Original article

Developmental dysplasia of the hip in neonates: Evolution of acetabular dysplasia after hip stabilization by brief Pavlik harness treatment

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Abstract

Background: The recommended treatment duration in neonates with developmental dysplasia of the hip (DDH) varies depending on whether prolonged Pavlik harness therapy is believed to favourably affect the course of the acetabular dysplasia. According to one theory, several months of additional Pavlik harness therapy after achieving hip reduction contributes to correct the acetabular dysplasia. Another theory holds that hip dislocation induces the acetabular dysplasia, which corrects spontaneously once the femoral head is properly seated in the acetabulum. Here, we evaluated this second theory by studying outcomes after early brief Pavlik harness therapy.

Hypothesis: Acetabular dysplasia associated with neonatal hip instability undergoes self-correction provided stable hip reduction is achieved very early after birth. Therefore, the duration of Pavlik harness therapy can be substantially shortened.

Materials and methods: We defined hip instability as either reducible hip dislocation or a very easily dislocatable hip with a soft clunk precluding determination of spontaneous hip position as dislocated or reduced. Static and dynamic ultrasound scans were obtained. Patients with ultrasonographic instability (pubo-femoral distance > 5 mm with less than 50% of coverage) underwent a second physical examination and received treatment. We re-evaluated 42 abnormal hips in 30 patients after a mean follow-up of 6.7 years (range, 5–14 years). Mean age at treatment initiation was 5 days (range, 1–15 days) and mean treatment duration was 34 days (range, 15–75 days).

Results: Mean acetabular angle was 20° (range, 12°–30°) and mean Wiberg’s latero-lateral angle was 30° (range, 22°–35°). Blunting of the lateral angle of the bony roof was noted in 8 hips at last follow-up. In 1 patient whose hip was stable clinically but unstable by ultrasonography at 21 days of age, recurrent dislocation occurred at 5 months of age. The Severin class was 1a in all patients.

Discussion: Despite continuing controversy about whether hip dislocation induces dysplasia or vice versa, the need for early treatment is universally recognised. The optimal treatment duration, however, remains debated. Proponents of the familial determinism of DDH consider that acetabular shaping is genetically programmed when the femoral head is centred in the acetabular socket. Others advocate routine prolongation of Pavlik harness therapy for 2 months or longer, based on the opinion that this strategy decreases the dislocation recurrence rate and that mechanical hip unloading may promote correction of the dysplasia. Mean treatment duration in our population was 34 days and our sole objective was to treat the instability. The hip was reduced and held in its proper position long enough to allow sufficient capsule and ligament tightening to stabilise the hip. Under these conditions, the acetabular dysplasia underwent self-correction that was not related to treatment duration.

Conclusions: Very early Pavlik harness therapy to ensure rapid hip reduction and stabilisation optimises the potential of the acetabulum for spontaneous remodelling.

Level of evidence: Level IV, retrospective study.

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1. Introduction

In neonates with developmental dysplasia of the hip (DDH), a focus of continuing controversy is whether very early treatment...
providing perfect femoral head centring and joint stability restores hip normality, thereby allowing early treatment discontinuation; or whether prolonged treatment is required. Management strategy errors in DDH may produce any of four different outcomes: spontaneous hip reduction, hip subluxation with partial acetabular contact, complete hip dislocation, or acetabular dysplasia with a normally centred femoral head [1,2]. Long-term longitudinal studies of patients with hip subluxation and dysplasia have shown a high incidence of degenerative osteoarthritis [3] related to increased loads applied to an abnormally small surface area. Promptness of the diagnosis and treatment has emerged as a crucial determinant of treatment duration and outcomes [4–6].

Opinions vary regarding the optimal duration of flexion harness treatment in DDH. Pavlik [7] recommended a ‘few months’, but durations have ranged from 21 days [8] to 6 months [9]. This variability reflects the existence of two opposing theories. According to one theory, once hip reduction is achieved, prolonged harness therapy for several months may prevent recurrences and contribute to correction of the acetabular dysplasia [9–11]. The other theory holds that the dislocation induces the dysplasia [2,12], which undergoes self-correction provided the femoral hip is stably centred in the acetabular socket, a result that requires only a few weeks of treatment.

Here, we studied a uniform population of neonates with hip instability managed by early and brief Pavlik harness therapy. Our study rationale was that the outcomes in these patients would provide information on the potential for self-correction of the acetabular dysplasia.

2. Material and methods

We conducted a single-centre retrospective study of patients managed at the Saint-Denis Teaching Hospital, Saint-Denis, France, between 1987 and 2011.

2.1. Inclusion and exclusion criteria

The clinical and ultrasound diagnosis of DDH, as well as Pavlik harness treatment initiation, had to be performed within the first few days after birth. We defined hip instability as either reducible hip dislocation with a clearly perceived reduction clunk and spontaneous re-dislocation or as a very easily dislocatable hip with a soft clunk indicating dislocation (no perception that the femoral head slipped over the acetabular rim) and precluding determination of spontaneous hip position as dislocated or reduced. Both static and dynamic ultrasound scans were obtained. Patients with ultrasonographic instability (pubo-femoral distance > 5 mm with less than 50% coverage) underwent a second physical examination and received treatment.

We did not include neonates with dislocatable hips and a hard clunk (clear perception that the femoral head slipped over the acetabular rim during the manoeuvre, indicating normal spontaneous hip position) managed only with clinical and ultrasound monitoring, which indicated spontaneous normalisation. Other exclusion criteria were irreducible dislocation, teratologic dislocation, and less than 5 years of radiological follow-up.

2.2. Patient population

We included 42 abnormal hips in 30 patients (14 with left-sided DDH, 4 with right-sided DDH, and 12 with bilateral DDH). There were 24 girls and 6 boys with a mean age at treatment initiation of 5 days (range, 1–15 days) and a mean treatment duration of 34 days (range, 15–75 days).

2.3. Treatment protocol

Size 0 Pavlik harness treatment was started at the diagnosis of hip instability. The hips were flexed to 110° with the knees at the level of the navel and no forced abduction, as recommended by Pavlik [7,13]. A clinical and ultrasound evaluation was performed once a week. The harness was worn continuously for the first 8 days (reduction phase). Then, once the clinical and ultrasound data confirmed that the hip was stable, removal of the harness during bathing was allowed (consolidation phase). Complete treatment discontinuation was decided based on clinical and ultrasound criteria. Clinical stability criteria were disappearance of the clunk and full symmetrical abduction. Ultrasound stability criteria were at least 50% femoral head coverage on static images and absence of instability during dynamic manoeuvres (pubo-femoral distance < 4 mm) [14]. Antero–posterior pelvic radiographs were obtained at 4 and 18 months of age then at last follow-up.

2.4. Assessment criteria

The diversity, inconsistent quality, and long time since ultrasound study performance precluded classification and angle measurements. We therefore relied on two criteria, the pubo-femoral distance and the percentage of femoral head coverage. During the physical examination, pain, a limp, and hip motion range limitation were sought. The radiographs obtained at last follow-up were used to measure the acetabular angle and lateral centre-edge angle of Wiberg; however, Wiberg’s angle was taken into account only after 5 years of age, as its measurement is unreliable in younger patients [15]. The appearance of the lateral angle of the bony acetabular roof was described as blunted (not prominent) or normal (markedly prominent). At last follow-up, the hips were classified based on Severin’s criteria (suitable for use after 3 years of age).

3. Results

The main data are reported in Table 1. Mean follow-up was 6.7 years (range, 5–14 years) and follow-up was longer than 10 years in 4 patients. None of the patients had pain, limping, or motion range limitation. Mean acetabular angle was 20° (range, 12–30°) and mean Wiberg’s angle 30° (range, 22–35°). Blunting of the lateral angle of the bony roof was visible in 8 of the 42 hips at last follow-up. Severin’s class was 1a in all cases.

No cases of avascular necrosis of the femoral head or femoral nerve palsy were recorded. Recurrent dislocation at 5 months of age was noted in 1 patient whose hip was clinically stable at 21 days of age but had less than 50% of femoral head coverage at treatment discontinuation. The recurrent dislocation was managed using continuous traction according to Somerville-Petit for 15 days, followed by cast immobilisation for 5 weeks. The outcome was favourable at last follow-up (11 years of age).

4. Discussion

A chicken-and-egg controversy exists regarding DDH: either the dysplasia is viewed as causing the dislocation or vice versa. Advocates of the dysplasia-first theory argue that gradual worsening of minimal acetabular dysplasia results in displacement of the femoral head, either at birth or within the first few postnatal months, and that maintaining the hip in abduction results in normalisation of the shape of the acetabulum. Thus, the sequence of categories in Graf’s classification [16,17] is normal (type 1), dysplastic (type 2b–c), subluxated (type 3), and dislocated (type 4). This theory prevails at present and explains the widespread use
of the term ‘developmental hip dysplasia’ (DDH). According to the other theory [2], acetabular dysplasia with normal femoral head centring is ascribable to the mechanical loads applied in utero, and the disappearance of these loads at birth results in a high acetabular index of the centred hip with gradual remodelling to a normal acetabular shape. The acetabulum undergoes ossification during the first 3 postnatal months, under the effect of the pressure applied by the femoral head. However, neither the acetabular index value, nor an abnormal lateral angle of the bony roof reliably predicts future development. Endogenous factors such as acetabular dysplasia, excessive femoral neck anteversion, and capsule laxity support a role for genetic factors but are neither consistently present nor necessary and therefore must be viewed as mere predisposing factors. Strong evidence points to mechanical factors related to foetal posture as the main culprit: tight flexion with adduction and external rotation puts abnormal pressure on the greater trochanter, dislodging the femoral head superiorly and posteriorly. This theory is consistent with the natural history of DDH: the hip instability noted at birth is followed either by irreducible dislocation or by spontaneous stabilisation with complete normalisation or residual abnormalities (subluxation or dysplasia).

Table 1
Main characteristics of the study patients.

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R: right; L: Left; RD: reducible dislocation; SC: soft clunk; N: normal; B: blunted; Pres.: presentation; Durtn.: duration; CEA: center-edge angle; FU: follow-up; HTE: acetabular angle; VCE: Wiberg angle.

12 bilateral
18 unilateral
14L4 R

5.3 34.3 19.8 30 20.1 31.9 B = 8 N = 34 80.1 6.7 years
The degree of belief placed in one or the other of these two theories can influence decisions regarding treatment initiation and duration. Age at Pavlik harness treatment initiation varies widely [18]. The need for early detection and treatment, in contrast, is universally recognised [5,6,19], although variations from a few days to several months have been reported [7,9,12]. In neonates, prompt hip reduction and stabilisation is likely to maximise the benefits related to acetabular remodelling. According to Diméglio et al. [20], normal acetabular development is greatest at birth then decreases gradually. For this reason, treatment was typically started promptly as possible in our patients. In a prospective study of 546 hips treated within the first 3–6 weeks of life with Pavlik harness, Cashman et al. [21] noted hip dysplasia (centre-edge angle <20°) in 3.5% of hips after 11 years of follow-up and recommended regular monitoring until 5 years of age. Persistent late dysplasia was noted in some cases but was also present in the contra-lateral hip, indicating a contribution of genetic factors to the final acetabular coverage angle. Pavlik harness therapy during the first postnatal week has been criticised as technically difficult and hazardous; with reported avascular necrosis rates ranging from 0% [4,22] to 22% [23]. A high rate of avascular necrosis can be ascribed to excessive tightening of the harness straps without regard for the child’s crying. In practice, harness sizes that are perfectly well suited to neonates are commercially available. Using appropriately sized harnesses with scrupulous attention to the recommendations of Pavlik, we have seen no cases of avascular necrosis [8].

After 1 month of age, the optimal duration of harness therapy is a major issue. In a European study of 3611 hips reported by Grillo et al. [19], the harness was worn until the radiographs returned to normal, i.e., for a mean of 6.3 months, and the persistent dysplasia rate was 4.65%. A practice survey in The Netherlands done by Heeres et al. [18] showed a mean treatment duration of 2 months (range, 0.75–6 months) in babies younger than 6 months of age and 3.5 months (range, 2–6 months) in those aged 6 to 12 months. In a retrospective study of 343 hips managed between 2001 and 2005, Bialik et al. [4] used a clinical and ultrasound observation period of 2–6 weeks after birth to ensure that only ‘true DDH’ would be treated, and they prolonged the duration of the treatment based on dysplasia severity in Graf’s classification. Treatment duration was significantly longer in patients treated after 13 weeks of age compared to those treated before 5 weeks of age. Westcott et al. [24] found no significant outcome differences between groups treated for 7.3 weeks and 9.2 weeks, respectively, with a follow-up protocol based solely on the method described by Graf.

Tucci et al. [10] reported long-term outcomes of Pavlik harness treatment as described above (mean, 6.7 weeks) in 74 hips. The harness was worn continuously for 8 weeks and discontinuously for the next 11 weeks. Whereas radiographs were normal after 5 years, after 10 years 17% showed acetabular alterations consisting of sclerosis or deformity of the lateral acetabular roof (versus 4 cases in our study), with no increase in acetabular slope or subluxation. The authors advocated regular follow-up until skeletal maturity. Whether the described changes met the definition of true acetabular dysplasia is unclear, and studies referring to this article deserve critical appraisal [11,25].

Several authors [9–11,26] recommend routine prolonged harness treatment, even after hip stabilisation is achieved, for about 2 to 3 months. They argue that prolonged treatment is necessary to prevent recurrent dislocation (1 case in our study, but the treatment was stopped although ultrasonographic coverage was less than 50%) and can provide enough time for dysplasia self-correction to occur.

Hip dysplasia diagnosed after 3 months of age must be analysed separately. Mladenov et al. [27] reported spontaneous dysplasia correction in 69% of stable hips after 2 years of follow-up. In the remaining 31% of cases, the acetabular index showed a 1 standard deviation difference versus the normal value for age. In a comparison by Gans et al. [28] of 31 dysplastic hips treated from 6 to 12 months of age and 39 untreated dysplastic hips, the acetabular index improvement in the treated group was 5.3°, a difference deemed significant.

Taken in concert [29], these studies support early treatment initiation, which allows a decrease in treatment duration. Self-correction of the dysplasia seems to occur once the mechanical loads related to the instability are eliminated. However, few studies have investigated the self-correction potential of the dysplastic acetabulum. Schwend et al. studied untreated acetabular dysplasia in Navajo individuals followed-up for 35 years [30]. The centred edge angle improved from 7° at 1 year of age to 29° at 12 years of age. However, this result should be viewed with caution, as centred edge angle measurement is unreliable before 3 years of age. Among 144 hips with residual dysplasia in 72 patients re-evaluated by Dornacher et al. [31] 3 years after abduction therapy for a mean of 108 days (continued until full normalisation of ultrasound criteria), the acetabular index returned to normal in 65 patients, whereas the remaining 7 patients (9 hips) exhibited residual acetabular dysplasia. Some of the initially normal contra-lateral hips exhibited dysplasia after 3 years, suggesting a role for an endogenous factor in acetabular development and a need for long-term radiological monitoring. In a study of 311 patients, Lee et al. [32] confirmed the demographic differences between patients diagnosed with hip dysplasia in childhood and those diagnosed in adolescence and adulthood and concluded that these constituted distinct patterns of dysplasia. In both groups, a familial predisposition was found, supporting natural and probably genetically programmed changes in acetabular shape when the hip is centred.

Mean treatment duration in our study was 34 days and our sole objective was correction of the hip instability. The hip was therefore reduced (continuous harness use for a mean of 8 days to ensure reduction), and once hip stability was confirmed by the clinical examination and ultrasound criteria (coverage > 50%), the treatment was continued until capsule and ligament tightening was sufficient to ensure hip stability, i.e., for about 3 weeks (with removal of the harness only for bathing). With this protocol, self-correction of the acetabular dysplasia occurred and was not influenced by prolonging the treatment. Although our study design was retrospective and the number of patients limited, no complications or residual dysplasias were noted at last follow-up. Our clinical data are not supported by a full ultrasonographic assessment, given the long time since the management of the first patients. Our results indicate a need for radiological follow-up after 4 and 18 months then after 5 years. However, follow-up until skeletal maturity would be the only means of definitively validating this treatment option [33] and separating the influence of genetic and mechanical factors.

5. Conclusion

Early brief treatment of DDH in neonates is a reasonable option only if prolonged clinical and ultrasound follow-up is provided. The analysis of our results supports the potential for self-correction of the acetabular dysplasia provided the hip is centred and stabilised. The short treatment duration seems ascribable to the early treatment initiation, and delayed treatment would be expected to require a longer treatment duration.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.
References


