Med. J. Cairo Univ., Vol. 90, No. 1, March: 279-290, 2022
www.medicaljournalofcairouniversity.net

The Dega Osteotomy in the Treatment of Developmental and Neuromuscular Hip Pathology. Is it a Versatile Osteotomy?

MOHAMED A.M. KHATTAB, M.Sc.; MOHAMMAD S.S. MOHAMMAD, M.Sc.; MOKHTAR A. ALSAYED, M.D.; MAGED M. ELBAZ, M.D.; AHMED M.E.E.A. MOAWAD, M.D.; MOHAMAD F. LBRAHIM, M.D.; MOHAMED EL-SOBKY, M.D.; MOHAMED HEGAZY, M.D. and AMR ARAFA, M.D.

The Department of Orthopedic Surgery, Faculty of Medicine, Cairo University

Abstract

Background: The management of developmental dysplasia of the hip (DDH) in walking children is difficult. Although much confusion still surrounds the actual procedure of the Dega osteotomy, it is one of the most commonly used osteotomies in the management of DDH.

Aim of Study: The aim of this study was to evaluate the use of the Dega osteotomy in the treatment of hip pathology resulting from both developmental dysplasia (DDH) and neuromuscular disease (NM).

Patients and Methods: The cases were operated in Abo-El-Reesh Hospital in Cairo and Kafr El-Shiekh El Aam hospital from September 2013 to November 2015. The follow-up period ranged from 18 to 24 months. Patients were divided into two groups. Dega osteotomy in DDH cases (group I) was performed in 26 hips in twenty one patients. Dega osteotomy in CP cases (group II) was performed in twenty four hips in twenty patients. The Dega was customized at the time of surgery to provide more anterior or posterior coverage depending on the needs of the individual hip. Patients were assessed for age, sex, and relevant medical and surgical history (e.g. open or closed reduction of a dislocated hip, adductor tenotomy, psoas lengthening, and femoral osteotomy). Clinical notes were obtained for range of motion, and evidence of discomfort or activity restriction. The acetabular index and center-edge angle, migration percentage were measured preoperatively and postoperatively on X-ray. CT scan was used to determine the defect in the acetabulum either posteriorly or anteriorly in selected cases.

Results: Younger age was significantly associated with better results. Males got slightly better results than females. However, it was was statistically insignificant. from 24 hips of CP group, insignificant difference was found between affection of the right and the left sides. Significant effect on the final end results was found as regarding the type of CP, where results were better for diplegic than quadriplegic patients. (*p*-value 0.0423).

Conclusion: The Dega osteotomy works well for dysplasia in both DDH and NM populations, and can easily and safely be combined with associated procedures for single-stage correction of acetabular dysplasia. Dega is a versatile osteotomy which can be used well to cover the femoral head in the presence of any acetabular defect whether anterior, posterolateral or even posterior defect in both DDH and NM populations without affecting the acetabular volume.

Key Words: *Cerebral palsy – Dega osteotomy – Developmental dysplasia of the hip.*

Correspondence to: Dr. Mohamed A.M. Khattab, The Department of Orthopedic Surgery, Faculty of Medicine, Cairo University

Introduction

THERE are a variety of described operative procedures to address acetabular dysplasia in children. These are logically divided into those that redirect the acetabulum, such as the Salter and triple osteotomies; those that reshape the acetabulum; the Pemberton and Dega osteotomies; and augmentation procedures, such as the shelf and Chiari osteotomies. The ultimate goal in any of these is to provide a stable, congruent, and functional joint, preferably with normalized anatomy. While good results have been reported with the different osteotomies, the Pemberton and Dega procedures have the advantage of producing an immediate improvement in the shape of the acetabulum. In addition, in contrast to the rotational osteotomies, the increased lateral coverage does not compromise coverage posteriorly **[1]**.

Dega originally published a description of his oste otomy in 1969, though authors have noted that the English translation was unclear. It involves an incomplete transiliac osteotomy, and takes advantage of the inherent flexibility of the triradiate cartilage and surrounding bone in the pelvis of young children to reshape the acetabulum. This

differs from the Pemberton in that the latter osteotomy extends directly to the triradiate cartilage [2].

Subluxation and dislocation of the hip is a major source of disability for children with cerebral palsy, with the incidence ranging between 3% and 75%. Hip dislocation and subluxation are caused by multiple factors including contraction of muscles, a deformed proximal femur and acetabular deficiency. Contraction of the adductor and flexor muscles leads to disturbances of the muscular balance of the hip joint region, to deformation of the acetabulum and proximal femur such as coxavalga; increase of anteversion and to subsequent hip dislocation and subluxation [3].

These issues gradually worsen the acetabular deformity and deficiency, aggravating the hip dislocation and subluxation. Dislocation of the hip is associated with poor sitting balance, pelvic obliquity, scoliosis and difficulty in perineal care. Therefore, preventive treatment for dislocation of the hip is important, and if the hip is dislocated, treatment of the cause and stable reduction of the dislocated femoral head are necessary. It has been suggested that all these problems can be improved with one-stage correction by soft tissue release, femoral derotationalvarus osteotomy and Dega osteotomy [4].

Developmental dysplasia of the hip is the preferred term to describe the condition in which the femoral head has an abnormal relationship to the acetabulum. This term includes frank dislocation (luxation), partial dislocation (subluxation), instability and an array of radiographic abnormalities that reflect inadequate formation of the acetabulum [5,6].

The aim of this study is to evaluate the use of the Dega osteotomy in the treatment of hip pathology resulting from both developmental dysplasia (DDH) and neuromuscular disease (NM).

Patients and Methods

The present study was prospective observational study. The cases were operated in Abo-El-Reesh hospital in Cairo and Kafr El-Shiekh El Aam hospital from September 2013 to November 2015. The follow-up period ranged from 18 to 24 months. The study was approved by the Research Ethics Committee at faculty of medicine cairo university. An informed consent was provided by all study participants at the beginning of the study.

Patients were divided into two groups. Dega osteotomy in DDH cases (group I) was performed in 26 hips in twenty one patients. Dega osteotomy in CP cases (group II) was performed in twenty four hips in twenty patients.

Fifty hips in forty one patients with hip dislocation and dysplasia were included in this study. Twenty six hips (in 21 patients) with DDH and 24 hips (in 20 patients) with spastic CP. The age of these groups of patients ranged from 1 to 6 years, 25 girls and 16 boys. Nine patients had a bilateral dislocation (21.9%), 12 had right sided dysplastic hips (29.3%) and 20 were left sided (48.8%).

Patients with arthrogryposis, post septic hip dislocation, age <1 or >6 years and recurrent dislocation were excluded.

Patients in the present study were subjected to obstetric history, Associated congenital anomalies, Family history, Previous lines of treatment.

Methods in group I (DDH Cases):

Main presenting symptom (limping in unilateral cases and waddling in bilateral cases).

Clinical examination (Patients were examined for bilaterality), Radiological evaluation & classification (a routine plain X-ray pelvis. All the patients were followed-up clinically and radiologically in accordance with the modified McKay criteria and Severin classification respectively.

The plan of treatment in this group was based on the preoperative clinical and imaging findings, together with the intraoperative findings. Open reduction, capsulorrhaphy, adductor tenotomy was performed accompanied with Dega osteotomy; a femoral shortening osteotomy was performed for eleven cases.

All cases were operated upon under general anesthesia. First step was to examine the hip to determine the need for adductor tenotomy.

An Adductor tenotomy was performed in all cases in this study group except two. Open reduction was performed in all cases in this study (open reduction and Dega osteotomy was performed in fifteen hips, open reduction, Dega osteotomy and femoral shortening were performed in eleven cases).

The child was immobilized in a hip spica for eight to twelve weeks. After removal of cast, Active mobilization, hydrotherapy and weight bearing were encouraged. Routine X-ray examination was done immediately post-operative & after cast removal at three and six months postoperatively.

Methods in group II (CP Cases):

Every patient caregiver was subjected to history taking (name, age, sex, residence, habits, activity level of the patient, developmental history, maternal history, obstetric history of the patient), General examination: General condition, pulse, temperature, respiratory rate, gait and posture. Local examination (range of hip motion, limb length discrepancy & neurovascular examination).Routine laboratory investigations (Complete blood count (CBC), Renal function tests (blood urea, serum creatinine), Liver function tests (serum bilirubin, SGOT, SGPT), Random blood sugar, Coagulation profile) and radiological examination: (plain X-rays).

Operative treatment was indicated in spastic unstable hip in children from 2 to 6 years old with migration percentage greater than 40%. It was done in patients with subluxation or dislocation in the form of open reduction (soft tissue release, varus-derotation shortening femoral osteotomy (VDRO) and Dega osteotomy). Surgical treatment included Open Reduction and Pericapsular Dega Osteotomy and femoral osteotomy.

A modified scoring system was used to assess the results of the operation which included. Post-operative scoring according to Trevor D., et al., [7] which includes clinical (pain, Movement, Limp and radiological criteria (centre Edge Angle of Wiberg, the appearance of femoral head, shenton's line, evidence of degenerative changes).

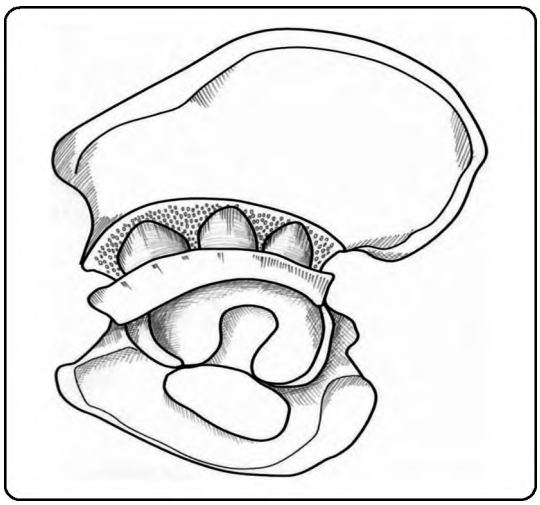

Fig. (1): A modified Dega acetabuloplasty is performed by cutting bicortically, not only the anterior inferior iliac spine, but also the sciatic notch. The osteotomy includes outer cortices of the ilium of the anterior, middle and posterior portions. It enables a larger graft to be placed posteriorly.

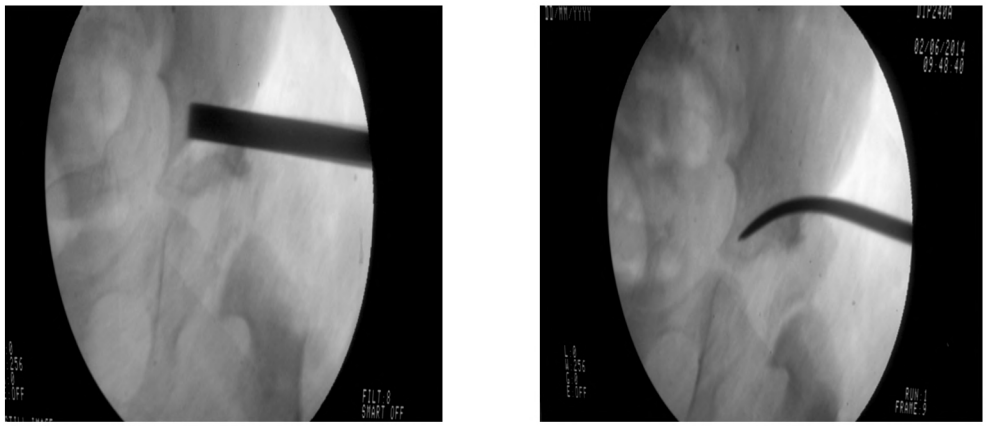

Fig. (2): Intraoperative radiology of Dega osteotomy.

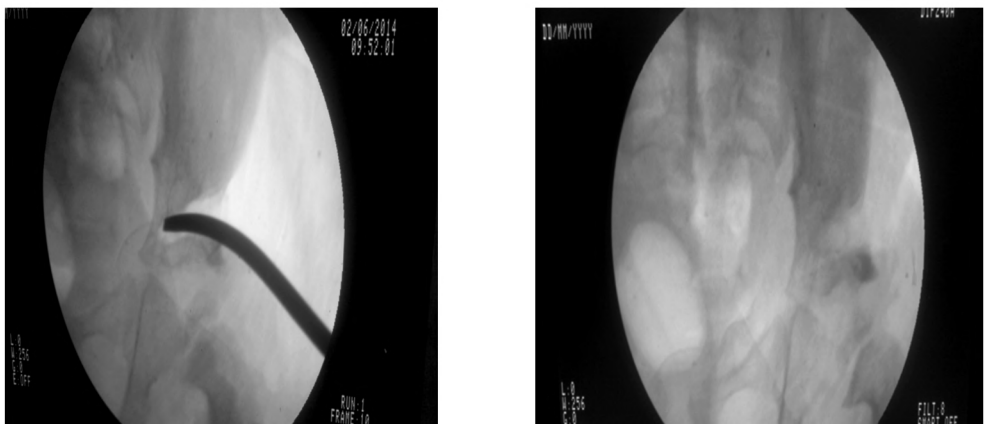

Fig. (3): Intraoperative radiology of Dega osteotomy during and after doing it.

Results

Table (1) shows that; the younger the age of the patients was, the better were the results. This was statistically significant.

Table (2) shows that; males got slightly better results than females. This was statistically insignificant.

Table (3) shows that; from 24 hips of CP group, insignificant difference was found between affection of the right and the left sides.

Table (4) shows that; significant effect on the final end results was found as regarding the type of CP, where results were better for diplegic than quadriplegic patients. (p-value 0.0423).

Table (5) shows that; one case (5%) had partial loss of fixation with screw pull out and overvarization (the neck shaft angle became about 85°). One case (5%) had partial loss of fixation with the second proximal screw pulled out. One case (5%) had overcorrection of the range of abduction up to 80° and this was considered as reversal of the deformity. One case (5%) presented with superficial infection. Culture & sensitivity was done and appropriate antibiotic was given till the infection totally resolved. Two cases (10%) developed supracondylar femoral fracture as a result of vigorous postoperative physiotherapy.

Table (1): Relation between final end results and age of the patient.

Age	Result										p-value
	Excellent		Good		Fair		Poor		Total		
	N	%	N	%	N	%	N	%	N	%	
2-< 4	4	20	3	15	1	5	1	5	9	45	0.024
4-6	6	30	4	20	1	5	0	0	11	55	
Total	10	50	7	35	2	10	1	5	20	100	

*Significant at p-value <0.05.

Table (2): Relation between final end results and gender of patients.

Gender	Result										p-value
	Excellent		Good		Fair		Poor		Total		
	N	%	N	%	N	%	N	%	N	%	
Male	6	30	3	15	2	10	1	5	12	60	0.061
Female	4	20	3	15	1	5	0	0	8	40	
Total	10	50	7	30	3	15	1	5	20	100	

*Significant at p-value <0.05.

Table (3): Relation between final end results and the affected side.

Side	Result										p-value
	Excellent		Good		Fair		Poor		Total		
	N	%	N	%	N	%	N	%	N	%	
RT	6	25	4	16.6	1	4.1	2	8.2	13	54.7	0.635
LT	4	16.6	4	16.6	2	8.2	1	4.1	11	45.3	
Total	10	41.6	8	33.3	3	12.5	3	12.5	24	100	

Insignificant at p-value >0.05.

Table (4): Relation between final end results and type of CP.

Type of CP	Result										*p*-value
	Excellent		Good		Fair		Poor		Total		
	N	%	N	%	N	%	N	%	N	%	
Spastic quadriplegic.	5	25	6	30	3	15	1	5	15	75	0.0423
Spastic diplegic	5	100	0	0	0	0	0	0	5	25	
Total	10	47.61	7	33.33	3	14.29	1	4.77	20	100	

Significant at *p*-value <0.05.

Table (5): Post-operative complications.

Complications	No. of cases	%
Partial loss of fixation and overvarization	1	5
Partial loss of fixation	1	5
Overcorrection of the range of abduction	1	5
Superficial infection	1	5
Supracondylar femoral fracture	2	10

Discussion

The Dega has been used in both developmental dysplasia (DDH) and neuromuscular (NM) populations, published series have focused on one or the other. Although this allows for focused assessment of outcomes, it leaves open the question as to whether comparable results are achieved in both populations when indications and surgical technique are similar [8].

The clinical and radiographic results in the present study were comparable with the results of different authors for each of the two groups. The largest series in the English literature was presented by Reichel and Hein [9] though they report the procedure as a "modified" Dega. Seventy hips with DDH underwent the osteotomy, most combined with femoral osteotomy and some with open reduction. At average follow-up of 10 years, 80% were noted to have very good or good clinical results. The poorer results were associated with 22 cases (31 %) of AVN, 18 of which were associated with preoperative closed reduction attempts or traction. Relevant comparisons can also be made to series by Grudziak and Ward [2] and Jozwiak et al., [10]. The former noted good clinical results and 4 complications requiring reoperation in 24 hips with DDH. The latter noted good maintenance of correction over a 12-year follow-up period in 30 hips in patients with cerebral palsy, though there was a 23% incidence of subluxation.

In this study, Dega osteotomy was accompanied by open reduction in all hips, and in some cases femoral shortening was added. These results are similar to those obtained by previous series done by Grudziak et al., [11], who considered that Dega osteotomy is just one component of the comprehensive, complicated surgery required to treat severe DDH in children of walking age.

In our study, we documented excellent & good clinical and radiographic results in DDH patients, comparable with those reported by Grudziak et al., [11]. Concentric reduction of the hip was achieved and maintained in all patients, and all had a decrease in the acetabular dysplasia, usually to normal values as measured by the acetabular index and the center-edge angle. Labaziewicz and Piskorski [12] reported that only three of seventy-two hips needed a secondary operation due to redislocation immediately following an open reduction and a Dega osteotomy, one hip had dislodgment of the graft, and one hip required a secondary procedure to undo excessive correction of the neck-shaft angle.

Senger et al., [12] reported the results of treatment of 201 cases of congenital dislocation of the hip. There were four postoperative redislocations, one femoral fracture, and one case of coxavara resulting from excessive correction of the neck-shaft angle. Pucher et al., reported no redislocations [13].

In our study we had only one re-dislocation from Dega osteotomy in DDH group. However, serious complication: In two patients, for whom fluoroscopic control was not used, the osteotomy extended into the hip joint & the osteotomy site is low & in these two cases AVN occurred to hip but we did not perform re-operation to any case.

In this study, image intensification was used during Dega osteotomy except in two cases. Disruption of the physis occurs as the osteotome crosses the growth plate which may cause violation of the triradiate cartilage, so we recommended use of C-arm in performing Dega osteotomy. These results are similar to those obtained by previous study done by, Akifusa et al., [14].

Girls were more commonly affected in DDH group with an incidence of 61.9%, (13 girls and 8 boys), this is similar to previous series done by Huang et al., Brougham et al. & Chen et al., [15-17].

In this group, left sided involvement was more common with an incidence of 39.9%, while the right side was affected in 33.3% and bilateral affection in 23.8%. This is found in the literature and previous series done by Huang et al., Fixsen JA & Li PLS, which considered that the left side is the most commonly affected, they said that may be due to the fact that the most common intrauterine position in the one in which the left hip is adducted against maternal sacrum [16,18,19].

In 2002, Böhmand Brzuske,found in their long term follow-up study done to evaluate the efficacy of Dega osteotomy after an average of 31 years that the long-term clinical outcome was significantly influenced by the grade of dislocation on the radiographs made at the first examination.

In this study, we couldn't found any significance because all patients in this study were grade IV.

In this study, there was a significant reverse correlation between the age and the results. The younger the child, the better the results. These results are similar to those obtained by previous series done by Otaify & Visser; they believe that the results of treatment of DDH are largely dependent on the age of the child in which the treatment is undertaken [20,21].

In this study, cases with DDH presented special problems, which included high displacement of the femoral head, acetabular insufficiency and disproportion between the size of femoral head and the acetabulum and deformities of proximal femur, added to soft tissues contracture and shortening. Therefore, surgical treatment was applied for all the cases in our series and was found effective.

Bialik et al., & Ando et al., stressed that aggressive treatment to restore normal hip joint is indicated to prevent irreversible cartilage injury, which can result in the development of osteoarthritis [22,23].

Fixsen et al., & Akifusa et al., reported that pelvic osteotomies reduce the load at the shallow acetabulum by increasing the contact area, improving the moment arm of the hip, and normalizing weight-bearing forces. Although this osteotomy may have to be combined with other operative procedures [14,18].

In this study, we did not apply traction before the operation. Pemberton, who stressed that in high dislocation, traction is applied before the operation for a maximum of 3 weeks, this does not cause excessive softening of the bone and it does make the reduction easier with less force on the head [10].

Our results are similar to those obtained by previous series done by Angliss et al., Fixsen et al., & Bialik et al., they concluded that a one-stage procedure without preoperative traction did not increase the risk of AVN and its use is becoming more justifiable than before as it produces acute correction of all pathology elements at one stage and can result in remodeling of the acetabulum and a functional hip. They have also demonstrated that the results are as equal as or even better than the staged correction [2,18,24].

Wada and associates reported that a few investigators have evaluated the long-term functional and radiological outcome of a one-stage operation for the treatment of DDH in a child after the walking age. Most of these studies used different combinations of surgical treatment without standarising a fixed surgical protocol for treatment. This made it difficult to compare their results with other series [14].

In this study, the anterolateral Smith Peterson approach with a Bikini incision was used in all our cases that were operated upon with open reduction as all obstructing elements are dealt with under direct vision, capsulorrhaphy can be done easily and pelvic osteotomy was performed through the same approach. Similar approach was done by Grudziak JS, Metin et al., and Konigsberg et al. (2003) [2,25,26].

In this study, the test of stability was useful and reliable as a mean of assessing the need for a pelvic or femoral osteotomy at time of open reduction. It was found similar to that applied by previous series done by Zadeh et al., [27].

Although, Fixsen et al., & Schoenecker et al., claimed that it is advisable to include an acetabular procedure in the primary operation, whatever stable the hip may appear after open reduction and femoral osteotomy, but this is not the rule in many studies [18,28]. However, in our study we recommend using Dega osteotomy as an acetabular procedure in the primary operation because it adds more to the stability of the hip joint.

In the present study, the incidence of AVN was 14% in Dega osteotomy for DDH group; compared

to the literature, the variation of this incidence was 0-73% as reported by Tonnis in [29]. It was documented by Mellerowicz et al., & Danielsson that the different modalities in treating DDH and the age at which we start treatment in these cases are the obvious reasons for differences in the percentage of AVN. They stressed that the percentage of AVN in surgically treated late-diagnosed DDH cases will probably never reach 0, even if all known prophylactic measures are used [30,31]. Malvitz et al., & Haidar et al., considered that AVN was the most severe complication after conservative or operative treatment of DDH [32,33]. Murray &Metin et al., attributed AVN to either femoral shortening being not done [34,35], or pressure increased across the femoral head after innominate osteotomy [34], or due to force reduction of the hip in older children or due to immobilization in wide abduction and internal rotation [36].

In our study, in DDH group, we observed the acetabular defect intraoperatively to be anterior in fifteen hips (57.6%), anterolateral in six hips (23.1%) and posterior in five hips (19.2%). All of these hips were treated by Dega osteotomy which provided an excellent coverage to the femoral head. These results was similar to those done by Grudziak JS, Metin et al. and Konigsberg et al., [2,25,26].

Our study emphasized the necessity of performing the Dega osteotomy in a technically sound manner, with particular attention paid to obtaining stability at the osteotomy site and preserving the elastic recoil that results from an intact sciatic notch.

In our limited experience with the Degatransiliac osteotomy, the procedure was satisfactory for the treatment of acetabular dysplasia in children below 6 years in DDH patients.

In our study, in CP group, we observed the acetabular defect intraoperatively to be anterior in eight hips (33.3%), anterolateral in seven hips (29.2%) and posterior in nine hips (37.5%). All of these hips were treated by Dega osteotomy which provided an excellent coverage to the femoral head.

Since Dega [37,38] was first introduced in 1969, many studies have been conducted using this technique [39]. However, the procedure as originally described did not sufficiently increase coverage of the femoral head, because the posteromedial cortex of the ilium and the greater sciatic notch were not cut. To produce better results, Mubarak et al., [40] and McNerney et al., [41] described the modified osteotomy in which bicortical cuts were made in the anterior inferior iliac spine and the greater sciatic notch. With this modified procedure, posterior coverage of the femoral head is increased by placing a larger bone graft in the posterior part of the osteotomy. Moreover, while other pelvic osteotomies require internal fixation, more stability is obtained without internal fixation by inserting autologous bone fragments from the ilium or from the proximal femoral shortening osteotomy into the osteotomy site.

In our patients, stable reduction of the femoral head was followed by a remarkable improvement in abduction. Furthermore, this was achieved without increased pain because of the release of contracted muscles and the increased stability of the hip joint as well as improved comfort in the seated position. Some of them had scoliosis with fixed pelvic obliquity. As it was difficult to determine the degree of pain or discomfort quantitatively for our young patients, we asked parents about the patients' pain (decreased, maintained or increased). The pain that patients complained of in this study may be considered to be irritability caused by hip motion when the hip is unstable. We believe that this irritability and the contracted soft tissues are the major causes preventing ambulation and of comfort in the seated position. After stable reduction of the hip joint, some of the patients were able to walk again with a walker for short distances, and most could sit comfortably.

Considering the overall results bony procedures were added to soft tissue disease for moderately, severely subluxated & dislocated hips. This included Dega osteotomy to increase the acetabular coverage & change the configuration.

The bone quality of these patients was severely porotic as apparent in 2 cases where there were loosening of the proximal screws (no good purchase), this may be related to disuse atrophy of the bone components.

Proximal femoral osteotomy was done in most cases to decrease the pressure on the femoral head that resulted from severe muscle spasm which might predispose to AVN of the femoral head, so femoral shortening augmented the effect of muscle lengthening.

Overvarization of the neck shaft angle in one patient was attributed to the loosening of the proximal screws as a result of bone osteoporosis. This did not cause any problem to the case which was fully united radiologically.

Pain decreased in 15 patients and was still persistent in only one case; this may be attributed

to persistence of subluxation due to inadequate acetabular coverage. The patient was older (6 years) and the femoral head was deformed and the acetabulum was severely dysplastic.

As we see from the relation between the final end results and the age of the patient that the younger the age of the patient, the better the final results. This was because the longer the time the femoral head is not in contact with the acetabulum (no stimulation of the femoral head and acetabular development); the more was deformed femoral head and the more dysplastic acetabulum and hence the worse final end results of the operation.

Considering the type of CP (spastic diplegic or quadriplegic), better results were gained in diplegic patients. This was noticed by parent or caregiver satisfaction as these patients were ambulatory preoperatively and improved regarding the pain and perineal care postoperatively. In quadriplegic patients there was inability to ambulate preoperatively and postoperatively. This gave false impression of no improvement and no benefit from the operation.

Root et al., [42] presented a subseries of 18 patients with hip dislocations treated with open reduction, varusderotational femoral osteotomy, and various forms of pelvic osteotomies. After an average follow-up of 7 years, seven patients had a migration percentage of less than 25%; 11 hips had a migration percentage between 25% and 50%. All hips were painless, but the incidence of AVN and improvement in ambulation are difficult to determine because the results were not specifically reported for the subseries of dislocations.

Jozwiak et al., [10] reported a series of 25 patients treated with open reduction, VDRO, and Degatransiliac osteotomy; 9 of them had hip dislocations. At an average follow-up of 13.8 years, all nine hips remained stable without any evidence of subluxation or dislocation. Thirty-percent of patients in the overall series developed AVN, but it is again unclear what the incidence of AVN was in the dislocation subgroup.

Mubarak et al., [40] described a one-stage open reduction procedure that included appropriate soft tissue lengthening, VDRO, and Dega osteotomy in CP cases. Although their results were excellent in treating the subluxated hip, they experienced a 33% incidence of AVN and a 16% incidence of resubluxation after open reduction of the completely dislocated hip in their initial series. In an expanded follow-up study by McNerney et al., [41] the average migration percentage at final follow-up (mean 8.4 years) for a subseries of 19 dislocated hips was 20.6%. Three patients (16%) were found to be subluxated at final follow-up. Five of 19 hips (26%) developed AVN after the procedure.

AVN is recognized as a potentially serious complication of open reduction of the dislocated hip. In Mubarak et al., original [40] subgroup of dislocated hips treated with one-stage open reduction, there was a 33% incidence of AVN. This may be due to older age patients included in this study (between five and sixteen years old); also the complication may have been due to occult vascular injury that was incurred during the femoral osteotomy and insertion of the plate. In an expanded series, McNerney et al., [41] reported a 26% incidence in a series of 19 patients; in this study, the iliopsoas release was done through the same anterolateral incision. We emphasize the importance of performing an iliopsoas release on the proximal fragment as we believe that a gentle reduction is not possible without this step. This resulted in a successful reduction without any pressure on the femoral head that may predispose the hip to osteonecrosis.

In our series, we did not find evidence of AVN in any of our patients of CP group at the time of final follow-up. This is in contrast to the results of other previously mentioned studies [39,43]. Our findings are similar, however, to those of Gordon et al., [44], who did not report any cases of AVN after one-stage hip reconstruction in a series of 13 dislocated hips. It may be that a more sensitive test such as magnetic resonance imaging would have revealed signs of osteonecrosis; however, using all available plain radiographs (early postoperative and final follow-up), we could not detect any changes consistent with osteonecrosis in our patients.

In their series, Mubarak et al., [40] described two cases of postoperative AVN of the femoral head, which eventually reconstituted. It is possible, given the long interval between some follow-up visits that subclinical osteonecrosis may have developed and healed without our knowledge.

Two patients of ours sustained supracondylar femur fractures after immobilization. This rate is similar to Samilson et al., [45] series, in which 40 of 274 patients had sustained fractures after immobilization. All of these fractures resulted from physiotherapy in an osteoporotic extremity even though immobilization was limited to 4 weeks, and only active range of motion was allowed ini-

tially as vigorous passive motion was more likely to cause a fracture.

Overall, our experience with one-stage reconstruction consisting of soft tissue lengthening, open reduction, femoral osteotomy, and Dega osteotomy for hip dislocation in patients with cerebral palsy has shown good results. The procedure has demonstrated relatively few complications and provides the patient with a stable hip and an improved quality of life as measured by ease of perineal care, absence of decubitus ulcer formation, better sitting tolerance, and improved ambulation in the previously ambulatory population.

In our study we recommend the use of Dega osteotomy in the treatment of both DDH and NM hip disease because the osteotomy is safe and effective in both conditions. The Dega osteotomy is utilitarian, as it may provide increased acetabular coverage anteriorly, posteriorly, laterally or in any combination of those depending on where it is hinged (which means that Dega Osteotomy is a versatile one).

We find in our study that the Dega osteotomy works well for dysplasia in both DDH and NM populations, and can easily and safely be combined with associated procedures for single-stage correction of acetabular dysplasia **[46]**.

Aksoy and Yilgor in 2013 found that Degaacetabuloplasty is widely considered as safe and effective in the treatment of hip pathologies resulting from both DDH and neuromuscular diseases, but the number of clinical follow-up series in the literature is not sufficient. The aim of their study was to report the results of 35 patients (43 hips) with DDH in whom acetabulardysplasias were treated by Degaacetabuloplasty **[47]**.

Their study showed that acetabular dysplasia could be corrected effectively with Dega acetabuloplasty. This is an incomplete osteotomy that improves the overall coverage of the femoral head, anteriorly, laterally, as well as posteriorly depending on where it is hinged. The graft was stable and no internal fixation was required; therefore, there was no need for a second operation for implant removal. It did not cause leg-length discrepancy and could be carried out bilaterally if necessary. Detailed information is also available in the literature on Degaacetabuloplasty published in its original language.

One advantage of Dega acetabuloplasty over Salter is that Dega does not cause posterior instability. Correction of the AI in Dega can be higher than Salter, because the correction limit of Salter is 15-20 degree. It should also be kept in mind that Salter osteotomy requires a second surgical intervention to remove the pins, which poses another surgical risk to the patient.

Al-Ghamdiet al., **[48]** suggested that various surgical techniques have been described to treat acetabular dysplasia, although redirectional innominate osteotomies such as the Salter innominate osteotomy, Sutherland double innominate osteotomy.

Although large case series on the utility of the Dega and modified Dega in treating spastic hip dysplasia exist, there are limited publications in the English literature regarding the use of this technique on patients diagnosed with DDH. This study described and analyzed the radiographic outcome of 21 cases diagnosed with DDH and treated with a modified Dega osteotomy. The principal aim was to assess the impact of this surgical technique on the acetabular index (AI) at final follow-up. Secondary aims included assessing the impact of the surgical technique on the center edge angle (CEA), AI of Sharp, Reimer's extrusion index, and the continuity of the Shenton line, and grading the results of the treatment at final follow-up by the Severin classification system **[48]**.

Osteotomies were performed in a manner similar to that described by Mubarak et al., **[40]**. The osteotomies were started slightly cephalad to the anterior inferior iliac spine anteriorly and directed toward the posteromedial pelvic wall such that the osteotomy ended near the midpoint of the horizontal ilioischial and iliopubic limbs of the triradiate cartilage. The posterior and anterior inner and outer table cortices were included in the osteotomy. After completion of the osteotomy, variable sized bone grafts were positioned antrolaterally, laterally, and posterolaterally to obtain greater anterior coverage than posterior coverage.

The modified Dega osteotomy is a versatile osteotomy that allows one to improve acetabular coverage. Although there are a number of publications on its use in neuromuscular hips, there is a paucity of the English language literature with respect to its use in patients with DDH. The goals of their study were to assess the impact of this surgical technique in patients with DDH on the AI. In addition, the AI of Sharp, CEA, Reimer's extrusion index, continuity of the Shenton line, and the Severin grade were also assessed. They showed an improvement in AI from 37 to 19 de-

grees (mean difference, 18), which is comparable with our results and found nearly similar. Grudziak and Ward [2] achieved a correction from 33 preoperatively to 12 degrees at follow-up in their case series of 24 hips. In achieving a final follow-up CEA of 25 degrees, we feel in our study that the modified Dega osteotomy enables us to improve lateral coverage to near normal values.

There were a number of limitations to this small case series. First, there was measurement error of the radiographic parameter measurements, which relied on defining landmarks such as the tear drop, medial wall of the acetabulum, lateral edge of the sourcil, and center of the femoral head. In DDH, many of the landmarks were obscured due to the underdevelopment of the acetabulum and as such, measurement error was increased. Furthermore, the ossific nucleus of the femoral head may be eccentric or absent and measurements that rely on the center of the femoral head may be biased or indeterminate due to this phenomenon. Another limitation of this study is the lack of assessment of anterior coverage.

In our work we prefer to do open reduction, capsulorrhaphy, iliopsoas release and Dega osteotomy using Smith Peterson approach which give a very good exposure and these procedures have a little limitation of indication in patients with cerebral palsy.

Conclusion:

- The Dega osteotomy works well for dysplasia in both DDH and NM populations, and can easily and safely be combined with associated procedures for single-stage correction of acetabular dysplasia.
- Dega is a versatile osteotomy which can be used well to cover the femoral head in the presence of any acetabular defect whether anterior, posterolateral or even posterior defect in both DDH and NM populations without affecting the acetabular volume.

References

1-LALONDE F.D., FRICK S.L. and WENGER D.R.: Surgical correction of residual hip dysplasia in two pediatric age-groups. JBJS, 84 (7): p. 1148-1156, 2002.

2-GRUDZIAK J.S. and Ward W.T.: Dega osteotomy for the treatment of congenital dysplasia of the hip. JBJS, 83 (6): p. 845-854, 2001.

3-MINEAR W.L. and TACHDJIAN M.O.: Hip dislocation in cerebral palsy. J. Bone Joint Surg. Am., 38-a (6): p. 1358-64, 1956.

4- BAKER, L.D., DODELIN R. and BASSETT F.H.: Pathological changes in the hip in cerebral palsy: Incidence, pathogenesis, and treatment: A preliminary report. JBJS, 44 (7): p. 1331-1411, 1962.

5- ARONSSON D.D., et al.: Developmental dysplasia of the hip. Pediatrics, 94 (2): p. 201-208, 1994.

6- HERRING J.: Developmental Dysplasia of the Hip and Pemberton's Osteotomy. Herring J.A., ed. Tachdjian's Pediatric Orthopaedics. 3üncü baskı (Vol. 1), Pennsylvania., WB Saunders Co., 2002.

7- TREVOR D., JOHNS D. and FIXSEN J.: Acetabuloplasty in the treatment of congenital dislocation of the hip. The Journal of bone and joint surgery. British Volume, 1975. 57 (2): p. 167-174.

8- BARRIE J. and GALASKO C.: Surgery for unstable hips in cerebral palsy. Journal of pediatric orthopedics. Part B, 5 (4): p. 225-231, 1996.

9- REICHEL, H. and HEIN W.: Dega Acetabuloplasty Combined With Intertrochanteric Osteotomies: Long-Term Results. Clinical Orthopaedics and Related Research (1976-2007), 323: p. 234-242, 1996.

10- JÓZ´WIAK, M., et al.: Dega's transiliac osteotomy in the treatment of spastic hip subluxation and dislocation in cerebral palsy. Journal of pediatric orthopedics. Part B, 9 (4): p. 257-264, 2000.

11- GRUDZIAK J., et al.: Combined one-staged open reduction, femoral osteotomy, and Dega pelvic osteotomy for developmental dysplasia of the hip. J. Pediatr. Orthop., 13: p. 680, 1993.

12- SENGER A., et al.: Results of the surgical treatment of congenital dislocation of the hip joint by open reduction and transiliac and corrective osteotomies of the proximal end of the femur. Chirurgia narzadow ruchu i ortopedia polska, 1988. 53 (3): p. 190-194.

13- PUCHER A., LABAZIEWICZ L. and KACZMARCZYK J.: Early results of surgical treatment for congenital hip dislocation in children using Degi's method in children under 18 months of age. Chirurgia narzadow ruchu i ortopedia polska, 59 (2): p. 135-142, 1994.

14- WADA A., et al.: Pemberton osteotomy for developmental dysplasia of the hip in older children. Journal of Pediatric Orthopaedics, 23 (4): p. 508-513, 2003.

15- HUANG S.-C. and WANG J.-H.: A comparative study of nonoperative versus operative treatment of developmental dysplasia of the hip in patients of walking age. Journal of Pediatric Orthopaedics, 17 (2): p. 181-188, 1997.

16- BROUGHAM D., et al.: Avascular necrosis following closed reduction of congenital dislocation of the hip. Review of influencing factors and long-term follow-up. The Journal of bone and joint surgery. British, Volume, 72 (4): p. 557-562, 1990.

17- CHEN I.-H., KUO K.N. and LUBICKY J.P.: Prognosticating factors in acetabular development following reduction of developmental dysplasia of the hip. Journal of Pediatric Orthopedics, 14 (1): p. 3-8, 1994.

18- FIXSEN J.A. and LI P.L.: The treatment of subluxation of the hip in children over the age of four years. The Journal of bone and joint surgery. British Volume, 80 (5): p. 757-761, 1998.

19- BROUGHAM D.I., et al.: Avascular necrosis following closed reduction of congenital dislocation of the hip. Review of influencing factors and long-term follow-up. J Bone Joint Surg Br., 72 (4): p. 557-62, 1990.

20- OTAIFY A.: One-stage surgery for developmental dysplasia of the hip in older children. Pan Arab J. Orthop. Trauma, 6: p. 49-61, 2002.

21- VISSER J.D.: Functional treatment of congenital dislocation of the hip. Acta Orthopaedica Scandinavica, 55 (sup 206): p. 1-109, 1984.

22- ANDO M. and GOTOH E.: Significance of inguinal folds for diagnosis of congenital dislocation of the hip in infants aged three to four months. Journal of pediatric orthopedics, 10 (3): p. 331-334, 1990.

23- BIALIK V., et al.: Developmental dysplasia of the hip: a new approach to incidence. Pediatrics, 103 (1): p. 93-99, 1999.

24- ANGLISS R., et al.: Surgical treatment of late developmental displacement of the hip: results after 33 years. The Journal of bone and joint surgery. British Volume, 87 (3): p. 384-394, 2005.

25- BAKI C., et al.: Single-stage open reduction through a medial approach and innominate osteotomy in developmental dysplasia of the hip. The Journal of bone and joint surgery. British volume, 87 (3): p. 380-383, 2005.

26- KONIGSBERG D.E., et al.: Results of medial open reduction of the hip in infants with developmental dislocation of the hip. Journal of Pediatric Orthopaedics, 23 (1): p. 1-9, 2003.

27- ZADEH H., et al.: Test of stability as an aid to decide the need for osteotomy in association with open reduction in developmental dysplasia of the hip: a long-term review. The Journal of bone and joint surgery. British Volume, 82 (1): p. 17-27, 2000.

28- SCHOENECKER, P.L., ANDERSON D.J. and CAPELLI A.M.: Results After Failure of Post-Reduction Abduction Splinting in Patients Who Had Congenital Dislocation of the Hip. The Journal of Bone and Joint Surgery-american Volume, 77 (7): p. 990-997, 1995.

29- TÖNNIS D.: Surgical treatment of congenital dislocation of the hip. Clinical orthopaedics and related research, (258): p. 33-40, 1990.

30- DANIELS SON L.: Late-diagnosed DDH: A prospective 11-year follow-up of 71 consecutive patients (75 hips). Acta Orthopaedica Scandinavica, 71 (3): p. 232-242, 2000.

31- MELLEROWICZ, H., MATUSSEK J. and BAUM C.: Long-term results of Salter and Chiari hip osteotomies in developmental hip dysplasia. Archives of orthopaedic and trauma surgery, 117 (4): p. 222-227, 1998.

32- MALVITZ T.A. and WEINSTEIN S.L.: Closed reduction for congenital dysplasia of the hip. Functional and radiographic results after an average of thirty years. The Journal of bone and joint surgery. American Volume, 76 (12): p. 1777-1792, 1994.

33- HAIDAR R.K., et al.: Simultaneous open reduction and Salter innominate osteotomy for developmental dysplasia of the hip. The Journal of bone and joint surgery. British Volume, 78 (3): p. 471-476, 1996.

34- MURRAY R.: The aetiology of primary osteoarthritis of the hip. The British journal of radiology, 38 (455): p. 810-824, 1965.

35- DOGAN M., et al.: One-stage treatment of congenital severely dislocated hips in older children through various acetabuloplasty techniques: 22 children followed for 1-5 years. Acta. Orthopaedica, 76 (2): p. 212-219, 2005.

36- FONG H., et al.: Chiari osteotomy and shelf augmentation in the treatment of hip dysplasia. Journal of Pediatric Orthopaedics, 20 (6): p. 740-744, 2000.

37- SALTER R.B.: Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. The Journal of Bone and Joint Surgery. British Volume, 43 (3): p. 518-539, 1961.

38- HELLINGER, J. and SCHMIDT H.: The pericapsular osteotomy of the os ilium in the treatment of flat acetabula. Archives of orthopaedic and traumatic surgery, 101 (1): p. 53-57, 1982.

39- PERLIK P., WESTIN G. and MARAFIOTI R.: A combination pelvic osteotomy for acetabular dysplasia in children. The Journal of bone and joint surgery. American Volume, 67 (6): p. 842-850, 1985.

40- MUBARAK S.J., VALENCIA F.G. and WENGER D.R.: One-stage correction of the spastic dislocated hip. Use of pericapsular acetabuloplasty to improve coverage. The Journal of bone and joint surgery. American Volume, 74 (9): p. 1347-1357, 1992.

41- MCNERNEY N.P., MUBARAK S.J. and WENGER D.R.: One-stage correction of the dysplastic hip in cerebral palsy with the San Diego acetabuloplasty: results and complications in 104 hips. Journal of Pediatric Orthopaedics, 20 (1): p. 93, 2000.

42- ROOT L., et al.: The severely unstable hip in cerebral palsy. Treatment with open reduction, pelvic osteotomy, and femoral osteotomy with shortening. The Journal of bone and joint surgery. American Volume, 77 (5): p. 703-712, 1995.

43- NOONAN K.J., et al.: Varus derotation osteotomy for the treatment of hip subluxation and dislocation in cerebral palsy: Statistical analysis in 73 hips. Journal of pediatric orthopedics. Part B, 10 (4): p. 279-286, 2001.

44- GORDON J.E., et al.: Pemberton pelvic osteotomy and varus rotational osteotomy in the treatment of acetabular dysplasia in patients who have static encephalopathy. JBJS, 78 (12): p. 1863-71, 1996.

45- SAMILSON R.L., et al.: Dislocation and subluxation of the hip in cerebral palsy: Pathogenesis, natural history and management. JBJS, 54 (4): p. 863-873, 1972.

46- KARLEN J.W., et al.: The Dega osteotomy: A versatile osteotomy in the treatment of developmental and neuromuscular hip pathology. Journal of Pediatric Orthopaedics, 29 (7): p. 676-682, 2009.

47- AKSOY C., et al.: Evaluation of acetabular development after Dega acetabuloplasty in developmental dysplasia of the hip. Journal of Pediatric orthopaedics B, 22 (2): p. 91-95, 2013.

48- AL-GHAMDI A., et al.: Dega osteotomy for the correction of acetabular dysplasia of the hip: A radiographic review of 21 cases. Journal of Pediatric Orthopaedics, 32 (2): p. 113-120, 2012.

الشق العظمى ديجا لعلاج أمراض مفصل الفخذ الناتجة عن النقص الخلقى التطورى والعيوب العصبية العضلية. هل هو شق عظمى متعدد الاستخدام؟

يتضمن العلاج الجراحى لحلات مفصل الفخذ التصلبى غير المستقر تحرير الأنسجة الرخوة وإطالتها، إحداث شق عظمى فى الجزء القريب لعظمة الفخذ بجانب إحداث شق عظمى للحوض (شق ديجا). هذا العلاج والتدخل الجراحى قد يصل فى بعض الأحيان إلى الطرق الإنقاذية والتى تتمثل فى استئصال الجزء القريب لعظمة الفخذ، والشق العطمى الداعم للحوض وذلك فى حالات التشوهات العظيمة للحق والأطفال الأكبر سناً.

أن مادة البحث تشمل خمسون مفصل لاربعون حالة. ويهدف هذا البحث إلى تقييم الشق العظمى ديجا واثبات صلاحيته فى علاج خلع مفصل الفخذ الناتج عن الخلع التطورى والشلل الد ما غ. وقد تم التركيز فى هذا البحث على استخدام الأشعة العادية وتقييم الحالة أثناء الجراحة التقييم الجراحى والاشعاعى اللازم للعلاج الجراحى لحالات مفصل الفخذ غير المستقر وكانت مجدية للغاية، كما قسم البحث إلى جزئين، الجزء الأول ويشمل مراجعة ما نشر بالأبحاث العلمية المختلفة عن نمو مفصل الفخذ مع الوصف التشريحى له مع شرح الأسباب والتشريح الباثولوجى للمرضين والطرق المختلفة لتشخيصهما وعلاجهما.

والجزء الثانى ويشمل وضع الخطة العلاجية لحالات الخلع التطورى لمفصل الفخذ وحالات مفصل الفخذ غير المستقر فى الأطفال المصابين بالشلل الدماغى التصلبى عند الأطفال الذين تتجاوز أعمارهم العام ويقل عمرهم عن ستة أعوام.

وأظهرت نتائج البحث عن وجود التئام كامل إكلينيكى وباستخدام الأشعة السينية للشقوق العظمية فى الفخذوالحوض فى كل المرضى فى مدة ما بين ٨–١٠ أسابيع بمتوسط قدره ٨.٩٦ أسبوع. وقد توصلنا إلى أن الهدف الأساسى عند تصليح تزحزح وخلع مفصل الفخذ فى حالات الشلل الدماغى هو إزالة الألم الذى يسببه هذا التزحزح والخلع وكذلك تحسين العناية بالعجان وميلان الحوض وتحسين الوضع الجلوسى للطفل.