Dega osteotomy for the treatment of developmental dysplasia of the hip

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Received 18 March 2016
Accepted 18 December 2016

The Egyptian Orthopaedic Journal
2017, 52:38–44

Background
The neglected developmental dysplasia of the hip with adaptive changes in bone and soft tissue is difficult to treat. Dega osteotomy is added to open reduction to confer concentric stable reduction with good coverage of the head of the femur.
Patients and methods
Forty hips in 32 patients were treated using open reduction and Dega osteotomy. There were 30 dislocated and 10 subluxated hips according to Tonnis grading. Radiographic parameters used in this study included the acetabular index, the acetabular angle of sharp, the caput-collum-diaphyseal angle, and the center-edge angle of Wiberg; the final radiographic outcome was evaluated according to the Severin classification. Clinical results were evaluated according to the modified McKay criteria.
Results
The mean follow-up period was 96 months. The final results according to Barrett's modification of McKay's criteria were as follows: 34 (85%) with favorable results and 6 (15%) hips with unfavorable results. According to the Severin criteria for the evaluation of radiographic results, 74% were types I and II whereas 26% showed types III and IV; no hips were rated as Severin's groups V or VI. Eight (33.4%) hips in children with unilateral involvement had developed coxa magna, but in no case did this interfere with hip concentricity. Three hips showed avascular necrosis on the latest radiographs.
Conclusion
The Dega osteotomy added to the open reduction, capsulorrhaphy, and femoral shortening is a safe, simple, and adequate procedure for the management of neglected developmental dysplasia of the hip patients after 2 years of age, with lower complication rates. Restoring the acetabulum to normal or nearly normal can result in good long-term results.

Keywords:
Dega, developmental dysplasia, hip

Egypt Orthop J 52:38–44

1110-1148

Introduction

The treatment of developmental dysplasia of the hip (DDH) in the older walking patients is difficult because of adaptive shortening of the extra-articular soft tissues, acetabular dysplasia, capsular constriction, increased femoral anteversion, and fixed inversion of the limbs [1].

Open reduction can be performed with or without femoral and/or pelvic osteotomy. The one-stage procedure (open reduction, capsulorrhaphy, and innominate osteotomy) is preferred by many authors. In those late presenting children, a pelvic osteotomy is needed to achieve a stable concentric reduction [2]. The types of innominate osteotomies can be divided into two main types: complete and incomplete. The Salter [3] osteotomy is an example of complete transiliac osteotomy and Pemberton [4] osteotomy is an example of incomplete pelvic osteotomy [5].

The Dega osteotomy is one of the most commonly used osteotomies in the management of DDH. Dega described two different types of incomplete transiliac osteotomies. Dega's initial osteotomy was first mentioned briefly in a 1964 German publication [6], but it was not until 1969, in a Polish publication, that he first referred to this initial osteotomy as a supra-acetabular semicircular osteotomy [7].

The aim of this prospective study is to evaluate the results of Dega osteotomy, the remodeling potential of the triradiate after the osteotomy, and the hip function after a minimum of 7 years of follow-up in terms of symptoms and signs of hip arthrosis.

 DOI: 10.4103/eoj.eoj_14_17

Patients and methods

Between May 1996 and November 2003, 40 hips (32 patients; 24 unilateral and eight bilateral) were treated using open reduction and Dega osteotomy (20 females and 12 males). This prospective study was conducted at Zagazig University Hospitals, after approval of our ethical committee for research in accordance with the ethical standards laid down in the 1964 declaration of Helsinki and its later amendments.

The mean age of the patients at the time of the operation was 3.5 years (2–8 years); 28 (70%) were left sided and 12 (30%) were right sided. Written consent was obtained from the patients' parents for all cases. Among the included hips were 30 dislocations (Tonnis grades 4 and 3) and 10 subluxated hips (Tonnis grade 2) [8] (Table 1).

Previous management for the hips studied included failed trial of closed reduction.

Six (15%) hips failed open reduction and capsulorrhaphy through an anterior approach (four hips; 10%). Of the included hips, 30 (75%) were virgin-neglected hips with no history of previous treatment.

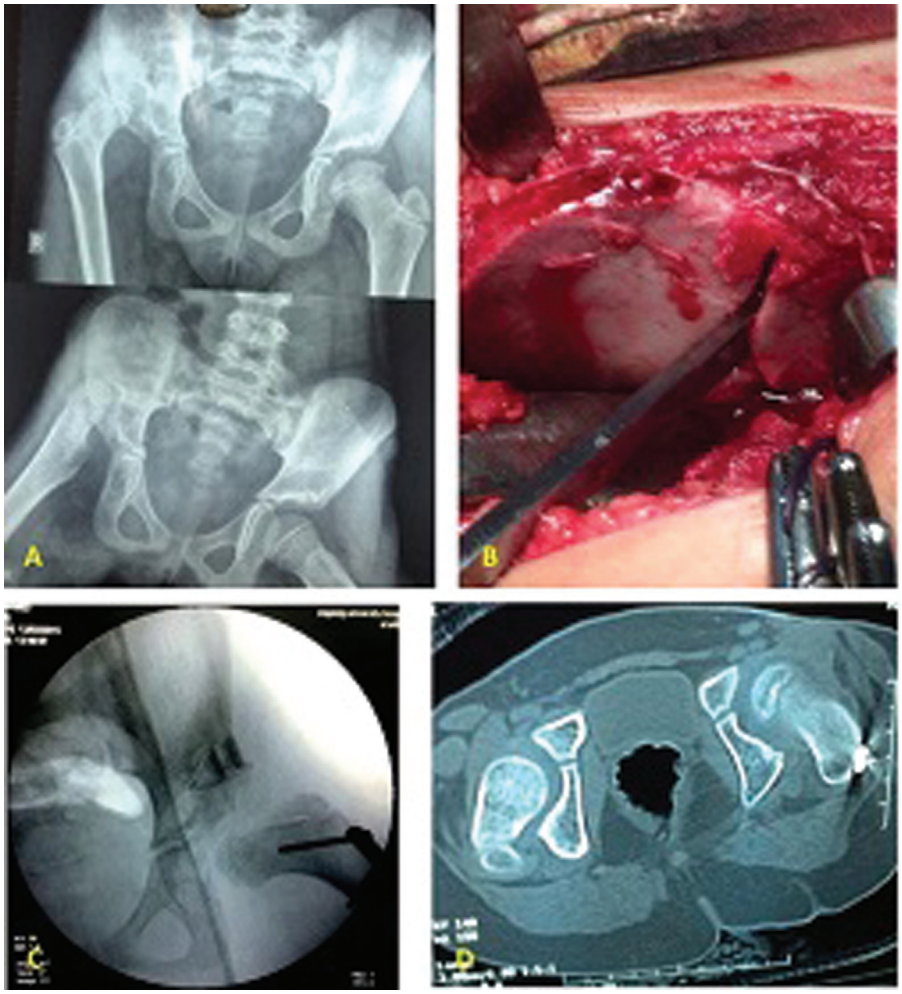
The 'bikini' skin incision (modified Smith–Peterson) was used in all cases.

The Dega osteotomy was performed as described by Dega [7] in his original paper; this was ensured under strict fluoroscopic guidance. A tricortical iliac crest graft (30%) or a fashioned graft from the femoral shortening-osteotomy was then inserted at the

Table 1 Preoperative Tonnis classification of operated hips

Tonnis grades	*N* (%)
Grade 1	0 (0)
Grade 2	10 (25)
Grade	38 (20)
Grade 4	22 (55)
Total	40 (100)

Figure 1



Male patient with right side DDH: A) preoperative AP and Lateral X- Ray; B) Intraoperative photo for Dega osteotomy; C) Intraoperative radiograph for the osteotomy and reduction; D) postoperative C T scan for reduction of hip joint.

osteotomy site. Femoral shortening was performed in 28 (70%) hips. Stabilization of the femoral osteotomy was performed using small dynamic compression plates in all cases. A hip spica cast was applied immediately after surgery for all the hips for at least 6 weeks and the hip spica was removed only after healing of the osteotomy site.

The average operating time was 135 (range: 110–160) min. The average blood loss was 300 (range: 250–450) ml. The follow-up period ranged from 84 to 108 (mean: 96) months.

Anteroposterior and lateral views plain radiograph were made immediately postoperatively, after 6 weeks or at removal of the spica cast, and then at 6-month intervals until the last follow-up.

A computed tomographic scan was performed for all patients to check the adequacy of the reduction within 1 week after the surgery (Fig. 1).

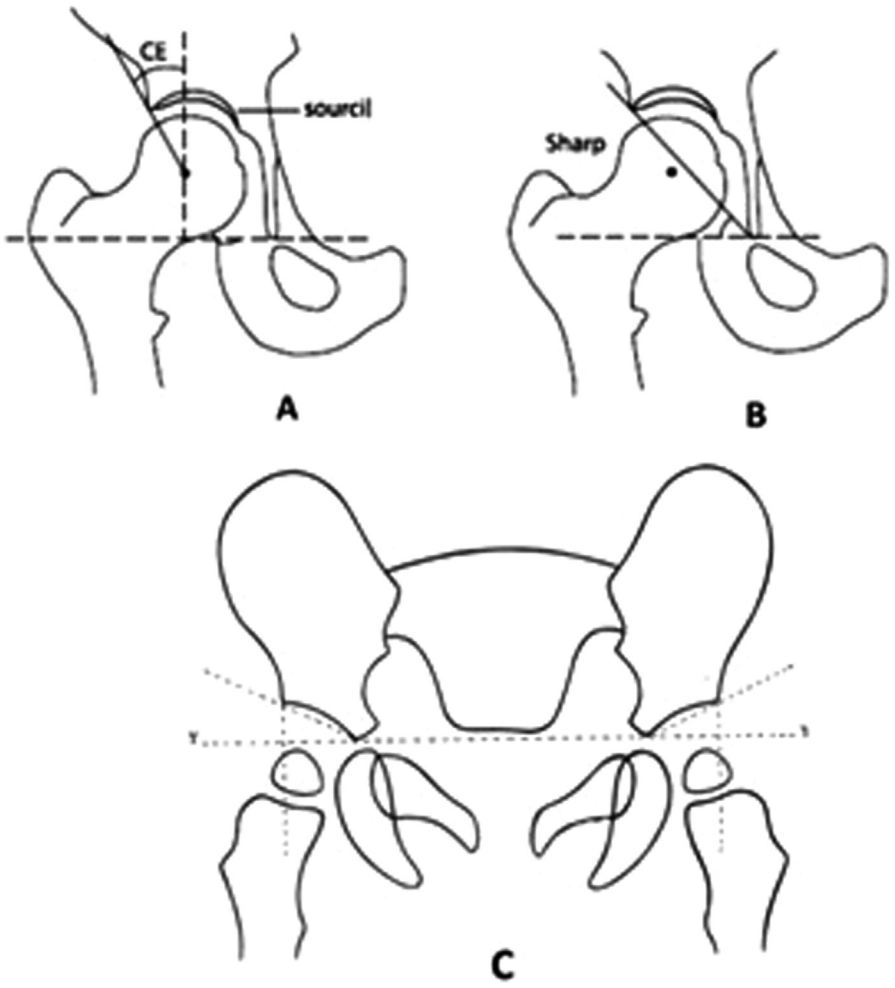
After assessment of radiographic healing of the osteotomy site, progressive weight bearing was begun. Walking was allowed 4 months after surgery.

Other radiographic parameters used in this study included the acetabular index (AI), the acetabular angle of sharp [9], the caput-collum-diaphyseal angle [10], and the center-edge angle (CEA) of Wiberg [11]; the Shenton line was evaluated to assess the femoral head/acetabulum relationship (Fig. 2) [10].

Preoperatively, the presence of avascular necrosis (AVN) of the femoral head was determined using the criteria of Salter and Severin [12,13].

The function of the hip, the range of motion, and limb-length discrepancy were recorded; at the final follow-up, all clinical data were recorded and the results were evaluated according to the modified McKay criteria [14]. According to these modifications, excellent results included stable and painless hip, with a full

Figure 2



A diagram for measurement of three angles used for follow up and evaluation of acetabulum after osteotomy and reduction: A) Center edge angle (CEA); B) Angle of Sharp; C) Acetabular index (AI) [16].

range of motion and a negative Trendelenburg sign; good results included a negative Trendelenburg sign with a mild restriction of movement (slight loss of the normal hip range of motion); fair results included a moderate stiffness and a positive Trendelenburg sign, but stable and painless; and poor results included ultimately unstable, painful hip, and/or requirement for further surgical intervention.

Statistical correlation and significance between variables were calculated using the χ^2-test, Fisher test, or t-test.

Results

The final clinical evaluation of the studied hips was performed according to Barrett's modification of McKay's criteria [14]; 18 (45%) hips showed excellent results. Sixteen (40%) hips showed good results. Four (10%) hips showed fair results. Finally, two (5%) hips showed poor results (Table 2).

There was a statistically significant correlation between the final clinical outcome and the age of the patients at the time of surgery; the younger the age of the patient at the time of the index surgery, the better the final clinical outcome. The correlations between the final clinical outcome and the Tonnis preoperative grade of hip dislocation as well as the final radiographic outcome were also found to be significant.

Radiographic evaluation

According to the Severin criteria for the evaluation of radiographic results, 74% were types I and II whereas 26% showed types III and IV; no hips were rated as Severin's group V or VI (Table 3).

Both clinical and radiographic average results were compared across the five subgroups (age at surgery, grade of dislocation, failed conservative treatment, and presence of ossific nucleus).

The mean preoperative AI in hips was 36.5° (range: 22–46°), and after surgery, the mean was 20° (range: 8–28°), which yielded an average descent of 15.5±4° (Table 4).

It was difficult to measure the (CEA of Wiberg) in most cases before the operation because there were 30 dislocated hips. The early postoperative values ranged from 10 to 35°, with a mean of 25°, but the values of the CEA showed further improvement at the final follow-up and ranged from 15 to 45°, with a mean of 35° (Table 4). In addition, the Shenton line was discontinuous before osteotomy in 80% of hips and after osteotomy continuity was observed in 90% [statistically significant difference ($P<0.05$) in the postoperative correction of the Shenton line].

The angle of Wiberg in the hips presented a post-surgery mean of 26±7°; this was statistically significant ($P<0.05$). The caput-collum-diaphyseal ranged from 115 to 156° (mean: 130°); compared with the preoperative assessment, it remained almost unchanged.

Nine (34.6%) hips in children with monolateral involvement had developed coxa magna, but in no case did this interfere with hip concentricity. Three hips showed AVN on the latest radiographs. Two hips were type II and one hip was type III in Bucholtz–Ogden system of AVN grading. Two of these hips had shown signs of AVN before surgery. One (3.8%) hip developed AVN after surgery.

Statistical analysis (Mann–Whitney test) of the differences in the distribution of excellent, good,

Table 2 The final clinical outcome on the basis of Barret's modification of McKay's criteria

Final clinical outcomes	Score	*N* (%)
Favorable (44 hips)	Excellent	18 (45)
	Good	16 (40)
Unfavorable (14 hips)	Fair	4 (10)
	Poor	2 (5)
Total		40 (100)

Table 3 The final radiographic outcome according to the Severin classification system

Severin grades	*N* (%)
Grade I	16 (40)
Grade II	14 (35)
Grade III	6 (15)
Grade IV	4 (10)
Total	40 (100)

Table 4 Radiographic evaluation of the studied cases

	Preoperative [mean (range)] (deg.)	Direct postoperative [mean (range)] (deg.)	Final follow-up [mean (range)] (deg.)	Notes
Acetabular index	36.5 (22–46)	20 (8–28)	23 (10–32)	
Acetabular angle of sharp	50 (30–60)	35 (25–50)	40 (30–50)	
CEA of Wiberg	–	25 (10–35)	35 (15–45)	

CEA, center-edge angle.

Figure 3

Male patient 11 years old with recurrent hip dislocation after a previous surgery: A) Preoperative X-Ray with right hip dislocated; B) intraoperative x-ray C) postoperative X-Ray after 3 months; D&E) x-ray after removal of all metals.

fair, and poor results within these categories did not show any significance.

Complications

Three (5%) hips showed AVN at the final follow-up examination, including the case with preoperative AVN. Residual acetabular dysplasia was found in six (15%) hips. Two (5%) hips required another surgery during the follow-up period. Dega osteotomy was performed again in one case at 25 months postoperatively. Chiari medial displacement osteotomy was performed in one hip at 102 months combined with proximal femoral varus osteotomy (Fig. 3).

Pain occurred in eight (20%) hips and led to surgery in two hips; in six hips, the pain was tolerated by the patient, was managed adequately by conservative measures, and required no further surgical intervention.

The complications encountered in this study are shown in Table 5.

At the final follow-up period, 32 (80%) hips showed survival with a favorable outcome (excellent or good results) (Fig. 4).

Table 5 Complications

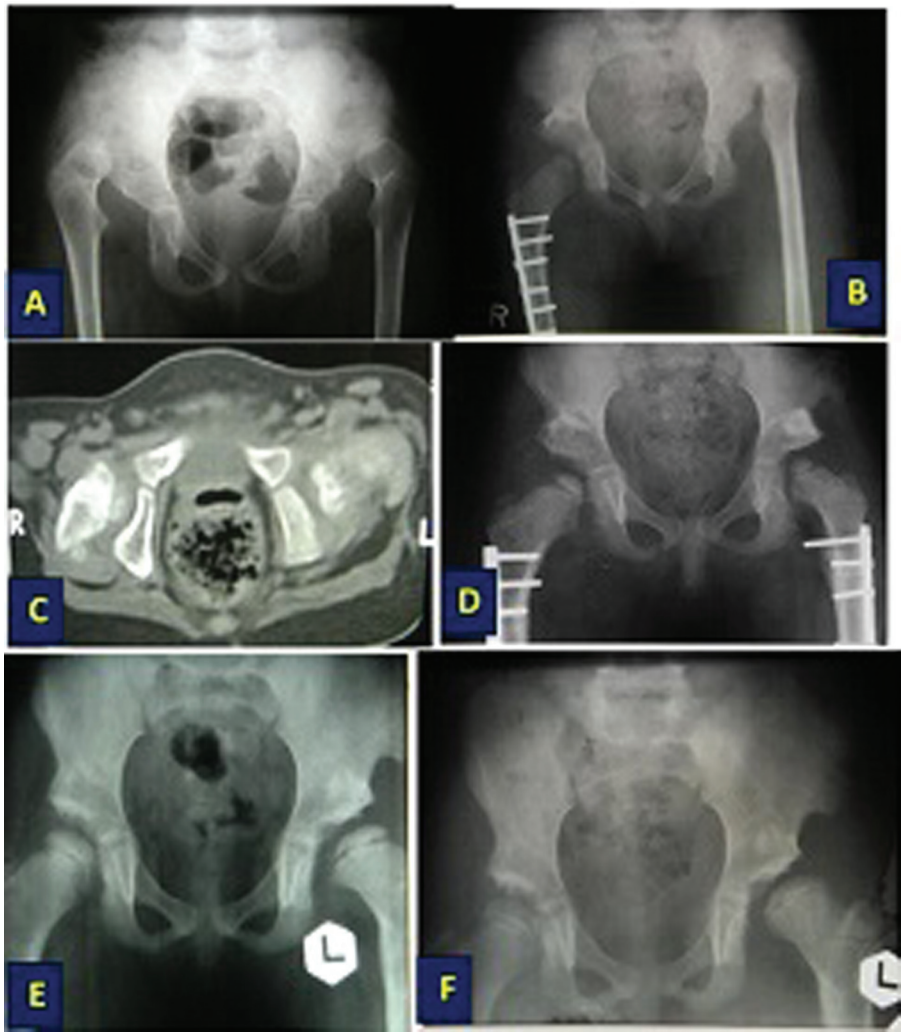
Complications	*N* (%)
Injury of superficial cutaneous nerve of the thigh	3 (7.5)
Superficial wound infection	2 (5)
Limb-length discrepancy of 2 cm	4 (10)
Avascular necrosis	2 (5)
Pain	8 (20)
Residual acetabular dysplasia	6 (15)
Need for another surgery	2 (5)
Positive Trendelenburg test	6 (15)

In terms of the degree of hip joint arthrosis at the final follow-up examination, 20 (50%) hips were considered normal and showed no signs of hip arthrosis (grade 0); in 10 (25%) hips, there were small spurs, with no joint space narrowing and slight abnormality (grade 1); in eight (20%) hips, joint space narrowing was found in addition to osteophytes (grade 2); and in two (5%) hips, severe hip arthrosis was found, with almost total loss of the joint space (grade 3 arthrosis).

Discussion

The Dega osteotomy is considered to be one of the common osteotomies performed by pediatric

Figure 4



Female patient with bilateral DDH: A) Preoperative X-ray; B) postoperative right side operated; C) C-T scan after reduction of right side; D) postoperative with 2 sides operated; E) X-ray after 3 years; F) X-ray after 6 years.

orthopedic surgeons. The long follow-up period is of special importance as it has been estimated that degenerative joint disease of the hip secondary to dysplasia, subluxation, and/or dislocation occurs in 20–50% of affected hips [15].

It was reported that normal values for the AI range from 33 to 40°, whereas angles of 47°are characteristic of patients with hip dysplasia [16]. In this study, the AI was used as one of the monitors of the acetabular remodeling after Dega osteotomy as the mean AI was significantly corrected from 36.5° (range: 22–46°) preoperatively to an average of 15.5±4° at the final follow-up of 108 months.

These results were comparable with the results in the series of El-Sayed *et al.* [1], in which the Dega osteotomy was performed for 58 hips, and they reported that growth of the acetabular index took place and was checked using the AI; this control showed a significant improvement from a mean preoperative AI of 39° to an immediate postoperative mean AI of 18°. These findings are comparable with the results of Reichel and Hein [17], and Karlen *et al.* [18].

The CEA in this study improved to a mean immediate postoperative value of 25°, but the values of the CEA showed further improvement at the final follow-up and ranged from 15 to 45°, with a mean of 35°. In this study, it was observed that hips with favorable (CEA) (Ia, Ib, II) were found to have no evidence of arthrosis in contrast to hips with unfavorable CEA (III–V) that showed a less favorable outcome and variable degrees of hip arthrosis. These findings were similar to the results of many studies [19–22].

Three (5%) cases developed AVN in this study. AVN is one of the major complications in DDH management, and there are differences in the rate of AVN reported in various studies. Some studies included only primary

untreated hips, others included only patients with a previous history of attempts of closed reduction, and some series included all patients with DDH, even those with a history of failed open reduction. As suggested by many authors, this might correlate directly to the type of pelvic osteotomy because of premature closure of the triradiate, which might also lead to residual acetabular dysplasia [1,19,20,22]. Controversy is still present in the literature about the upper age limit that is suitable for reduction in neglected cases of DDH. It was found that as long as the triradiate cartilage is still open and growing, there is a possibility of achieving a stable concentric reduction [1]. In this study, the final clinical evaluation according to Barrett's modification of McKay's criteria [14] was 85% favorable results (excellent and good) and 15% unfavorable results (fair and poor) results. There was a statistically significant correlation between the final clinical outcome and the age of the patients at the time of surgery; the younger the age of the patient at the time of the index surgery, the better the final clinical outcome.

Femoral shortening in older patients of DDH can facilitate easy reduction and reduce the tension on the proximal femoral epiphysis. In this series, femoral shortening was performed in 28 hips using the segment as a graft for the osteotomy site with good final results.

It was found in this study that the combination of an open reduction, capsulorrhaphy, femoral shortening, and Dega osteotomy is believed to be an adequate single-stage surgery in late presenting patients. Our results correlate with the findings of many authors [1,15,17,19,20] as the first operation of the patient is the golden chance for better results and a favorable outcome with fewer complications.

Conclusion

The Dega osteotomy added to the open reduction, capsulorrhaphy, and femoral shortening is a safe, simple, and adequate procedure for the management of neglected DDH patients after 2 years of age with lower complication rates. Restoration of the acetabulum to normal or nearly normal can result in good long-term results.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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