A sonographic study of perinatal hip development: from 34 weeks of gestation to 6 weeks of age

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A sonographic study of perinatal hip development was performed by consecutive measurement of Graf's α and β angles in fetal and newborn hips. The study group consisted of infants with sonographically normal hip findings at birth. Forty fetuses were examined by fetal hip sonography at 34, 36 and 38 weeks of gestation. Postnatally, hip sonography was performed in the first and sixth week of age. Maturation curves of the bony (α-angle) and cartilaginous (β-angle) acetabular roof from 34 weeks of gestation to 6 weeks of age were established. Prenatally, the mean α-angles were above the level that corresponds to a mature hip joint. A significantly higher value of the mean α-angles was found after birth. The mean β-angles of the fetuses did not differ from those of the newborns. Our results revealed that the fetal hip joint is sonographically mature at 34 weeks of gestation. Further progression of hip development occurs around term. *J Pediatr Orthop B* **12:365–368 © 2003 Lippincott Williams & Wilkins.**

Journal of Pediatric Orthopaedics B 2003, **12**:365–368

Keywords: ultrasound, hip development, fetal hip, maturation curve, morphology

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Introduction

Since its introduction by Graf about 20 years ago [1,2], hip sonography has not only become a widely accepted tool in diagnosis of developmental dysplasia of the hip but has also provided important knowledge on the postnatal development of the hip joint. The measurement of Graf's α and β angles provides a quantitative evaluation of the bony (α-angle) and the cartilaginous (β-angle) acetabular roof of the hip. Reference values and maturation-curves for postnatal hip development based on the measurement of the α-angle were described in a previous study [3]. The sonographic appearance of the hip during the last trimester of gestation was investigated by sonographic studies on preterm neonates and on fetal hips [4–10]. Langer *et al.* [5] reported more Graf IIa hips, as compared with type I, among preterm than among term neonates, whereas a study by Gardiner *et al.* [4] revealed no difference between the α-angles of preterm newborns and terms babies. However they reported higher average β-angles among infants born at term than those born preterm. To our knowledge, no study has examined perinatal hip development by consecutive sonographic measurement of the α and β angles at the fetal and postnatal period. The aims of the present study were (1) to investigate, using fetal hip sonography, perinatal hip development from 34 weeks of gestation to 6 weeks postnatal, and (2) to provide sonographic standard values and maturation curves of the fetal α and β angles for the last 6 weeks of gestation.

Methods

After approval by the local ethics committee and obtainment of written informed consent, 40 fetuses (18 male, 22 female) of 40 pregnant women formed the study group. The study design included sonography of the fetal hip at 34, 36 and 38 weeks of gestation and hip sonography of the newborns in the first and sixth weeks of life. Fetal hip sonography was performed, with the pregnant women in a supine position, using a high-resolution real-time ultrasound system ACUSON 128 (ACUSON GmbH, Erlangen, Germany) with a 5 MHz linear transabdominal transducer. The examinations were conducted by two obstetricians (E.H, K.S.) and observed by an orthopaedic surgeon (H.S.), experienced in hip sonography. The position of the fetuses (cephalic or breech position) at the time of the examination was documented. Lateral midacetabular views of the fetal hip in Graf's standard plane were obtained. The fetal hip sonograms were documented with a monochrome printer and assessed by the orthopaedic surgeon. In addition to the examination of the fetal hip, the amniotic fluid index (AFI), was measured to determine intrauterine conditions, such as oligohydramnios (AFI < 5 cm) or polyhydramnios (AFI > 24 cm) [5,11]. Hip sonography of the newborns was performed by the orthopaedic surgeon (H.S.) with a 7.5 MHz linear transducer (Siemens Sonoline; Siemens AG, Erlangen, Germany) according to Graf's technique.

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Table 1 Grading system of fetal hip sonograms

Grade	Visualization
1	Lower iliac margin
	Lateral pelvic wall
	Acetabular labrum
2	Lower iliac margin
	Lateral pelvic wall
3	Insufficient visualization of lower iliac margin or lateral pelvic wall

Table 2 Distribution of the fetal hip sonograms into the different grades

Grade	Number of hips
1	29 (26.9%)
2	72 (66.7%)
3	7 (6.5%)
Total	108

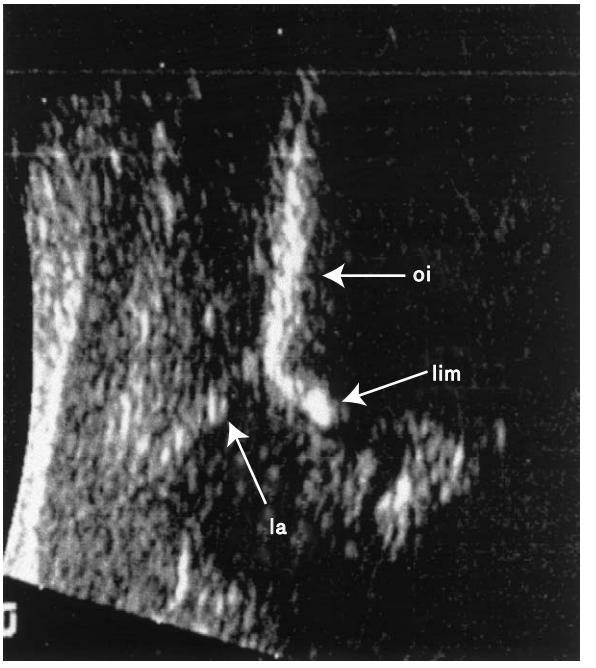
The fetal sonograms were classified into three different categories with regard to the visualization of Graf's landmarks of hip sonography: the lower iliac margin at the triradiate cartilage, the lateral pelvic wall seen as a clear-cut vertical line and the acetabular labrum. The criteria for the distribution of the fetal sonograms into the different categories are shown in Table 1. Fetal sonograms classified as grade 3 were excluded from further evaluation. Only sonograms of neonates born at term were included in the study. Quantitative evaluation of the sonograms was achieved by the measurement of Graf's α and β angles. The means and standard deviations of the α and β angles were calculated. A maturation curve of both angles from 34 weeks of gestation to 6 weeks of age was established. The sonographic data were analysed statistically using the Student's *t*-test.

Results

At each examination of the fetus only the hip joint close to the anterior abdominal wall was accessible to the ultrasound probe. A total of 108 fetal hip sonograms were obtained (59 right, 49 left hips). The fetal positions at the time of the examination were 97 cephalic and 11 breech positions. Seven fetal sonograms (6.5%) were graded as poor and excluded from further evaluation (Table 2). The remaining 101 (93.5%) sonograms fulfilled the criteria for measurement of the α-angle. The acetabular labrum (β-angle) was visualized in 29 (26.9%) fetal hips (Figs 1 and 2). Thirty babies were born at term (40 gestational weeks), four preterm (37–39 gestational weeks) and six infants after 41 gestational weeks. The distribution into the hip types of Graf at birth was as follows: eight type Ia (13.3%); 42 type Ib (70%); and 10 type IIa (16.7%).

The means and standard deviations of the α and β angles at the different gestational and postnatal weeks are listed in Tables 3 and 4. A statistically significant increase of the mean α-angle from 38 weeks of gestation to birth ($P = 0.015$) and from the first to the sixth postnatal week ($P < 0.0001$) was observed. The maturation curves for both α and β angles from 34 gestational weeks to the sixth postnatal week are presented in Figures 3 and 4. A lower value of the mean α-angle of 11 fetal hips scanned in breech position compared with those in cephalic position was observed at each examined gestational and postnatal week. In one fetus with breech position, pathological α-angles were found in both hips. The right hip revealed an α-angle of 48° at 36 gestational weeks. The left hip showed an α-angle of 46° at 38 gestational weeks. After the delivery in breech position, a Graf type IIa on both hips with an α-angle of 50° on the right and 55° on the left side was observed.

Fig. 1



Lateral mid-acetabular view of a left fetal hip at 38 weeks of gestation in Graf's standard plane. The iliac bone (oi), the lower iliac margin (lim) and the acetabular labrum (la) are visualized. Alpha angle, 57°; β-angle, 72°.

The means of the amniotic fluid indices were 17.8 cm (10.8–26.3) at 34 weeks, 18.6 cm (7.6–26.9) at 36 weeks and 18.5 cm (12.4–26.1) at 38 weeks of gestation. No correlation between the amniotic fluid indices and the α or β angles of the fetuses was detected. Polyhydramnios was diagnosed in two pregnancies. In both cases normal sonographic hip findings were observed prenatally and after birth.

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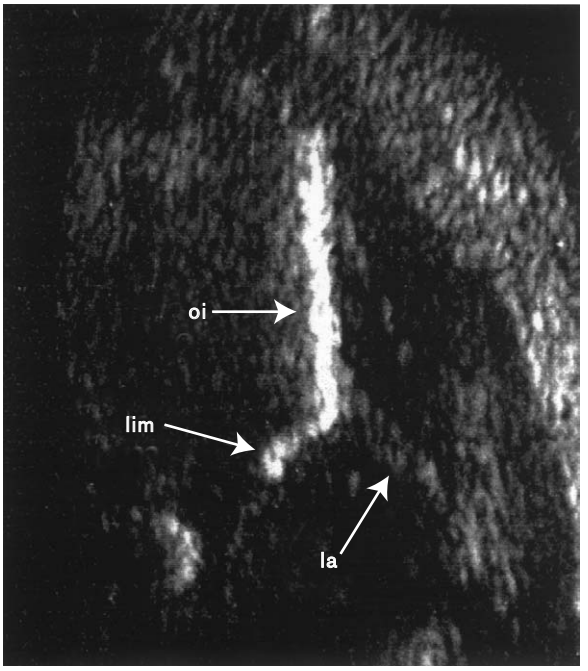
Fig. 2



Lateral view of a right fetal hip at 34 weeks of gestation. Graf's reference points are clearly visible: the iliac bone (oi), the lower iliac margin (lim) and the acetabular labrum (la). Alpha angle, 60°; β-angle, 71°.

Table 3 Evaluation of the alpha-angles from 34 weeks of gestation to 6 weeks of age

	Gestational week			Postnatal week	
	34	36	38	1	6
Number of hips	35	35	31	60	42
Alpha angle (°)					
Maximum	72	72	68	71	76
Minimum	52	48	46	50	60
Mean	61.1	60.7	61.2	63.5	66.8
SD	5.0	4.7	4.4	4.1	3.6
P	NS	NS	NS	0.015	<0.0001

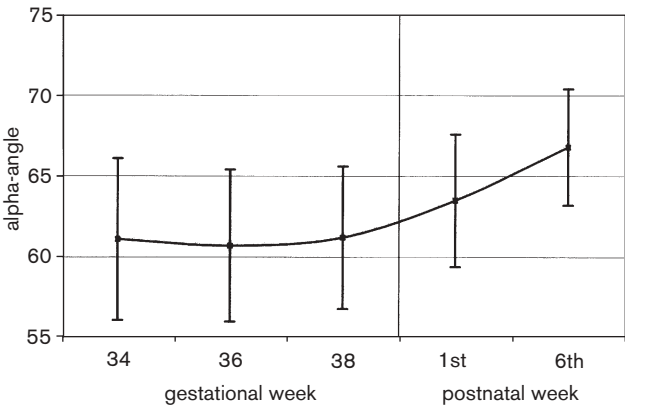
Table 4 Evaluation of the beta-angles from 34 weeks of gestation to 6 weeks of age

	Gestational week			Postnatal week	
	34	36	38	1	6
Number of hips	12	10	7	60	42
Beta angle (°)					
Maximum	76	85	75	87	75
Minimum	44	42	49	49	47
Mean	63.6	63.9	62.3	62.4	60.9
SD	8.2	10.9	8.4	8.0	6.1
P	NS	NS	NS	NS	NS

Discussion

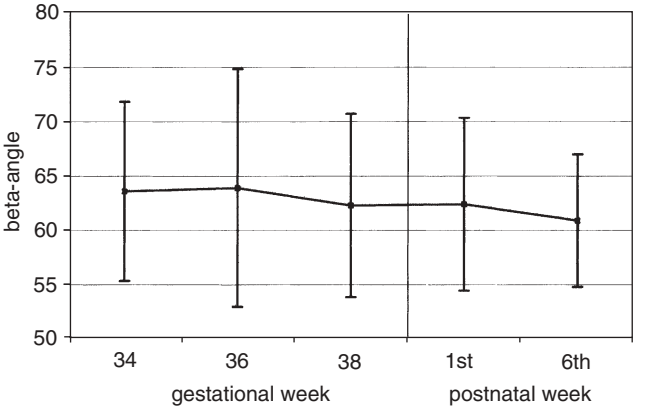
The sonographic appearance of the fetal hip and technical aspects of fetal hip sonography were described in previous studies [6–10]. In accordance with Wagner *et al.* [8], we found the use of the cine loop to be crucial for the visualization of Graf's landmarks, particularly the acetabular labrum, in the standard plane. The clinical applicability of fetal hip sonography as a diagnostic tool for prenatal detection of hip dislocation is limited by the fact that only the hip joint next to the anterior abdominal wall can be visualized.

Fig. 3



Maturation curve of the α-angle from 34 weeks of gestation to 6 weeks of age.

Fig. 4



Maturation curve of the β-angle from 34 weeks of gestation to 6 weeks of age.

The present study provides standard values and maturation curves of the fetal α and β angles. The study group consisted of infants with Graf types Ia, Ib and IIa hips at birth. As a consequence, no conclusions about the fetal development of pathological hips can be drawn.

Wagner *et al.* [10], in a sonographic study on fetal hip development reported mean α-angles between 52 and 66°

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from 34 to 40 weeks of gestation. Other studies compared the α and β angles of preterm neonates with those of babies born at term and revealed controversial results. Langer *et al.* [5] reported a physiological delay in hip maturity, whereas in a study by Gardiner *et al.* [4], the α-angles did not differ between preterm and term infants. In the present study a plateau-like sequel of the mean α-angles above the value that corresponds to a mature hip joint (60°) was observed. The mean α-angle of the neonates scanned in the first week of age was significantly higher ($P < 0.015$) than the prenatal values. These findings indicate that the fetal hip joint is sonographically mature at 34 weeks of gestation. The development of the bony acetabular roof persists between 34 and 38 weeks of gestation and progresses around term. Pathological hip findings (α-angle $< 50°$) were observed in both hips of one fetus in breech presentation at 36 and 38 weeks of gestation. After delivery, both hips were Graf type IIa. Breech presentation is a well-known risk factor for developmental dysplasia of the hip. A trend towards lower α-angles of fetuses in breech position than those in cephalic position was observed prenatally and after birth.

Around term the fetus is exposed to changes in uterine conditions. The influence of the hormone relaxin on the development of the fetal hip joint and its stability as well as mechanical influences are discussed [4,11].

To determine intrauterine conditions the amniotic fluid indices were measured at each ultrasound examination. No correlation was detected between the α and β angles and the amniotic fluid indices. Except in two cases of polyhydramnios, a normal amniotic fluid volume was observed in all pregnancies of our study group. In the two cases of polyhydramnios α-angles within the standard deviation were measured during the fetal period. After birth, both infants showed sonographically mature hips. The levels of the hormone relaxin were not measured in the present study.

Gardiner *et al.* [4] found a greater average β-angle among term than among preterm babies, indicating that the cartilaginous acetabular roof of term infants is more often deformed or displaced. In contrast with the present study, pathological hips were included in their study group. They stated that a combination of mechanical and hormonal factors is responsible for the difference in the β-angles. In the present study the means of the β-angles appeared constant during the last 6 weeks of gestation and showed no significant difference to the values measured after birth. Our results reveal that in normal hips no deformation or displacement of the cartilaginous acetabular roof occurs at the end of gestation.

In conclusion, the present study is the first to describe maturation curves of Graf's α and β angles during the perinatal period. Using fetal hip sonography, we were able to provide standard values of intrauterine hip development, which are of interest for the interpretation of hip findings in premature children. We observed no correlation between the changes of intrauterine conditions and hip morphology. Further studies are required to investigate the perinatal development of pathological hips [12].

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