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Prevention of dislocation of the hip in children with cerebral palsy

THE FIRST TEN YEARS OF A POPULATION-BASED PREVENTION PROGRAMME

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In 1994, a register for cerebral palsy and a health-care programme were started in southern Sweden with the aim of preventing dislocation of the hip in children with cerebral palsy. It involved all children with cerebral palsy born in 1992 or later.

None of the 206 affected children born between 1992 and 1997 has developed a dislocation following the introduction of the prevention programme. Another 48 children moved into the area and none developed any further dislocation. Of the 251 children with cerebral palsy, aged between five and 11 years, living in the area on January 1, 2003, only two had a dislocated hip. One boy had moved into the area at age of nine with a dislocation and a girl whose parents chose not to participate in the programme developed bilateral dislocation. One boy, whose condition was considered to be too poor for preventative surgery, developed a painful dislocation of the hip at the age of five years and died three years later.

Eight of 103 children in a control group, consisting of all children with cerebral palsy living in the area between 1994 and 2002, and born between 1990 and 1991, developed a dislocation of the hip before the age of six years.

The decreased incidence of dislocation after the introduction of the prevention programme was significant ($p < 0.001$). Dislocation of the hip in cerebral palsy remains a serious problem, and prevention is important. Our screening programme and early intervention when lateral displacement of the femoral head was detected appear to be successful.

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Children with cerebral palsy have an increased risk of lateral displacement of the femoral head, leading in some cases to dislocation. The reported incidence of lateral displacement or dislocation is related to the severity of the condition and varies between 7% in ambulatory children and 60% in those with total-body involvement.[1,2] However, no population-based studies have been published.

Dislocation of the hip in cerebral palsy results in significant morbidity in terms of pain,[3-5] contractures, problems with sitting, standing or walking,[6] fractures,[7,8] skin ulceration and difficulty with perineal care,[6,8] pelvic obliquity and scoliosis.[9]

The first suggestion that dislocation in cerebral palsy was preventable was published nearly 50 years ago.[10] We initiated a population-based prevention programme for children with cerebral palsy with the aim of preventing dislocation of the hip by early detection and intervention. We now describe and analyse the results of the first ten years of this programme.

Patients and Methods

In 1994, a cerebral palsy register and health-care programme for children with cerebral palsy was started in southern Sweden involving all children born with cerebral palsy in the area since 1990. The condition was defined as "an umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development".[11] Only children who were alive at two years of age and had their cerebral lesion before that time were included. The subtype of cerebral palsy was determined after the fourth birthday according to the method of Hagberg, Hagberg and Olow.[12] Gross motor function was classified according to the classification system (GMFCS) of Palisano et al[13] which is an age-related five-level system in which level I is the least and level V the most affected (Table I).

The study area has a population of 1.3 million. The total population of children born in 1990 and later were systematically reviewed in

Table I. The gross motor function classification system (GMFCS).[13] The levels represent the highest level of mobility that a child is expected to achieve between six and 12 years of age

Level	
I	Walks without restrictions; limitations in more advanced gross motor skills
II	Walks without assistive devices; limitations walking outdoors and in the community
III	Walks with assistive devices; limitations walking outdoors and in the community
IV	Self-mobility with limitations; children are transported or use power mobility outdoors and in the community
V	Self-mobility is severely limited even with the use of assistive technology

Table II. Subdiagnosis and GMFCS* level in 103 children with cerebral palsy born between 1990 and 1991 (control group) and 258 children born between 1992 and 1997 (study group)

	Born 1990 to 1991	Born 1992 to 1997	Total
Subdiagnosis			
Spastic			
Hemiplegia	29	86	115
Tetraplegia	9	17	26
Diplegia	43	99	142
Ataxic	7	14	21
Dyskinetic	14	37	51
Not classified	1	5	6
GMFCS level		118	153
I	35		
II	21	26	49
III	14	26	40
IV	7	27	34
V	16	33	49
Not classified	10	26	36

* GMFCS, gross motor function classification system

1998 and 2002 in order to identify all children with probable cerebral palsy.[14] In those aged four years and older the diagnosis and subtypes of cerebral palsy were established. The prevalence of children with cerebral palsy aged from four to seven years and living in the area on January 1, 1998 was 2.4 per 1000 children.[14] Our study of dislocation of the hip also included children with cerebral palsy who moved out of and into the area or died during the study period from 1994 to 2002 (n = 361).

In addition to an active search for children with cerebral palsy in order to offer them participation in the programme as early as possible, the health-care programme included a continuing standardised follow-up of the diagnosis, gross motor function, clinical findings and treatment. The local physiotherapist and occupational therapist completed a record twice a year until the age of six years and then once a year. The results were computerised and the local team received a report showing the development of the child over time.

A standardised radiological follow-up of the hips was carried out. They were examined on an anteroposterior radiograph at diagnosis, then at least once a year in children with the diplegic, tetraplegic or dystonic type cerebral palsy until the age of eight years, and then on an individual basis. Children with spastic hemiplegia or pure ataxia were only examined radiologically at four years of age. The hip programme began in 1994 and included children born in 1992 or later.

In the present study children born between 1990 and 1997 and living in the area between 1994 and 2002 were analysed. Data for children born in the area were used until the children had moved out of the area or died. Children who had moved into the area were included in the follow-up programme, but their results were analysed separately.

The control group. There were 103 children born between 1990 and 1991; 87 lived in the area when the programme started and 16 had moved in at a median age of nine years (5 to 11; inter-quartile range 8 to 9). By January 1, 2003, three children had died at six, nine and 11 years of age, respectively. One child had moved out of the area at the age of eight years.

The study group. There were 258 children born between 1992 and 1997; 210 were born in the area and 48 had moved in at a median age of three years (0 to 9; inter-quartile range 2 to 5). Twenty-two children did not participate in the prevention programme. Four families declined to participate, and 18 children were identified during the review undertaken in 2002 and then included in the programme. However, information regarding their hips at the census date (January 1, 2003) was collected from their clinical records. Of the remaining 236 children three had died at two, seven, and eight years of age, respectively, all from causes not related to the prevention programme. Four children had moved out of the area at five, six, eight and nine years of age, respectively.

The control and study groups were comparable with regard to the proportion of subtype of cerebral palsy and GMFCS level (Table II). In the classification system,[13] spastic diplegia includes all children in whom the lower limbs are more affected than the upper ones. This is in contrast to spastic tetraplegia which is defined as massive total motor disability with all four limbs severely involved, the upper limbs at least as severely as the lower.

The migration percentage[15] (MP) and acetabular index[16] (AI) were measured on the radiographs (Fig. 1). All radiographs were assessed by one of the authors (GH). Both measurements have been shown to be reliable.[15,17] However, recently some doubt on the inter- and intra-measurer reliability has been raised, suggesting that repeated measurements should be made by one individual.[18] Hips with an MP < 33% and an AI < 30° were regarded as normal. In children with lateral displacement or acetabular dysplasia, the findings were compared with earlier measurements and data from the physiotherapist's follow-up. The decision

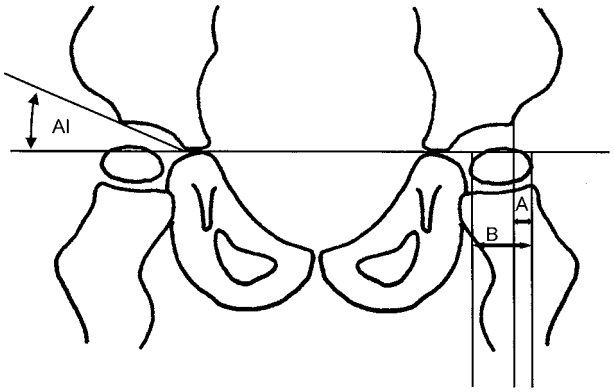

Fig. 1

Diagram showing measurement of the acetabular index (AI) and migration percentage (MP; MP = A/B x 100).

with regard to preventative treatment was made together with the child's family and the local treatment team.

In the younger and in older children with minor displacement, orthopaedic surgery usually involved bilateral tenotomies of the adductors and iliopsoas. With marked displacement, or if the lateral displacement was not reduced within one year after adductor-iliopsoas tenotomy, a varus osteotomy of the proximal femur was performed. In children with marked dysplasia, acetabular reconstruction was sometimes necessary. Post-operatively, the children were treated by positioning the hips in extension and abduction during lying and sitting. Standing frames and abduction splints were often used. Treatment with a hip spica plaster was rarely necessary.

In children for whom reduction of spasticity was planned using selective dorsal rhizotomy (SDR) or continuous infusion of intrathecal baclofen (ITB), it was often possible to wait and see if the decreased spasticity reduced lateral hip displacement. The indications for SDR and ITB were when problems were directly related to increased muscle tone, and the decision to employ such treatment was made irrespective of the degree of lateralisation of the hip.

Statistical analysis. Fisher's test was used to evaluate the efficiency of the prevention programme.

Results

At the date of census, eight children in the control group had developed unilateral dislocation of the hip, always between the age of three and six years. All children with dislocated hips had severe pain, at least periodically. All had pelvic obliquity and scoliosis. In three patients, resection of the femoral head and subtrochanteric valgus osteotomy were performed to reduce pain. Three of the children with dislocation had died. A further nine of the 103 children in the control group had developed lateral displacement. All had been operated upon to prevent dislocation, six by adductor-iliopsoas tenotomy and three by varus femoral osteotomy. Five children in the control group had been treated by SDR, and three with ITB.

None of the 206 children monitored by the prevention programme from the time of diagnosis has developed dislocation of the hip ($p < 0.001$). None of the 48 who moved into the area between 1995 and 2002 developed any further dislocation.

One boy had a dislocated hip when he moved into the area. One girl whose family were unwilling to participate in the prevention programme has developed bilateral dislocation. One boy, born in 1993, with spastic tetraplegia had a lateral displacement of the hips (MP 40 left, 74 right) at the age of three years. Operation by adductor-iliopsoas tenotomy was recommended, but the child's respiratory condition was such that he was only expected to survive for a short period. Surgery was therefore not undertaken. The right hip dislocated within two years and the child died at eight years of age.

In the study group 50 children (78 hips) showed lateralisation of the hip with an MP exceeding 33% (Table III). At the date of census, 54 of these hips had been corrected to normal (MP < 33%). Of these, 11 were operated on by adductor-iliopsoas tenotomy, and 16 by proximal varus femoral osteotomy. Five children (six hips with lateralisation) have been treated by SDR, and two children (three hips) with ITB. In 18 hips the MP corrected to normal with no operative treatment. These hips had a mean MP of 35% (33 to 42).

At the date of census 24 hips still had an MP equal to or exceeding 33% (Table III). Three children (five lateralised hips) had died. In nine hips the MP was decreasing, and in two it remained at 33%. In seven hips preventative surgery was planned. One child was operated on just before the date of census.

The AI was increased (> 30°) in 18 children (23 hips) in the study group. The mean AI in these hips was 34° (30 to 40). All hips with an increased AI also had an MP greater than 33%. At the census date the AI was normal in all except seven hips. In one case, with an AI of 40°, a pelvic osteotomy was performed after the date of census. It was decreasing or approaching 30° in the remaining six hips.

In total, 25 children, five in the control group and 20 in the study group, have been operated on by SDR at a median of four years of age (3 to 6). Of these, 17 had normal hip radiographs before and after operation. In the remaining eight children, eight hips showed lateral migration before SDR. In five hips the lateral migration corrected without further treatment post-operatively. In a further two hips the MP decreased, and in one hip it remained at 33%. Two hips were normal before SDR, but have developed lateralisation after the procedure. In one boy (case 24, Table III) the MP increased to 42% at eight years of age, and a varus femoral osteotomy was performed. In the other case the MP increased to 34%. This hip will be investigated by further radiography before a decision is made regarding preventative surgery.

Table III. Data on the 50 children (78 hips) with lateral migration in the study group

Case	Diagnosis*	GMFCS† level[13]	Side	Age at highest MP (yrs)	Highest MP	Age at operation (yrs)	Treatment‡	Age at latest follow-up (yrs)	MP at latest follow-up	Comments
1	T	5	L	7	40	7	ad	11	27	
2	D	3	L	9	34		0	10	26	
3	Dy	4	R	5	35		0	9	18	
4	H	1	L	7	34		0	9	32	
5	T	5	L	3	53	3	ad	8	10	
6	D	3	L	4	33		0	8	28	
7	D	4	R	5	33		0	9	24	
8	D	1	R	4	33		0	6	29	
9	D	3	R	9	33	5	SDR	11	33	
10	Dy	5	L	5	61	5	ad			
			L	6	82	6	ost	10	37	
11	D	3	L	7	39					Planned for adductor-psoas tenotomy
		3	R	5	36		0	7	28	
12	Dy	5	L	5	35	6	ITB	6	27	
			R	6	33	6	ITB	6	33	
13	Dy	5	L	3	44	3	ad	6	46	
			R	3	50	3	ad			Died at six years of age
			R	5	73	5	ost	6	40	
14	T	5	R	4	62	4	ost	9	20	
15	D	4	R	5	45	5	ad	7	47	Planned for femoral osteotomy
16	D	3	L	4	35	3	SDR	7	29	
			R	4	39	3	SDR	7	29	
17	D	3	L	4	33		0	10	29	
			R	5	41		0	10	36	
18	T	5	L	5	33	7	ITB	10	25	Died at 10 years of age
			R	6	44	7	ITB	10	29	
19	D	3	L	5	57	6	ad	7	46	
			R	5	40	6	ad	7	20	
20	D	4	L	7	54	7	ost	10	23	
			R	7	75	7	ost	10	63	Planned for new femoral + pelvic osteotomy
21	D	2	R	9	33	7	SDR	11	24	
22	A	4	L	5	39		0	11	33	
			R	7	42		0	11	30	
23	T	5	L	6	45	6	ad	10	31	
			R	6	38	6	ad	10	28	
24	D	4	R	8	42	8	ost	10	28	Operated SDR at 3 years of age
25	Dy	3	R	6	35		0	10	31	
26	D	4	L	3	50	8	ost	9	23	
			R	5	33	8	ost	9	4	
27	T	5	L	3	80	3	ost	8	11	
			R	3	80	3	ost	8	25	
28	T	5	L	4	48	5	ost	7	20	
			R	5	83	5	ost	7	11	
29	D	3	L	4	47	4	ost	7	20	
			R	6	63	4	ost	7	50	Planned for new femoral osteotomy
30	D	1	L	3	33	4	ost	6	29	
			R	3	35	4	ost	6	31	
31	T	5	L	7	52	8	ad	10	30	
			R	5	68	8	ost	10	27	
32	Dy	5	L	5	79	5	ad	10	28	
			R	5	58	5	ad	10	33	
33	T	5	L	3	63	4	ad	10	11	
			R	3	39	4	ad			
			R	5	79	5	ost	10	40	
34	D	3	L	4	47	3	SDR	10	29	
			R	4	57	3	SDR	10	52	
35	D	3	R	5	35		0	8	32	
36	H	1	L	4	33		0	7	22	
37	T	5	L	7	64	7	ost	11	26	
38	A	4	R	7	33		0	10	30	

* according to Hagberg et al[12]; H, spastic hemiplegia; D, spastic diplegia; T, spastic triplegia; Dy, dystonic type; A, athetonic type

† GMFCS, gross motor function classification system

‡ 0, no treatment; ad, adductor-psoas tenotomy; ost, varus osteotomy of the proximal femur; SDR, selective dorsal rhizotomy; ITB, intrathecal baclofen pump

Table III (cont.) Data on the 50 children (78 hips) with lateral migration in the study group

Case	Diagnosis*	GMFCS† level[13]	Side	Age at highest MP (yrs)	Highest MP	Age at operation (yrs)	Treatment‡	Age at latest follow-up (yrs)	MP at latest follow-up	Comments
39	D	4	L	3	47	3	ad	8	28	
			R	3	56	3	ad			
			R	5	59	5	ost	8	32	
40	D	2	R	2	33		0	8	21	
41	T	5	L	3	40		0	7	32	Died at 8 years of age
			R	3	74		0	7	100	
42	T	5	L	4	44	4	ad	6	50	Planned for femoral osteotomy
			R	4	47	4	ad	6	36	
43	Dy	4	L	7	50	7	ad			
			R	3	33		0	7	29	
44	D	3	L	3	33	5	SDR	6	25	
			R	3	36	5	SDR	6	33	
45	T	5	L	5	35		0	6	37	Planned for adductor-psoas tenotomy
			R	5	35		0	6	32	
46	T	5	L	9	72	9	ost	10	44	
47	D	2	L	5	46	4	SDR	10	16	
48	D	3	L	3	38		0	9	30	
			R	4	42		0	9	43	Planned for adductor-psoas tenotomy
49	D	4	L	4	44	5	ad	9	31	
			R	5	50	5	ad	9	29	
50	T	5	L	2	42					Died at three years of age
			R	2	36					

* according to Hagberg et al[12]; H, spastic hemiplegia; D, spastic diplegia; T, spastic triplegia; Dy, dystonic type; A, athetonic type

† GMFCS, gross motor function classification system

‡ 0, no treatment; ad, adductor-psoas tenotomy; ost, varus osteotomy of the proximal femur; SDR, selective dorsal rhizotomy; ITB, intrathecal baclofen pump

Seven children have been treated with ITB, three in the control group and four in the study group. The hips in two children in the study group showed lateral displacement before treatment with ITB. At the date of census three of these hips were normal and one showed an MP of 33%.

Discussion

Of the 103 children in the control group, eight have developed dislocation of the hip. This cannot be looked upon as the natural history of untreated hips. Some of the nine children operated upon for lateral displacement would probably have had dislocation if they had not had the operation. Some of the children with lateral displacement and treated by SDR or with ITB could also have developed dislocation of the hip. In the study group, 50 (21%) of 236 children showed lateral displacement of the hip. The displacement returned to normal without operative treatment in 12. The remaining 38 (16%) would probably have had dislocation without preventative surgery. This suggests that the natural risk for hip dislocation in a total population of children with cerebral palsy is between 15% and 20%.

The children in the study group were aged between five and 11 years at the date of census. They are still at potential risk of dislocation, but they are older than the age at dislocation in the control group, and it is known that most dislocations of the hip occur before seven years of age.[19] The lower incidence at this age in the study group as compared with the control group is statistically significant ($p < 0.001$). At present, there are only two children with cerebral palsy in a total of about 400 up to the age of 12 years in southern Sweden, who have a dislocated hip. These are the boy who moved into the area with an established dislocation and the girl who did not participate in the programme.

A dislocated hip in a child with cerebral palsy is a serious problem. The reported frequency of children with pain varies, probably due to the difficulty in assessing pain in these children. Cooperman et al[3] and Bagg et al[5] who used standardised criteria for assessment of pain have reported the highest incidence of 50% to 90%. Pain often results in increased muscle tone with increased energy requirements. A child with dislocated hips often deteriorates with undernourishment, increased contractures, postural difficulties, skin ulceration and problems with perineal care. Perhaps it is no mere coincidence that four of the five children who died at more than four years of age during the study period had dislocations of the hip.

We chose an MP of 33% as the indication for intervention according to the definition of subluxation of Reimers.[15] Other reports have used an MP of 30% to 40% as the indication for surgery.[20,21] Several hips with an MP between 33% and 40% returned to normal levels without operative treatment. These children had not received any additional non-operative treatment as a result of the radiological findings. No hip with an MP exceeding 42% returned to normal without operative treatment. We recommend radiological follow-up at intervals of six months before a decision about surgery is made in hips with an MP of between 33% and 40%, especially if the child is walking and has a good range of movement in the hip.

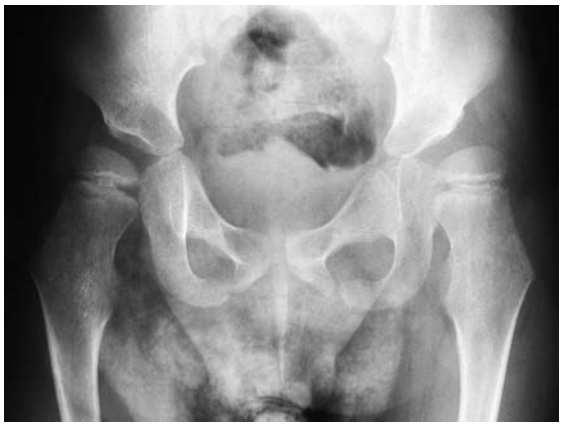

Fig. 2a

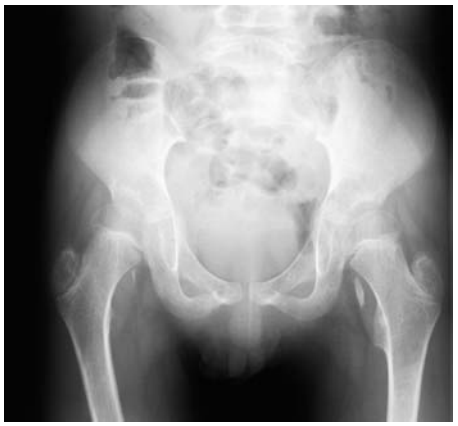

Fig. 2b

Radiographs showing the hips of a boy (case 32) with dystonic-type cerebral palsy, GMFCS 5. a) At five years of age with a migration percentage (MP) of 79% on the left and 33% on the right. He underwent bilateral adductor-psoas tenotomy and b) at ten years of age with an MP of 28% on the left and 58% on the right.

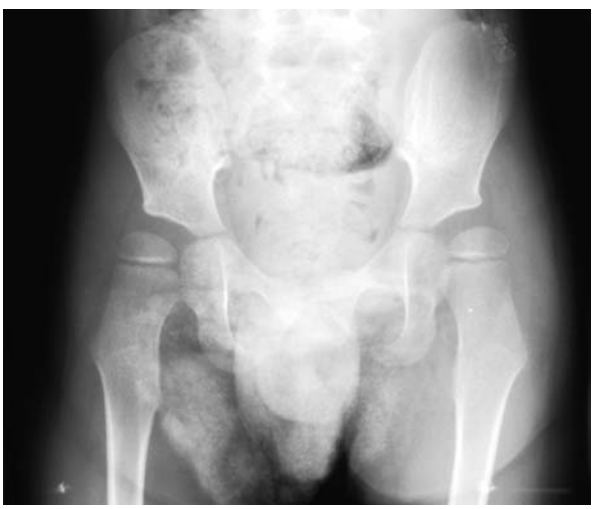

Fig. 3a

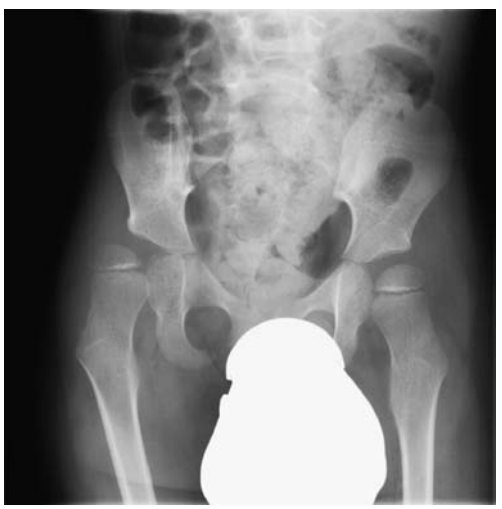

Fig. 3b

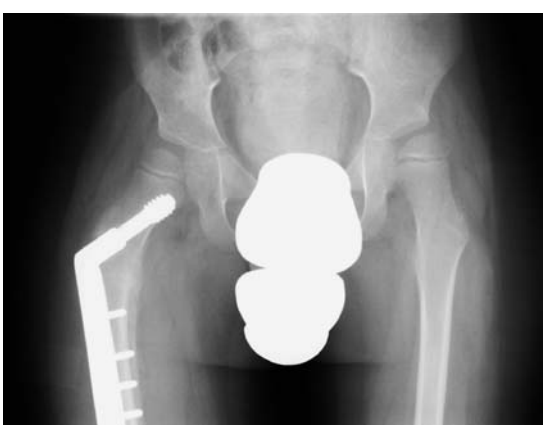

Fig. 3c

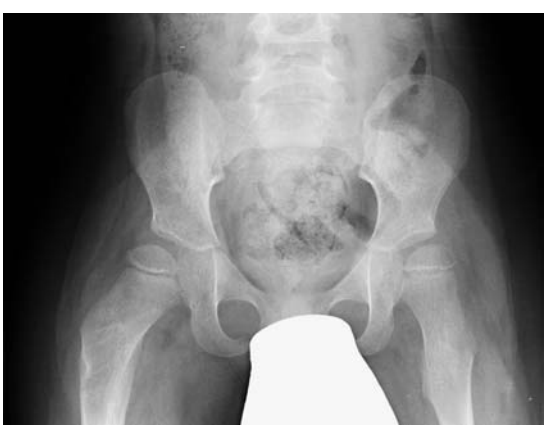

Fig. 3d

Radiographs showing the hips of a boy (case 13) with dystonic-type cerebral palsy, GMFCS 5. a) At three years of age with a migration percentage (MP) of 44% on the left and 50% on the right. He underwent bilateral adductor-psoas tenotomy, b) at five years of age with an MP of 47% on the left and 73% on the right, c) after operation with proximal femoral varus osteotomy and d) at six years of age with an MP of 46 % on the left and 40% on the right.

The AI was increased in 23 hips, all of which also showed an increased MP. Our results do not support the findings of Cooke, Cole and Carey[22] that lateral displacement is always preceded by an increased AI. Our findings indicate that the MP could be used as the only measurement in a screening programme for dislocation of the hip. It also suggests that lateral displacement precedes acetabular dysplasia.

Children with spastic hemiplegia and pure ataxia are included in the radiological follow-up, but normally radiographs were only taken at diagnosis and at four years of age. One reason for their inclusion is that some children with spastic diplegia in their early years may present with unilateral symptoms. Some children with ataxic diplegia could present with mainly ataxic symptoms, and be initially misdiagnosed.

The combination of adduction and flexion spasticity or contracture appears to cause the lateral displacement.[23] Soft-tissue surgery should address both of these deformities. We always combine adductor and iliopsoas tenotomy, and we always perform the surgery bilaterally in children with bilateral spasticity or dystonia. If a child who cannot walk has a knee contracture exceeding 20°, the knee is treated post-operatively by serial casting. The combination of iliopsoas tenotomy and treatment of the knee contracture is probably the reason why no child has developed hyperabduction post-operatively, a reported complication.[6,24]

Varus osteotomy of the proximal femur has been carried out in 15 children (21 hips) in the study group. During the first years of the programme some children were diagnosed and referred late when it was considered to be too late for an adductor-psoas tenotomy. However, in doubtful cases, we often prefer to do an adductor-psoas tenotomy first. If no decrease in lateral displacement is seen within one year, we perform a proximal varus femoral osteotomy (Figs 2 and 3).

The new techniques of reducing spasticity by SDR, ITB and botulinum toxin have probably prevented lateral displacement in some cases. In one boy a lateral displacement of 44% corrected to normal within one year after treatment with ITB. It has been suggested that SDR could increase the risk of dislocation by increasing the muscle imbalance at the hip.[25] All children treated by SDR were operated upon up to L2 and no signs of increased muscle imbalance were seen in these patients.

The main challenge for this programme was the early identification of all children with cerebral palsy in the population.[14] The health-care programme has been developed in collaboration with the local child rehabilitation team of physiotherapists, occupational therapists, paediatricians and orthopaedic surgeons. All interventions have the support of both the local team and the paediatric orthopaedic surgeon. This collaboration has been essential both to start and run the programme. However, it is our experience that once the child has been included in the follow-up programme, an orthopaedic surgeon should be responsible for the hips, arranging radiological screening and the analysis of the results.

In the future we hope to be able to discover which children in the population are at risk of dislocation of the hip in relation to subtype of cerebral palsy, function and other information from the collected data. We also hope to improve the timing of radiological examination and the choice of intervention for lateral displacement.

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