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ORIGINAL STUDY

One-stage treatment of developmental dysplasia of the hip in untreated children from two to five years old A comparative study

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A total of 38 children (49 hips) were retrospectively investigated to assess the efficacy and safety of one-stage treatment of developmental dysplasia of the hip (DDH) in untreated children from two to five years of age. Our method consisted of open reduction, Salter innominate osteotomy, femoral shortening and derotation osteotomy. The patients were distributed into two groups according to the age at which they were operated : Group I included 19 patients aged < 3 years (24 hips) and Group II included 19 patients aged ≥ 3 years (25 hips). Mean follow-up was 5.08 years for Group I and 5.76 years for group II. Clinical and radiological assessment at final follow-up showed that the outcome was not significantly different between the two groups. Furthermore, after this follow-up period, the rates of avascular necrosis were similar. Children with DDH between two and five years of age were treated successfully with one-stage treatment.

Keywords : developmental dislocation of the hip ; one-stage surgical treatment ; older children.

INTRODUCTION

The primary goal of correction of developmental dysplasia of the hip (DDH) is the concentric reduction of the hip. The principles of the treatment of DDH for a child over two years are different from those for a newborn (*2,10,14,20*). No consensus exists regarding the best management after walking age for DDH (*9,20,22*). This condition can result in soft-tissue contractures of the muscles, tendons and capsule around the hip, which prevent reduction and can put pressure on the developing femoral head during or after reduction, leading to ischemia (*9,11, 22,26*). Closed or open reduction without osseous realignment has been associated with residual dysplasia (*17,20*). Femoral shortening has been shown to facilitate reduction and does not appear to increase the prevalence of avascular necrosis (AVN) of the femoral head (*8,19,22,25*). Many authors have recommended a one-stage procedure for hip reconstruction consisting of open reduction, femoral shortening with or without varus derotational osteotomy

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and pelvic osteotomy in children older than three years of age (*4,6,12,13,19,20,22,26,27*). However, there is limited information available on the comparison of one-stage treatment before and after the age of three years.

Despite neonatal screening and early treatment of DDH in newborns and infants, it is not rare to see an older child with untreated or neglected DDH (*6,26*). Due to economical and educational disparities, we often see these types of cases in the Southeastern region of our country.

In this study we present our functional and radiographic findings in children aged from two to five years with previously untreated DDH. The aim of this study was to compare the results of a one-stage operative procedure in patients with DDH before the age of 3 years versus after that age.

MATERIAL AND METHODS

Written informed consent was obtained from all parents, and approval to use their medical records and re-evaluate each patient was given by the Local Research Ethics Committee. We retrospectively reviewed the medical records of 54 consecutive patients (age range : 2 to 5 years) with DDH who were treated between 1998 and 2008 by a single-stage combined procedure by the same surgeon (RY). We excluded 15 patients who had an associated muscular or teratologic dislocation (n = 2) or previously treated DDH (n = 9) or who did not have follow-up (n = 4). Thus, we evaluated 38 previously untreated consecutive patients (49 hips). The operative treatment consisted of open reduction, Salter innominate osteotomy (SIO), femoral shortening, and derotation osteotomy. A minimum postoperative follow-up period of two years was required for inclusion in this study.

The patients were distributed into two groups according to the age at which they were operated : Group I included 19 patients aged < 3 years of age (24 hips) and Group II 19 patients aged ≥ 3 years of age (25 hips).

The average age was 2.6 years at the time of surgery : 2.15 ± 0.17 years (range 2.0 to 2.6) in Group I, and 3.39 ± 0.48 years (range 3.0 to 4.8) in Group II. There were 35 girls (44 hips) and 3 boys (5 hips). Twenty three patients had a dislocation of the left hip, 26 of the right hip, and 11 had bilateral dislocation. Preoperative traction was not attempted. We evaluated the initial radiographs using the method of Tönnis (*28*). In Group I there were 8 Tönnis type III and 16 Tönnis type IV hips ; in Group II there were 8 Tönnis type III and 17 Tönnis type IV hips.

The follow-up ranged from two to 10 years. The mean follow-up period was 5.08 years (range 2-10 years) for Group I and 5.76 years (range 3-10 years) for Group II.

Surgical technique

The operation started with percutaneous adductor tenotomy. The surgical approach combined two incisions : a Smith-Petersen approach to expose the innominate bone, and a lateral incision for the subtrochanteric derotational shortening osteotomy procedure (*15*). SIO was performed precisely as described by Salter in his first report (*21*). The capsule was opened and the socket defined and cleaned. The transverse ligament and inferior capsule were divided and the ligamentum teres was excised. The amount of correction of the derotation or femoral shortening was decided intraoperatively under direct visualization. Femoral shortening ranging between 1 to 2 cm in length was performed in all hips. Excess anteversion (more than 40°) of the proximal femoral segment was found in many cases, and derotation of the proximal segment of the femoral osteotomy was performed in all hips. However, varus position was not added to decrease the neck shaft angle. The osteotomy was fixed with a small dynamic compression plate. None of the femoral heads were fixed to the acetabulum by a Kirshner wire for maintenance of reduction. Capsule excision and capsulography were performed after reduction. A spica cast was worn for six weeks, followed by full time abduction bracing for six weeks and night-time only bracing for an additional six weeks. Patients were encouraged to move in an abduction brace. In bilateral cases, in order to reduce the stiffness on the operated side and to prevent the graft and bone collapsing at the osteotomy site related to immobilization osteoporosis, operation of the other hip was delayed four or six weeks after removal of the splint and the patient was rehabilitated during this time interval.

A conventional anterior-posterior (AP) pelvic radiograph was taken immediately after surgery and at six weeks and an AP and frog leg lateral, at three, six and 12 months. Final clinical and radiological evaluations were performed using the medical records and radiographs prepared or taken at the time of the most recent follow-up visit (Figs. 1, 2). Evaluations and measurements were performed by the orthopedic surgeon (MAA) who was not involved in the care of the patients. The same surgeon also assessed the radiographs at diagnosis, immediately postoperatively and at the most recent

Fig. 1a. — Preoperative radiograph of a 3-year-old child with developmental dysplasia of the left hip.

Fig. 1b. — Six months after one-stage combined surgery

follow-up. All patients were followed up clinically and radiologically in accordance with the modified McKay criteria (16) and Severin classification (23) (Table I and II). Excellent and good results were considered as satisfactory, fair and poor as unsatisfactory. Sharp's acetabular index (AI) angle (24) and Wiberg's center-edge (CE) angle (30) were measured. The grade of AVN of the femoral head was evaluated according to the system of Kalamchi and Mac Ewen (11) : Grade I, changes affecting the ossific nucleus ; Grade II , lateral physeal damage ; Grade III , central physeal damage and Grade IV, total

Fig. 1c. — Three years after operation, good clinical result

damage to the femoral head and physis. We measured the limb length clinically from the anterosuperior iliac spine to the medial malleolus.

A modified scoring system of Trevor *et al* (29) was used for clinical and radiological evaluation of the results. According to this evaluation scheme the total score is 20 and the 18-20 range is accepted as excellent, 15-17 as good, 12-14 as moderate, and below 12 as poor (Table III).

Statistical analysis

All statistical analyses were conducted using the SPSS 11.5 computer program. The Mann-Whitney U test was used to determine differences in the parametric values (preoperative AI and last follow-up AI, the CE angle and the scoring system of Trevor) between the groups. The chi-square (χ^2) test was used to evaluate the nonparametric values, such as the preoperative Tönnis grade, and the follow-up Severin and McKay criteria. P values < 0.05 were considered significant.

RESULTS

None of the patients had any intraoperative or immediate postoperative complications such as infection or graft displacement.

Excellent clinical results were obtained in 37 hips (75.6%), good results in eight hips (16.3%), fair results in three hips (6.1%), and poor result in

Fig. 2a. — Preoperative radiograph of a 2-year-old child with bilateral developmental dislocation of the hip.

Fig. 2b. — One-stage combined surgery on the right side and on the contralateral side 3 months later.

Fig. 2c. — The 7-year postoperative radiograph

Fig. 2d. — Nine years after operation. Note type II avascular necrosis of the left hip.

Table I. — Modified McKay criteria

Grade	Criteria
Excellent	Stable, painless hip, no limp, negative Trendelenburg sign, and a full range of movement
Good	Stable, painless hip, slight limp, negative Trendelenburg sign, and a slight decrease in range of movement
Fair	Stable, painless hip, limp, positive Trendelenburg sign, and limitation of movement
Poor	Unstable or painful hip, or both ; positive Trendelenburg sign

Table II. — Severin's table

Grade		Criteria
Excellent	IA	CE angle > 19°, age 6-13 years ; CE angle > 25°, age > 14 years
Good	IB	CE angle 15-19°, age 6-13 years ; CE angle 20-25°, age > 14 years
	II	Moderate deformity of femoral head, femoral neck, or acetabulum, but otherwise the same as grade IA or IB
Fair	III	Dysplastic hip, no subluxation ; CE angle < 15°, age 6-13 years ; CE angle < 20°, age > 14 years
Poor	IV	Subluxation
	V	Femoral head in false acetabulum
	VI	Redislocation

Table III. — Method of assessment using the modified scoring system of Trevor *et al* (29)

Symptoms and signs	Severity		Points
Pain	None		3
	Occasional		2
	Persistent		1
Movement	Full		5
	Slight limitation but no fixed deformity		4
	More than half the normal range		3
	Less than half the normal range		2
	Little		1
Limp	Absent		1
	Present		0
Function as described by the patient and assesed in the follow-up clinic	Full		3
	Slightly limited		2
	Severely limited		1
Radiological feature	Age < 14 years	Age ≥ 14 years	
The CE of Wiberg	≥ 20°	≥ 25°	4
	15°-19°	20°-24°	3
	10°-14°	15°-19°	2
	< 10°	< 15°	1
Appearance of the femoral head	Normal		3
	Partial coxa plana or coxa magna		2
	Complete coxa plana or other severe deformity		1
Shenton's line	Intact		1
	Broken		0

one hip (2.0%). Radiological results were excellent in 33 hips (67.4%), good in eight hips (16.3%), fair in seven hips (14.3%), and poor in one hip (2.0%). We found satisfactory results, clinically in 45 hips (85%) and radiographically in 41 (75%) (Table IV).

In Group I, clinical results were excellent in 16 hips (66.6%), good in five hips (20.8%), fair in two hips (8.3%), and poor in one hip (4.1%). In Group II, 21 hips (84%) were rated excellent, three hips (12%) good, and in one hip fair (4%). Twenty-one hips (87.5%) in Group I and 24 hips (96%) in Group II yielded satisfactory results, whereas three hips (12.5%) in Group I and one hip (4%) in Group II yielded unsatisfactory results. However, there was no significant difference between the two groups according to McKay's clinical criteria at final follow-up ($p > 0,05$).

Table IV. — Results of Group I and Group II

	Clinical	Radiological
Group 1		
Excellent	16 (66.6%)	14 (58.4%)
Good	5 (20.8%)	4 (16.6%)
Fair	2 (8.3%)	5 (20.8%)
Poor	1 (4.1%)	1 (4.1%)
Satisfactory	21 (87.5%)	18 (75%)
Unsatisfactory	3 (12.5%)	6 (25%)
Group 2		
Excellent	21 (84%)	19 (76%)
Good	3 (12%)	4 (16%)
Fair	1 (4%)	2 (8%)
Poor	0 (0.0%)	0 (0.0%)
Satisfactory	24 (96%)	23 (92%)
Unsatisfactory	1 (4%)	2 (8%)

Radiological findings in Group I were excellent in 14 hips (58.4%), good in four hips (16.6%), fair in five hips (20.9%) and poor in one hip (4.1%). Nineteen hips (76%) were rated excellent, four hips (16%) good and two hips (8%) fair in Group II. Eighteen hips (75%) in Group I and 23 hips (92%) in Group II yielded satisfactory results, whereas six hips (25%) in Group I and two hips (8%) in Group II yielded unsatisfactory results. However, there was no significant difference between the two groups according to Severin's radiographic criteria at final follow-up ($p > 0.05$).

In Group I, the preoperative mean AI measured 36° (18°-47°), the early postoperative mean AI 23° (15°-30°), or an average improvement of 13°. In Group II, the preoperative mean AI measured 35.3° (22°-47°), the early postoperative mean AI 22° (16°-28°), or an average improvement of 13.3°. In the final radiological examinations in Group I, the mean AI measured 18° (10°-30°), or a total improvement of 18°. In Group II final AI measured 15.9° (10°-25°), or an improvement of 19.4°. In the final radiological examinations Wiberg's mean CE angle measured 28.1° (0°-40°) in Group I, and 29° (18°-40°) in Group II. In all patients, the AI and CE angle improved at the latest follow-up. There were no statistical differences between the two groups regarding the preoperative, early postoperative, last follow-up AI angle and last follow-up CE angle ($p > 0.05$). At the last follow-up, only two of the patients had a leg length discrepancy of more than 1.5 cm (Case 13 and 14).

According to the Kalamchi and MacEwen criteria, AVN was observed in 16 hips (32.6%). In group I, AVN was observed in nine hips (37.5%) : five of them had grade I, three grade II, and one grade III AVN. In Group II, AVN was observed in seven hips (28%) : three of them had grade I and four grade II AVN. No patient with AVN had subsequent surgery.

Finally, according to the evaluation scheme of Trevor *et al*, in Group I, the mean score was less than in Group II (16.0 and 17.2 respectively). In Group I, eleven hips (45.8%) were rated excellent, seven hips (29.1%) good, five hips (20.8%) fair, and one hip (4.1%) poor. In Group II, thirteen hips (52%) were rated excellent, eleven hips (44%) good, and one hip (4.1%) fair. However, there was no significant difference between the two groups according to the evaluation scheme of Trevor *et al* at final follow-up ($p > 0.05$).

One hip redislocated and was classified as a poor clinical result.

DISCUSSION

The goals of operative treatment in ambulatory age with DDH are to correct hip dysplasia without complications such as avascular necrosis and

recurrent subluxation or dislocation (*6,9,19*). Olney *et al* (*19*) reported that a one-stage procedure was too agressive, but was considered to be less traumatic for the hip compared to closed reduction and prolonged immobilization. Therefore, several authors suggested a one-stage procedure consisting of open reduction, pelvic osteotomy and femoral osteotomy (*4,6,8,12,13,19,20,25-27*), particularly in children older than three years of age (*4,7,20,22*). Furthermore, several studies describe the treatment of DDH with a one-stage operation in children over two years of age (*2,3,5,8,18*). In this study we treated with a one-stage operative procedure previously untreated DDH in children from two to five years old. Berkeley *et al* (*2*) reported a series of 51 dislocated hips in patients between 12 and 36 months. They performed a derotational femoral osteotomy in 85% of the hips and a femoral shortening osteotomy in only two hips. They found excellent radiographic results in 57% and good results in 35%. Galpin *et al* (*8*) reported a series of 33 dislocated hips in patients older than two years of age who were treated with a one-stage open reduction, femoral shortening, and pelvic osteotomy. They found satisfactory results clinically in 85% of hips and radiographically in 75%. Nakamura *et al* (*18*) reported long term results after one-stage treatment in children with an average age of 2 years and 1 month. They found satisfactory results clinically in 73% and radiographically in 45%. El-Sayed (*5*) reported on 55 children (71 hips) with neglected DDH who had a one-stage combined operation between the ages of 2 and 4. They found satisfactory results clinically in 87% and radiographically in 83%. Our results also support their findings.

Avascular necrosis of the femoral head is still a serious complication in treatment of DDH (*3,5-7,12,18,26*). Femoral head AVN does not occur in untreated hips. Therefore, there is no doubt that it is an iatrogenic complication (*1*). Particularly in a higher grade of dislocation combined with an inverted limbus, hypertrophic soft tissue in the acetabulum and older age of the patient at treatment onset, AVN of the femoral head is more prone to occur (*6,11,25,27*). Some studies show that femoral shortening can facilitate reduction and reduce the risk of AVN (*8,19,22,25*).

Galpin *et al* (*8*) reported a rate of AVN of 9.0%. El-Sayed (*5*) reported 4.2%, whereas Nakamura *et al* (*18*) reported a rate of AVN as high as 54.5% in long term results. Our AVN results are similar to Nakamura *et al* (*18*). We found 16 hips (32.6%) with AVN, but this included one single case of grade III AVN.

Redislocation is another severe complication (*6,9*). Galpin *et al* (*8*) reported four cases (12.1%), while El-Sayed (*5*) did not report any case. Only one redislocation (2.0%) was encountered in our series.

This study was retrospective and patients were not randomised. Prospective randomised controlled trials with larger sample sizes are needed to support our findings.

In summary, after analyzing retrospectively two small groups of patients treated with a one-stage procedure before and after the age of three years, in a uniform age group of children between 2 and 5 years of age, we found no difference between the two groups. We think that single-stage surgery has advantages that include reducing the risk of severe AVN of the femoral head while correcting associated femoral and acetabular deformities. Therefore, we believe that a one-stage operation without preoperative traction is convenient and effective in children older than two years of age.

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