Residual Dysplasia After Successful Pavlik Harness Treatment

Early Ultrasound Predictors

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Abstract: The purpose of this study was to evaluate a group of children treated with Pavlik harness for developmental dysplasia of the hip (DDH) to determine early ultrasound characteristics that predict poor acetabular development after walking age. From a group of 487 infants with DDH, 55 met inclusion criteria of (1) ultrasound documentation of major neonatal hip instability, (2) treatment with Pavlik harness, and (3) a minimum of 4 years of follow-up. These 55 infants had 100 abnormal hips. Harness treatment alone was successful in treating 87 of 100 hips. Persistent or late acetabular dysplasia was defined from serial radiographs. At a mean follow-up of 5.3 years, 5 of the 87 (6%) were found to have sequelae (late acetabular dysplasia, avascular necrosis of the femoral head, or both). Three sonographic findings present on the initial ultrasound predicted late sequelae: (1) dynamic coverage index of 22% or less, (2) alpha angle less than 43 degrees, and (3) abnormal echogenicity of the cartilaginous roof on initial ultrasound. Abnormal echogenicity was the most specific single predictor of residual dysplasia (sensitivity 100% and specificity 88%). The structurally normal cartilaginous roof is non-echogenic except for a short triangular fibrous tip (the labrum). Pathologic cartilage becomes echogenic beyond the tip as hyaline cartilage becomes fibrous and deformed. In unstable hips that respond well to Pavlik harness treatment, it would appear that mid-term acetabular development can be affected when early transformation of roof cartilage accompanies displacement and instability.

Key Words: hip dysplasia, hip ultrasound, Pavlik harness, transformation of roof cartilage

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Since 1946,[1] the Pavlik harness has been in continual use as a treatment of developmental dysplasia of the hip (DDH) and has gained wide acceptance throughout the world. Properly applied, it is considered to have a high rate of hip reduction with few complications.[2] However, avascular necrosis (AVN) of the femoral head and persistent or late acetabular dysplasia (LACD) after early successful Pavlik harness treatment are known to occur, and these hips require continued monitoring until skeletal maturity.[3,4] The reported incidence of AVN ranges from 2.38% to 16%,[2,5] and the incidence of LACD ranges from 3.5% to 17%.[3,6]

During the past two decades, ultrasound has become the standard method for diagnosis of neonatal hip instability and for management with the Pavlik harness.[7,8] Ultrasound can assess both stability[9–12] and morphology[13–15] and is used with accuracy until the ossification center of the femoral head develops, when radiographs become reliable.[16]

The purpose of this study was to identify early predictors of midterm outcome (>4 years of follow-up) in infants with successful Pavlik harness treatment. Using analysis of the dynamic and morphologic ultrasound characteristics seen on initial studies, we tried to find ultrasound parameters that distinguish hips at risk for persistent or late deficiency in acetabular development from those with normal midterm development. An ability to predict hips at risk brings an opportunity to modify management.

METHODS

Of 487 infants treated with the Pavlik harness at a tertiary care pediatric hospital, 55 had clinical and radiologic follow-up for more than 4 years after discontinuation of the harness. These 55 patients (100 abnormal hips) were initially diagnosed by ultrasound to have significant instability (moderate to severe subluxation or dislocation).

Patient demographics were reviewed for generally accepted risk factors influencing successful Pavlik harness reduction: sex, race, birth rank, pregnancy, breech presentation, family predisposition, bilaterality, side of pathology, age at start of harness treatment, and mean follow-up.

During the course of harness treatment, active function of the quadriceps muscles was assessed clinically at each follow-up visit. Associated anomalies were documented (eg, clubfeet, pes metatarsoadductus, calcaneovalgus, torticollis). After walking age, the patient's gait pattern was carefully described, as well as any limb length discrepancy.

Serial ultrasound measurements were used to monitor the course of treatment. The treatment protocol in the harness was described in a previous study.[17] Duration of treatment in the harness was recorded for each phase (full-time wear, weaning period) and for total harness wear. All patients were monitored

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by serial anteroposterior radiographs of the pelvis and hips, beginning when Pavlik harness treatment ended and continued periodically well beyond the time when walking began.

Ultrasounds were obtained using a 7.5/5-MHz linear transducer according to the dynamic technique of Harcke and Grissom.[18] Both stability and morphology measurements were obtained from the serial ultrasounds. Stability was defined by a sonographic measure called dynamic coverage index (DCI). This index was measured with the same reference points used for femoral head coverage of Terjesen,[19] but instead of measuring in the coronal neutral view, we performed all measurements in a true stress view: coronal flexion with adduction (Fig. 1). Stability of the hip was classified according to DCI and femoral head reducibility, as shown as in Table 1. The acetabular morphology was described by the alpha angle and type according to Graf and Wilson.[20] The echogenicity of the cartilage roof was graded as normal (lack of echogenicity in the hyaline cartilage acetabular roof) or increased, and presence or absence of deformity was noted (Fig. 2). All morphologic measurements were made in the coronal neutral view. The hips were divided into two major morphologic types according to static ultrasound scans (see Table 1).

Acetabular dysplasia was measured using the acetabular index[21] until 5 years of age. After this age, the center–edge angle of Wiberg[22] was used (see Table 1). LACD was defined according to the criteria[11,23,24] in Table 1. AVN of the femoral head was evaluated according to the five criteria of Salter[25] and classified according to the classification of Kalamchi and MacEwen.[26] The success of long-term anatomic reduction was evaluated by assessing the degree of femoral head displacement with respect to the acetabulum according to grades 1 to 4 of the Tönnis classification.[27]

For the purpose of analysis by final outcome, hips were classified into two groups according to response to Pavlik harness treatment and subsequent radiographic outcome at the conclusion of the follow-up period. The full success group consisted of hips that responded to Pavlik harness treatment and showed normal acetabular and proximal femoral morphology. The late sequelae group comprised hips that successfully completed Pavlik harness treatment but showed abnormal morphology after 4 years: presence of LACD according to the criteria in Table 1 and/or AVN according to the mentioned criteria of Salter.[25]

To identify ultrasound criteria to differentiate the five hips with late sequelae from the 82 full success hips among the 87 hips successfully reduced by the Pavlik harness, we analyzed the following criteria: DCI of 22% or less, alpha angle less than 43 degrees, and presence of echogenicity in the hyaline cartilage portion of the acetabular roof.

Statistical Analysis

To examine outcome predictions based on initial sonographic instability and morphologic measures, two-by-two contingency tables were computed to tabulate outcome (late sequelae or full success) against predicted outcome for only those 87 hips that appeared to respond successfully to the Pavlik harness. Separate tables were computed for DCI (DCI $\leq$22% predicting failure), for alpha angle (alpha angle $<$43 degrees predicting failure), and for a predictor based on the presence of echogenicity of the cartilaginous roof (presence of echogenicity predicting late sequelae). The Fisher exact test probability test was applied for testing the accuracy of each ultrasound criterion. The likelihood ratio chi-square test was

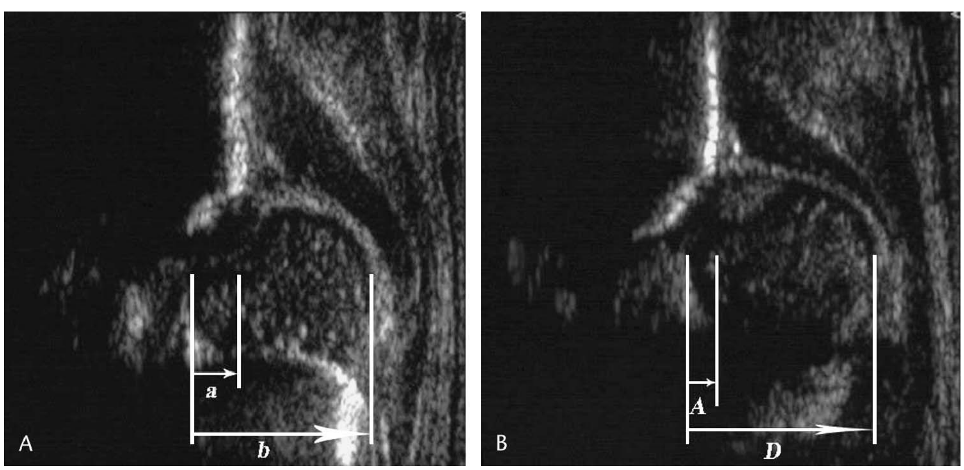

FIGURE 1. A, Coronal neutral view showing measurement of Terjesen's femoral head coverage = a/b = 24%. B, The same hip in coronal flexion view with adduction showing measurement of DCI = A/D = 11%. Note the greater displacement in the stress view and the reduction in the percentage of coverage. DCI is measured in the following way in the illustrated stress view. Reference line 1 is tangential to the most medial echo contour of the femoral head. Reference line 2 is tangential to the straight echo of the iliac bone, which with a linear transducer and proper sectioning through the mid-acetabulum should be parallel to the ultrasound image baseline. This line crosses the bony rim (''Erker'') and is similar to the radiographic Perkins line. Reference line 3 is tangential to the echo of the most lateral portion of the femoral head, covered by the joint capsule. Distance A is measured between line 1 and line 2 and reflects the portion of the femoral head covered by the bony acetabular roof when the femoral head is stressed in adduction out of the acetabular socket. Distance D is measured between line 1 and line 3 and reflects the femoral head diameter. The percentage reflecting the ratio A/D defines DCI.

TABLE 1. Table With Grading of Ultrasound Stability, Ultrasound Morphology and Radiographic Criteria for LACD

US Stability Grading		
Severity	DCI (%)	
Dislocated, irreducible*	DCI <10% and femoral head is irreducible in flexion/abduction	
Dislocated, partially reducible	DCI <10% and femoral head is reduced in flexion/abduction	
Severely subluxated	DCI is in the range 10–35%	
Moderately subluxated	DCI is between 35–50%	
Stable	DCI >50%	
US Morphology Grading		
Severity	α-Angle	
Centered	Mild Dysplasia α-angle 50–59°	Moderate Dysplasia (α-angle 43–49°)
Decentered	Severe Dysplasia (III A Graf) (α-angle <43° hypoechogenic cartilage roof)	Severe Dysplasia (III B Graf) (α-angle <43° echogenic cartilage roof)
Radiographic Criteria for LACD		
Age interval	AI°	Wiberg CE°
Up to 1 year	≥32°	–
2 years	≥30°	–
3 years	≥28°	–
4 years	≥26°	–
5–8 years		<15°
8–12 years		<20°

*In coronal flexion and transverse flexion views with abduction, reducibility of the severely unstable hips was classified as reducible, partially reducible, or irreducible. Description of the femoral head centrage in accordance to the most posterior lip of the acetabular socket in lateral transverse view with flexion and abduction is very similar to that of Suzuki, who uses an anterior transverse view[12] with three group classifications.[8]

used to determine the significance of each predictor or possible two-way interactions among variables.

RESULTS

Forty-nine patients (89%) were girls and six were boys. Ninety-one percent were Caucasian, 5% were Hispanic, and 4% were African-American. Sixty-two percent were first-born, 30% were second-born, and 8% were third-born. Thirty percent of the babies were born with breech presentation. Family predisposition was found in 17%. According to ultrasound criteria, there were 100 abnormal hips (54 left hips, 46 right hips). Forty-five patients (82%) had bilateral hip involvement (90 hips), and 10 patients had unilateral hip involvement (10 hips). The relative degree of abnormality in these hips is discussed later.

For the associated anomalies, there were two infants with torticollis, one with congenital knee dislocation, one with curly toe, one with hand syndactyly, and one with clavicular fracture.

The orthopaedic management regimen for all hips began with a trial period in the Pavlik harness. The harness was discontinued if sonographic improvement was not demonstrated after 3 weeks.[17] Eighty-seven hips (87% of all treated hips) showed progressive improvement during the 3-week trial period; for these patients, the harness was continued with a program of full-time wear followed by a period of weaning. No impairment in the active function of the quadriceps muscles was found in any of these hips on each follow-up visit during the course of harness treatment. This group with successful early reduction was divided into full success and late sequelae. In the successful early reduction group, the last clinical examination at long-term follow-up showed normal range of hip motion and gait pattern in all patients, with no evidence of limb length discrepancy. The serial radiographs from end of harness wear until last follow-up visit for the 87 hips revealed a normal radiographic appearance in 82 hips. This group of hips is defined as full success. In the remaining five hips (6% of the early successfully reduced hips, 5% of all hips), radiographic abnormalities were found; this group is defined as late sequelae (Fig. 3). Four had LACD. In one of these four, there was concomitant type I AVN of the femoral head. The fifth hip showed type I AVN without LACD. The acetabular dysplasia in two of the five hips was surgically corrected with a Salter innominate osteotomy, and the other two dysplastic hips are being observed. The Tönnis classification[27] showed grade 1 in all hips.

Mean age at the start of Pavlik harness treatment was 16 days. For the successfully reduced hips, mean starting age was 16 days; for the hips unreduced by harness, it was 17 days. The mean follow-up for the 55 studied patients was 5.3 years (range 4 years to 9 years and 9 months). The mean durations of treatment in the harness were as follows: full harness wear, 57 days; weaning period, 46 days, and total harness wear, 103 days. According to severity of instability, total harness wear was 98 days for the moderate subluxations and 106 days for the severe subluxations and dislocations.

Outcome results after hips were sorted according to initial severity of hip instability are shown in Table 2. Degree of instability was a discriminator for outcome in cases of moderate subluxation (DCI 35–50%); all hips responded to Pavlik treatment with no late sequelae. With more severe instability and displacement, there were mixed outcomes.

Outcome after hips were sorted according to initial severity of acetabular dysplasia is shown in Table 3. Morphology of the acetabular roof and the alpha angle was a discriminator for full success when the alpha angle exceeded 43 degrees and the cartilage roof was non-echogenic. With decentering, severe dysplasia, and echogenic cartilage roof, there were mixed outcomes. Some hips showed full success, whereas others with the same severity manifested late sequelae.

To identify ultrasound criteria to differentiate the five hips with late sequelae from the 82 full success hips among the 87 hips successfully reduced by the Pavlik harness, three different criteria were as follows: DCI of 22% or less, alpha angle less than 43 degrees, and presence of echogenicity in the hyaline cartilage portion of the acetabular roof. All three of these measures provided significant levels of prediction (Fisher exact test probability <0.01 in all cases), and all three perfectly predicted abnormality in the five cases with late

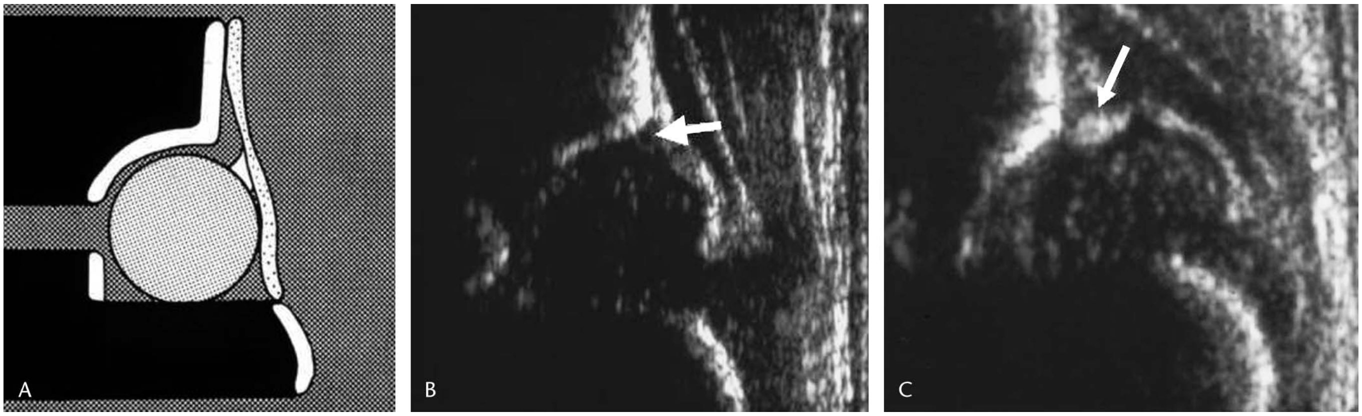

FIGURE 2. Coronal neutral view of the hip. Schematic (A) and normal sonogram (B) noting the location of the roof cartilage. The structurally normal cartilaginous roof is non-echogenic and has a short triangular fibrous tip (the labrum) seen as increased echogenicity (open arrows). C. Pathologic cartilage becomes echogenic beyond the tip as hyaline cartilage becomes fibrous and deformed (closed arrow).

sequelae (100% sensitivity). However, the three measures differed in the extent to which they correctly classified the 82 cases of long-term success; they differed in specificity, with DCI providing 67% specificity, alpha angle providing 80% specificity, and echogenicity providing 88% specificity. Echogenicity nominally outperformed both of the other features (chi-square test for echogenicity vs. DCI, chi-square = 15.96, $P < 0.01$). Examination of the raw data for these contingency analyses revealed that examining DCI of 22% or less, alpha angle less than 43 degrees, or both revealed no information that cannot be learned by examining the echogenicity data alone regarding specificity.

DISCUSSION

This study is based on an extensive analysis of 100 hips that had more than 4 years of follow-up. They reflect a well-defined population with DDH and significant neonatal hip instability because of an ultrasound-based diagnosis. Their short- and mid-term outcome statistics, however, do not necessarily reflect the complete spectrum of the DDH population. Cases with shorter follow-up were excluded. The short-term success percentages for Pavlik harness treatment would undoubtedly be better if cases treated for instability with shorter follow-up were included. Also, the inclusion criterion of midterm follow-up for an individual patient has the potential to select out more difficult cases. The orthopaedic surgeon is more likely to follow severe cases and not to discharge the patient. The fact that 5 of 87 hips manifested late sequelae may not be indicative of the overall success of the Pavlik harness in this hospital and, in some part, reflected the selection criteria.

The patient demographics are typical for DDH. Girls outnumber boys, and outcome revealed no gender predisposition to either success or failure of harness treatment or late sequelae. The pattern of harness treatment was dictated by clinical protocol keyed to the severity of neonatal hip instability and response. For patients with successful response to Pavlik harness treatment, the full success and late sequelae outcome groups had no difference in mean age for starting treatment or for duration of treatment and weaning.

Traditionally, there have been differing opinions concerning the relationship between instability and acetabular dysplasia. Some researchers have found that instability leads to dysplasia,[28–30] whereas others report that dysplasia allows instability to occur.[21,31,32] Acetabular development after restoration of stability is likely to involve multiple factors. Genetic predisposition,[33,34] trauma during treatment,[25] and forces after ambulation all have the potential for affecting mid- and long-term development. The aim of the current study was to identify early ultrasound observations that can predict or establish risk of midterm sequelae. We felt compelled to analyze sonographic parameters that incorporated both concepts for dysplasia and instability. Hence, both morphologic and dynamic observations were included.

Our criteria for analysis reflect published techniques and one newly presented concept, DCI. Parameters were chosen to be comprehensive and not to prove that one technique is better than another. The DCI (see Fig. 1B) was measured in a coronal flexion view with adduction and differs from Terjesen's femoral head coverage. The Terjesen's femoral head coverage (see Fig. 1A) is an indicator of hip centering and can assess hip instability and reduction. We used the same reference points for measure as used for femoral head coverage,[19] but instead of measuring in the coronal neutral view, we performed all measurements in a true stress view: coronal flexion with adduction. This stress view provides a more accurate assessment of the true degree of hip instability, as illustrated by the example case in Figure 1.

We agree that the final outcome of treatment relates to the initial severity of instability and dysplasia. There are studies that suggest patterns that have probability for outcome of treatment by Pavlik harness.[8,35,36] These studies, like that by Harding et al,[17] are focused on a short-term outcome and selection of initial treatment. Most studies discuss results in a short-term time frame of less than 2 to 3 years and do not continue to track results for mid- and long-term outcome.

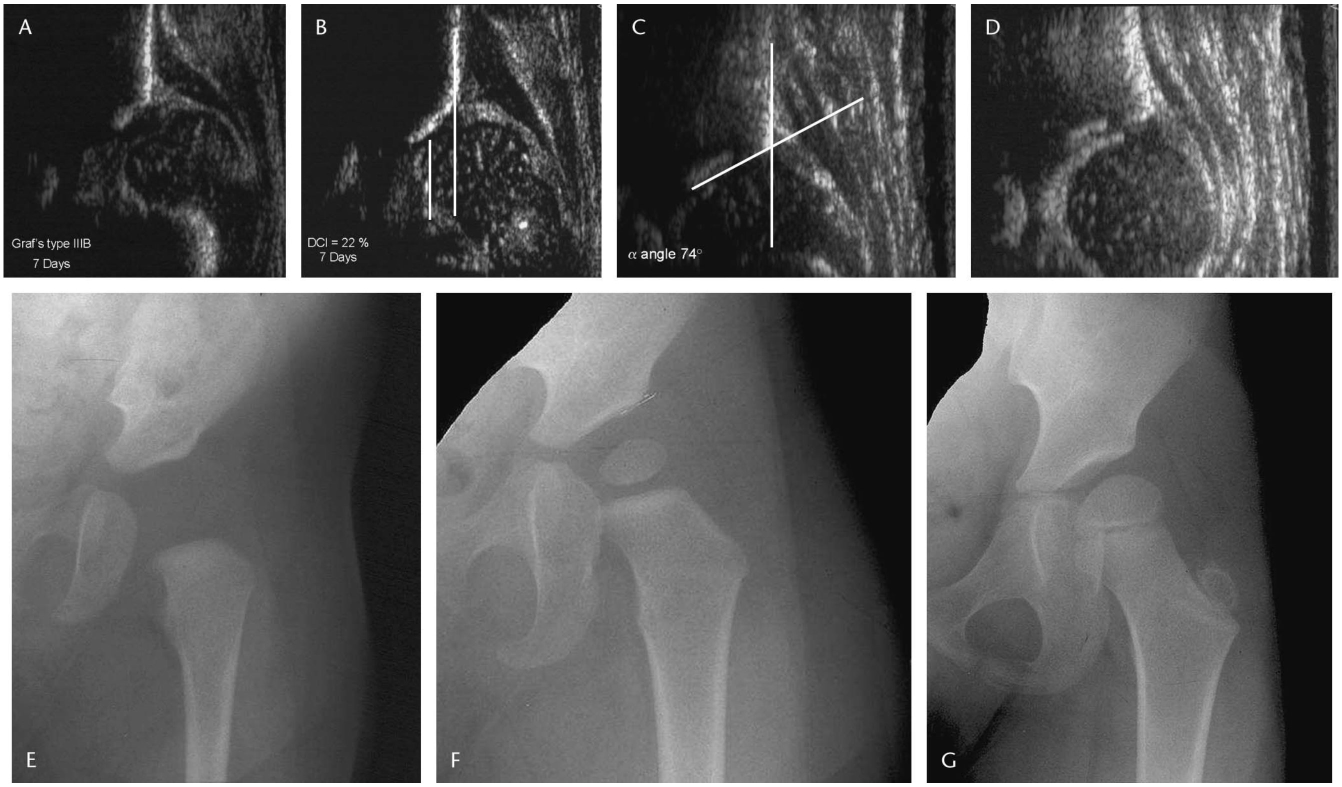

FIGURE 3. Serial sonograms and radiographs of a girl with left neonatal hip instability successfully reduced early in the Pavlik harness; at a follow-up of 5 years and 2 months the hip showed late acetabular dysplasia. A, Coronal neutral view sonogram at age 7 days shows severe dysplasia, Graf's type IIIB with an immeasurable alpha angle and echogenic, pathologically transformed cartilaginous roof. B, Coronal flexion view with adduction stress, showing the true severity of the hip instability, with DCI 22%. The femoral head is subluxated superiorly (cranial) and laterally from the acetabulum. C, Sonogram in coronal neutral view at age 14 weeks when harness wear was discontinued shows normal acetabular development: Graf's type IA with alpha angle 74 degrees and normal echogenicity of the cartilaginous roof. D, Coronal flexion view with adduction stress at age 14 weeks, showing stable hip with DCI 58%. E, Radiograph at age 1 year 3 months, acetabular index 29 degrees. Normal acetabular development. F, Radiograph at age 3 years 4 months, acetabular index 28 degrees. Mild acetabular dysplasia with rounding of the superior lateral bony margin. G, Radiograph at age 5 years 2 months, showing acetabular dysplasia as measured by Wiberg's center–edge angle of 12 degrees.

Our mean follow-up of 5.3 years (range 4 years to 9 years 9 months) gives a good perspective of hip development after walking begins. The difference between outcome after the end of harness treatment and mid-term outcome for the different severity groups is due to the appearance of sequelae after successful harness application. Our data contain the interesting observation that regardless of the degree of initial severity, the harness has some potential for success. The data also contain sonographic gradings of pathology that can be used to guide therapy on a mid- and short-term basis. When the midterm global clinical outcome was examined according to initial ultrasound hip instability (see Table 2), all moderate subluxations (DCI 35–50%) were 100% successfully treated in the Pavlik harness with no sequelae. However, severe subluxations (DCI 10–35%) had an almost equal rate of full success at 95%. For dislocated/partially reducible hips (DCI <10%) treated with the harness, the full success rate was also high at 86% on a midterm follow-up. Early ultrasound and long-term radiographic follow-up is especially important in this group to manage treatment adequately. Irreducible dislocations, from our experience, do not warrant a trial period of harness wear, as all ultimately fail. That is the reason why we could find only one such case for our midterm series.

When results were analyzed in accordance with acetabular morphology (see Table 3), all hips with mild and

TABLE 2. Outcome Distribution of Every Hip According to Severity of Initial Sonographic Instability

	Outcome		
Severity of Instability	Full Success	Early Success With Late Sequelae	Total
Moderate Subluxation (DCI 35–50%)	34 (100%)	0 (0%)	34
Severe Subluxation (DCI 10–35%)	36 (95%)	2 (5%)	38
Dislocated/Partially Reducible (DCI <10%)	12 (86%)	2 (14%)	14
Dislocated/Irreducible (DCI <10%)	0 (0%)	1 (100%)	1
Total	82 (94%)	5 (6%)	87

TABLE 3. Clinical Outcome Distribution of Every Hip According to Severity of Initial Morphological Impairment

Severity of Acetabular Dysplasia	Outcome: Full Success	Outcome: Early Success With Late Sequelae	Total Hips
Centered			
Mild dysplasia α-angle 50–59°	42 (100%)	0 (0%)	42
Moderate dysplasia (α-angle 43–49°)	24 (100%)	0 (0%)	24
Decentered			
Severe dysplasia (III A Graf) (α-angle <43° hypoechogenic cartilage roof)	6 (100%)	0 (0%)	6
Severe dysplasia (III B Graf) (α-angle <43° echogenic cartilage roof)	10 (67%)	5 (33%)	15
Total	82 (94%)	5 (6%)	87

moderate dysplasia (alpha angle >43 degrees) and Graf's type IIIA were treated with full success for midterm outcome. Graf's type IIIB hips had a 33% midterm failure rate, and this necessitates even closer attention to this group of hips after successful harness treatment is completed. Alternatively, it may be more reasonable for this morphologic type to be treated by another type of splint from the time of diagnosis. It is recommended that Graf's type IV hips be treated by closed or open hip reduction at the time of diagnosis. Our study, which was based on harness treatment, did not include hips of this type.

With regard to specific sonographic criteria to predict late sequelae, three criteria (DCI ≤22%, alpha angle <43 degrees, and presence of echogenic hyaline cartilaginous roof) show 100% sensitivity. For specificity, however, echogenicity is the best single predictor. Echogenicity on ultrasound of the normally non-echogenic hyaline cartilaginous roof indicates pathologic transformation of the hyaline cartilage into fibrocartilage. Normally, the bulk of the cartilaginous acetabular roof is hyaline cartilage, with only the labrum being fibrocartilage. With sonography, the hyaline cartilage is echo-poor, and the fibrocartilage, with greater acoustic impedance, is echogenic, which transforms the appearance of the cartilaginous roof.

During harness treatment, ultrasound monitoring showed that in all successfully reduced hips, the echogenic acetabular roof's cartilage reverted to non-echogenic tissue. Improvement in tissue echogenicity, however, may not be indicative of midterm full growth potential. Once severely damaged, these hips may be prone to risk of late sequelae, despite obvious success at short-term follow up. Figure 4 illustrates the late appearance of labral abnormality 2 years after a posttreatment sonogram showed a normal labrum.

One can speculate on the need to alter treatment of hips at risk for late sequelae. It could be that severe forms of instability with abnormal pathoanatomy should not be treated initially in the harness despite the expectation that some would do well. More rigid splinting might place less stress on the remodeling labrum. A prospective study of these hips will be difficult because it will require at least 5 years of follow-up to document LACD.

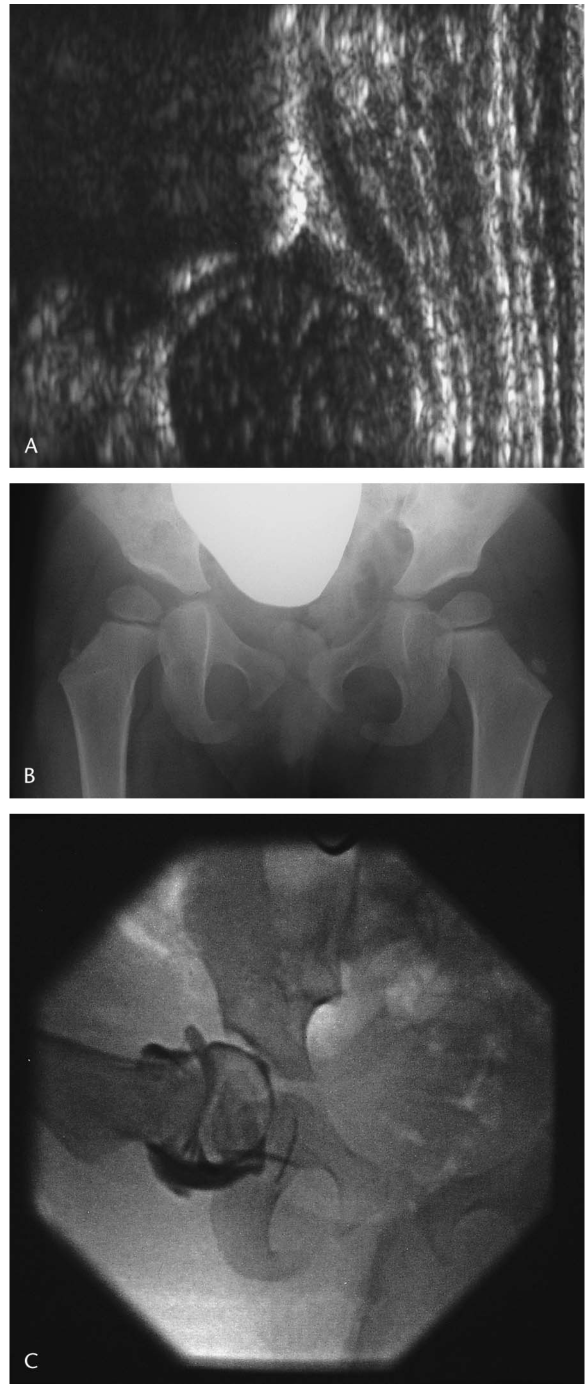

FIGURE 4. Late acetabular dysplasia of the right hip in a girl with bilateral DDH successfully treated in Pavlik harness. A, Coronal sonogram out of harness at time of weaning (age 3 months). Acetabulum is well formed, there is minimal rounding of the bony lip, and the labrum appears normal. B, Anteroposterior pelvis at age 2 years 11 months shows right acetabular dysplasia. Left acetabulum is normal. C, Arthrogram at age 2 years 11 months prior to Salter innominate osteotomy. The labrum is mildly elevated and blunted.

The nutrition and vascularity of the acetabular labrum and the junction zone of the labral attachment to the hyaline cartilage acetabular roof are still not well understood.[37] Graf[38] pointed out that there is still no clear evidence of possible microdamage of the labral–capsular complex during successful closed reduction and of the possible sequelae in childhood and adolescence and labral lesions in adulthood. Acetabular dysplasia is one of the causes of acetabular rim syndrome[39,40] during and after adolescence and of hip osteoarthritis at an even later age.

Although treatment of DDH with the Pavlik harness has a low complication rate, several studies[3,4] have shown that sequelae can appear at long-term follow-up. The problem of late sequelae, such as AVN and LACD or persistent acetabular dysplasia after successful early reduction in the harness, is recognized. Tucci et al[3] recommended continued follow-up of hips with DDH treated in the harness until skeletal maturity. Our finding of 5 in 87 (5.7%) with midterm sequelae agrees with his study. This consistent finding also is related to the fact that both studies selected hips with clearly significant pathology. Our delineation of a smaller risk pool is intended to obviate the need for following all hips to skeletal maturity.

Rachbauer et al[41] advised continuing radiographic monitoring after early successful treatment under sonographic control, although these researchers could not define an end point for this continued monitoring. Taylor and Clarke[42] reported in a prospective study that no factors that could be found in the history, treatment, or ultrasound appearance at an early stage to be predictive of late dysplasia. In a later study at the same institution, Cashman et al[6] concluded that with radiologic monitoring after discontinuation of the harness, the trend of the acetabular index measurement can identify severe late dysplasia by 18 months of age. All of the late dysplasias could be identified by the measurement of the center–edge angle until 5 years of age. These researchers recommended periodic radiologic follow-up for these patients up to 5 years of age. The aim of the current study, in contrast to that by Cashman et al,[6] was to identify a way to predict late sequelae earlier in the course of treatment based upon sonographic observations. The identification of criteria such as the pathologic cartilaginous roof echogenicity as a strong predictor of late sequelae achieves this purpose. Absence of this observation at the time of diagnosis can potentially reduce the number of children who receive prolonged periodic radiographic follow-up and, therefore, reduce radiation exposure and expense.

The current study also has implications for how the orthopaedic surgeon discusses the child's care with parents. At the conclusion of a successful harness treatment, parents tend to assume their child will continue to have a normal hip. Knowledge of specific pretreatment criteria such as pathologic echogenicity is a warning sign that a hip is at risk for late sequelae. Parents should be advised that long-term follow-up is needed. The orthopaedic surgeon can also correct parental expectations of an anatomically normal hip later in life. Conversely, low-risk patients may safely avoid prolonged follow-up.

In conclusion, severity indicators that present on the initial hip ultrasound at the time of diagnosis have prognostic value for both short- and midterm harness treatment outcome. Increased risk for the development of sequelae can be expected in hips with DCI of 22% or less, alpha angle less than 43 degrees, or fibrocartilaginous transformation of the hyaline cartilaginous roof. The most specific of the three, roof transformation, is demonstrated sonographically as increased echogenicity in the cartilage.

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