

# Diagnosis of congenital hip dysplasia in the newborn

## Evaluation of a screening program

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**Background and purpose** Screening of newborn infants for congenital hip dysplasia may be done by clinical examination, ultrasound, or radiography—or a combination of these. Studies that have used clinical examination followed by ultrasound imaging for infants with certain risk factors have shown excellent results, but they were performed by very experienced practitioners. We wanted to find out whether the results of such screening would be equally good with less optimal staffing. Thus, we evaluated the real-life performance of a screening program for detection of congenital hip dysplasia in newborn infants.

**Subjects and methods** We performed a retrospective chart review of all infants (n = 1,983) referred for evaluation for suspected congenital hip dysplasia from one single obstetric hospital, where 19,820 infants had been screened from 1992 through 2001. Infants were referred either because of a positive finding during the Ortolani and Barlow examinations or because of the presence of risk factors.

**Results** The reasons for referral of the 1,983 infants (10% of those examined) were: positive clinical signs in 255 (1.3% of all examined) and risk factors in 1,547 (7.8%), and a combination of both in 114 (0.6%). 67 other infants (0.3%) who had passed the initial pediatric screening were later referred from the local health centers. Finally, 23 of the 1,983 infants were subsequently referred again by their health center for renewed orthopedic evaluation. Of the infants who were treated (298/1,983 = 15% of those referred), those with a patho-

logical examination result were represented proportionately more than infants who were referred because of risk factors (0.8% as opposed to 0.5%). Delayed diagnoses occurred in 1.7/1,000 infants

**Interpretation** The performance of a screening protocol for congenital hip dysplasia in a real-life setting involving several physicians both on the pediatric and orthopedic side may not live up to expectations based on the use of such a protocol in an optimized setting. This type of analysis of screening data may serve to pinpoint weaknesses, and thus lead to adjustments that may enhance quality. ■

Congenital dislocation of the hip (CDH) is one of the more common pathological findings during routine examination of newborn infants. Clinical examination of the hips to rule out this anomaly was included in the standard newborn examination in Norway in 1954 (Walther and Moe 1954). Ultrasound examination as a supplement or adjunct in certain cases was introduced by Graf (1983) in the 1980s. The ultrasound method used in Norway at present is called Terjesen's method (Terjesen et al. 1989). The method is a modified version of the methods of Graf (1983) and Morin (Morin et al. 1985), in which the femoral head coverage is determined by measuring two distances: from the acetabular floor to the lateral bony acetabular rim

(a) and from the acetabular floor to the lateral joint capsule (b). The femoral head coverage (FHC) is given as the ratio of distance a to distance b, expressed as a percentage ( $a/b \times 100\%$ ). The relation between the acetabulum and the femoral head is also assessed subjectively by a dynamic examination, and the hip is tested for any instability in all directions—especially posteriorly (the Palmen/Barlow maneuver; Barlow 1962, Palmen 1984).

There is no national consensus in Norway regarding screening policy, but there is fairly good agreement between the different clinics. Ultrasound is mostly used as an adjunct to clinical examination (selective screening), following the protocol of two well-known randomized controlled studies (Rosendahl et al. 1995, Holen et al. 2002).

Previous studies involving screening for CDH may be said to have occurred in optimized settings, where the number of physicians involved has been limited (Rosendahl 1995, Holen et al. 2002). Thus, the participating pediatricians had solid clinical experience and worked in close cooperation with the radiologist or the orthopedic surgeon. It seemed reasonable to try to determine whether the results achieved under such conditions would be representative of the results attainable with the same kind of protocol when the number of physicians both on the pediatric and orthopedic side was higher, and the clinical experience was more varied. It is likely that this will often be the case in everyday screening of newborn infants for CDH. The decision to implement a particular screening protocol should probably be based on results that can be attained under such real-life conditions.

In the present study we examined the rate of referral for orthopedic evaluation and ultrasound examination following clinical screening for CDH. We also wanted to know what the indications were for referral, how many of those referred were treated, and how many were diagnosed with CDH after the newborn period (“late diagnosis”). Furthermore, we were interested in how the results from our maternity clinic, which we believe is probably representative of other such clinics in Norway, compare with other published data. Finally, we believed that the results might give indications as to how and where improvements could be made.

## Materials and methods

The setting was a maternity clinic in a general hospital serving two communities west of Oslo (total population about 140,000). 19,820 infants were born during the decade studied (1992–2001). Each infant was examined clinically by a pediatrician on the second or third day of life. If unstable hips by Ortolani’s and Barlow’s tests, reduced abduction, positive family history (confirmed hip dysplasia in a first-degree relative or more than one case if more distantly related), breech delivery, torticollis, or malformation of the feet were present, the infant was referred to the orthopedic surgeon at the adjoining hospital for further clinical and ultrasound examination within a week. The clinical findings and risk factors noted by the pediatrician were recorded by him or her on a form that accompanied the child to the orthopedic surgeon.

The orthopedic surgeons performed both a clinical and an ultrasound examination. This was mostly done by 2–3 senior surgeons. If done by a junior, less experienced doctor, the results were confirmed by a senior orthopedic surgeon. Ultrasonography was done with a 7.5-MHz linear transducer according to the method of Terjesen (Terjesen et al. 1989). The results were recorded separately for the left and right sides and divided into 5 groups according to FHC: < 40%, 40–44%, 45–49%, 50–54%, and > 54%.

Based on the clinical and ultrasound examinations, the orthopedic surgeon either started treatment immediately or, if his examination was not conclusive, saw the infant at follow-up himself until a conclusion could be reached. All follow-up examinations of infants with pathological or inconclusive findings were performed at the same clinic. If the hips were judged to be normal, the baby was referred to the well-baby clinic for routine follow-up there. If the well-baby clinic detected or suspected hip pathology later on, the infants were referred back to the same orthopedic hospital. Thus, follow-up of infants belonging to the local population was complete. The study was performed by retrospective chart review of all infants examined or treated for CDH at that orthopedic hospital. Clinical information concerning infants who moved to other parts of the country before the follow-up program was completed, was collected

from the local clinics that continued the follow-up. Infants who—after routine referral to the well-baby clinic as being normal—subsequently moved to other parts of the country, were not traced. This accounted for 8.5% of the infant population within the first year of life, according to Statistics Norway. Assuming the same rate of missed diagnoses in this group, another 3 infants would be added to those diagnosed late (see below).

We defined a diagnosis of CDH made after the fourth week of life as “late”. In the group with “late” diagnosis, some were under follow-up by the orthopedic surgeon and some were referred back from the well-baby clinic or a local doctor because of clinical findings (“missed diagnoses”). For most of the patients with delayed or missed diagnoses, radiographs of the hips were obtained. These images were interpreted by the orthopedic surgeon along with the ultrasound results. These hip radiographs were re-evaluated by a radiologist.

Abduction splinting was the routine treatment, either using Frejka’s pillow in the newborn period or LIC cast later.

The results were recorded for analysis in the statistics program SPSS II. Proportions were compared by means of the Pearson chi-squared test or Fisher’s exact test in cases where the assumptions of the chi-squared test were not met. The study was performed in accordance with the ethics regulations extant at the time of data collection.

## Results

1,916 infants from the population of 19,820 (9.7%) were referred following pediatric examination in the newborn period (early referrals), and 67 (0.3%) were referred later from the well-baby clinic and local doctors. 23 of these 1,983 infants were later referred again from their local health center for renewed orthopedic evaluation.

1,547 infants (7.8% of the newborns, 81% of the early referrals) were referred because of risk factors without positive clinical signs (Ortolani or Barlow), while 255 infants (1.3% of the newborns, 13% of the early referrals) had positive clinical signs but no risk factors. Finally, 114 infants (0.6% of the newborns, 5.9% of the early referrals) were referred for positive clinical signs plus one or more

risk factors. Thus, the pediatrician found a positive Ortolani or Barlow result in 1.9% of the infants.

298 infants (1.5% of the total population and 15% of those referred for orthopedic evaluation) were diagnosed and treated for CDH. Of these, 165 (55% of those with CDH) had positive clinical signs (with or without risk factors), while 99 (35%) had risk factors only. 34 infants (11%) had no risk factors; nor were clinical signs found by the pediatrician, and they were diagnosed late. They were put in traction until a satisfactory position of the femoral head was achieved. Occasionally, traction in the longitudinal axis was supplemented with abduction and inward rotation. This process usually took 2–4 weeks. When the femoral head was aligned with the socket, a closed reduction was performed under general anesthesia and a cast was applied. The result was checked with CT or MRI. The cast was retained for 4–6 months, during which time the infants were seen regularly for follow-up. After removal of the cast, the infants were seen at 3, 6, and 12 months. None of the infants required surgery and all had normal radiographs and clinical findings at the end of treatment.

The clinical experience of the pediatricians who shared the case load at the maternity clinic varied quite substantially, ranging from 3–20 years of practice. Table 1 shows the number of infants referred from the different pediatricians because of clinical findings, the decisions made regarding treatment in each baby, and the sensitivity and positive predictive value (PPV) of the clinical examination for each doctor, calculated on the basis of number treated by the orthopedic surgeon, which we chose to define as the “gold standard”. The number of referred infants per physician mainly reflects the duration of their employment at the maternity hospital. We have no record of the total number of infants examined by each doctor. Some referrals were unsigned and could not be traced to a specific referring physician. We observed a great variability in the performance of the doctors, with sensitivities ranging from 20% to 100%, and PPVs ranging from 27% to 92%.

We examined how the orthopedic surgeon was influenced by the presence of symmetry or asymmetry between the hips regarding FHC measurements (Table 2). The data were categorized on the basis of the hip showing the lowest FHC value, and then

**Table 1.** Calculated sensitivity and positive predictive value (PPV) for the pediatricians' clinical examinations

Doctor	No. of patients referred due to positive clinical signs of CDH	No. of patients referred for any cause, who were treated for CDH	No. of patients judged to have positive clinical signs, who were treated for CDH	Estimated sensitivity (%)	Estimated PPV (%)
1	137	84	55	66	40
2	62	66	40	61	65
3	12	16	11	69	92
4	67	37	28	76	42
5	8	15	3	20	38
6	22	6	6	100	27
Total	308 <sup>a</sup>	224	143	64	46

<sup>a</sup> The total number of patients (308) examined by the physicians is less than the total number of patients referred with positive clinical signs because some referral forms were unsigned and the referring physician could not be reliably determined.

**Table 2.** Association between the results of the ultrasound examination and the decisions made by the orthopedic surgeon. The material has been divided into two groups: with or without any difference in classification of right and left hip

Lowest FHC (%) of right and left	Nos. judged to be pathological by the orthopedic surgeon (%)		P-value
	No difference	Difference	
< 40	4/4 (100)	20/20 (100)	1
40–44	26/27 (96)	71/73 (97)	1
45–49	29/40 (73)	78/156 (50)	0.01
50–54	28/851 (3.3)	3/205 (1.5)	0.2
> 54	5/523 (1.0)	–	–
Total	92/1445 (6.4)	172/454 (37.9)	< 0.001

**Table 3.** Results of the femoral head coverage (FHC; %) measurements and the orthopedic surgeon's decision on whether or not to start treatment. The material has been divided into two groups depending on whether or not the referring pediatrician found a positive Ortolani/Barlow test

Lowest FHC (%) of right and left	Nos. judged to be pathological by the orthopedic surgeon (%)		P-value
	Positive	Negative	
< 40	20/20 (100)	4/4 (100)	1
40–44	59/60 (98)	38/40 (95)	0.6
45–49	57/76 (75)	50/120 (42)	< 0.001
50–54	25/155 (16)	6/901 (0.7)	< 0.001
> 54	4/55 (7.3)	1/468 (0.2)	0.001
Total	165/366 (45)	99/1533 (6.5)	< 0.001

divided according to whether the FHC values for the right and left hips were in the same or different FHC groups ("no difference" and "difference", respectively). There was a tendency for FHC values in intermediate groups (45–49%, 50–54%) to be regarded as indications for treatment more often in cases where there was no difference between the hips.

Table 3 shows the decisions of the orthopedic surgeons stratified according to the clinical findings reported by the pediatricians. Because of the referral form, the orthopedic surgeon was familiar with the pediatrician's findings when he performed his own examination. For infants with FHC values in intermediate to high groups (45–49%, 50–54% and > 54%), the probability of ending up with treatment was much greater if the pediatrician had found a positive Ortolani/Barlow test.

In 32 of the 34 infants with CDH diagnosed after the fourth week of life, radiographic examination was performed in addition to ultrasound before treatment was started. All of these infants also had radiographic examination of the hips at the end of treatment. Radiographs from

the first examinations of these 32 infants, which had initially been read by the orthopedic surgeon, were re-examined (as part of this study) by a radiologist who was blinded regarding the results of the orthopedic examination and also the original interpretation of the radiographs—though he was aware that all infants had been treated. For 8 of the 32 infants the radiologist interpreted the radiographs as normal, while the orthopedic surgeon had judged them all to be pathological. In 6 of these infants, however, the orthopedic surgeon found clinical and/or ultrasound-based signs of hip dysplasia. For 2 of the 8 infants, the ultrasound and clinical examinations by the orthopedic surgeon were normal, but he interpreted the radiographs as being abnormal and treatment was started on this basis. In 24 of the cases studied, there was agreement between the radiologist and the orthopedic surgeon: both judged the radiographs to be pathological.

## Discussion

The aim of the present study was to describe the decision protocol in the diagnostic work-up for CDH in the newborn, to evaluate the performance of this protocol in an everyday setting, and to compare our results with data from other clinics. Evaluation of the quality of the neonatal hip examination is difficult since there is no gold standard. In our study we have used the orthopedic surgeon's decision to treat with abduction splinting (Frejka's pillow) as the gold standard, recognizing that there is an element of arbitrariness in this, as shown by our data.

Congenital dislocation of the hip, defined as the application of orthopedic treatment, was diagnosed in 298 infants in our population of 19,820 screened babies (15 per 1,000). In comparison, Paton et al. (1999) found a dislocation rate of 2.2 per 1,000, while Holen et al. (2002) found 9.3 per 1,000. Rosendahl et al. (1994) compared the effect of selective vs. general vs. no ultrasound screening for CDH on treatment rates. In their total population of 11,925 infants, 24 infants per 1,000 received treatment for CDH (including those diagnosed late), while of those infants subjected to general ultrasound screening 35 were treated per 1,000.

Infants who were only screened by clinical examination had a treatment rate of 21 per 1,000. Thus, it appears that estimation of the true incidence of CDH is an exercise fraught with risk. Lehmann et al. (2000) performed a meta-analysis of published data and arrived at the following estimates of the incidence of CDH: 8.6 per 1,000 based on clinical screening by a pediatrician, 12 per 1,000 based on screening by an orthopedic surgeon, and 25 per 1,000 based on ultrasound screening. The incidence found in our study appears to fall within this range.

The proportion of screened newborns in our study who were referred by the pediatricians for ultrasound examination in the newborn period because of risk factors and/or clinical hip pathology was about the same as reported in the literature (Lagerlöv and Njå 1986, Rosendahl et al. 1994, Andersen et al. 2000, Prytz et al. 2000). Risk factors as an isolated finding accounted for 81% of our referrals. It is worth noting that whereas infants with positive clinical signs in our study contributed only 19% of the referrals, they accounted for 57% of the infants who were treated. Referrals from the well-baby clinics and local doctors after the newborn period constituted 0.5% of the birth population.

The percentage of positive clinical signs in the newborn to some extent reflects the examiner's clinical skills. There appears to be agreement in the literature that the quality of the clinical examination of the hips in the newborn period is an important factor in deciding which screening program to choose (Bjerkreim 1974, Palmén 1984, Rosendahl et al. 1997, Terjesen 1998). "Perfect" results, achieved in selected programs where a limited number of experienced hands are involved both on the pediatric and the orthopedic side (Rosendahl 1995, Terjesen 1998, Andersen et al. 2000, Holen et al. 2002), may not reliably predict the performance of the same approach in a more realistic setting where both pediatricians and orthopedic surgeons may rotate in and out of the service. The importance of clinical training in examination of the hips is well illustrated by our data (Table 1). Doctors 5 and 6 had fewer years of experience than the other pediatricians. Doctor 6 had a sensitivity of 100%, but may have referred "too many" infants for ultrasound, as only about 1 in 4 of those referred were treated. Doctor 5 had both a low sensitivity and a

low positive predictive value, which means that a number of patients with clinically unstable hips were not detected, while on the other hand others were referred needlessly for ultrasound examination. We believe that results such as these may be useful for quality control and physician training purposes. When deciding which doctor is “best”, a decision must be made as to what kind of error has the most serious consequences. One may argue that the sensitivity of the examination should have priority, as a high sensitivity should reduce the number of late or missed diagnoses.

As there is clearly a tendency for the hips to normalize during growth, it is possible that some are treated unnecessarily. The greatest effect on the treatment rate might be to delay the orthopedic and ultrasound follow-up for some time after the newborn period, at least in the absence of obvious clinical hip instability at the initial pediatric screening. Thus, in the study by Paton et al. (1999), infants with risk factors only were screened at 8–9 weeks of age. The implementation of such a policy will require a well-organized clinic to prevent dropouts and a highly qualified ultrasound examination to be sure that the hips do indeed normalize. We have now changed our screening policy so that only infants who are found to have unstable hips during the initial pediatric examination are referred for immediate orthopedic evaluation, whereas infants who only have risk criteria are seen by the orthopedic surgeon at approximately 4 weeks of age.

The screening and treatment policy described in our study was based on the work of Terjesen (1998), who found the mean FHC in girls to be 54% and in boys to be 56%. The lower limit of the normal range (mean  $-2$  SD) was about 45%. When our FHC (%) results are grouped as described (Table 2), it seems that the orthopedic surgeons' decision concerning treatment in the presence of borderline FHCs (45–49%) may have been influenced by factors other than the FHC (%) value. Thus, in cases of borderline FHC values (45–49%) the orthopedic surgeon was more inclined to judge the hips as being pathological when both hips had borderline FHCs than when one hip was borderline and the other was normal ( $p = 0.01$ ). The results for FHC values of 50–54% also show this tendency ( $p = 0.2$ ). The reasons for this are not clear. However, we speculate that the fact that there was one hip

with normal FHC may have made the orthopedic surgeon more lenient as far as the other (borderline) hip was concerned, and thus more inclined to follow the development without therapeutic intervention. In our total material, however, asymmetric hips were treated statistically significantly more often than the symmetric ones.

In addition, if the pediatrician had judged the hips to be abnormal, there was a greater tendency for the orthopedic surgeon to judge borderline FHCs to be abnormal and start treatment (Table 3). The records contain no systematic information concerning the orthopedic surgeon's reasoning. However, one may reasonably assume that just knowing that another physician had found unstable hips would “prime” the orthopedic surgeon's mind towards easier acceptance of pathology. If his own examination yielded equivocal results, the cautious approach may well have been to emphasize a positive finding by the pediatrician and conclude with a decision to treat. The orthopedic surgeon's judgment may also have been influenced by his own clinical examination and by the dynamic part of the ultrasound examination, but these data were not recorded. Thus, it was not possible in this material to evaluate the effect of this type of information. However, our study highlights the limitation in using the orthopedic surgeon's decision to treat or not as the gold standard for evaluation of the quality of a screening program.

Clinical examination of the hips is part of the routine program in our well-baby clinics. In our material the most frequent finding that raised suspicion of CDH was reduced or asymmetric abduction of the hips. Indeed, one-third (24/65) of infants with asymmetric abduction—either as an isolated finding, or in combination with other signs—ended up being treated. Other authors have also described this finding as being the most frequent reason for later referral (Lagerløv et al. 2002). The finding of a “clunk” as an isolated sign did not predict need for treatment (0/5), whereas the isolated finding of asymmetric skin folds led to a treatment decision in one-third of the patients (4/14).

Late diagnosis of CDH (after 4 weeks of age) is often used as a marker for the quality of the total screening and follow-up procedures. In our material of 19,820 newborns, late diagnosis was made in 34 cases (1.7 per 1,000). This figure is similar to

those published by others (Lagerløv and Njå 1986, Starnes et al. 1986, Prytz et al. 2000) but higher than reported from another clinic in Norway, which used the same screening procedure and ultrasound technique (Terjesen 1998). Another study from Norway has also reported lower figures (Rosendahl et al. 1992). However, differences in the criteria for using the term “delayed diagnosis of CDH” may also play a role. Thus, if only sub-luxated or dislocated hips are counted, the rate of delayed diagnosis of CDH will be lower than if hips with acetabular dysplasia as an isolated radiographic finding are also included. In our study we had 5 infants in this category among the 34 with late diagnosis. Furthermore, a policy that includes clinical follow-up by the orthopedic surgeon in cases with equivocal findings at the first examination could lead to later definitive diagnosis, and consequently the case may be defined as having been diagnosed late. Among our cases, 6 infants followed with repeated ultrasound examinations were not conclusively diagnosed until after 4 weeks of age.

Late diagnosis occurred in 11% of all infants diagnosed with CDH in our series. This can be compared with 7.5% in the study by Holen et al. (2002) in the group screened by the same process as in our study, and 18% in the study by Paton et al. (1999). Thus, from this point of view it may be argued that our rate of delayed diagnosis was not unreasonably high. However, in the infants screened with primary ultrasound in the study by Holen et al. (2002), only 1.4% of all infants with CDH were diagnosed late, suggesting that improvements are possible.

The results at the end of treatment showed normal radiographic findings in all infants with delayed diagnosis, whichever way this is defined. Also, there were no cases with necrosis of the femoral head or need for surgical intervention. Although these results may be said to be satisfactory, there may still be room for improvement. Indeed, one of the aims of our study was to pinpoint weaknesses in our approach.

In conclusion, we have re-examined the performance of a screening program for CDH that used a two-stage approach consisting of initial clinical hip examination by a pediatrician followed by referral to an orthopedic surgeon in cases with positive or suspect clinical signs and/or specific risk factors. Although apparently identical to previously

published protocols, our program did not fully live up to the excellent results suggested by some of those studies. We speculate that one reason for this apparent shortcoming may be the fact that a number of different pediatricians and orthopedic surgeons were involved in the screening process during the years covered by our study, as opposed to previous studies using the same approach where a very limited number of highly experienced physicians were involved. We believe that our setting was quite realistic, and indeed probably representative of many such screening programs around the world. Thus, our results may better reflect the actual performance of the screening approach we used than results from similar screening approaches in optimized settings. Program directors who are contemplating changes in their policy of screening for CDH may find our data useful. Finally, we believe that analysis of screening data may serve to pinpoint weaknesses in the program, and thus hopefully lead to adjustments that may further enhance quality.

#### **Contributions of authors**

PHF performed the chart review and participated in the data analysis. ID performed the statistical analyses. NI reviewed all the orthopedic data. GU reviewed the radiographic data and performed the blinded study of previous hip films. PHF, ID, NI, and GU all participated in writing of the manuscript. TWRH conceived the study, reviewed the data analysis, revised successive versions of the manuscript, and prepared the final version.

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