrasonography of the newborn hip

Christian D Peterlein[1*], Karl F Schüttler[1], Stefan Lakemeier[1], Nina Timmesfeld[2], Christian Görg[3], Susanne Fuchs-Winkelmann[1], Markus D Schofer[1]

- ✓ 207 newborns
- ✓ Measured by Peads. Ortho, Ortho and Student
- ✓ a-angle, b-angle and FHC were measured twice (1242 exams)

Objective scorings

The best results with respect to limits of agreement were achieved for the α-angle (mean range: -5.12 - +5.61), followed by the β-angle (mean range: -10.12 - +10.09), and finally for FHC (mean range: -10.52 - +11.03). The

Reproducibility of different screening classifications in ultrasonography of the newborn hip, Christian D Peterlein et al., BMC Pediatrics 2010 10:98

COMPARISON BETWEEN METHODS (2012)

Evaluation of three ultrasound techniques used for the diagnosis of developmental dysplasia of the hip (DDH)

Authors: E. M. D. B. Pacheco[1], E. J. N. M. Bronzatto[2], G. L. P. Martins[2], F. Reis[1], I. M. R. Pereira[3], N. M. G. Caserta[2]; [1]Campinas/BR, [2]Campinas, SP/BR, [3]Campinas, Sao Paulo/BR

Keywords: Dysplasias, Diagnostic procedure, Ultrasound, Pediatric, Musculoskeletal system, Musculoskeletal joint

DOI: 10.1594/ecr2012/C-2049

- ✓ 225 infants clinically suspected of DDH
- ✓ Mean age : 7.79±6.44 weeks
- ✓ Graf vs Harcke vs Terjensen
- ✓ Calculate Specificity and Sensitivity

Comparing the results, it was proven that the most adequate ultrasound technique for the diagnosis of DDH was Graf's technique, being the alpha angle (acetabular inclination angle) the most reliable criteria for treatment indication. Considering the cutting point at the level of type IIa(+), the Graf's technique reached 100% of sensitivity and 96,6% of specificity for the confirmed (definitive) diagnosis; 87.5% and 96.4% for the confirmed and

Using Harcke's technique, the best cutting point was achieved when classifying the hips with isolated instability as normal. The sensitivity value was 100% and the specificity value was 95.8% for the confirmed (definitive) diagnosis; 80.0% and 96.4% for the

Using Morin's technique, considering as normal the hips with the percentage of coverage of the femoral head by the bony acetabulum greater or equal to 44%, the sensitive value was 93.3%, and the specificity value was 76.2% for the confirmed (definitive) diagnosis;

Evaluation of three ultrasound techniques used for the diagnosis of developmental dysplasia of the hip, Pacheco et al., Sao Paolo

COMPARISON BETWEEN METHODS (2015)

World Journal of Orthopedics

Submit a Manuscript: http://www.wjgnet.com/esps/
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
DOI: 10.5312/wjo.v6.i11.886

World J Orthop 2015 December 18; 6(11): 886-901
ISSN 2218-5836 (online)

REVIEW

Developmental dysplasia of the hip: What has changed in the last 20 years?

Pavel Kotlarsky, Reuben Haber, Victor Bialik, Mark Eidelman

Review article
- Incidence
- Screening methods
  - Radiographs
  - U/S
- Treatment
- Follow-up

different conclusions[70,71]. A study that compared the Graf, Suzuki and Harcke methods, a correlation was found between the three methods in normal and dislocated hips; however, Graf type IIa and IIb hips were frequently regarded as normal when evaluated by the other two methods[72]. There is no conclusive evidence to prefer one method over the other. However an effective ultrasonographic method should include simple, precise, quantitative and consistent definitions for a proper examination and diagnosis, and Graf's method meets all these requirements[69].

Kotlarsky P, Haber R, Bialik V, Eidelman Developmental dysplasia of the hip: What has changed in the last 20 years? *World Journal of Orthopedics*. 2015;6(11):886-901. doi:10.5312/wjo.v6.i11.886.

Summary

Article	Reliability	Sensit/Specif	Interobserver	Intraobserver	Reproducibility
Diaz A. M.D. et al. Journal of Pediatric Orthopaedics B: 1994 (Graf vs Harcke vs Suzuki)	**Graf**	-	-	-	-
Czubak et al. Acta Orthopaedica Scandinavica. 1998 (Graf vs Terj.)	**Equal**	**Terjesen**	**Terjesen**	-	-
Langford et al. Ultrasound.2001 (Graf vs Terj.)	**Graf needs more experience**	-	-	-	-
Falliner et al. JBJS, 2006 (Graf vs Terj.)	**Equal**	**Graf**	**Equal (except for students)**	**Graf**	**Graf**
Peterlein et al.BMC Pediatrics. 2010 (Graf vs Terj)	**Graf**	-	-	-	**Graf**
Pacheco et al. ECR. 2012 (Graf vs Terj vs Harcke)	**Graf**	**Graf**	-	-	-
Kotiarsky et al. World Journal of Orthopaedics. 2015 (Review)	**Graf**	**Graf**	-	-	-

CONCLUSION

Graf technique outweighs other techniques

Well-described with guidelines

"Checklist 1 and 2"

Has no **GREY** zones

Takes into account changing anatomy in first 12 weeks of life

So use a method that

- Reproducible scans
  - High specificity
- Reliable scans
  - Very high sensitivity

Summary

Article	Reliability	Sensit/Specif	Interobserver	Intraobserver	Reproducibility
Diaz A. M.D. et al. Journal of Pediatric Orthopaedics B: 1994 (Graf vs Harcke vs Suzuki)	**Graf**	-	-	-	-
Czubak et al. Acta Orthopaedica Scandinavica. 1998 (Graf vs Terj.)	**Equal**	**Terjesen**	**Terjesen**		
			for students)		**Graf**
Peterlein et al.BMC Pediatrics. 2010 (Graf vs Terj)	**Graf**	-	-	-	**Graf**
Pacheco et al. ECR. 2012 (Graf vs Terj vs Harcke)	**Graf**	**Graf**	-	-	-
Kotiarsky et al. World Journal of Orthopaedics. 2015 (Review)	**Graf**	**Graf**	-	-	-

Any Questions??????