Salter versus Dega osteotomy after open reduction of developmental dysplasia of the hip in young children

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Background

Numerous pelvic osteotomies for the treatment of developmental dysplasia of the hip have been described.

Objective

To compare the outcome of two types of pelvic osteotomy, Salter and Dega, for the treatment of late-diagnosed developmental dysplasia of the hip.

Patients and methods

This prospective study included 32 patients (36 hips), 18 girls and 14 boys, mean age 2.3 ± 0.5 years. Patients were randomized for management with Salter or Dega pelvic osteotomy after open reduction and capsulorrhaphy with or without femoral shortening osteotomy. The Salter osteotomy group included 19 hips and the Dega osteotomy group included 17 hips. The median follow-up period was 12 months (range 9–20 months).

Results

We achieved an overall success rate of 88.9% in the 36 hips, with no significant difference between the two techniques (89.5% in the Salter group and 88.2% in the Dega group, $P=1.000$). Both techniques achieved comparable reduction of the acetabular index (20.3 ± 9.0° in Salter vs. 22.0 ± 8.9° in Dega group, $P=0.565$). There was no significant difference in the center-edge angle between the two groups (34.8 ± 13.0° in the Salter group and 37.4 ± 12.1° in the Dega group, $P=0.554$).

Conclusion

We achieved comparable results with Salter and Dega osteotomy. The latter has a further advantage of avoiding a second surgery required in the Salter technique to remove hardware.

Keywords:

Dega osteotomy, developmental dysplasia of the hip, Salter osteotomy

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Introduction

Developmental dysplasia of the hip (DDH) is an important cause of childhood disability. This disorder underlies up to 9% of all primary hip replacements and up to 29% of individuals 60 years of age and younger [1]. This term refers to a range of developmental hip disorders from a hip that is mildly dysplastic, concentrically located, and stable to one that is severely dysplastic and dislocated [2].

The primary aim of treatment is to achieve concentric reduction of the hip, thereby increasing the chances of a functionally and anatomically good outcome. Treatment of patients with DDH should be ideally carried out during infancy. If this was not possible, treatment has to be instituted as early as possible in childhood, preferably before the age 4 years, to take maximum advantage of the inherent remodeling capabilities of the hip joint [3].

If the hip remains dislocated and the child grows older, secondary changes around the hip create more difficulties to closed or open reduction. Thus, children older than 18 months of age with DDH usually require additional procedures to manipulate these secondary changes in the proximal femur and acetabulum. The current treatment approach consists of primary open reduction with a medial or an anterolateral approach, capsulorrhaphy, and simultaneous acetabuloplasty [4–6].

Numerous pelvic osteotomies for the treatment of DDH have been described [7]. Their objectives are to improve femoral head coverage and coxofemoral joint stability. The Salter osteotomy uses a single osteotomy line located at the inferior gluteal line. In this reorientation osteotomy, the acetabulum tilts in retroversion, improving the anterior and lateral coverage, but reducing the posterior coverage. Dega acetabuloplasty, through an incomplete osteotomy line, reduces the diameter of the acetabulum and improves the overall femoral head coverage. A drawback of the Salter technique is the need for another surgery to remove hardware, which is not required in the Dega technique.

The purpose of this study is to evaluate the use of two types of pelvic osteotomy: Salter and Dega, in conjunction with open reduction and/or femoral shortening in the treatment of late-presented DDH.

Patients and methods

This prospective study included 32 patients (36 hips) with DDH recruited from Abo-El-Reesh hospital between May 2007 and June 2009. Patients were included if they were below 3 years of age. Patients with teratologic, postseptic, syndromatic, or recurrent dislocation were not included in the study. Six hips had been treated previously by closed reduction and immobilization before walking age with an unsatisfactory outcome. The median follow-up period was 12 months (range 9–20 months).

The study included 18 girls and 14 boys, mean age 2.3 ± 0.5 years (range 1.5–3 years). Four patients had bilateral dislocation, whereas 19 had left-sided and 11 had right-sided dislocation. A positive family history was reported by the parents of only one patient (affected sister). Twenty-three children (71.8%) were delivered vaginally and nine (28.2%) were delivered by cesarean section. There were no other associated anomalies in the studied group. The main complaint was limping in unilateral cases and a waddling gait in bilateral cases.

Treatment protocol and randomization

All patients were treated by open reduction and capsulorrhaphy. Patients were randomized for further management with Salter or Dega pelvic osteotomy with or without femoral shortening osteotomy. The Salter osteotomy group included 19 hips and the Dega osteotomy group included 17 hips.

Operative technique

Provided the hip is stable in flexion and abduction, we performed Salter or Dega pelvic osteotomy after open reduction. A femoral shortening osteotomy was performed for 11 cases in the Salter osteotomy group and nine cases in the Dega osteotomy group.

Salter osteotomy

It consists of wide exposure of the sciatic notch cutting with a Gigli saw from beneath the notch to a point next to the anterior inferior iliac spine; this completes transiliac osteotomy cuts through the lateral and medial cortex of the iliac bone. Two K-wires are used to fix the osteotomy.

An intraoperative check radiograph was performed. The child was placed supine and an anteroposterior radiograph was taken. One criterion for a good osteotomy is the existence of a posterior hinge between the two iliac fragments with no diastasis or backward displacement of the distal fragment.

Postoperative immobilization

A plaster or a fiberglass hip spica cast is made, with the hip positioned in slight abduction and neutral rotation. In certain cases, the opposite limb is included to obtain better stability.

Table 1 Tönnis grading system

Grade 1	Capital femoral ossification center is medial to the Perkins line
Grade 2	Ossification center is lateral to the Perkins line but below the superior acetabular rim
Grade 3	Ossification center is level with the superior acetabular rim
Grade 4	Ossification center is above the superior acetabular rim

Table 2 Clinical manifestations of unilateral cases (n=28)

	N (%)
Lower limb-length discrepancy (LLD)	19 (67.9)
Abductor lurch	18 (64.3)
Positive Galeazzi sign	15 (53.6)
Positive Trendelenburg's sign	14 (50.0)
Tip-toe walking	3 (10.7)

Table 3 Modified McKay's clinical grading of the Salter group

Grades	Salter group (n=19)	Dega group (n=17)
Excellent	2 (10.5)	4 (23.5)
Good	15 (78.9)	11 (64.7)
Fair	2 (10.5)	1 (5.9)
Poor	0 (0.0)	1 (5.9)

Table 4 Severin's radiological grading of the Salter group

Grades	Salter group (n=19)	Dega group (n=17)
I	11 (57.9)	12 (70.6)
II	6 (31.6)	3 (17.6)
III	1 (5.3)	2 (11.8)
IV	1 (5.3)	0 (0.0)

Postoperative follow-up

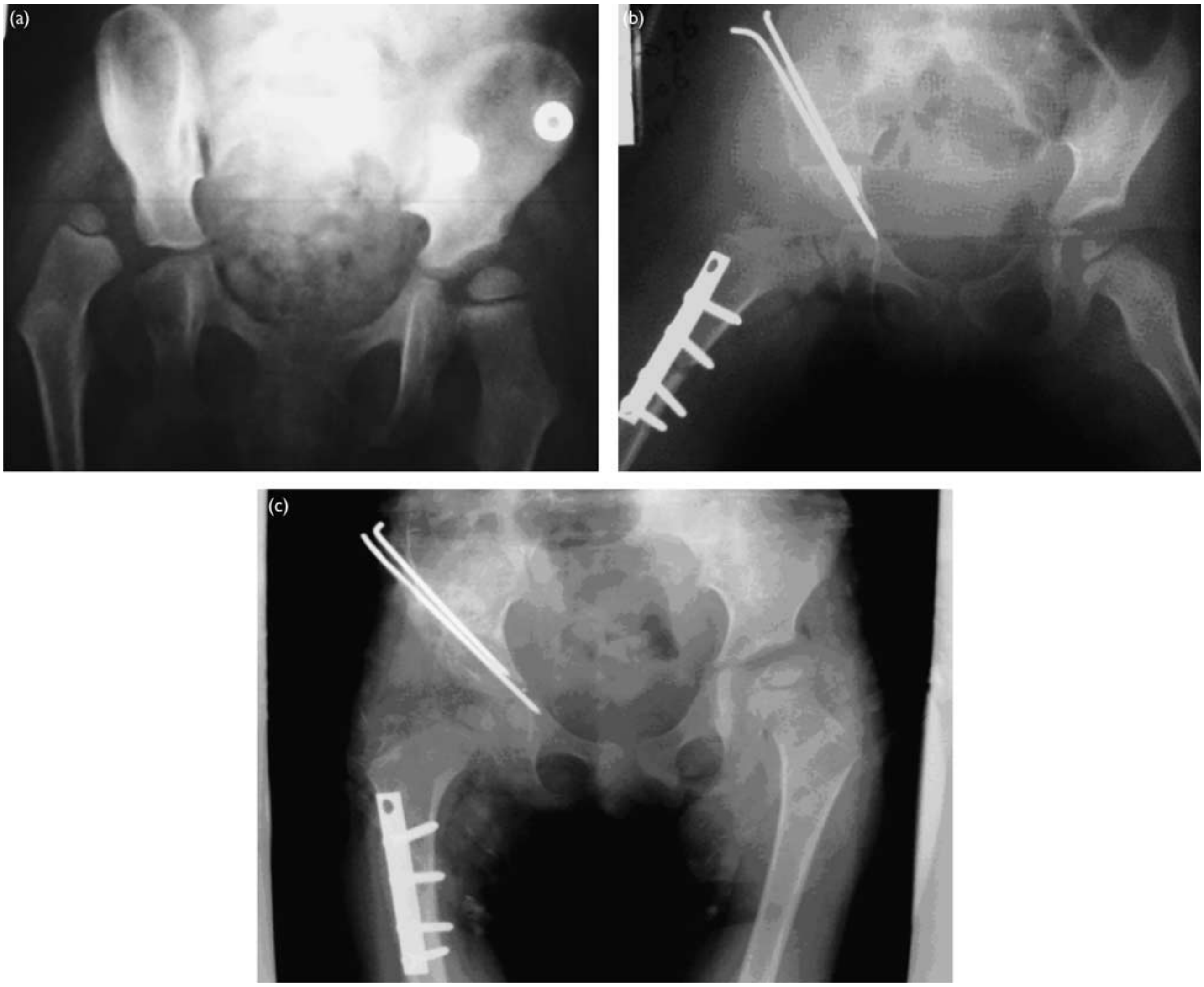
After 45 days, the casts are removed and clinical and radiological evaluations are performed. Weight bearing is generally allowed 2 weeks after cast removal. K-wires are removed after complete healing of the graft.

Dega acetabuloplasty

This technique consisted of incomplete semicircular osteotomy of the iliac bone, in which the osteotomy runs obliquely from the lateral superior to medial inferior from a point midway between the anterior superior and anterior inferior iliac spine to just anterior to the greater sciatic notch. The osteotomy is opened with osteoclasis of the unosteotomized part of the iliac bone, which keeps the inserted graft under compression without the need for internal fixation contrary to Salter osteotomy, and so, there is no need for another operation to remove the K-wires.

In the cases with femoral shortening, nine cases, the part removed from the femur for shortening was used as a graft, and in the other eight cases, we used a tricortical bone graft from the iliac crest.

Figure 1



Salter osteotomy and femoral shortening in a 3-year-old child. (a) Preoperative radiograph, (b) immediate postoperative radiograph, and (c) 12 months postoperative radiograph.

Postoperative treatment

A hip spica cast is applied after the surgery for 6 weeks.

Assessment

All patients were evaluated clinically and radiologically before treatment and during follow-up visits. Radiological evaluation comprised plain radiograph on the pelvis (anteroposterior view) measuring the center-edge (CE) angle of Wiberg's and acetabular index. The degree of dislocation was evaluated according to the Tönnis classification [8](Table 1).

Outcome measures

The primary outcome measure of this study was treatment success, which was evaluated clinically and radiologically using modified McKay's criteria and Severin's radiological criteria, respectively. Results were considered successful if graded excellent or good.

Results

Preoperative clinical characteristics

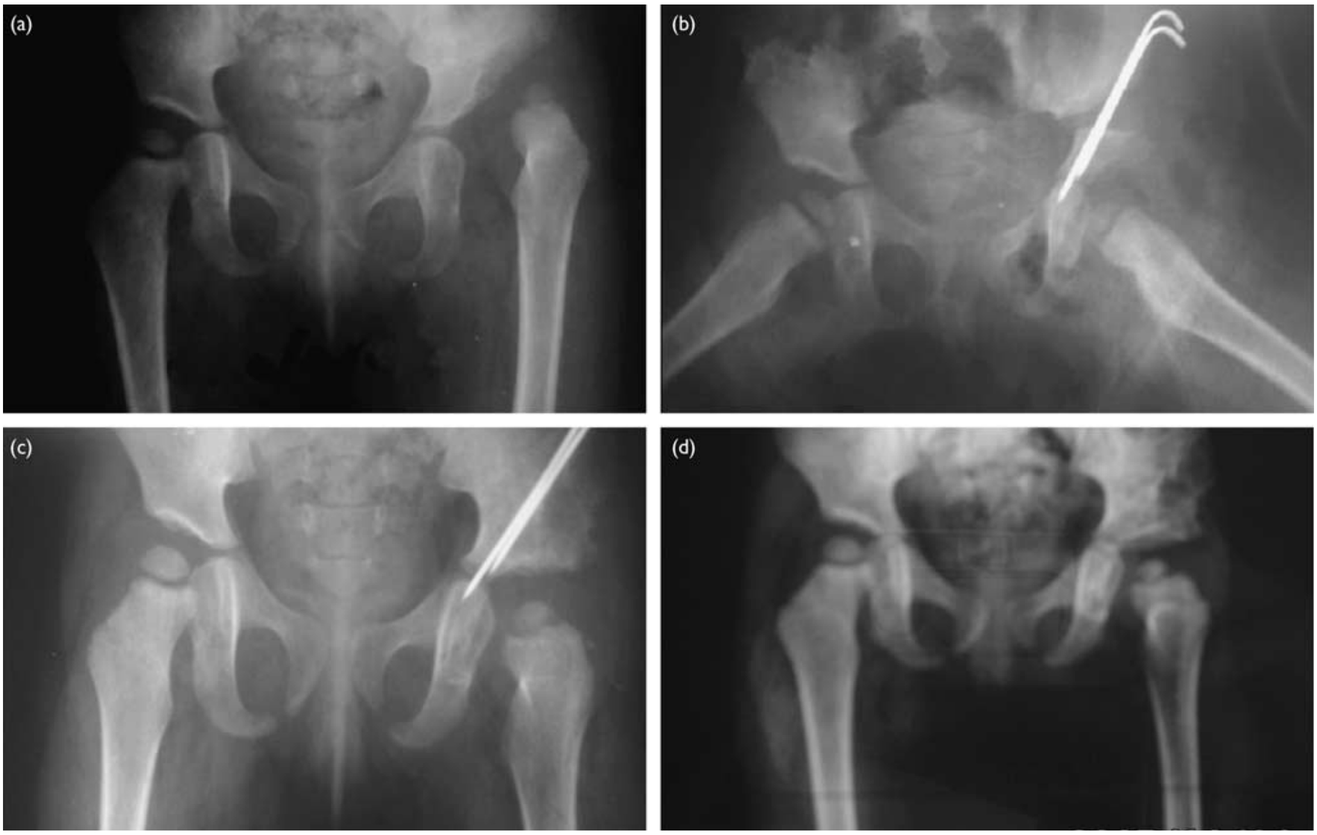
All patients showed limited abduction with a range between 15 and 30°. In addition, 12 patients had hyperlordosis of lumbar spine secondary to flexion contracture of the dislocated hip. The four patients with bilateral disease showed wide perineum, limited abduction, and excessive rotation of the hips. The Trendelenburg's sign was positive in all cases. Clinical manifestations of the unilateral cases are shown in Table 2.

Preoperatively, the acetabular index of all patients was above 30°. The average acetabular index was 47.8° (range 40–57°). All patients had negative CE angles. All patients were classified as Tönnis grade 4.

Postoperative clinical evaluation

The clinical classification according to the modified McKay's criteria [9] is shown in Table 3. There was

Figure 2



Salter osteotomy in a 22-month-old child. (a) Preoperative, (b) 2 months postoperatively, (c) 6 months postoperative, and (d) 18-month follow-up radiographs.

no significant difference between the two groups ($P = 0.478$).

Radiological evaluation

Radiological grades (Severin's classification) [10] of the two groups are shown in Table 4. The results were comparable in the two groups ($P = 0.611$).

Success rate

The success rate (according to modified McKay's criteria and Severin's classification) was 88.9% (32 of 36 hips). The success rate was comparable in the two groups: 89.5% in group I and 88.2% in group 2 ($P = 1.000$).

Acetabular index

The average preoperative acetabular index was $47.8 \pm 5.1^\circ$ (range 40–57°). Postoperatively, the acetabular index reached a mean of $26.7 \pm 9.5^\circ$ in the last follow-up visit. Salter osteotomy resulted in a decrease in the acetabular index of $20.3 \pm 9.0^\circ$ compared with a $22.0 \pm 8.9^\circ$ decrease after Dega osteotomy, with no significant difference between the two groups ($P = 0.565$).

Center-edge angle

Preoperatively, the CE angle of Wiberg was negative in all hips. Postoperatively, the average CE angle on last examination was $36.0 \pm 12.5^\circ$ (range 7–55°). There was no significant difference between the two groups ($P = 0.554$). The CE angle was $34.8 \pm 13.0^\circ$ in the Salter group and $37.4 \pm 12.1^\circ$ in the Dega group.

Complications

We had one case of redislocation in the Salter osteotomy group, 1 month after the removal of the hip spica, and avascular necrosis of the femoral head in two cases, one in each group.

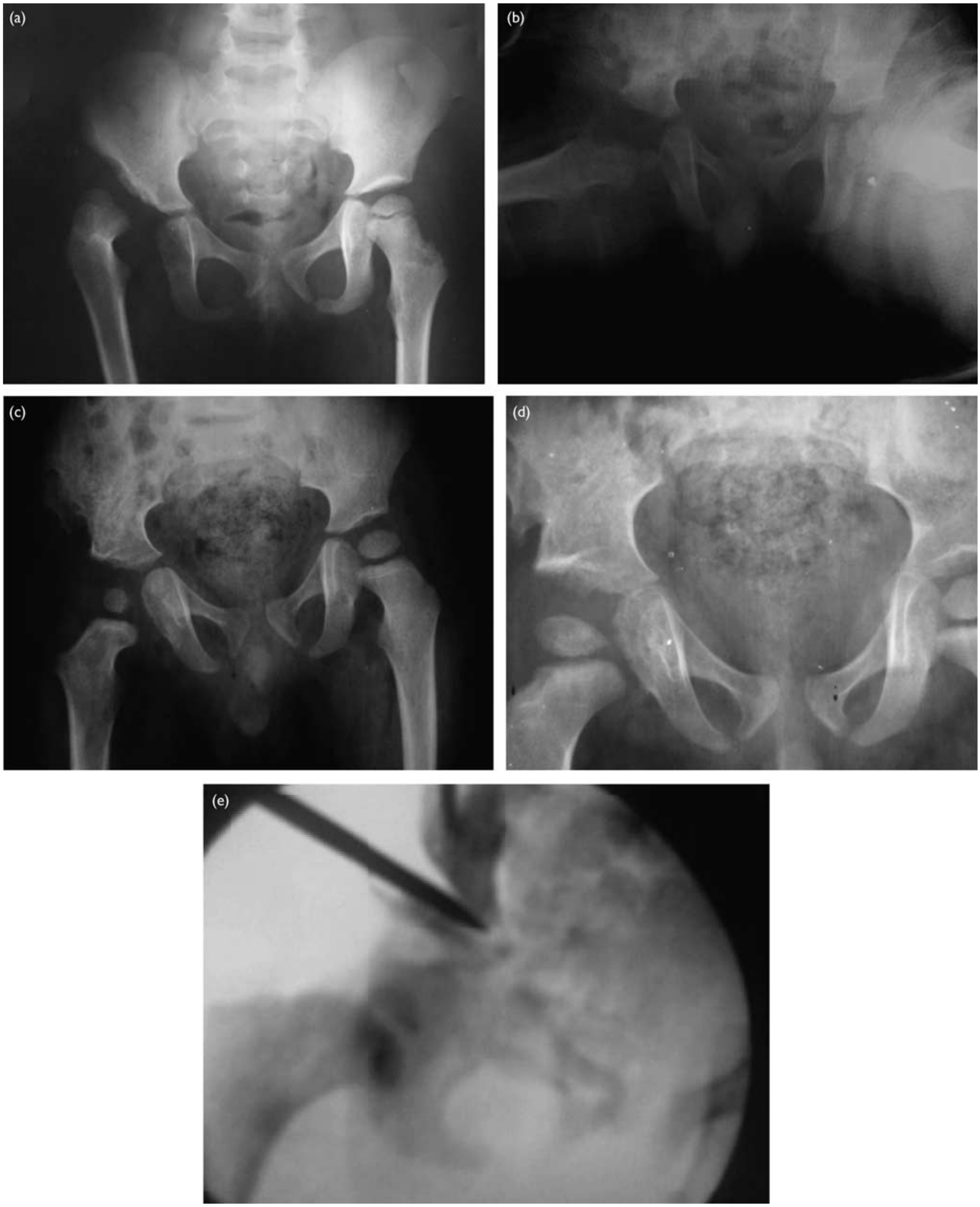
Figs 1–4 show images of radiograph films of four cases of the current series, two cases with Salter, and the other two with Dega osteotomies.

Discussion

In this study, we attempted two types of pelvic osteotomy in children younger than 3 years of age with DDH. We included 36 hips from 32 children. As reported in the literature [7,11–13], the condition affects girls more than boys (female/male ratio 1.3 : 1) and the left hip more than the right hip (53 vs. 34%).

According to modified McKay's criteria and Severin's classification, we achieved an overall success rate of 88.9% in the 36 hips, with no significant difference between the two techniques ($P = 1.000$). Both techniques led to a comparable reduction in the acetabular index

Figure 3

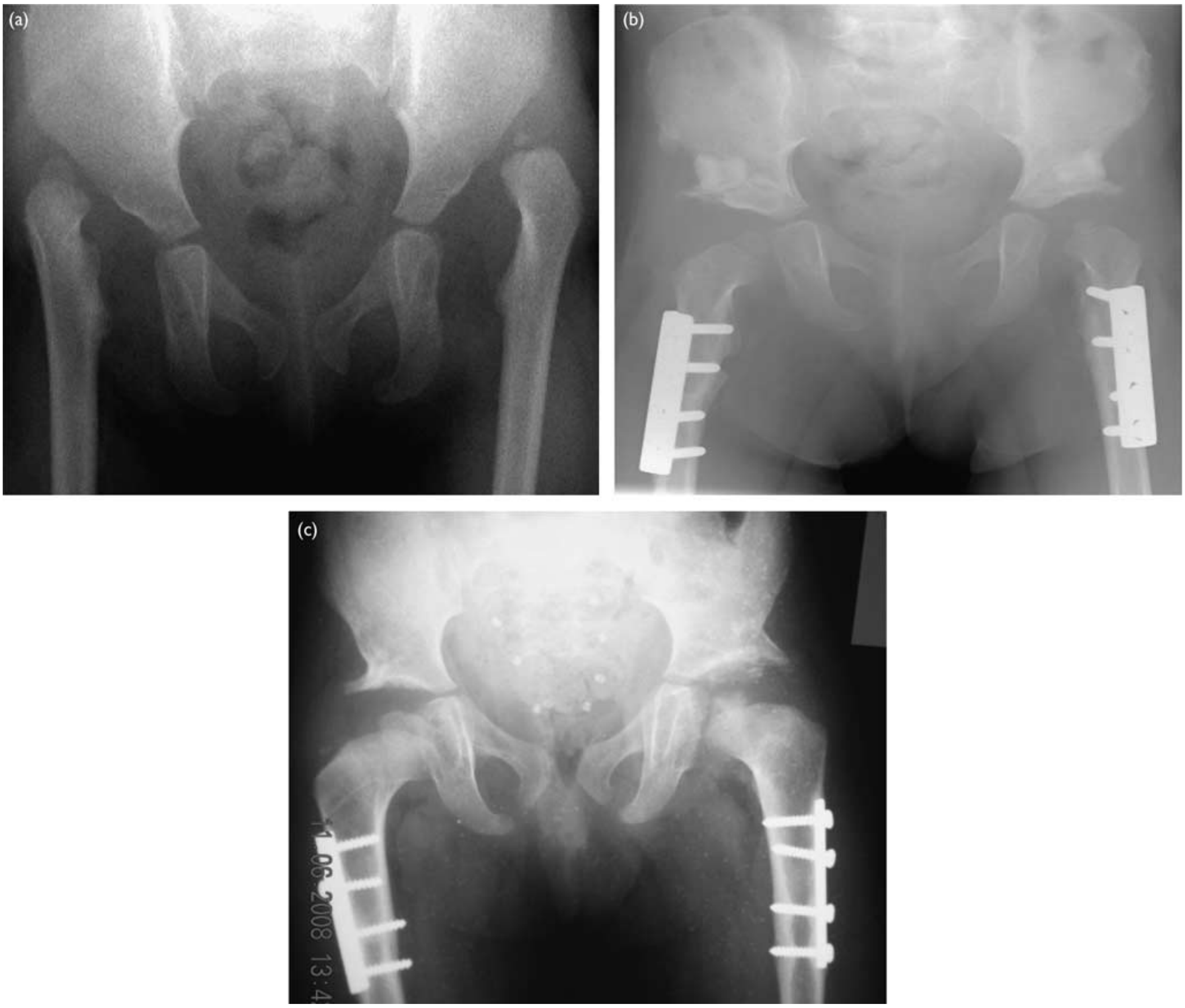


Dega osteotomy in a 2-year-old child. (a) Preoperative, (b) early postoperative, (c, d) 9 months and 2-year follow-up postoperative radiographs, and (e) demonstration of Dega osteotomy under an image intensifier.

($P = 0.565$). Similarly, on final examination, there was no significant difference in the CE angle between the two groups ($P = 0.554$).

In a retrospective cohort study of 99 hips with developmental dysplasia, López-Carreño *et al.* [14] compared 43 hips treated by Dega osteotomy with 56 hips treated

Figure 4



Dega osteotomy with femoral shortening in a 3-year-old child. (a) Preoperative, (b) early postoperative, (c) follow-up postoperative radiographs after 2 years with the left side showing radiographic manifestation of avascular necrosis of the femoral head with no complaints.

by Salter's osteotomy. They reported a statistically significant difference in favor of the Dega osteotomy in acetabular index reduction (18 vs. 11°). In the current study, we found no significant difference between the two osteotomies in the reduction of the acetabular index ($P = 0.565$). We believe that this difference was because older patients (up to 30 years) were included in López-Carreño's series. All patients of the current series were 3 years old or younger. However, greater flexibility function in Dega osteotomy, as the triradiate cartilage functions as a hinge for osteotomy, compared with the limited flexibility of the symphysis pubis ,which is the hinge in the Salter procedure, may explain the difference [15,16]. However, in Salter osteotomy, the well-centered, stabilized hip has a positive biomechanical influence on secondary maturation and normal development of the hip [17–19].

According to Severin's classification, Dega osteotomy resulted in a higher frequency of excellent results (71 vs. 58%). However, the success rate judged as excellent + good results showed no significant difference between the two groups ($P = 0.611$). Similarly, there was no significant difference between the two techniques in López-Carreño's series.

Several authors have reported a 71–94% major improvement in parameters such as the acetabular index, the CE angles, the Reimers index, the acetabular depth-to-width ratios, the Severin classification, the Tönnis grading, and McKay's criteria of a Salter osteotomy with a mean follow-up of 5.5–30.9 years [20–24].

Other investigators have reported higher failures, especially in older children (9–12 years), where enough reorientation of the acetabular fragment to adequately cover the femoral head could not be achieved [25–27]. However, Salter *et al.* [28] concluded that, in most carefully selected young adults in up to the fifth decade of life, innominate osteotomy has proved successful.

In a long-term follow-up study (average of 31 years), Paul and Annemarie [25] found that the results of Salter osteotomy were significantly influenced by the radiographic grade of dislocation. All patients of the current series had grade IV disease.

In the current study, Dega osteotomy and open reduction in 17 hips resulted in excellent and good clinical and radiographic outcome in 88% of cases, a figure comparable with that of Grudziak and Ward [29]. They reported a decrease in the acetabular index from 33 to 12° and CE of 31° postoperatively. After a 9-year follow-up, Ruszkowski and Pucher [30] reported excellent or good clinical results in 89% and radiographic results in 72%, despite a 45% rate of avascular necrosis before surgery.

A recent retrospective study revised the results of Dega osteotomy in 26 hips, done at a mean age of 3.1 years, combined with open reduction in 13 cases. They reported good and excellent results in most of the cases, with a decrease in the acetabular index from 37 to 13° [31].

The worst complication in surgical treatment for developmental hip dysplasia is avascular necrosis. In this study, we encountered avascular necrosis of the femoral head in two cases, one in each group. Previous studies have reported variable incidences of avascular necrosis between 1 and 13% [20,32,33]. In different types of treatment modalities for DDH, age at operation is an important factor affecting the incidence of avascular necrosis; in older children, the incidence is almost zero [18,34].

Avascular necrosis may be attributed to neglect of necessary femoral shortening [35], increased pressure across the femoral head after Salter osteotomy [36], forceful reduction of the hip in older children, or immobilization in wide abduction and internal rotation [37].

In the current study, we found one case of redislocation in the Salter osteotomy group. These results are similar to those reported by previous series [34,38–40]. It is a well-known disadvantage that Salter osteotomy does not provide a posterior acetabular coverage, which may cause posterior displacement of the femoral head [13,16,41]. Adequate immobilization after Salter osteotomy was required to allow healing of the capsule and soft tissue and union of the osteotomy to prevent any redislocation. Dega osteotomy confers posterior as well as lateral and anterior coverage [15]. It was originally designed for patients with cerebral palsy, who have greater lateral and posterior acetabular deficiencies [16].

Conclusion

We can conclude that Salter and Dega pelvic osteotomy produce a comparable outcome in the treatment of young children with DDH, with an overall success rate close to 90% and an acceptable minimum rate of postoperative complications. Salter osteotomy has the disadvantage of the need for another surgery to remove hardware, whereas Dega osteotomy does not have this disadvantage.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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