Ultrasound measurements of the newborn hip

Comparison of two methods in 657 newborns

Jaroslaw Czubak, Tomasz Kotwicki, Tomasz Piontek and Hubert Skrzypek

We compared ultrasound measurements using the Graf and Terjesen methods in 657 newborns. The alpha angle and femoral head coverage (FHC) were analyzed. The rate of DDH was 3.9%, according to Graf and 2.9%, according to Terjesen. The spontaneous increases in alpha angle and FHC were 5° and 7%, respectively, during the first 2 months. Good accordance between the two methods was shown. A few hips were normal, according to one method and were subluxated, according to the other one. The methods gave similar results, except the percentage of "immature hips" IIa (29%) and "possible dysplastic hips" (14%). This might be a sign of better specificity of the Terjesen method. Good interobserver agreement and simple classification favor use of the Terjesen method. The method of Graf is the most commonly used and gives adequate evaluation of the hip, if the method of examination and rather complicated classification are followed closely.

Department of Pediatric Orthopaedics, Karol Marcinkowski University of Medical Sciences of Poznañ, Poland. Correspondence: Dr. Jaroslaw Czubak, Department of Pediatric Orthopaedics, Institute of Orthopaedics and Rehabilitation, ul. 28 Czerwca 1956 nr 135/147, 61-545 Poznañ, Poland. Tel +48 61-310 360. Fax -334 421
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Several methods for ultrasound evaluation of newborn and infant hips have been used and described (Graf 1983, Harcke et al. 1984, Dahlström et al. 1986, Terjesen et al. 1989a, b, Tönnis et al. 1990, Suzuki et al. 1991, Zwierzchowski et al. 1994). However, there is no agreement as to the best method.

We have analyzed the sensitivity of the Graf (1983) method, which is the most commonly used and of the Terjesen (1989a, b) method. The latter was chosen because of its simplicity and direct relationship to radiographic examination.

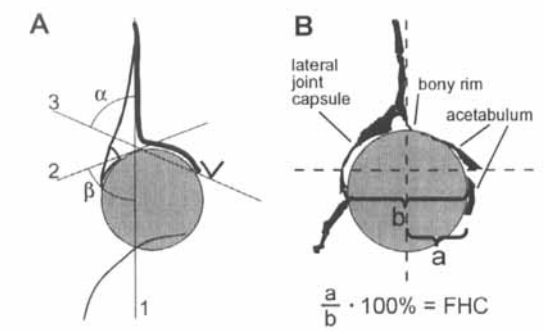
Patients and methods

From May 1993 to December 1994, 657 of 826 newborns born in Franciszek Raszeja Hospital in Poznañ were examined in the Institute of Orthopedics and Rehabilitation in Poznañ. All mothers were advised to come for examination of the baby's hips in the first weeks of life, but some failed to do so for some unknown reason. Since we were unaware of the pediatricians' clinical findings of the newborns, our examination was considered the primary one. There was no treatment before our first examination. Pediatricians routinely ordered wide diapers for all newborns. The group comprised 326 boys and 331 girls, altogether 1,314 hips. The age at the first examination was mean 23 (5–42) days. The largest number of patients underwent first examination in the 3rd week of life. Subsequently, the infants were examined at least twice in every 6-week period.

The ultrasound section of the hip in the Terjesen method is similar to that in the Graf method (Figure). We prefer to place the child in a lateral position during examination. An Aloka 500 ultrasound machine was used with the 5 MHz linear transducer. Two distances were measured on the sonogram: from the acetabular floor to the level of the acetabular rim (a) and from the acetabular floor to the lateral joint capsule (b). From these two measurements, the percentage a/b × 100% was calculated and referred to as femoral head coverage (FHC). According to Terjesen et al. (1989a, b), a normal FHC is equal to or higher than 50%, whereas 49–40% indicates possible dysplasia, 39–10% subluxation and below 10% dislocation. It should be emphasized that FHC equal to 49–40% in newborns is possible dysplasia and in infants older than 4 months it is dysplasia.

The alpha angle in the Graf method was compared to the FHC. The following points were evaluated: the influence of this method on the number of cases diagnosed as hip dysplasia during the first, second and third examinations, as well as the changes in the alpha angle and FHC between the first and third measurements. For evaluation of interobserver variation, the FHC measurements were made by 4 examiners, 2 orthopedic surgeons with experience in ultrasound ex-

Schematic drawings of the principles of the (A) Graf and (B) Terjesen methods.



A: 1 - Baseline
2 - Cartilage roof line
3 - Bony roof line
α - Bony roof angle
β - Cartilage roof angle

B: Distance a is from the acetabular floor to the level of the lateral acetabular rim and b is from the same point of the acetabular floor to the lateral joint capsule. Both distances are measured perpendicular to the baseline of the ultrasound image.

amination and 2 students with little experience. The scans were made only by experienced doctors (JC, TK).

For statistical evaluation of the various parameters, we used the Student's t-test and the correlation coefficient (r). The differences were considered significant when $p < 0.05$.

Results

We found similar but not identical percentages of dislocated or subluxated hips: 3.9% for Graf and 2.9% for Terjesen (Tables 1–2).

With the Graf method, the frequency of immature hips, type IIa, was 29%, whereas with the Terjesen method, 14% of hips had "possible dysplasia" (FHC 49–40%). The average increase of the alpha angle was 5° between the first and second measurements and 2° between the second and third measurements. The average increases in FHC were 7% and 3%, respectively. The increases in both parameters were statistically significant ($p < 0.001$). A statistically significant correlation ($r = 0.57$) between the alpha angle and FHC was found ($p < 0.001$).

21 children (3.2%) with 25 abnormal hips were treated, using the Pavlik harness. The indications for treatment were: a positive Ortolani test (11 hips), limited abduction (below 70°) and ultrasound abnormalities (alpha less than 50°, FHC less than 50% (14 hips). In all treated cases, stable reduction and normalization of ultrasonography were achieved after 21 (6–41) weeks (Table 3).

4 examiners performed FHC measurements of 422 hips. The average interobserver difference was 2.8%–3.9%. The standard deviation for all pairs of examiners was 3.2%.

The third examination showed that 1.9% of the hips had an alpha angle ranging from 50° to 60° and in 98.1% of hips it was above 60°. The FHC ranged from 40% to 49% in 2.2% of hips and appeared to be above 50% in 97.8% of the measured hips. Hips which had not achieved normal ultrasound parameters were observed until the alpha angle and FHC exceeded 60° and 50%, respectively. None of these hips was treated.

We analyzed the frequency of discrepancy between the methods—i.e., cases diagnosed as subluxation by one method and normal or suspected dysplasia by the other (Table 4). In 14 hips during the first examination, the alpha angle was more than 50° (Graf type II a) whereas FHC was less than 40% and indicated subluxation. The number of discrepancies decreased to 4 hips in the second and no hips in the third examination.

During the first examination, 13 hips had alpha angles from 43° to 50°, which means type II c and D in the Graf classification, whereas FHC exceeded 40%. 13 hips were diagnosed as subluxated by both meth-

Table 1. Ultrasound results according to the Graf classification at the primary examination in 657 newborns

Graf type	α angle	β angle	Number of hips			%
			Left	Right	Total	
I	≥ 60°		440	449	889	67.7
IIa	50°–59°		195	188	383	29.1
IIc	43°–49°		14	12	26	2.0
D	43°–49°	> 77°	2	0	2	0.2
III	< 43°		8	8	16	1.2
IV			4	2	6	0.5

Table 2. Ultrasound results according to the Terjesen classification at the primary examination in 657 newborns

Type	FHC% [a]	Number of hips			%
		Left	Right	Total	
Normal	≥ 50	532	555	1087	82.8
Possible dysplasia	40–49	98	89	187	14.3
Subluxation	10–39	26	10	36	2.7
Dislocation	< 10	0	2	2	0.2

[a] FHC% femoral head coverage in percentage

Table 3. Primary clinical examination, and first and second ultrasound examinations of 21 treated children

		Clinical examination		Ultrasound examination			
				First		Second	
Case	Side	Limited abd.	Pos. Ortolani	α-angle	FHC	α-angle	FHC
1	L	+	+	40	41	47	50
	R			62	64	60	62
2	L			60	54	55	54
	R	+		54	54	51	34
3	L	+	+	38	33	41	38
	R	+	+	65	48	66	50
4	L	+		48	38	49	31
	R			57	48	59	54
5	L			58	46	48	43
	R	+		49	36	47	43
6	L			49	53	62	62
	R	+	+	42	0	56	58
7	L	+	+	43	20	71	60
	R		+	40	0	71	71
8	L	+		40	40	60	42
	R			44	40	65	45
9	L			53	42	70	62
	R	+	+	41	31	60	54
10	L		+	30	33	67	62
	R			61	54	63	62
11	L			62	54	63	69
	R		+	49	31	49	54
12	L		+	40	33	49	53
	R			58	46	60	53
13	L	+		45	43	48	48
	R			65	62	66	63
14	L	+		46	31	63	67
	R			64	58	63	67
15	L		+	37	28	60	70
	R			41	28	61	75
16	L	+		42	20	67	58
	R	+		70	60	53	62
17	L	+		52	50	56	46
	R			61	57	49	50
18	L	+		49	46	63	58
	R	+		36	43	66	58
19	L	+		49	38	62	64
	R			70	69	66	62
20	L	+		52	50	60	64
	R			61	67	60	64
21	L	+		50	43	55	48
	R			56	54	57	54

ods. A greater discrepancy was noted for type III according to Graf. There were only 2 hips diagnosed as dislocated by both methods, 9 were subluxated, 3 were possible dysplastic and 2 normal, respectively, according to the Terjesen method. The number of discrepancies decreased to 1 hip and no hip in the second and third examinations, respectively.

Discussion

The frequency of dislocated and subluxated hips found in our study (3.2%) using the Graf and Terjesen methods is somewhat smaller than the 4% found by Dega et al. (1959). Their study was based on 36,000 newborns in our city during 1952–58, using only clinical signs.

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 [a]

[a] incomplete data in 2 hips

The treated group of 21 infants (3.2%) was excluded from the analysis of natural history. We found a considerable spontaneous improvement in the hips of the remaining 636 infants, revealed by an increase in the alpha angle and FHC (5° and 7%, respectively) during the first 2 months of life and a slightly smaller increase in the following 2 months. Our figures were smaller than those of Hangen et al. (1995), who reported an increase of 8.5° monthly in the alpha angle, but agreed with the results of Castelein and Sauter (1988).

A good interobserver agreement between 4 examiners was achieved, using the Terjesen method. We did not do this kind of evaluation using the Graf method, because our inexperienced colleagues found it difficult to define ultrasound landmarks for the measurements. It was usually easy to find the acetabular floor and the lateral part of the head, using the Terjesen method.

The results obtained with the Graf and Terjesen methods were in good agreement. A large percentage of type IIa hips according to Graf (29%), were found with the alpha angle ranging from 50° to 60, and slightly reduced FHC indicating suspected hip dysplasia, according to Terjesen (14%). These groups probably reflect immaturity of the hips during the first weeks of life. In these hips, ultrasonography could not establish a reliable, definite diagnosis in the newborn period. It seems that both methods are very sensitive for evaluating newborn hips. Thus a question arises, whether the routines of ultrasound screening should be changed from the newborn period to 2–3 months of life, when most hips are mature.

The use of both methods resulted in twice as large a number of cases diagnosed as possible and slight dysplasia in the newborn using the Graf method, as compared to the Terjesen method. In our opinion, this is a sign of better specificity of the Terjesen method. All these hips normalized without any treatment. This

supports the findings of previous reports (Castelein and Sauter 1988, Terjesen et al. 1989a, b).

The number of discrepancies between the methods is interesting. Using the Graf method, the number of immature hips which are normal according to the Terjesen method is 5 times larger than the number of possible dysplastic hips with the Terjesen method but normal in the Graf method. The number of discrepancies in the subluxated group is very similar, but it increases in dislocated hips. This may be because the criteria for dislocated hips do not correlate well in both methods or there is a poor correlation between the slope of the acetabulum (Graf method) and the head coverage (Terjesen method). In our opinion, head coverage better describes the relation of both parts of the hip than the measurement of the slope of the acetabulum.

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 found nearly as good interobserver agreement as that reported by Holen et al. (1994) and previously by Terjesen et al. (1989). The Graf method is, however, the most commonly used and gives an adequate evaluation of the hip, if the method of examination and rather complicated classification are followed carefully.

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