Acta Orthop. Belg., 2019, **85**, 545-553

ORIGINAL STUDY

Combined open reduction and Dega transiliac osteotomy for developmental dysplasia of the hip in walking children

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The iliac osteotomy described by Dega in Poland, in 1969, is an acetabuloplasty that changes the acetabular configuration and its inclination. The aim of this work is to analyze a group of patients with DDH treated by combined open reduction and Dega transiliac osteotomy ,to evaluate the results and determine the advantages and disadvantages, as well as, assess the factors affecting the final outcome of such procedure. A prospective study was conducted during the period, from November 2010 to October 2014, on 39 hips, in 29 children, with neglected DDH after walking age, either diagnosed late or after failure to respond to previous non operative treatment. The mean age at the time of surgery was 27.6 months ranging from 18 to 48 months. All hips were followed up clinically and radiologically for a mean period of 33.6 months (range from 18 to 48 months). No patient was lost to follow up. At the end of follow up, satisfactory final clinical results were obtained in 34 hips (87.2%) and unsatisfactory in 5 (12.8%) according to McKay's criteria. Radiologically, satisfactory results were obtained in 32 hips (82.1%) and unsatisfactory in seven (17.9%), according to Severin's criteria. In conclusion, the results of our series show open reduction combined with Dega transiliac osteotomy to be a safe and efficient method for the surgical treatment of DDH in selected patients, and can easily and safely be combined with associated procedures for single stage correction of acetabular dysplasia.

Keywords : DDH at walking age ; open reduction ; Dega iliac osteotomy.

INTRODUCTION

The management of developmental dysplasia of the hip aims at early diagnosis and treatment. It is claimed that adequate acetabular remodeling is possible only during the first 18 months of life. After this, satisfactory development cannot always be assured by non-operative treatment following closed reduction *(35)*. Many methods of management have been described, but all have complications and result in a proportion of hips which develop imperfectly *(49)*. Albiñana and others *(1)* noted that 80% of hips with an acetabular index of 35 degrees or more 2 years after reduction had a poor outcome.

There are a variety of described operative procedures to address acetabular dysplasia. These

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No benefits or funds were received in support of this study.
The authors report no conflict of interests.

are logically divided into those that redirect the acetabulum, such as the Salter osteotomy *(36),* triple osteotomies *(40,44),* Ganz osteotomy *(14),* double innominate osteotomy *(41),* and those that reshape the acetabulum : the Pemberton *(29)* and Dega osteotomies *(6) ;* and augmentation procedures, such as the shelf and Chiari osteotomies *(4).* The ultimate goal in any of these is to provide a stable, congruent, and functional joint, preferably with normalized anatomy *(46,23).* 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 *(5).* The iliac osteotomy described by Dega in Poland in 1969 *(17)* is an acetabuloplasty that changes the acetabular configuration and its inclination. This allows an adequate acetabular coverage for anterior, lateral, and mainly posterior deficiencies *(28).*

In his 1969 German publication, Dega did not provide a detailed written description of the supra-acetabular semicircular osteotomy, but he did emphasize that the medial iliac cortex was not to be cut in any area, to guard against the possibility of the acetabular fragment displacing medially in a "manner consistent with a Chiari osteotomy". The supra-acetabular semicircular osteotomy starts 1 to 1.5 cm cephalad to the acetabular rim and extends obliquely medially toward the triradiate cartilage, but it does not penetrate the inner cortex of the ilium. This osteotomy was described, and schematically represented, as a semicircular cut through the lateral wall of the ilium directed toward but not through the medial cortex of the ilium. This earlier supra-acetabular osteotomy unequivocally did not transect the inner cortex of the ilium. It did, however, establish a basis for the subsequent development of what Dega termed a transiliac osteotomy *(17).* This description emphasized the importance of maintaining an intact sciatic notch hinge while simultaneously cutting the inner iliac cortex over both its anterior and its middle extent. Unfortunately, the accompanying schematic illustrations in the 1974 publication do not accurately match the written description of the incomplete transiliac osteotomy *(16,38).*

The aim of this work is to analyze a group of patients with DDH treated by combined open reduction and Dega transiliac osteotomy to evaluate the results and determine the advantages and disadvantages, as well as, assess the factors affecting the final outcome of such procedure.

PATIENTS AND METHOD

A prospective study was conducted during the period, from November 2010 to October 2014, on 39 hips, in 29 children, with neglected developmental dysplasia of the hip after walking age, either diagnosed late or after failure to respond to previous non operative treatment, treated by combined open reduction and Dega transiliac osteotomy with other associated surgical procedures. Patients who had a neuromuscular disease, a connective tissue disorder, or an infection of the hip, and patients with residual dysplasia following previous operative treatment, were excluded from this study. The mean age at the time of surgery was 27.6 months ranging from 18 to 48 months. There were 24 girls (82.8%) and 5 boys (17.2%). Ten patients had bilateral hip involvement (34.5%) and 19 patients unilateral involvement (65.5%). In unilateral cases, the left side was affected in 14 hips (48.3%) and the right in 5 hips (17.2%).

All patients in this study were subjected to history taking which was obtained from the parents, pre-operative clinical examination and radiological examination. The height of dislocation was classified according to the method described by Tönnis *(45).* In our study, only 2 hips were grade 2 (5.1%), 8 hips were grade 3 (20.5%) and 29 hips were grade 4 (74.4%). The acetabular index ranged from 36° to 47° with a mean average of 41.6° (SD ± 3.2°). The center-edge angle ranged from -144° to -23° with a mean average of -77.7° (SD ± 28.1°).

In our study, all hips fulfilling the criteria of inclusion had a combined open reduction, capsulorrhaphy and Dega transiliac osteotomy. Concomitant surgical procedures such as : hip adductor tenotomy, femoral shortening were done according to the intraoperative requirements. Adductor tenotomy was done in all hips, either using the open technique in 24 hips (61.5%), or the percutaneous technique in 15 hips (38.5%). Femoral shortening was performed through a separate lateral approach for the proximal femur, in 14 hips (35.9%). None of the hips required varus or derotation to be combined with femoral shortening. All operations were done under general anesthesia on a radiolucent table. The patient was in supine position with slight elevation of the affected side by placing a roll under the ilium. The entire lower limb and the affected half of the pelvis was prepared and draped. In all hips operated, the anterior approach to the open reduction of the hip was performed through an oblique incision ("bikini" incision).

The exposure of the iliac bone was performed by one of two ways according to the surgeon's preference :

1. Iliac apophysis splitting : The insertion of the oblique abdominal muscles was feathered off using electrocautery. The apophysis was palpated, and a scalpel was used to split the cartilaginous apophysis longitudinally in its center *(36)*.

2. Iliac aopophysis reflection : The abductor muscles were sharply reflected off of the lateral wall of the ilium just distal to the iliac apophysis. The apophysis itself was not split, but it was detached laterally at the junction of cartilage and outer bony table, from the anterior superior iliac spine to the posterior crest. Then the whole iliac apophysis was displaced medially *(18)*.

For open reduction, the rectus femoris was dissected from the underlying joint capsule, and its conjoint tendon was divided and retracted distally. The joint capsule was dissected with a periosteal elevator medially from the ilium and from any false acetabulum down to the true acetabulum, and laterally from the abductor muscles. The capsule was exposed superiorly around to the posterior aspect to facilitate capsulorrhaphy, and inferiorly to its insertion into the bottom of the acetabulum. The psoas tendon was identified as it crosses the superior pubic ramus just medial to the anteroinferior iliac spine. The tendon fibers were divided, leaving the muscle intact, taking care to protect the nearby femoral nerve. The capsule was incised parallel with and about 1 cm distal to the rim of the acetabulum, then incised at right angle to the first incision, thus creating a T-shaped incision. Kocher clumps were used to retract the capsule and expose the femoral head and the ligamentum teres. The ligamentum teres was detached from the femoral head and grasped with a Kocher clamp. The ligamentum teres was traced down to the true acetabulum and to the transverse acetabular ligament, and excised. The transverse acetabular ligament was divided to enlarge the inferior aspect of the acetabulum, and any pulvinar in the true acetabulum was excised using a rongeur or sharp dissector. For an inverted, hypertrophied labrum, several radial incisions in the labrum were made to enlarge the acetabulum and allow reduction of the femoral head.

The hip, then, was allowed to redislocate. Next, the Dega osteotomy was performed to decrease acetabular dysplasia and to enhance containment of the femoral head. The orientation of the osteotomy was first marked on the lateral cortex of the ilium. The direction of the osteotomy is curvilinear when viewed from the lateral cortex, starting just above the anterior inferior iliac spine, curving gently cephalad and posteriorly to reach a point superior to the midpoint of the acetabulum, and then continuing posteriorly to end approximately 1 to 1.5 cm in front of the sciatic notch. Leaving the sciatic notch intact prioritizes anterior and lateral coverage, whereas leaving a portion of the inner table and entering through the notch allows more posterior coverage. The direction of required coverage is determined intraoperatively from direct observation of the hip joint. A more cephalad starting point and a steeper osteotomy angle allow for more lateral coverage. Finally, the closer the osteotomy is to the acetabulum, the thinner and more pliable will be the acetabular fragment, theoretically allowing for more reshaping and less redirection to occur. The most cephalad extent of the osteotomy is in the middle of the acetabulum, at a point on the ilium determined by the steepness of the acetabulum. Very steep acetabular inclinations required correspondingly a higher midpoint. A guidewire was inserted under fluoroscopic control at the most cephalad point of the curvilinear marking line, directed caudally and medially to ensure that the osteotomy will exit at the appropriate level just above the horizontal limb of the triradiate cartilage. A straight 0.25 or 0.5-in (0.64 or 1.3-cm) osteotome was used to perform the bone cut, which extends obliquely medially and inferiorly, paralleling the guide-wire to exit through the inner cortex just above the iliopubic and ilioischial limbs of the triradiate cartilage. With experience, the osteotomy cut might be performed safely without fluoroscopic guidance, as per Dega's original description ; however, we preferred to use fluoroscopy.

A half inch osteotome or small laminar spreader was then used to gently lever open the osteotomy site either anteriorly or laterally in a controlled manner. While the osteotomy site was being opened, the osteotomy cut on the outer cortex of the ilium propagates toward the sciatic notch as a greenstick fracture. However, since the posterior portion of the inner cortex is still intact, the outer cortical greenstick fracture does not weaken the recoil and stability at the osteotomy site. The osteotomy site was kept open by inserting two correctly sized bone grafts. The correct graft height was determined by simply noting the opening of the osteotomy gap created by the laminar spreader or the levering osteotome. In congenital dysplasia, acetabular deficiency is most pronounced anteriorly, mandating placement of the larger graft more anteriorly. A smaller graft is then wedged more posteriorly, just in front of the intact sciatic notch. Care was taken to ensure that both grafts are of an appropriate height and that the amount of correction of the dysplastic acetabulum provides enough coverage of the femoral head. The grafts were fashioned from a bicortical segment of iliac crest bone or, alternatively, if femoral shortening had been performed, the segment of the femur that was removed was utilized as a graft. In cases in which there was a substantial gap at the osteotomy site, autogenous femoral or iliac crest graft were not sufficient. Under these circumstances, the height of the graft was increased by utilizing solvent bovine cancellous bone block (Tutobone block ®) cut into trapezoidal sections. In our series, iliac bone graft was utilized in 13 hips (33.3%), femoral bone graft was utilized in 14 hips (35.9%) and Tutobone block ® was utilized in 12 hips (30.8%).

Once the grafts were inserted, they became stable because of the inherent recoil at the osteotomy site produced by the intact sciatic notch. Metallic internal fixation was not necessary except in one hip, requiring fixation with 2 k-wires. Variations in the graft size and placement, extent of the outer and inner cortical cuts, and thickness of the acetabular fragment make it possible to both reorient and reshape the acetabulum. Next, capsulorrhaphy was performed by suturing the lateral flap of the T-shaped incision as far medially as possible beyond the anterior inferior iliac spine. The two halves of the iliac epiphysis were sutured together over the iliac crest, or reduction of the displaced epiphysis over the iliac bone, according to the approach used. The rectus femoris and the sartorius were sutured to their origins. Next, the subcutaneous tissue and skin were closed with a continuous subcuticular suture. Postoperative each patient was immobilized in one and one-half hip spica cast with the hip in slight flexion, approximately 10 degrees of internal rotation and 20°-30° abduction.

A radiograph of the hips through the cast was obtained before the child was discharged from the hospital. Another set of radiographs was obtained 2 to 3 weeks after surgery to ensure that the graft has not collapsed or dislodged. The cast was removed after 8-12 weeks depending on the healing of the osteotomy site. Range-of-motion exercises were started and full weight bearing was resumed 3 weeks after removal of plaster, provided that knee range of motion is greater than 90 degrees. All hips in this study were followed up clinically and radiologically for a mean period 33.6 months (range from 18 to 48 months). No patient was lost to follow up. Clinical results were determined by using McKay's criteria modified by Berkeley et al *(3)*. Radiological results were classified according to modified Severin's criteria *(19)*. (Table 1, 2)

Data was analyzed using SPSS (Statistical Package for Social Sciences) version 15. Qualitative data was presented as number and percent. Comparison between groups was done by Chi-Square test. Quantitative data was presented as mean ± SD and range (min – max). Paired t-test was used for comparison within groups. Student t-test was used to compare between two groups. F-test (One Way Anova) was used to compare between more than two groups. Spearman's correlation coefficient was used to test correlation between variables. $P < 0.05$ was considered to be statistically significant.

Table 1. — McKay's criteria modified by Berkeley et al (1984)

Grade	Rating	Criteria
I	Excellent	Stable, painless hip, no limp, negative Trendlenburg's sign, full range of motion (more than 15 degrees internal rotation).
II	Good	Stable, painless hip, slight limp, slight decrease in range of motion, negative Trendlenburg's sign,.
III	Fair	Stable, painless hip, limp, positive Trendlenburg's sign, and limited range of motion or a combination of these.
IV	Poor	Unstable or painful hip, or both, positive Trendlenburg's sign.

Table 2. — Modified Severin`s criteria

Rating	Class	Criteria
Excellent	I	Normal hip appearance, center-edge angle >25°.
Good	II	Moderate deformity of the femoral head, neck, or acetabulum, concentric reduction, center-edge angle >25°.
Fair	III	Dysplastic hip, no subluxation, center-edge angle <20°.
Poor	IV	Subluxation of the femoral head.
	V	Articulation of the femoral head with a false acetabulum.
	VI	Redislocation

RESULTS

At the end of follow up the overall final clinical result was excellent in 28 hips (71.8%), good in 6 (15.4%), fair in 4 (10.3%) and poor in one hip (2.5%). Therefore, satisfactory results were obtained in 34 hips (87.2%) and unsatisfactory in 5 (12.8%) according to the McKay's criteria. Radiologically, 17 hips (43.6%) were Class I (excellent), 15 (38.5%) were Class II (good), 5 Class III (fair) (12.8%) and 2 Class IV (poor) (5.1%). Therefore, satisfactory results were obtained in 32 hips (82.1%) and unsatisfactory in seven (17.9%), according to Severin's radiological criteria. The acetabular index (AI) was improved in all hips at final evaluation. The pre-operative radiographs revealed an average AI of 41.6º ranging from 36º to 47º (Std. Deviation 3.2). AI measured at the end of follow up was reduced to an average of 18.4º, ranging from 10º to 29º (Std. Deviation 4.7). The average improvement in the acetabular index was 23º, ranging from 13º to 33º (Std. Deviation 5.7). There was statistically significant improvement after surgery (t= 25.261, p=0.00). The Center Edge Angle (CEA) pre-operatively was negative in all hips with average -77º, ranging from -144º to -23º (Std. Deviation 28.1). The average CEA at the final follow up was 27.1º, ranging from -8º to 54º. The average improvement in the CEA was 104.7º, ranging from 41º to 186º (Std. Deviation 33.8). There was statistically significant improvement after surgery (t= -19.362, p=0.00).

The average femoral shortening was 1.2 cm (range, 1 to 2). Although femoral shortening was necessary for femoral head reduction in 14 hips (35.9%) in this study, the overall final result was not significantly affected by the femoral shortening as a combined procedure (p=0.259). We noticed in our study that none of the hips with Tönnis Grade 2 dislocation required femoral shortening, only one hip with Tönnis Grade 3 dislocation required femoral shortening and 13 hips with Tönnis Grade 4 dislocation required femoral shortening. Though this was not statistically significant (P=0.133).

There were 17 hips (43.6%) with Severin's class I ; all (100%) had satisfactory clinical results. In 15 hips (38.5%) with Severin's class II, 13 (86.7%) had satisfactory clinical results and two (13.3%) had unsatisfactory results.In 5 hips (12.8%) with Severin's class III ; 4 (80%) had satisfactory clinical results. Two hips (5.1%) with Severin's class IV finally had unsatisfactory clinical results. There was a statistically significant relation between the final radiological and clinical results (P= 0.00).

Complications

Two hips (5.1%) had resubluxation and had an unsatisfactory result. One patient (3.4%) had a distal femoral fracture during the early period of mobilization after cast removal. One hip (2.6%) developed avascular necrosis (AVN) of the femoral head at the time of final examination and was classified type 4 according to the Kalamchi and McEwen classification, and was complicated also by a resubluxation of the femoral head. Three hips (7.7%) developed AVN type 3, six hips (15.4%) AVN type 2 and seven hips (17.9%) AVN type 1. Only four of them showed unsatisfactory final outcome, while the remaining were satisfactory. One hip (2.6%) was complicated, intraoperatively, by a major vascular injury. Repair of the superficial femoral artery was done by the vascular surgeon, with satisfactory final clinical and radiological outcome.

DISCUSSION

Several types of pelvic osteotomies to stabilize the reduced hip in older children have been described. Currently, incomplete transiliac acetabuloplasty with the use of the technique of Dega and the complete pelvic osteotomy of Salter are most often performed. When the dysplasia is severe, Dega osteotomy is the procedure of choice as it provides more correction to the acetabular index, while, when the dysplasia is mild to moderate, Salter osteotomy can provide satisfactory correction, but caution should be taken during Salter osteotomy when combined with femoral derotational osteotomy to avoid posterior subluxation of the femoral head *(13)*. In our study, the average improvement in the acetabular index was 23º, ranging from 13º to 33º (Std. Deviation 5.7). There was statistically significant improvement after surgery ($t=25.261$, $p=0.00$).

In the late presenting high dislocations, it is always necessary to provide stability without tension which is achieved by performing a concomitant femoral shortening osteotomy. Currently, the trend is to avoid the use of pre-operative skeletal traction. Schoenecker and Strecker *(37)* found this femoral diaphyseal shortening to be superior to traction as an aid in operative reduction of developmental dysplasia of the hip with a decreased rate of the development of avascular necrosis and a decreased rate of redislocation when compared with skeletal traction. Tönnis *(45)* concluded that sufficient shortening and dissection of the iliopsoas and rectus femoris tendons are of great importance in preventing increased pressure and ischemic necrosis. In our study, we found femoral shortening to be needed in 14 hips (35.9%). Twelve hips (85.7%) had satisfactory clinical results and two (14.3%) had unsatisfactory results. Twenty five hips (64.1%) did not require femoral shortening. Twenty two (88%) had satisfactory clinical results and three (12%) had unsatisfactory results. The overall final clinical results was not significantly affected by the femoral shortening as a combined procedure ($p=0.259$). Also, we noticed that none of the hips with Tönnis Grade 2 dislocation required femoral shortening, only one hip with Tönnis Grade 3 dislocation and 13 hips with Tönnis Grade 4 dislocation required femoral shortening. Though, this was not statistically significant ($P=0.133$).

Some authors have advocated the use of a derotational osteotomy with almost all open reductions, as excessive femoral anteversion very often accompanies the dislocation. Nevertheless, many surgeons elect simply to perform open reduction since femoral rotation will be spontaneously corrected with growth. Specific criteria for derotational osteotomy have yet to be established *(26)*. In our study, none of the operated hips required varus or derotation to be combined with femoral shortening.

In our study, 29 patients (39 hips) with developmental dysplasia of the hip were treated by combined open reduction and Dega transiliac osteotomy with or without femoral shortening. The age ranged from 18 months to 48 months. Thirty four hips (87.2%) and 32 hips (82.1%) had a satisfactory (good or excellent) clinical and radiological results respectively at the final follow up. The study of Galpin et al *(13)* involved the treatment of 33 hips in 25 patients 2 years of age or older with idiopathic developmental dysplasia of the hip. Twenty-one patients underwent a procedure involving an open reduction and combined femoral and pelvic osteotomies. They reported satisfactory clinical and radiographic results in 85% and 75% of their patients respectively. Other authors have reported similar results with the Salter innominate osteotomy *(2,7,9,31,35,47)*, or the Pemberton acetabuloplasty *(10,11)*. Results of the Dega acetabuloplasty have been reported by Dega *(6)*, Franke et al *(12)* and Synder and Zwierzchowski (42). Ruszkowski K and Pucher A (33) studied retrospectively 33 hips in 26 children at an average of 9 years 5 months after simultaneous open reduction and Dega transiliac osteotomy for developmental dislocation of the hip . All children were younger than 2 years of age at surgery. At the latest follow-up 89% of the clinical results and 72% of the radiographic results were rated excellent or good. Comparison of our results to those reported was not reasonable because of differences in the patient populations and other variable criteria. Most of these studies have used either only absolute radiographic hip parameters, such as the acetabular center-edge angle of Wiberg (48) or a combination of measured and described radiographic criteria, such as the Severin classification (39). Although the reported measurements are close to the results presented here.

The theoretical location of the hinge in the Dega osteotomy can involve, to varying degrees, the sciatic notch, the posterior portion of the inner pelvic cortex, the horizontal limb of the triradiate cartilage, and the symphysis pubis. Since the hinge point is variable and not confined solely to the triradiate cartilage, it is believed that the risk of damage to this structure is lower than it is with other incomplete transiliac osteotomies, such as those of Pemberton (29) and Perlik et al. (30). In our study, we did not report any case of triradiate cartilage injury. Special care should be taken when placing the tricortical graft in the Dega procedure, as it should be placed where it can be supported by the lateral cortical layer of the iliac osteotomy. If it is completely introduced over the cancellous bone it may produce graft impaction and the acetabular index correction will be reduced. This occurred in two hips, where we could not observe an important improvement of the acetabular index because of a faulty graft placement technique. These results are similar to those obtained by previous series done by Lopez-Carreno E et al, (24).

In our series, two hips (5.1%) had resubluxation of the hip and had an unsatisfactory result. The incidence was compared with studies that used a combined open reduction and pelvic osteotomy in treatment. Rudolf et al (32) reported three redislocations (5.5%) in 54 hips after surgical treatment of congenital dislocated hips by open reduction, femoral and pelvic osteotomies. Grill (15) reported 12 redislocations and resubluxations (24%) in 50 hips. Ruszkowski K and Pucher A (33) reported one redislocatation (3%) among 33 hips in 26 children. Grudziak (17) reported that only one of his 24 hips (4%) had a redislocation and it ended by having an excellent final result. Ryan et al (34) reported 7 out of 25 hips (28%) having resubluxation and redislocation. Salter and Dubos (35) reported 13 (43%) of thirty hips resubluxed or redislocated.

In our study, there was one patient (3.4%) who had a distal femoral fracture during the early period of mobilization after cast removal. Grill (15) reported five of 50 hips (10%) having distal femoral fractures. Zadeh et al (50) reported that eight of 92 hips (8.7%) had femoral fractures. This type of fracture is more liable to occur after cast removal due to a long period of immobilization. However, it was easily treated by a short period of cast immobilization with good healing and remodeling.

One hip (2.6%) in this study developed avascular necrosis of the femoral head at the time of final examination and was classified type 4 according to Kalamchi and MacEwen (20) classification, and was complicated also by a resubluxation of the femoral head. 3 hips (7.7%) developed AVN type 3, 6 hips (15.4%) developed AVN type 2 and 7 hips (17.9%) developed AVN type 1. Only 4 of them showed unsatisfactory final outcome, while the remaining were satisfactory. Domzalski (8) reviewed the medical records of 101 patients (144 hips) with developmental dysplasia of the hip who were treated with Dega's (102 hips), or Salter's (42 hips) osteotomy with open reduction and femoral intertrochanteric osteotomy. The minimal follow-up was 17 years. At the last follow-up, there were proximal femoral growth disturbances in 52 hips (36%). Zionts and MacEwen (51) identified major AVN in two (5%) of their patients after a follow up period from 5 to 20 years with an average of 12 years. Ryan et al (34) reported 11 out of 25 hips (44%) having avascular necrosis after an average 10 years and six months follow up. Karakas et al (21) reported 4 (7%) out of 56 hips having avascular necrosis after a mean follow up period of 7.5years (range, 2-16 years).

This variation in the incidence of avascular necrosis between different studies may firstly be attributed to the classification system used and the strictness with which the criteria were interpreted. Thomas CL et al. *(43)* suggested that the actual prevalence of growth disturbances may vary less than the criteria with which they are defined. For example, Mau et al *(27)* reported only two instances of AVN after a follow up duration from two to four and half years, but 16 of 33 patients were noted to have "transient radiographic changes in the femoral heads". Similarly, Zionts and MacEwen *(51)* identified major AVN in approximately 5% of their patients, but also noted "temporary irregular ossification" in one third. Secondly, the prevalence of growth disturbances goes up with the length of the follow-up, since many changes become apparent relatively late. Studies with longer follow-up even after conservative treatment or isolated open reduction report a higher rate of AVN *(22,25)*. Thirdly, different regimes of conservative and surgical treatment may influence the prevalence of AVN. It is impossible to compare angle and tension of applied traction, as well as force and technique used to perform a closed reduction. Furthermore, regarding the surgical technique, the most important is not the method of osteotomy but the surgeon's skills. The lower incidence of AVN in this study may be attributed to the proper adjustment of the tension applied on the femoral head during open reduction, also the frequent use of femoral shortening. Although the results are encouraging in this study, a longer term follow up is needed as AVN cannot be excluded up to years after treatment.

In conclusion, the results of our series show open reduction combined with Dega transiliac osteotomy to be a safe and efficient method for the surgical treatment of DDH in selected patients, and can easily and safely be combined with associated procedures for single stage correction of acetabular dysplasia.

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