Hip joint development in children with type IIb developmental dysplasia

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Abstract

Purpose The aim of this study was to analyse the results of treatment of sonographically diagnosed type IIb developmental hip dysplasia and to identify residual hip dysplasia using clinical and radiological assessment.

Methods We retrospectively reviewed the data of 49 children (59 type IIb and 39 type I hips, according to Graf's monographic classification) treated in abduction braces. The mean age was 9.1 years (range 4–15) at latest follow-up.

Results According to the clinical classification of McKay in Barrett's modification, all the type I and type IIb hips had very good results. No statistical differences were found between type I and IIb hips when comparing both measured radiological parameters and radiological results according to the Severin classification at latest follow-up. Using our criteria (two or more radiological parameters were outside of their normal range), 12 out of 49 type IIb hips demonstrated

persistent dysplasia. Of the 12 hips, eight sonograms were normal at the end of treatment and four patients failed to normalise. No type I hips demonstrated two or more abnormal radiographic parameters at latest follow-up.

Conclusions Despite obtaining normal sonograms at the end of treatment, some children with type IIb dysplasia may demonstrate radiographic evidence of persistent hip dysplasia over a longer follow-up period. Our results suggest that these children should be monitored until skeletal maturity.

Introduction

Mild hip joint dysplasia in childhood is often asymptomatic and early degenerative joint disease is often the first mode of presentation. It can be difficult to determine the presence of significant joint dysplasia with clinical examination, until pain becomes a feature. A number of retrospective studies have suggested a relationship between radiological residual dysplasia and degenerative change [1, 2]. We also know that, despite early diagnosis and treatment, affected joints may continue to have persistent dysplasia [3]. It is clear that early diagnostics and long-term monitoring of the development of affected hip joints, ideally till skeletal growth is complete, is important [1]. Mild dysplasias require particular care as, although they are the most commonly diagnosed cases of dysplasia [4], they are underestimated and as a consequence either untreated or treated ineffectively.

The aim of this study was to analyse the results of treatment of sonographically diagnosed type IIb developmental hip dysplasia and to identify residual hip dysplasia using clinical and radiological assessment.

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Materials and methods

The study group included children treated during infancy for sonographically diagnosed type IIb developmental dysplasia of the hip (according to Graf's classification) from 1994–2003 [5]. All the patients in that group were contacted by post to attend for follow-up. Fifty-four out of 185 patients who were contacted, attended for follow-up. Five children were excluded from the study for the following reasons: primarily type IIc–III dysplasia, treated before at other centres ($n=3$); partial, left-sided hemiparesis, diagnosed in the second year of life ($n=1$); and no consent for radiological investigations ($n=1$).

Forty-nine children were included in the study who were treated during infancy for sonographically diagnosed dysplasia of type IIb. The first sonographic examination was performed at a mean of 13.6 weeks of life (range 4–32 weeks). In nine children, ultrasound (US) examination was done before the 12th week of life, identifying type IIa dysplasia, which did not return to normal state during subsequent follow-up examinations. Unilateral dysplasia was diagnosed in 39 children (30 left, nine right). Bilateral dysplasia was found in ten children. No clinical hip joint instability was found in any children. Twenty-four children were treated with Frejka pillow and 25 children with a Koszla splint. The mean treatment duration was 15.3 weeks (range 3–40 weeks).

Physical examination was performed with the patient supine with neutral limb position. Gait and Trendelenburg's test were assessed. McKay's criteria, using Barrett's modification [6], were also recorded during clinical assessment.

Radiological examination was performed using antero-posterior radiographs and in a neutral position of the lower limbs. In all cases, the lamp-cassette distance was standardized at 100 cm, with the central ray targeting the pubic symphysis. The radiological measurements used were according to Tonnis [7]. In children aged six years or less, the Hilgenreiner angle was measured ($n=12$). In children older than six years, Lequesne's angle was measured ($n=37$). Lequesne's angle is an equivalent of the Hilgenreiner angle, following triradiate

cartilage ossification [7]. As both parameters are determined with reference to similar anatomical points, in quantitative evaluations they were calculated together. The other radiological parameters included: Ullmann-Sharp's angle, Wiberg's angle, Idelberger-Frank's angle, decentricity distance, Heyman-Herndon's acetabular-head index, Heyman-Herndon's acetabular index and disruption of the Ménard-Shenton line [7]. The Severin classification was also used for radiological evaluation [8].

For the purposes of this study, those hips where at least two of the radiological parameters were outside their normal range were considered to show persistent dysplasia. Radiological parameters of the primarily dysplastic hip joints ($n=59$) were compared to those of normal hip joints ($n=39$).

Statistical analysis was performed by the Statistica program for Windows PL 7.0. Student *t*-test was used for comparison of indices between primarily dysplastic and normal hip joints. Values of $p<0.05$ were regarded as statistically significant.

Results

All children obtained very good results according to clinical assessment using the McKay criteria with Barrett's modification. No children reported any pain in their hip joints, nor were there any abnormal observations on clinical examination. No gait abnormalities were observed in any of the patients. Trendelenburg's test was negative in all patients. The mean age of the analysed group at follow-up examination was 9.1 years (range 4–15 years).

Using Severin's classification, 57 of the primarily dysplastic hip joints showed excellent results and two had good results. Using the same classification, all the primarily normal hip joints had excellent results.

Using our criteria of at least two radiological parameters outside of normal range, nine children out of 49 (12 hip joints) (20%) were considered to have persistent dysplasia at latest follow-up (Table 1) (Fig. 1a and b). Four out of the 12

Table 1 Details of hip joints in which at least two radiological parameters exceeded their accepted normal values

Sex/Age in years	♀/6		♀/6		♀/6		♀/8		♂/9		♀/9		♀/9		♂/10		♀/11	
Hip joint	L	R	R	L	R	L	L	R	L	R	L	R	L	R	L	R	L	R
Type IIb joint	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb
Ménard-Shenton line	1	1	0	1	1	1	0	0	0	0	0	0	0	0	1	1		
Lequesne's angle	20	12	13	9	15	11	12	8	12	13	7	15						
Wiberg's angle	23	26	19	30	20	19	20	20	27	24	23	23						
Ullmann-Sharp's angle	50	52	50	48	50	49	49	48	50	51	52	47						
Heyman-Herndon's acetabular index	43	43	52	55	51	40	46	46	51	55	57	52						
Heyman-Herndon's acetabular-head index	85	82	89	96	71	75	75	73	87	84	75	89						

L left, R right

Fig. 1 **a** Ultrasound of left (L) type IIb hip and right (R) normal hip. **b** Hips radiograph of nine-year-old boy whose ultrasound is presented in (a). Control X-ray revealed breakage of Ménéard-Shenton line and center-edge angle of 19° on the left side

hip joints in this group had not normalised with treatment prior to walking, while in the other eight hips, sonographic imaging demonstrated normal hip joints at the end of treatment. None of the primarily normal hip joints fulfilled the criteria for dysplasia at latest follow-up. Interruption of the Ménéard-Shenton arc was noted in seven out of 12 hip joints.

No significant differences were found between the primarily dysplastic and normal hip joints comparing either a quantitative analysis of radiological parameters (see Table 2) or radiological results using the Severin classification. Table 3 shows the number of hip joints which fulfilled the radiographic criteria for persistent dysplasia at latest follow-up, for both primarily dysplastic (type IIb) and normal (type I) hip joints.

Table 2 Mean $\pm$ standard deviation values of radiological parameters for primarily dysplastic (type IIb) and normal (type I) hip joints. A p value of <0.05 was considered significant

Parameters	Type I joints ($n=39$)	Type IIb joints ($n=59$)	p value
Hilgenreiner/Lequesne's angle	$5.5^\circ \pm 5$	$4.8^\circ \pm 6$	>0.05
Ullmann-Sharp's angle	$43.7^\circ \pm 3$	$44.3^\circ \pm 3$	>0.05
Wiberg's angle	$32.2^\circ \pm 5$	$31.2^\circ \pm 6$	>0.05
Idelberger-Frank's angle	$45.3^\circ \pm 3$	$45.1^\circ \pm 3$	>0.05
Decentricity distance	$1.9 \text{ mm} \pm 1$	$2.3 \text{ mm} \pm 1$	>0.05
Heyman-Herndon's acetabular-head index	90 ± 4	91.5 ± 9	>0.05
Heyman-Herndon's acetabular index	51.2 ± 4	51.2 ± 5	>0.05

Table 3 Number of hip joints which demonstrated values outside normal range, at latest follow-up, in primarily dysplastic (type IIb) and normal (type I) hip joints

Radiological parameter	Normal values	Type IIb	Type I
Ménéard-Shenton arch	Ruptured	7	0
Hilgenreiner/ Lequesne's angle	$>20^\circ / >10^\circ$	1/0	0/0
Wiberg's angle	$<20^\circ$	14	7
Ullmann-Sharp's angle	$\geq 45^\circ$	10	3
Heyman-Herndon's acetabular index	≤ 400	2	0
Heyman-Herndon's cephalic acetabular index	≤ 75	5	0

Discussion

Developmental hip joint dysplasia includes a spectrum of disorders which manifest with a variety of clinical presentations. The belief that a considerable number of asymptomatic, sonographically diagnosed abnormalities will undergo spontaneous normalisation [9] means that mild dysplasia of the hip may be underestimated and, as a result, may be inadequately monitored and treated. There is also a belief that, prior to the introduction of sonographic diagnostic imaging, type II dysplasias were not a significant clinical problem [10, 11].

This study has shown that cases of dysplasia, which with early diagnosis and therapeutic intervention were normalised, went on to demonstrate various abnormalities with later radiological assessment. Twelve out of 59 hip joints (20%) treated for type IIb dysplasia demonstrated radiological features of residual dysplasia (two or more radiological parameters outside of normal range). Interestingly, in eight out of 12 hips normalisation of ultrasound image was found following treatment. In the same group of 12 hips, two children had limb shortening of 0.5–1 cm, which also correlated with interruption of the Ménéard-Shenton arc on the corresponding side. No children demonstrated abnormal findings on clinical examination. No children reported any symptoms from their hip joints, even after significant episodes of loading. In a quantitative analysis of a range of parameters for type IIb and type I hip joints, no significant differences were found, as the majority of type IIb joints were normal. This may suggest that dysplasia is a condition affecting both hip joints, even if it manifests itself only in one.

Dornacher et al., using Graf's criteria, treated 90 children with dysplasia of types II–IV till full normalisation in sonographic images. Radiological assessment, performed at a mean of the 15th month of life, when children started walking, demonstrated features of mild (32.8% of cases) and severe (29% of cases) dysplasia. They found no correlation between Graf classification and radiological outcomes at follow-up [3]. Therefore, type II dysplasia may, with radiological assessment, show as much dysplasia as those of type

III or type IV. Rachbauer et al. reported on commencing treatment early in the neonatal department, when dysplasia of types IIa–IV was diagnosed. Despite this early intervention, 32% of hip joints demonstrated features of residual dysplasia with later radiological assessment. Among 42 hip joints of type IIa and IIb monitored radiologically after the 18th month of life, 11 were evaluated as mild and four as severe dysplasias [12].

Rafique et al. also report a case of late presentation of hip dysplasia with a normal early sonogram of the hip joint [13]. In Germany, a study showed that following the introduction of routine ultrasonography, 13% of children who required surgical intervention for hip dysplasia (ranging from closed reductions to corrective osteotomies) had previously normal US results [14]. Bone coverage of the femoral head is sometimes insufficient, even with an alpha angle of more than 60 degrees, and a normal sonogram in static examination does not exclude sonographic instability [15]. Gardiner and Dunn confirm that some sonographically unstable joints may demonstrate normal morphology in Graf's static examination, undergoing progression at subsequent follow-up [16]. Paton et al. demonstrated in their prospective study that dysplasias of type III can be sonographically stable in Harcke dynamic examination [17]. Roovers et al. reported that, in 99.6% of cases, type I hips remained normal after the third month of life [18]. Similarly, in Bialik's studies, only 0.3% of normal hip joints demonstrated considerable progression to dysplasia and this occurred in those patients where primarily severe dysplasia had been identified in the opposite hip joint [9]. Radiological examination of children with a family history of developmental hip dysplasia, with primarily normal sonogram, has not shown any association between family history and later hip joint development [19].

Conclusions

Despite obtaining normal sonograms at the end of treatment, some children with type IIb dysplasia may demonstrate radiographic evidence of persistent hip dysplasia in long-term follow-up. Although we did not identify any statistical differences between type IIb and I hip joints at latest follow-up, there remain a proportion of primarily type IIb dysplastic joints which demonstrate features of persistent dysplasia. Our results suggest that these children should be monitored until skeletal maturity and that further work should be carried out to confirm.

Conflict of interests The authors declare that they have no conflict of interest.

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References

1. Wedge JH, Wasylenko MJ (1979) The natural history of congenital disease of the hip. *J Bone Joint Surg Br* 3:334–338
2. Cooperman DR, Wallenstein R, Stulberg SD (1983) Acetabular dysplasia in the adult. *Clin Orthop Relat Res* 175:79–85
3. Dornacher D, Cakir B, Reichel H, Nelitz M (2010) Early radiological outcome of ultrasound monitoring in infants with developmental dysplasia of the hips. *J Pediatr Orthop B* 19:27–31
4. Synder M, Niedzielski K, Grzegorzewski A (2003) Ultrasonografia stawu biodrowego noworodków i niemowląt. *Ortop Traumatol Rehabil* 5:717–721
5. Graf R (1980) The diagnosis of congenital hip-joint dislocation by the ultrasonic Comboud treatment. *Arch Orthop Trauma Surg* 97:117–133
6. Barrett WP, Staheli LT, Chew DE (1986) The effectiveness of the Salter innominate osteotomy in the treatment of congenital dislocation of the hip. *J Bone Joint Surg Am* 68:79–87
7. Tönnis D (1987) Congenital dysplasia and dislocation of the hip in children and adults. Springer-Verlag, Berlin
8. Severin E (1941) Contribution of the knowledge of congenital dislocation of the hip joint. Late results of closed reduction and arthrographic studies of recent cases. *Acta Chir Scand* 84(Supp 63):1–142
9. Bialik V, Bialik GM, Blazer S, Sujov P, Wiener F, Berant M (1999) Developmental dysplasia of the hip: a new approach to incidence. *Pediatrics* 103:93–99
10. Eastwood DM (2003) Neonatal hip screening. *Lancet* 361:595–597
11. Feldman DS (1999) Re: How to avoid missing congenital dislocation of the hip. *Lancet* 354:1490–1491
12. Rachbauer F, Sterzinger W, Klestil T, Krismer M, Frischhut B (1994) Acetabular development following early treatment of hip dysplasia by Pavlik harness. *Arch Orthop Trauma Surg* 113:281–284
13. Rafique A, Set P, Berman L (2007) Late presentation of developmental dysplasia of the hip following normal ultrasound examination. *Clin Radiol* 62:181–184
14. Ihme N, Altenhofen L, von Kries R, Niethard FU (2008) Sonographisches Hüftscreening in Deutschland. Ergebnisse und Vergleich mit anderen Screeningverfahren. *Orthopade* 37:541–549
15. Graf R (2006) Hip sonography. Diagnosis and management of infant hip dysplasia, 2nd edn. Springer-Verlag, Berlin
16. Gardiner HM, Dunn PM (1990) Controlled trial of immediate splinting versus ultrasonographic surveillance in congenitally dislocatable hips. *Lancet* 336:1553–1556
17. Paton RW, Hinduja K, Thomas CD (2005) The significance of at-risk factors in ultrasound surveillance of developmental dysplasia of the hip. A ten-year prospective study. *J Bone Joint Surg Br* 87:1264–1266
18. Roovers EA, Boere-Boonekamp MM, Mostert AK, Castelein RM, Zielhuis GA, Kerkhoff TH (2005) The natural history of developmental dysplasia of the hip: sonographic findings in infants of 1–3 months of age. *J Pediatr Orthop B* 14:325–330
19. Osarumwense D, Popple D, Kershaw IF, Kershaw CJ, Furlong AJ (2007) What follow-up is required for children with a family history of developmental dysplasia of the hip? *J Pediatr Orthop B* 16:399–402