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Combined closed reduction by soft tissue release, Varus Derotation Shortening Femoral Osteotomy and/or Modified Dega acetabuloplasty in Spastic dysplastic hip in Cerebral palsy children

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ABSTRACT

Background: Evaluation of radiographic and clinical results of combined soft tissue release, varus derotation shortening (VDS) femoral osteotomy and modified Dega acetabuloplasty without an open reduction of the hip in treating paralytic dysplastic hip (PDH) in spastic cerebral palsy (CP). This approach aimed to treating (PDH) in CP patients is still open to a debate that revolves around the question "Whether the surgical treatment should be the same as in cases not suffering from Spastic CP?". Patients and methods Thirty five children with (50 hips) in spastic cerebral palsy were included. The mean follow-up was 4 years. Clinical results were analyzed using the Gross Motor Functional Classification System (GMFCS) in spastic CP patients. Radiographic assessment and measurements of migration percentage (MP) was done before and after surgery. Results: The rate of hip displacement was reduced in the treatment group by (0.5%) per year (95% confidence interval,−0.5% to 6%; p=0.16) when weighted for the uncertainty in rates as the differing numbers of (MP) measurements per subject. Postoperative radiographic results according to Severin placed 35 hips (70%) in grade 1 and 2 and 15 hips (30%) in grade 3 and 4. The average center-edge angle was 35°, the average acetabular index was 10°, and the average migration index was 15% for the hips in the <5 years children, and the values at the final evaluation were 40°, 10°, and 15% for the hips in > 5 years children. Conclusions: Significant correlation between improvement in GMFCS level results according to age before 5 years at the time of the procedure that the younger the age of the patient at time of the treatment, the significant clinical improvement. The clinical results were excellent in each group, and the radiographic parameters of the acetabular configuration were comparable at the final evaluation.

Keywords: Dega acetabuloplasty; Cerebral palsy, Spastic dysplastic hip

INTRODUCTION

Paralytic dysplastic hip (PDH) develops gradually, most often between the ages of 3 and 8 years and reports of the earliest development of PDH in CP patients as young as 6 months and the latest at 18 years **(1, 2)**. Acetabular dysplasia can develop in PDH when the process of femoral head migration is a long one and results in subluxation and dislocation. Acetabular dysplasia develops as early as 2.5 years of age **(3)**. A defect of the femoral head in its superior lateral quadrant is a characteristic of a certain number of cases with CP and PDH, especially those who suffer from pains on the side of the defect **(4, 5)**.

Cerebral palsy is a non-progressive damage to the brain and can occurs before, during or after delivery, with musculoskeletal system affected by various degrees. Hip subluxation and dislocation develops in response to muscle imbalance and spasticity **(6)**. The patient's problems vary from abnormal gait to painful seating and difficulty in personal hygiene. Prognosis grade of hip subluxation is correlated with (GMFCS) level minimal in level I and up to 90% in level V and natural history studies have shown that hips will dislocate in the absence of treatment if Reimers

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Migration index (MI) >60-70% **(7)**. The risk thought to be highest at 2-3 years of age. Hip displacement mainly occurs due to spasticity and contracture of the hip adductors and flexors and the medial hamstrings. The resulting muscle imbalance leads abnormal hip positioning in adduction, flexion and internal rotation. The decreased medial pressure allows the triradiate cartilage to grow wider, which results in the widening appearance of the tear drop on radiographs **(8)**.

Unequal distribution of the forces along the upper femoral epiphysis results in a valgus femoral neck shaft angle. Deformity of the femoral head occurs as a result of pressure from the capsule, the rim of the acetabulum, the abductors, and the ligamentum teres. Subluxation with strong tone in hip adductor and flexors lead to scissoring and predisposes to hip subluxation and dislocation. Dislocation is commonly posterior and superior (>95%). Degeneration with time, dysplastic and erosive changes in the cartilage of the femoral head can develop and lead to pain **(9)**. During physical examination - unreliable diagnostic assessment if used alone- decreased hip ROM, pain with hip motion and gait difficulty due to lever arm dysfunction were usually found. The acetabular index will be increased because of acetabular dysplasia. Coxa valga and increased femoral anteversion are demonstrated by increased neck shaft angle **(10).** AP and frog lateral hip abduction of <45° with partial uncovering of the femoral head on radiographs represents an at risk hip. (MP) index is the percent of femoral head with no acetabular coverage most accurate method to identify and monitor hip stability < 33% = at risk , >33% = subluxated hip. The radiological classification is a six-point ordinal scale based on MP, integrity of Shenton's arch, femoral head deformity, acetabulum deformity, and pelvic obliquity **(11,12)**.

In the treatment of a spastic hip a variety of soft tissue procedures including partial or total tenotomy of the adductors and iliopsoas are the most common soft tissue procedures in the treatment of hip contractures **(13)**. The goal is to achieve the optimum muscular balance. Anterior branch obturator neurectomy is performed if children have > 60% migration and are not expected to have ambulatory ability in the future **(14).** Therefore, the aim of the present study is to treat PDH in CP patients is still open to a debate that revolves around the question "Whether the surgical treatment should be the same as in cases not suffering from Spastic CP?.

PATIENTS AND METHODS

This study was conducted in orthopedic department of Zagazig University Hospitals. A random sample of patients with developmental dysplasia of the hip was recruited from the outpatient clinic of Zagazig University hospitals.

Prior to commencing the study, ethical clearance was sought from the Zagazig University hospitals and informed consents were obtained from guardians of all patients before participation in the study.

Inclusion criteria:

Thirty patients of developmental dysplasia of the hip were collected from the orthopaedic outpatient clinic of Zagazig university hospitals. Eligibility criteria required individuals who had developmental acetabular dysplasia (acetabular index >35°) with or without hip subluxation or frank dislocation between 1 and 8 years old with spherical femoral head.

Exclusion criteria:

Patients who had a neuromuscular disease, a connective tissue disorder, or an infection of the hip were excluded.

A treatment protocol was designed for the management of these cases in form of open reduction, capsulorrhaphy accompanied with Dega osteotomy with or without femoral osteotomy. All the patients were followed up clinically and radiologically with the modified McKay criteria and Severin classification respectively.

Surgical technique:

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The surgical technique involved the use of a radiolucent table and intraoperative fluoroscopy. All patients were operated under general anesthesia. The patients were positioned supine. All patients were examined for adductor tightness by palpating the adductors while doing abduction with hip flexion.

Adductor tenotomy was done in twenty four cases. In the other six hips adductor tenotomy was performed before the time of presentation and no adductor tightness was palpated.

Open reduction was performed in all cases except six cases in which open reduction was performed before the time of presentation and they needed only Dega osteotomy with or without femoral osteotomy.Modified anterolateral Smith-Peterson approach with Bikini incision was the surgical approach used for all cases needed open reduction.

A Bikini oblique incision was done for all cases needed open reduction. Superficial plane between the tensor fascia lata and the Sartorius muscle was identified. With periosteal elevator, the iliac crest was exposed subperiosteally. The periosteum was kept intact on both medial and lateral sides. Next step was the identification of the femoral nerve passing over the iliopsoas muscle. The iliopsoas muscle is attached to the underlying capsule by iliocapsularis muscle which was detached to separate the iliopsoas from the capsule **(Figure 1)**.

T-shaped capsulotomy was made by two capsular incisions (transverse and vertical incisions).Transverse incision was done parallel to the acetabular margin, leaving a 5-mm margin of the capsule. Then the head was exposed with the ligamentum teres. Usually we found the ligamentum teres hypertrophied, stretched and it was an obstacle for reduction. Cleaning and debridement of the acetabular floor using a nibbler in order to expose the articular cartilage. Closure of the femoral wound was done in layers begin with the vastus lateralis sheath then the iliotibial band then the subcutaneous tissues and finally skin layer.

We used a straight ½-inch osteotome to make the bone cut, which extended obliquely medially and inferiorly, paralleling the guidewire to exit through the inner cortex just above the triradiate cartilage. The osteotomy site was kept open by inserting two correctly sized bone grafts. The graft was fashioned from a tricortical segment of iliac crest bone in all cases except five cases in which femoral shortening had been done, we used the segment of the femur that was removed. In all our cases the graft was stable by elastic recoil of the acetabulum, and there was no need for internal fixation. Hip spica was applied for all patients. A spica cast was applied from the nipple line to the toes on both sides. **(Figure 2)**.

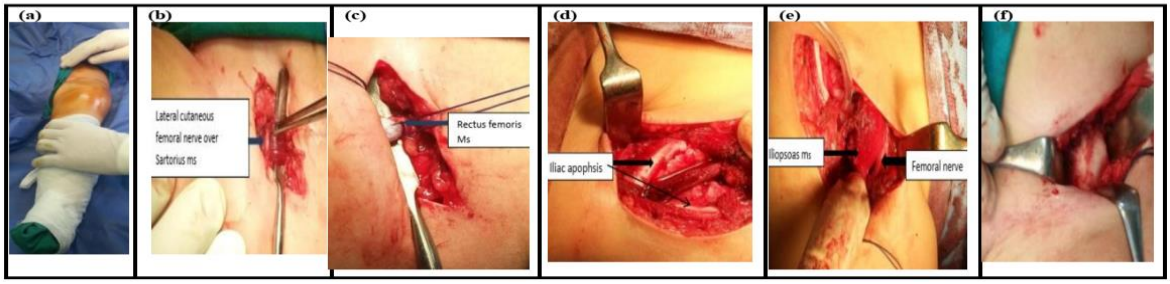

Figure (1): Surgical technique steps: (a) draping of the limb before surgery; (b) lateral cutaneous nerve of the thigh overlying the Sartorius muscle; (c) tagged rectus femoris muscle; (d) iliac apophysis split down to the iliac bone ; (e) femoral nerve overlying the iliopsoas muscle ; (f) capsule is well exposed medially and laterally.

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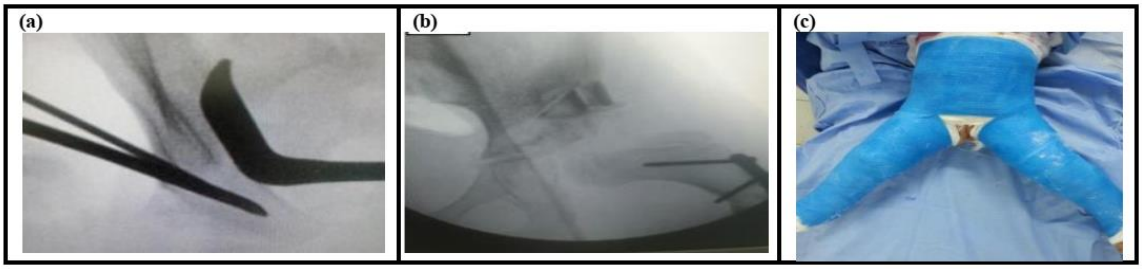

Figure (2): (a) showing direction of the osteotomy parallel to the k-wire; (b) showing Two fashioned bone graft are positioned inside the osteotomy site; (c) showing Postoperative hip spica for DDH

Follow-up:

Radiological follow up was done in the following manner (the same was done in all patients). Plain X ray pelvis showing both hip joints AP view was done immediate postoperative period, after cast removal (3 months postoperatively), at 6 months post-operative and at the final follow up (1year post-operative). CT with 3D reconstruction was done within one week after surgery for hip reduction confirmation and assessment of the pelvic osteotomy. CT with 3D reconstruction was done at the final follow up for evaluation of correction of acetabular dysplasia.

Statistical analysis:

Data collected throughout history, basic clinical examination, and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance; Differences between frequencies (qualitative variables) and percentages in groups were compared by Chi-square test. Differences between parametric quantitative independent groups by t test in paired by paired t. P value was set at <0.05 for significant results &<0.001 for high significant result.

RESULTS

The current study included 35 patients (50 operated hips), the age at time of presentation ranged from 18 months to 60 months**.** Twenty six patients (86.7%) were girls and four (13.3%) were boys **(Table 1).** There were five bilateral DDH cases and 25 unilateral cases. As regards the unilateral cases; 13cases were Lt sided DDH and 12cases were Rt sided DDH **(Table 2).** Only seven cases (seven hips) have previous history of open reduction and adductor tenotomy at time of presentation **(Table 3).** According to Tonnis grading; 4 hips were Tonnis grade I, 3 hips were Tonnis GII, 15 hips were Tonnis grade III and 13 hips were Tonnis grade IV **(Table 4).**

Mean preoperative acetabular index was 43.22 degrees and the mean acetabular index value at the final follow up was 21.88 degree **(Table 5)**. As regards the difference between the mean final follow-up AI (21.88) and the mean AI of the unaffected side (20.760), there was no significant statistical difference between them denoting near normal AI in treated cases with Dega osteotomy **(Table 6)**. Preoperatively CE angle was negative in 31 hips, post-operatively CE angle of all cases became positive with a mean of 28.48o. At the final follow up CE angle ranged from 18 to 40 with an average of 32.2 degrees **(Table 7)**.

According to Severin grading, at the final follow up twenty four hips were GIa & seven hips were GII and four hips were GIII **(Table 8)**. According to modified McKay's criteria, at the final follow up 19 hips were rated to be excellent & 12 hips were rated to be good & 4 hips were fair and non was poor **(Table 9)**.

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Regarding postoperative GMFCS (Level) according to age group, satisfactory clinical results was in GMFCS level 1, II as excellent in 22 patient and good in level III (3) patients so 25 patient were satisfactory (71.4%), 14 patients were below 5 age was and (11) patients were > 5 years, unsatisfactory results was in level GMFCS VI and V in 10 patients (28%), (3) patients were below 5 age was and (7) patients were > 5 years. More satisfactory clinical results below 5 age but it was statistically non significant (P = 0.155). There was a correlation between improvement in GFCS level results according to age at the time of the procedure that the younger the age of the patient the significant clinical improvement **(Table 10)**.

Satisfactory postoperative Severin grading was in 1, II as excellent in 24 patient was satisfactory (68%), satisfactory results (16) patients were below 5 age and 8 patients were > 5 years, unsatisfactory results was in Severin grading III, VI in 11 patients (31%), 1 patient was below 5 age and 10 patients were > 5 years). More satisfactory clinical results below 5 age but it was statistically non significant (P = 0.089). There was a correlation between radiological improvement and age group less than 5 years. No difference was found regarding the Postoperative course of average center-edge angle, acetabular index and migration index between cases operated before and after 5 years of age **(Table 11)**.

All of the osteotomy sites healed without complications. There was no evidence of premature closure of the triradiate cartilage on the radiographs. Femoral factures incidence occurred in 4 hips (8%) in distal femur following postoperative spica casting. Abduction contracture occurred with neurectomy of anterior branch of obturator nerve during adductor release occurred in 1 hip (2%). Concomitant femoral shortening was 3 hips (0.6%) in severe subluxations (MP >70%), but not in mild to moderate subluxations. The severely subluxated or dislocated hips in which femoral shortening was done associated with AVN occurred in 2 hips (4%), the cause of AVN in this group was the severity of preoperative dislocation **(Table 12)**.

Table (1): Sex distribution among the studied patients

Sex	No.	Percentage
Girls	26	86.7%
Boys	4	13.3%
Total	30	100%

Table (2): Distribution of affected side among the studied patients

Side	No.	Percentage
Left	13	43.3%
Right	12	40%
Bilateral	5	16.7%
Total	30	100%

Table (3): Previous management among the studied patients

Previous treatment	No. of the hips	percentage
Non	28	80%
AT+OR	7	20%
Femoral osteotomy	4	11.4%

Table (4): Distribution of degree of dislocation among the studied patients

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Tonnis grading	No.	Percentage
G I	4	11.4%
G II	3	8.6%
GIII	15	42.9%
G IV	13	37.1%
Total	35	100%

Table (5): Comparison between pre and final follow-up AI scores

Acetabular index	mean± SD	Average degrees of improvement	p value	Sig.
Preoperative	43.22±3.91	21.343	<0.001	HS
Final follow-up	21.88±3.6			

Table (6): Comparison between the final follow-up AI and the AI of the unaffected side

Acetabular index	mean± SD	P value	Sig.
Unaffected side AI	20.76 ±3.5	0.260	NS
Final follow-up AI.	21.88±3.6		

Table (7): Comparison between post and follow-up CE angle scores

Central edge angle	mean± SD	Average degrees of improvement	P value	Sig.
Post-operative	28.48	3.80	<0.001	Significant
Final followup	32.20			

Table (8): Severin grading of the included hips

Grade	No. of hips	Percentage
Ia	24	68.6%
II	7	20%
III	4	11.4%
IV	0	0%
Total	35	100%

Table (9): Modified McKay clinical grading of the included hips

The grade	No. of hips	Percentage
Excellent	19	54.3%
Good	12	34.3%
Fair	4	11.4%
Poor	0	0%
Total	35	100%

Table (10): Postoperative GMFCS (Level) according to age group

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GMFCS (Level)	Age less than 5 years	Age more than 5 years	Total Pt
1 and II	14	8	22
III		3	3
IV	1	3	4
V	2	4	6
Total	17	18	35

Table (11): Postoperative Severin grading according to age group:

GMFCS (Level)	Age less than 5 years	Age more than 5 years	Total Pt
1 and II	16	8	24
III and IV	1	10	11
Total	17	18	35

DISCUSSION

We retrospectively evaluated and followed up 35 patients (50 operated hips) 10 children were unilateral dysplastic hip and 10 children were bilateral. All patients were diagnosed with PDH in spastic CP based on ultra-sound, radiographic and clinical examinations. The mean age at diagnosis was 3 years (range: 2–6 years). 17 children were < 5 years age and 18 children were > 5 years ago. The aim of the current study is to provide a painless hip that allows stable sitting, positioning and easier personal hygiene, and in an ambulatory patient, treatment should allow walking without groin or hip pain.

The results of the following surgical procedures in our study were Closed reduction of the hip, soft tissue release (50 hip) modified Dega acetabuloplasty (35 hip) (anterolateral acetabular defect in 5 hip) (postrolateral acetabular defect in 27 hip) (posterior acetabular defect in 3), femoral osteotomy varus (90°-100°), shortening 2-3 cm and derotation osteotomy of the femur (in 50 hips). Two used operative procedures were compared by radiographic assessment. Group 1 patients (procedure 1) underwent closed reduction of the hip, soft tissue release, (modified Dega) acetabuloplasty and varus, shortening and derotation osteotomy of the femur (35hips), while group 2 patients (procedure 2) underwent closed reduction of the hip, soft tissue release and varus, shortening and derotation osteotomy of the femur (15 hip).

Femoral osteotomy is done at the intertrochanteric level closing wedge varus derotation shortening femoral osteotomy. The femur is fixed in a varus position with internal fixation. The aim is to achieve a neck-shaft angle of 90° to 100° **(15)**. Pelvic osteotomies can be divided into 2 major groups: reconstructive and salvage osteotomies. Reconstructive osteotomies can be divided into 2 subgroups: redirectional osteotomies which changes the orientation of the acetabulum (e.g., Salter, Periacetabular osteotomies) and reshaping osteotomies which will change the shape and size of the acetabulum (e.g., Pemberton, Dega osteotomies) **(16)**.

Dega reported on an incomplete transiliac osteotomy were the cut penetrated the outer table of the ilium, leaving a hinge posteriorly consisting of the intact posteromedial iliac cortex and sciatic notch. In modified Dega periacetabuler osteotomy, wedges of bone graft is inserted where the direction of the desired coverage is needed. The osteotomy utilises the sponginess of the triradiate cartilage to enclose the bony wedges, so fixation with pins is not usually necessary. A pre-requisite for the dega osteotomy is an open triradiate cartilage. A curved osteotomy through the ileum just proximal to the hip capsule, providing sufficient coverage and support for prevention of subluxation is done. As the hip is translated medially, the abductor muscle lever arm is reduced, decreasing the hip joint reactive forces **(17)**.

The modified Dega osteotomy stops several millimeters from the triradiate cartilage and hinged open laterally to correct the dysplasia and tricortical segment of the iliac wing is harvested

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for bone graft, and trapezoidal segments are fashioned to fit into the osteotomy site. Three trapezoidal segments of tricortical bone graft are impacted to hold the osteotomy site open. The elasticity of the intact medial cortex fixed the bone grafts in place; therefore fixation is not required and the segment of tricortical bone is arranged according to the site of acetabular defect **(18)**.

There was a significant functional outcome improvement for the combined intervention by combined closed reduction by soft tissue release, VDS femoral osteotomy and modified Dega acetabuloplasty in the management of spastic hip displacement in children with cerebral palsy. Soft tissue release is indicated if the migration index is greater than 25% to 30% in a child preferably less than 3 years. In case of severe subluxation or dislocation, proximal femoral osteotomy with pelvic osteotomy is usually indicated. Treatment decisions need to be based on careful, individualized clinical assessments and the nature of the acetabuler deficiency confirmed by using 3D CT or arthrographic methods. The modified Dega pericapsular osteotomy provides improved superolateral and posterior coverage and improves the long trough-like acetabulum in the more common superior or posterosuperior deficiency.

Shea et al. (14) illustrated a study with average age at the time of operation of **7** years and 9 months. The average follow-up was 10 years and 9 months. At the final follow-up examination, all of the hips were pain-free and satisfactorily reduced and none of the patients had deterioration in function. The average center-edge angle was -5° (range, - 45° to 18°) preoperatively and 38° (range, 17° to 53°) at the final follow-up examination. The average (MP) of Reimers was 55% (range, 30% to 100%) preoperatively compared with 12% (range, 0 to 46%) at the final follow-up examination. 16 of the 19 hips were followed until closure of the triradiate cartilage. There were no instances of posterior uncovering or osteonecrosis of the femoral head or premature closure of the triradiate physeal cartilage resulting in deficient acetabular coverage. Results suggested that good clinical and radiographic results achieved with the Pemberton pericapsular osteotomy, with simultaneous intertrochanteric osteotomy and soft-tissue release, as managment for subluxation or dislocation of the hip or acetabular dysplasia in cerebral palsy.

McNerney et al., (13)conducted another study including clinical follow-up of 44 patients with 61 involved hips. The arc of flexion/extension averaged 95° (range, 40–150°). 57 of the 61 hips measured had a functional range of motion with an arc of >=60°. 3 of the 4 hips with limited motion attributed to AVN of the femoral head, multiple procedures for progressive coxa vara, and surgery for windswept deformity to the hips. Abduction averaged 43° (range, 10–90°). 9 hips had abduction <30° at follow-up. The acetabular index improved from an average of 26° preoperatively (range, 11–42°) to 13° postoperatively (range, -12–30°) to 11° at final follow-up (range, -4–3°. Patients who were skeletally mature at final follow-up, the acetabular angle averaged 35° (range, 11–52°). Normal is considered <=42°.

Graham et al.(11) revealed a total of 45 hips in 31 patients who were managed surgically. The average age was 5.2 years (range: 2–16 years). The average follow-up was 9.6 years (range: 3–28 years). The radiographic results according to Severin were 35 hips (77.8%) in groups 1 and 2 and ten hips (22.2%) in groups 3 and higher. The average preoperative MP was 78.7% and the average postoperative MP was 15.2%. Redislocation occurred in 3 hips. Clinical results were disappointing: based on Ponsetti assessment 14 hips (36.8%) were in the first 3 groups and 24 hips (63.2%) in the last 3 groups.

Hägglund et al. (10) reported a total of 212 cases, 38 (18%) developed displacement with Migration Percentage (MP) >40% and 19 patient (9%) developed MP between 33 and 39%. Mean age at registration of hip displacement was 4 years, but some hips were MP > 40% at two years of age. The passive range of hip motion at the time of registration of hip displacement did not differ significantly from the findings in hips without displacement. The risk of displacement (MP > 40%) was directly related to the level of GMFCS function, classified according to the gross motor function classification system, GMFCS, from 0% in children in GMFCS level I to 64% in GMFCS level V.

Mallet et al. (18) included 20 hips in 20 children and retrospectively evaluated at skeletal

maturity. Mean age at surgery was 8.1 years and follow-up avoraged 9.1 years. All patients managed by Dega acetabuloplasty, soft-tissue release and femoral-shortening varus derotation osteotomy without open reduction. Reimers index, acetabular angle (AA) and neck angle (NSA) were compared on preoperative, postoperative and final follow-up radiographs. Dega osteotomy significantly improved the AA and the correction still stable at maturity. The NSA significantly decreased postoperatively from 153° to 115°, but recurrence of thc valgus deformity (l30°) of the proximal femur was recorded at maturity. Reimers index followed the same evolution. Progressive recurrence of the valgus of the proximal femur, due to addutctors spasticity and gluteus medius weakness, leads to a significant increase in the (MP) index.

CONCLUSION

This one stage procedure for hip dislocation effectively corrected the acetabular dysplasia and successfully managed neurological hips in CP patients. In our study, hip dislocation is preventable through surveillance and early identification followed by appropriate intervention; indicated by a significant decrease in the incidence of hip dislocation. The keystone in early detection is a combination of regular clinical examination and regular radiographs of the hips. All children with bilateral cerebral palsy require a pelvic radiograph by the age of 12 months. Children with spastic quadriplegia or diplegia should be monitored with regular clinical and radiological assessment every 6 to 12 months.

No conflict of interest.

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