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ORIGINAL PAPER

Developmental dysplasia of the hip in cerebral palsy – surgical treatment

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Abstract Developmental dysplasia of the hip (DDH) in cerebral palsy (CP) is very rare, and very little clinical data is available. We have analysed the results of open reduction of the hip (Howorth), acetabuloplasty (Salter, Pemberton), pelvic osteotomy (Chiari) and femoral osteotomy in the treatment of the DDH in CP patients. Radiographic assessment was based on the Severin grading classification system and measurements of migration percentage (MP) before and after surgery. Clinical results were analysed using the Ponsetti classification system in ambulatory patients. A total of 45 hips in 31 patients were treated surgically. The average age of the patients was 5.2 years (range: 2–16 years). The average follow-up was 9.6 years (range: 3–28 years). Analysis of the radiographic results according to Severin placed 35 hips (77.8%) in groups 1 and 2 and ten hips (22.2%) in groups 3 and higher. The average preoperative MP value was 78.7% and the average postoperative MP was 15.2%. Redislocation occurred in three hips. Clinical results were disappointing: based on Ponsetti assessment 14 hips (36.8%) were classified in the first three groups and 24 hips (63.2%) in the last three groups. This analysis suggests that these surgical procedures could be applied in treating DDH in CP.

Résumé La dysplasie de hanche chez les patients présentant une infirmité motrice d'origine (IMOC) cérébrale est rare. Nous avons analysé les résultats de la réduction sanglante de hanche (Horworth), l'acétabuloplastie (Salter, Pemberton), l'ostéotomie pelvienne (Chiari) et l'ostéotomie fémorale dans le traitement de la dysplasie de hanche chez l'IMOC. Ces résultats ont été évalués selon la classification de Séverin, avec la mesure du pourcentage de migration avant et après traitement. Les résultats cliniques ont été évalués selon la classification de Ponsetti chez les patients ayant conservé la marche 45 hanches. 31 patients ont été analysés, l'âge moyen des patients est de 5,2 ans, le recul moyen a été de 9.6 ans (3 à 28). L'analyse des radiographies selon Séverin montre que 35 hanches (77.8%) sont classées dans le groupe 1 et 2, 10 hanches (22.2%) sont classées dans le groupe 3 et plus. Le pourcentage de migration pré-op est de 78.7% et 15.2% en post-op. Une reluxation est survenue dans trois hanches. Les résultats n'ont pas été satisfaisants. Selon Ponsetti 14 hanches (36.8%) ont été classées dans les trois premiers groupes et 24 hanches (63.2%) ont été classées dans les trois derniers groupes. Cette analyse nous permet de penser que ces traitements chirurgicaux peuvent être appliqués lors d'une luxation congénitale de hanche chez l'infirme d'origine cérébrale (IMOC).

Each author certifies that this investigation was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.
All authors agree on the content and state that this article is original, that it has not been considered by another journal and that the material has not been previously published.

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Introduction

Developmental dysplasia of the hip (DDH) in cerebral palsy (CP) is a very rare condition about which very little

data is available [22]. Conversely, paralytic dislocation of the hip (PDH) has been the topic of a significant number of reports. Developmental dysplasia of the hip in CP can be properly treated only if diagnosed correctly – i.e. the clinician must be able to clearly distinguish DDH from PDH in patients with CP. The term DDH is used when referring to patients who are born with dislocation or instability of the hip, which may then result in hip dysplasia. It is congenital and can be diagnosed by ultrasound examination in newborns or during the first 12 months of life and by radiographic examination in children older than 5 months. PDH, however, develops gradually, most often between the ages of 3 and 8 years. A literature search revealed reports of the earliest development of PDH in CP patients as young as 6 months and the latest at 18 years [5, 21]. A clear distinction between DDH and PDH is possible on the basis of radiographs. A certain degree of dysplasia, both of the acetabulum and of the femoral head, is typical of DDH but not of PDH. Acetabular dysplasia can also develop into PDH when the process of femoral head migration is a long one and leads into subluxation and dislocation. Some authors state that this sort of acetabular dysplasia develops as early as 2.5 years of age [24]. A defect of the femoral head in its superior lateral quadrant is a characteristic of a certain number of patients with CP and PDH, especially those who suffer from pains on the side of the defect [6, 8]. The defect of the femoral head develops gradually and is the most frequent between the ages of 10 and 25 years [3].

One final characteristic of PDH – although irrelevant for diagnostic purposes – is that PDH occurs much more frequently than DDH in CP. The frequency of PDH in CP ranges from 1.5 to 75%, with an average frequency of 20% [7, 23], while there is no relevant data available on the frequency of DDH in CP.

The approach to treating DDH in CP patients is still open to a debate that often revolves around the question "Whether the surgical treatment should be the same as in patients not suffering from CP?". The purpose of this study was to evaluate radiographic and clinical results of acetabuloplasty, pelvic osteotomy and femoral osteotomy with or without an open reduction of the hip in treating DDH in CP.

Materials and methods

We retrospectively evaluated and followed up 31 patients (45 operated hips) from 1965 until 1997 at the Clinic for Orthopaedic Surgery and Traumatology, Clinical Centre University of Sarajevo and the Orthopaedic Hospital "Banjica" in Belgrade. All patients were diagnosed with DDH in CP based on ultra-sound, radiographic and clinical examinations. The mean age at diagnosis was 15.2 months (range: 1–77 months).

The results of the following surgical procedures were analysed:

- Open reduction of the hip (Howorth) [10], acetabuloplasty (Salter) [19], shortening and derotation osteotomy of the femur (13 patients; 20 hips);
- Acetabuloplasty (Salter), shortening and derotation osteotomy of the femur (five patients; seven hips);
- Acetabuloplasty (Salter) (two patients; two hips);
- Open reduction of the hip (Howorth), acetabuloplasty (Pemberton) [16], shortening, derotation and varus osteotomy of the femur (eight patients; 11 hips);
- Pelvic osteotomy (Chiari) [4] (three patients; four hips);
- Acetabuloplasty (Lance) [13] and varus osteotomy of the femur (one patient; one hip) (Table 1).

All patients were in a hip spica cast for the first 6 weeks postoperative, followed by rehabilitation without weight-bearing for the following 6 weeks. We allowed walking with weight-bearing 3 months after the operation.

Radiographic and clinical results were assessed using the Severin grading system of radiological outcomes [20], preoperative and postoperative migration percentage (MP) measurements [2] and the Ponsetti classification of clinical outcome in ambulatory patients [17].

Unilateral operations were performed in 17 patients, and bilateral operations in 14 patients. The identical procedure was carried out on both hips in all patients with bilateral DDH with one exception, a male patient subjected to acetabuloplasty (Salter) along with shortening and derotation osteotomy of the femur and pelvic osteotomy (Chiari) on another hip (patient No 27 in Table 1). Bilateral operations were usually performed with a 6-month interval between operations.

A total of 23 female (74.2%) and eight 8 male (25.8%) patients with CP were treated surgically. Five patients had spastic quadriplegia, nine had diplegia, 14 had paraplegia, two had hemiplegia and one had athetosis. The MP measurements [18] indicated that 11 patients (35.5%) had subluxation of the hip (seven unilateral, four bilateral), 19 (61.3%) had hip dislocation (ten unilateral, nine bilateral) and one patient had subluxation in one hip and dislocation in another. Of the 45 surgically treated, 25 were on the right side, 20 on the left. The average age of the patients at the time of surgery was 5.3 years (range: 2–16 years).

Prior to this operation 20 patients (64.5%) had been treated conservatively, three (9.7%) had had an unsuccessful surgical treatment in other hospitals (one had been treated in a brace preoperatively) and eight patients (25.8 %) had not had any kind of treatment. Of these 20 preoperatively treated patients, 12 were treated with braces

(Hilgenreiner, Pavlik) [9, 15], two patients had received a cast and six patients had been treated with both cast and braces (Table 1).

Of the three patients who had surgical treatment prior to the index operation, one (case no. 2) had previously been treated by a bilateral open reduction of the hip (Howorth), acetabuloplasty (Pemberton) and shortening, derotation and varus osteotomy of the femur. The second patient (no. 29) had previously been treated by unilateral open reduction of the hip (Howorth), acetabuloplasty (Salter) and shortening and derotation osteotomy of the femur. The third patient (no. 24) had previously been treated by unilateral open reduction of the hip (Howorth). Redislocation had occurred in all three patients (four hips).

Some patients required additional operations following the operations to treat DDH. In three hips (patients nos. 7 and 8) tenotomies of gracilis and adductor longus were performed at the time of hip surgery. In four hips (patients nos. 4, 16, 24, 28), the second operations were the same as the first. In addition, eight elongations of triceps surae (patients nos. 5, 8, 11, 16, 17, 24), two medial hamstring elongations (patients nos. 8, 17), two tarsectomies (patient nos. 5, 16) and one hip arthrodesis (patient no. 14) were performed.

Patients were followed up at 6-month intervals for the first 3 years after the operation and then at yearly intervals. The average follow-up was 9.6 years (range: 3–28 year). The results were evaluated at the final check-up.

Radiographic findings of MP were statistically analysed by the Wilcoxon test, Student *t*-test and the Mann-Whitney test. Statistical significance was set as $p<0.05$.

Results

Radiological assessment revealed a Severin grading of groups 1 and 2 in 35 (77.8%) hips and of group 3 or more in ten hips (22.2%). Of the 14 patients who underwent bilateral operations, ten patients had symmetrical results and four patients had asymmetrical results according to Severin grading (Table 1).

The average MP values before and after surgery were statistically significantly different ($p<0.001$). The average preoperative MP value was 78.7%; the average postoperative MP value was 15.2%.

Two similar, very frequently used operative procedures were compared by radiographic assessment. Group 1 patients (procedure 1) underwent open reduction of the hip (Howorth), acetabuloplasty (Pemberton) and shortening, derotation and varus osteotomy of the femur (11 hips), while group 2 patients (procedure 2) underwent open reduction of the hip (Howorth), acetabuloplasty (Salter) and shortening and derotation osteotomy of the femur (20 patients) (Fig. 1a–c). The average age of the patients at the time of surgery was approximately the same in both groups – 4.25 and 4.15 years, respectively. All patients were grouped according to the Severin grading system: in the patients of group 1, six hips (54.5%) were graded 1 and 2, and five hips (45.5%) were graded 3 and more; in the patients of group 2, 17 hips (85%) were graded 1 and 2, and three hips (15%) were graded 3 and more.

There was no statistically significant difference between the average preoperative MP values in hips operated on using these two operative procedures (group 1 and 2 $p=0.0776$). The average preoperative MP values in the hips operated by the first procedure were 94.5%, while the average MP values in the hips operated using the second procedure were 92.5%. Similarly, there was no statistically significant difference between the average postoperative MP values between these two groups ($p=0.227$). The average postoperative MP values in hips operated on by these two procedures were 22.7% (group 1) and 15.7% (group 2), respectively.

The Ponsetti-based analysis of the clinical results in ambulatory patients showed that nine patients (34.6%) and 14 hips (36.8%) fell into the first three groups of the assessment and 17 patients (65.4%) and 24 hips (63.2%) fell into the last three groups. The Ponsetti analysis of ambulatory patients with bilateral operations showed symmetrical findings in nine patients and asymmetrical in three patients (Table 1).

A Ponsetti-based comparison of clinical findings in ambulatory patients treated using the two procedures showed that two hips (25%) fell into groups 1–3 and six hips (75%) operated by the first procedure fell into groups 4–6. Seven hips (41.2%) operated on using the second procedure fell into groups 1–3, and ten hips (58.8%) fell into groups 4–6.

Before the operative treatment of the DDH 20 patients (64.5%) were able to walk without any support, while 11 (35.5%) were not able to walk. Following operative treatment of the DDH 26 patients (83.8%) were able to walk (three walked with hand support; patients 15, 30 and 31), while five patients (16.2%) remained unable to walk. In summary, six patients acquired the ability to walk after the operative treatment of the DDH (patients nos. 5, 8, 15, 17, 19 and 29).

Three patients (four hips) required revision for hip dislocations that followed operative treatment in other hospitals. In one of these patients (no. 2) revision included bilateral Chiari pelvic osteotomy, while in the other two patients (nos. 24 and 29) open reduction of the hip (Howorth), acetabuloplasty (Salter), shortening and derotation osteotomy of the femur were performed. Only a slight improvement was registered in the first patient, no change was registered in the second patient and a successful result was achieved in the third patient (Table 1).

Table 1 Data on the patients

Case no.	Sex	Type Of Cerebral palsy[a]	Walking ability		Age at operation (years)	Treatment before operation[b]	Type of hip operation[c]	Severin grading[d]	Migration percentage (%)				Ponsetti classification[d]	Follow-up (years)
			Walk before operation	Walk after operation					Before operation		After operation			
									Right	Left	Right	Left		
1	M	SD	+	+	16	BR,C	CO-R	2A	44		0		R4	3
2	F	SQ	+	+	12	OP	CO-R,L	R-6,L-3	40	38	0	0	R-6,L-5	10
3	M	SD	−	−	4	BR	H,PA, DSVO-R	2A	100		0			23
4	M	SP	−	−	2	BR	H,PA, DSVO-R,L	R-2A, L-2A	100	100	5	0		16
5	F	SQ	−	+	6	BR,C	H,PA, DSVO-L	4A		100		0	L5	28
6	F	SD	+	+	6	BR,C	H,PA, DSVO-L	3		100		37.5	L4	4
7	F	SD	+	+	2	BR	H,PA, DSVO-L	4B		100		61	L4	7
8	F	SD	−	+	7	BR	H,PA, DSVO-R	2B	70		25		R4	11
9	F	SP	+	+	14	BR,C	LA,VO-L	2A		51		0	L6	17
10	F	A	+	+	3	BR	H,PA, DSVO-R,L	R-3,L-3	100	100	53	35	R-4,L-4	20
11	M	SP	+	+	4	NT	H,PA, DSVO-R,L	R-1A, L-1A	100	100	9	24	R-2,L-2	18
12	F	SQ	−	−	3	BR	SA-R	2A	27.2		0			3
13	F	SP	+	+	7	C	SA-R	2A	47.6		13,6		R3	3
14	M	SQ	−	−	5	BR	H,SA, DSO-L	2B		100		0		10
15	F	SP	−	+	7	NT	H,SA, DSO-R,L	R-2A, L-2A	100	100	13	0	R-4,L-4	3
16	M	SH	+	+	5	NT	H,SA, DSO-R	6	100		100		R6	5
17	F	SD	−	+	4	BR	SA, DSO-R,L	R-2B, L-2A	50	62	31	15	R-4,L-4	6
18	F	SP	+	+	5	BR	SA, DSO-R,L	R-2A, L-1A	37.5	37.5	0	0	R-3,L-3	3
19	M	SD	−	+	3	BR,C	SA,DSO-R	2A	67		9		R4	4
20	F	SP	+	+	3	NT	H,SA, DSO-R,L	R-2B, L-2B	100	100	0	0	R-4,L-4	18
21	F	SP	+	+	3	NT	H,SA, DSO-R	1A	90		0		R1	6

22	F	SP	+	+	3	NT	H,SA, DSO-R,L	R-2A, L-2A	100	100	26	27	R-4,L-4	11
23	F	SP	+	+	3	BR,C	H,SA, DSO-R,L	R-2A, L-2A	40	100	6,5	0	R-4,L-5	19
24	M	SD	+	+	2	OP	H,SA, DSO-R	4B	20		48		R4	14
25	F	SD	−	−	7	NT	H,SA, DSO-R,L	R-3,L-2A	100	100	34	0		3
26	F	SP	+	+	5	BR	H,SA, DSO-R,L	R-2A, L-2A	100	100	33	26	R-2,L-2	9
27	F	SP	+	+	11	BR	CO-R; SA,DSO-L	R-2A, L-2A	37,5	45	0	20	R-3,L-2	6
28	F	SH	+	+	3	BR	SA,DSO-R	2A	40		31		R4	9
29	F	SP	−	+	3	OP	H,SA, DSO-R	1A	100		0		R2	3
30	F	SP	+	+	5	C	H,SA, DSO-L	1A		100		0	L2	3
31	F	SQ	+	+	3	NT	H,SA, DSO-R,L	R-1A, L-1A	100	100	0	0	R-2,L-2	4

[a] A, Athetosis; SD, spastic diplegia; SH, spastic hemiplegia; SP, spastic paraplegia; SQ, spastic quadriplegia
[b] BR, Brace; C, cast; OP, operation; NT, no treatment
[c] CO, Chiari osteotomy; DSO, derotation and shortening osteotomy; DSVO, derotation, shortening and varization osteotomy; H, Howorth; L, left; PA, Pemberton acetabuloplasty; R, right; SA, Salter acetabuloplasty; LA, Lance acetabuloplasty
[d] L, left; ; R, right

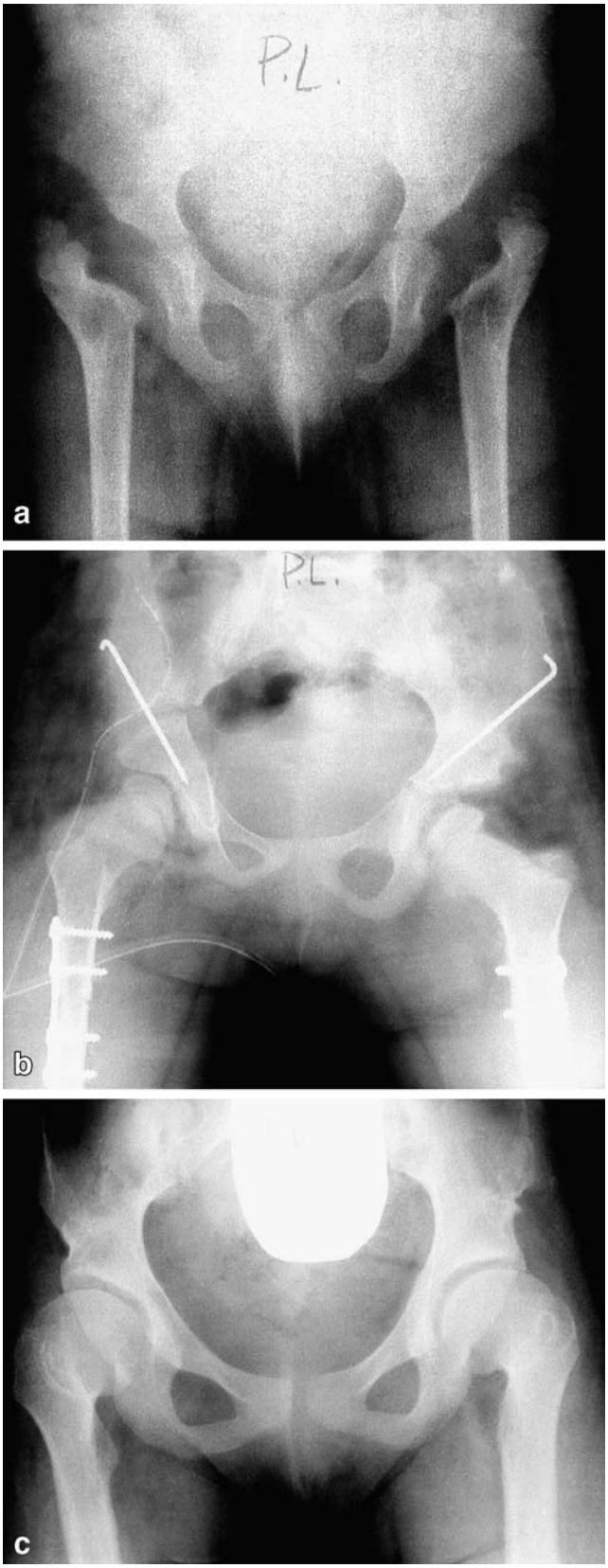

Fig. 1 **a** Congenital dislocation (DDH) of both hips in a CP patient (spastic paraplegia) preoperatively; patient was able to walk independently prior to the operation. **b** Both hips after surgery on a 5-year-old patient of group 2: open reduction (Howorth), acetabuloplasty (Salter) and shortening and derotation osteotomy of the femur. **c** Nine years after surgery of both hips. Result according to Severin grading is 2A bilaterally; result according to Ponsetti assessment is 2 bilaterally

Complications

Complications developed in seven patients (nos. 2, 5, 15, 16, 20, 22 and 24). Two patients (nos. 2 and 22) had a superficial wound infection which was successfully treated by dressings. Patient no. 15 had bilateral supracondylar fracture of the femur and subtrochanteric fracture on the operated side postoperatively, while patient no. 20 had supracondylar and subtrochanteric fracture of the femur on the operated side. These fractures occurred during the rehabilitation process. The subtrochanteric fractures were located just beneath the plate. Osteoporosis was judged to be the leading cause of these fractures. All fractures were successfully treated with a cast and had no influence on the final outcome.

Redislocation occurred in three patients (nos. 5, 16 and 24). Hip subluxation remained in patient no. 5, with the affected leg still 3 cm shorter; the patient had slight pains in the operated hip. Arthrodesis was carried out in patient no. 16 because of complaints of persisting pain. The hip was stabilised, and the patient no longer had pain; however, the leg on the affected side was still 10 cm shorter. The leg on the side of the dislocation remained 6 cm shorter in patient no. 24, who had minor pain. These discrepancies in leg length were compensated for by a support (no. 5) or special orthopaedic shoes with appropriate support (nos. 16 and 24). All three patients were able to walk. While the gait of patient nos. 5 and 24 consisted of a stagger accompanied by minor pain, patient no. 16 had no further pain and retained the ability to walk despite a significant discrepancy in length between the two legs, probably due to the hemiplegic form of CP.

Discussion

We were unable to establish the frequency of DDH in CP. Based on our retrospective investigation in which 31 patients were operated on in 32 years, the incidence rate of DDH in CP was one patient a year on average. There were predominantly more female patients, with females outnumbering males by 3:1. DDH on the right side was more common.

The average time to make the diagnosis of DDH was around 15 months, which is rather long. Those patients who

had had an early diagnosis were treated with braces or a cast before 1 year of age. The results of these earlier treatments were not satisfying, which ultimately led all of these patients to further surgery.

Although the level of dislocation, ability to walk or age were not strictly uniform for all patients, there was a general policy to applying the procedures under study. Open reduction of the hip with acetabuloplasty and femoral osteotomy were performed in all cases of dislocation and subluxation. Acetabuloplasy, femoral osteotomy or only pelvic osteotomy (Chiari) were performed in cases of dysplasia of the acetabulum or slight subluxation. Mostly ambulatory patients and patients that were estimated to have a good potential to walk were operated on. Open reduction of the hip (Howorth), acetabuloplasty and femoral osteotomy were performed in patients between 2 and 7 years of age, while Chiari osteotomy was performed in patients over 11 years of age. A literature search revealed clinicians who applied the same procedures in PDH in CP based on similar indications [14].

We analysed the results according to the Severin and Ponsetti grading/classification systems, which is accepted methodology for the surgical procedures applied in treatment of DDH [12, 25]. We also included an MP evaluation in the analysis, which is the usual method to handling data on PDH in CP [1, 11, 14]. The results were mostly good. Redislocation occurred only in three patients (9.7%) – i.e. three hips (6.6%). While radiographic results show better outcomes than the clinical results, there was not a single patient whose gait pattern worsened (Table 1). Twenty patients were able to walk preoperatively, two of whom required single-hand support (nos. 30 and 31) even after surgical treatment of the DDH. A total of 26 patients were able to walk independently after the operation. Of six patients who became independent ambulators following surgical treatment of the DDH, one patient needed single-hand support (no. 15), while the five other patients walked without any support (nos. 5, 8, 17, 19, 29). All six patients who gained the ability to walk were between 3 and 7 years of age at the time of the operation. It is possible that their motor development and maturation contributed to their becoming independent ambulators. Hip reduction and better pelvic balance might have also contributed. These assumptions should be investigated in future research.

Not a single patient had any hip pain preoperatively. Following the operation slight pain was reported by five patients (16.2%) in five hips (11.1%) (nos. 2, 5, 9, 16 and 23). Based on the Severin grading system, the result in three hips was 3 and more (nos. 2, 5, 16), while the result in two hips was 2 (nos. 9, and 23) (Table 1).

The analysis according to Severin and Ponsetti showed that the second procedure (Howorth, Salter, shortening and derotation osteotomy) gave better results (Fig. 1a–c). The analysis of MP values, however, showed both procedures to be equally successful.

Revisions after unsuccessful surgical treatment in other hospitals were performed in three patients (four hips). One revision gave good result, the second provided only slight improvement and the third was unsuccessful (Table 1).

The results of the analysis reported here show that acetabuloplasty, pelvic osteotomy and femoral osteotomy with or without open reduction of the hip, all procedures currently applied in children not affected by CP, can be recommended in patients with CP. This complex reconstructive surgery, in our opinion, is not indicated in patients not able to walk or not having a good potential to walk.

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