One-stage hip reconstruction for developmental dysplasia of the hip presenting in children between 3 and 5 years of age

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Received: 1 November 2019
Revised: 15 November 2019
Accepted: 25 November 2019
Published: 24 June 2021

The Egyptian Orthopaedic Journal 2020, 55:26–32

Background
Developmental dysplasia of the hip (DDH) is a broad term of anatomical abnormalities that can lead to permanent disability. The goals of management are to establish normal anatomy of the femoral head and acetabulum and then maintenance of this anatomy to promote normal development of the hip.
Aim
The purpose of this study is to evaluate the results of one-stage hip operation in DDH presented between 3 and 5 years of age.
Patients and methods
A prospective study was conducted on 32 children (36 hips) presented with DDH at an age between 3 and 5 years old. A total of 15 hips were Tonnis grade III and 21 hips were grade IV. The study had been done in Zagazig University Hospital between March 2011 and October 2014. Open reduction with shortening and derotation of the femur was done for all hips. Varus angulation for excessive valgus was added to the osteotomy in 18 (50%) hips, and Dega pelvic osteotomy was performed in 20 (55.6%) hips. Postoperatively hip spica was done for all the patients for 12 weeks.
Results
The mean follow-up period was 3 years and 4 months (range, 2–5 years). According to McKay system for clinical assessment, the outcomes for 20 (55.6%) hips were excellent, 11 (30.5%) hips were good, three (8.3%) were fair, and two (5.5%) were poor. According to Severin's classification system for radiological assessment, the outcomes for 20 (55.6%) hips were excellent, 10 (27.7%) hips were good, four (11%) were fair, and two (5.5%) were poor.
Conclusion
DDH in older children is better to be treated with one-stage hip reconstruction operation, where adequate stable concentric reduction can be achieved, and this can result in remodeling of the acetabulum and stable concentric reduction of the dislocated hip. DDH Tonnis grade III is risky for residual acetabular dysplasia and subluxation after one-stage hip reconstruction.

Keywords:
Dega osteotomy, developmental dysplasia of the hip, one-stage hip reconstruction, Body

Egypt Orthop J 55:26–32

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Developmental dysplasia of the hip (DDH) presented in older children is more difficult to treat. It is a broad term of anatomical abnormalities that can lead to permanent disability [1]. Residual acetabular dysplasia and hip subluxation in children result in premature arthritis of the hip in young adults [2]. The goals of management are to obtain early anatomical and stable reduction without compression on the femoral head and vessels, to allow the hip joint to develop normally [3].

Many studies have advised a one-stage surgical approach for hip reconstruction. A varus derotation osteotomy or a pelvic osteotomy is commonly done in addition to open reduction [4–8]. The purpose of this study is evaluation of the results of one-stage hip operation in patients with DDH presented between 3 and 5 years of age.

Patients and methods

A prospective study was conducted on 32 children (36 hips) who presented with DDH in the age between 3 and 5 years old. A total of 15 hips were Tonnis grade III and 21 hips were grade IV. The study was done in Zagazig University Hospital between March 2011 and October 2014. This study was approved by institutional ethics committee in Zagazik university.

The average age of the patients at the time of presentation was 3 years and 9 months.

There were 22 girls (26 hips) and 10 boys (10 hips). Dislocation of the left hip was seen in 18 patients, where 10 patients had dislocation of the right and four girls had bilateral dislocation.

Open reduction with shortening and derotation of the femur was done for all hips. Varus angulation for excessive valgus was added to the osteotomy in 18 (50%) hips, and Dega pelvic osteotomy was performed in 20 (55.6%) hips. Postoperatively hip spica was done for all the patients for 12 weeks.

Ethical permission for this study was obtained from the Zagazig University hospitals, and informed consent was obtained from all guardians before participation in the study.

Patients with neuromuscular disorders, teratological dislocation, and those who had previous treatment of the dislocation were excluded.

Preoperative evaluation

Hip dislocations were graded according to Tonnis classification system [9]. A total of 15 hips were Tonnis grade III and 21 hips were grade IV (Table 1, Fig. 1). Other radiograph parameters used in the studied cases included the acetabular index (AI) [10], the center-edge angle (CEA) of Wiberg [11], the migration percentage of Reimers (MI) [12], Shenton line disruption, the femoral neck shaft angle, and evaluation of the grade of the femoral head avascular necrosis (AVN) according to alterations in the central avascular segment signals on MRI.

Operative procedure

Open reduction with shortening and derotation of the femur was done for all hips. Varus angulation for excessive valgus was added to the osteotomy in 18 (50%) hips, and Bucholz–Ogden classification system [13].

Table 1 Developmental dysplasia of the hip types according to Tonnis (range, 3–5years)

Grades	Criteria	Number of hips (%)
I	Capital femoral epiphysis below Hilgenreiner medial to Perkins line	0
II	Capital femoral epiphysis lateral to Perkins line, but below the level of the superior acetabular rim	0
III	Capital femoral epiphysis at the level of the superior acetabular rim	15 (41.6)
IV	Capital femoral epiphysis above the level of the superior acetabular rim	21 (58.4)

Dega pelvic osteotomy was performed in 20 (55.6%) hips.

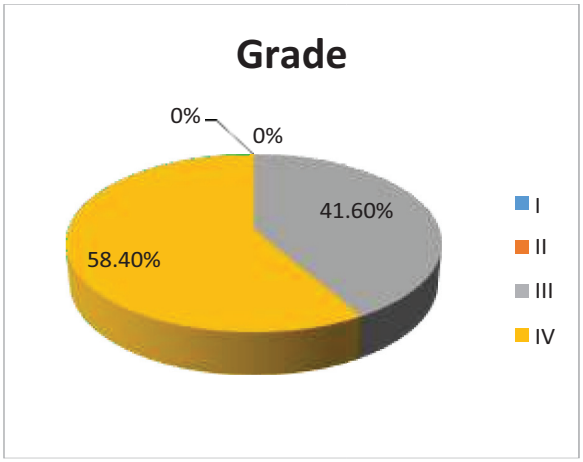
The mean operative time was 120±18 min (range, 90–145 min). The mean operative blood loss was 200±48.5 ml (range, 100–300 ml). The mean follow–up period was 3±0.98 years and 4 months (range, 2–5 years) after surgery.

Postoperative follow-up

The latest follow-up radiographs were classified as poor results; both patients had Tonnis grade III hip dislocation (Table 2 and Fig. 2).

Immediately after surgery, hip spica cast was applied. Then, a double hip spica was placed in 30° of flexion and 30° of abduction with 20° internal rotation. Roentgenograms were used to confirm reduction of the femoral head into the true acetabulum. The spica was applied for 3 months. The abduction orthosis had to be used at night for 2 months. The development of the joints was monitored from radiographs taken every

Figure 1



Graph shows Tonnis grades in the studied group.

Table 2 Clinical assessment according to McKay classification

Grades	Criteria	Number of hips (%)
Excellent	Stable, painless hip no limp, negative Trendelenburg sign and a full range of movement	20 (55.6)
Good	Stable, painless hip slight limp, negative Trendelenburg sign and a slight decrease in range of movement	11 (30.5)
Fair	Stable, painless hip, limp, positive Trendelenburg sign and limitation of movement	3 (8.3)
Poor	Unstable or painful hip, or both; positive Trendelenburg sign	2 (5.5)

month for the first 3 months after spica removal, followed by every 3 months until the end of the first year. Later on, radiographs were taken every 6 months.

Statistical analysis

The collected data through history, basic clinical examination, and outcome measures were coded, entered, and analyzed using Microsoft Excel software. Data were then imported into the Statistical Package for the Social Sciences (SPSS, version 20.0) software for analysis. According to the type of data, qualitative data were represent as number and percentage, and quantitative continuous data were represent by mean±SD. Comparison between paired quantitative parametric data was done by paired *t* test. *P* value was set at less than 0.05 for significant results and less than 0.001 for highly significant result.

Results

Clinical results

According to McKay system for clinical assessment [14], the outcome was excellent in 20 (55.6%) hips, achieving stable painless hip. A total of 11 (30.5%) hips were good, as there was a slight limp and limitation of last degrees of movement. Fair outcome was found in three (8.3%) hips with limp, positive Trendelenburg sign, limited abduction (10°–25°) and internal rotation in flexion (0–10), and exhibited radiological coxa plana due to AVN of the femoral head. Two (5.5%) hips were unstable and had residual subluxation.

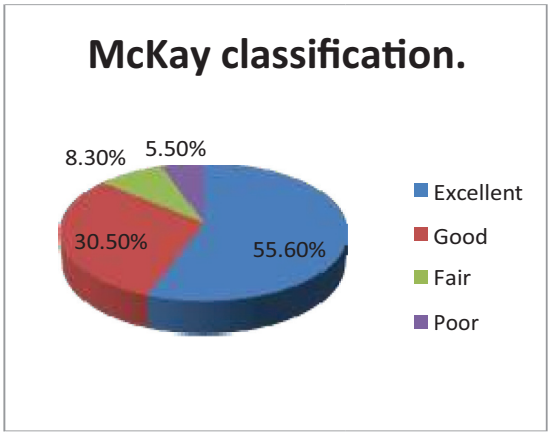
Radiographic results

The preoperative, the early postoperative, and latest follow-up radiographs were used to measure the AI, the CEA of Wiberg, the migration percentage of Reimers (MI), Shenton line disruption, and the femoral neck shaft angle. The AI improved in all hips at the latest follow-up examination, except in two hips, where the femoral head was subluxed. The mean preoperative AI was 44±9.5°, and at the end of follow-up, it was reduced to an average of 23±5.2° (range, 20–30°). The preoperative CEA was negative in all patients. The mean postoperative CEA improved in all hips at the latest follow-up period, except in two hips (10°), where the femoral head was subluxed. The average CEA at the end of follow-up was 30±7.6° (range, 20–50°). The mean postoperative migration percentage as described by Reimers was −0.21±0.05, and at the end of follow-up, the mean MI was −0.19 ±0.04. The Shenton line was intact in 34 hips. The neck shaft angle was increased from an average of 117 ±14.8° immediately postoperatively to an average of 125±15.3° at the latest follow-up examination (Figs 3–5). Severin's [15] classification system was used to grade the radiological results. According to this system, 20 (55.6%) hips had an excellent result, 10 (27.7%) were good, four (11%) were fair, and two (5.5%) were poor (Table 3, Fig. 6).

Complications

Superficial infection of the wound was encountered in three patients and was treated by local wound care and oral antibiotics. Superficial lateral cutaneous nerve of the thigh was injured in two patients. Supracondylar femoral fractures occurred in two patients after removal of the spica casts, which were managed conservatively without any effect on the final results. Two hips had residual subluxation at the latest follow-up. Limb-length discrepancy that might result from femoral shortening was seen in 28 patients who had unilateral dislocation; spontaneous normalization of the length of the shortened limb was noted, and we

Figure 2



Graph show clinical assessment according to McKay classification in the studied group.

Figure 3

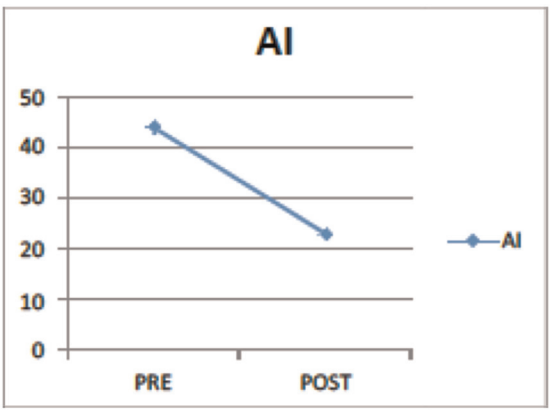


Chart show change of preoperative to postoperative values of acetabular index (AI).

Figure 4

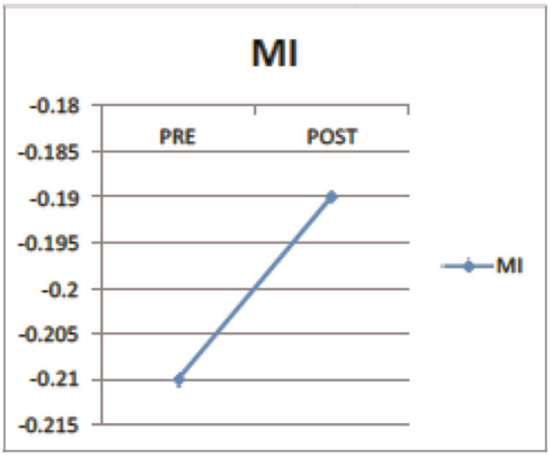


Chart show change of immediately postoperative to latest follow up values of migration percentage of Reimers (MI).

Figure 5

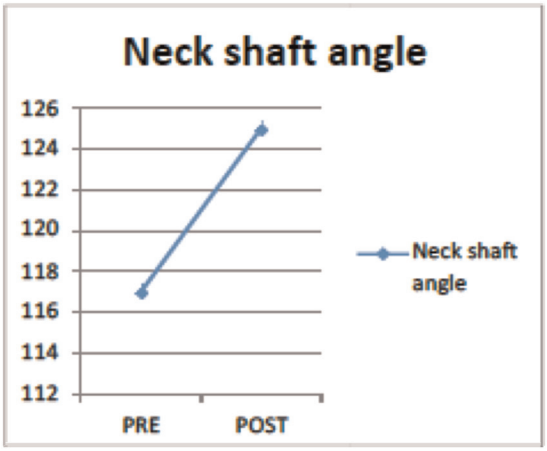
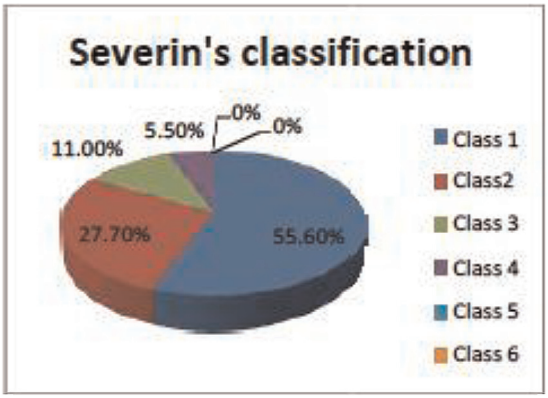


Chart show change of immediately postoperative to latest follow-up values of neck shaft angle.

Table 3 Radiographic assessment according to Severin's classification

Classes	Description	Center-edge angle (degrees)	Number of hips (%)
Class 1 (excellent)	Normal appearance	≥15 (5–13 years)	20 (55.6)
Class2 (good)	Mild deformity of the femoral head and neck or the acetabulum	≥15 (5–13 years)	10 (27.7)
Class3 (fair)	Dysplasia or moderate deformity of the femoral head and neck or acetabulum, or both	<15 (5–13 years)	4 (11)
Class4 (poor)	Subluxation of the femoral head	–	2 (5.5)
Class5 (failure)	Articulation of the femoral head with the false acetabulum	–	–
Class6 (failure)	Redislocation	–	–

Figure 6



Graph show radiological assessment according to Severin's classification system in the studied group.

observed no significant limb-length discrepancy in cases followed for 2 years or more. AVN was observed in the form of irregular ossification of the proximal femoral epiphysis in four hips. According to Bucholz and Ogden [13], the four hips were classified as type 1. Only mild loss of height of the epiphysis was noted in the final follow-up (Table 4, Figs 7 and 8).

Discussion

The goal of management of DDH in both infants and older children is concentric reduction of the head of the femur into the true acetabulum [3,16–18]. The age at operation was an important risk factor for treatment failure, and management of older children may be a challenge. Concentric reduction may be obstructed by soft tissue contracture with excessive compression on the femoral head. Poor motion of the hip joint and AVN of the femoral head may be produced from forced reduction. Many authors have reported that femoral shortening reduced the risk of osteonecrosis of the femoral head as well as facilitated reduction, and improved motion of the joint. Dysplastic acetabulum and femoral head flattening that is aggravated in older children, result in difficult reduction [4,5,19]. Many authors have reported that a one-stage hip reconstruction is safe and effective method for treatment of late-diagnosed DDH [4,19–21]. In this study, 32 patients (36 hips) who were three to 5 years of age with DDH have been treated with a one-stage hip reconstruction. The mean follow-up period was 3 years and 4 months. Open reduction with shortening and derotation of the femur was done for all hips. Varus angulation for excessive valgus was add to the osteotomy in 18 (50%) hips, and Dega pelvic osteotomy was performed in 20 (55.6%) hips.

Table 4 Bucholz–Ogden classification system of avascular necrosis of the proximal femur

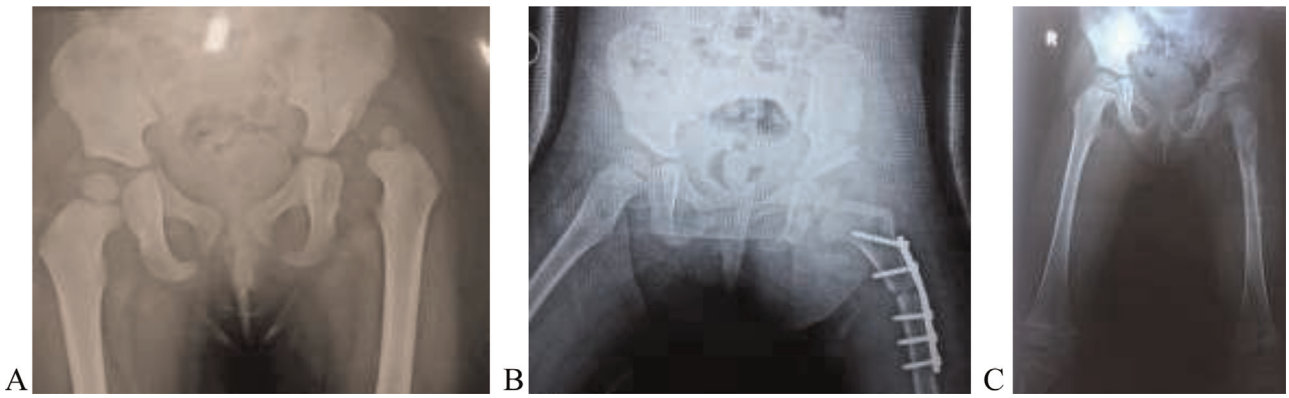
Types	Description	Number of hips (%)
1	Changes limited to femoral head; metaphysis not involved; hips usually heal without significant growth disturbance; outcome not compromised. Irregular ossification of the femoral head with no abnormalities of ossification of the metaphysis is the hallmark of type 1 AVN	4 (11)
11	Lateral metaphysis shows evidence of injury; femoral head grows into valgus deformity following premature lateral epiphyseal closure; relative overgrowth of greater trochanter	0
111	Entire metaphysic affected; femoral neck extremely short, with marked trochanteric overgrowth	0
IV	Lucent defect along medial metaphysis indicates growth disturbance of medial growth plate, which causes femoral head to grow into varus deformity; relative overgrowth of greater trochanter	0

AVN, avascular necrosis.

Femoral and pelvic osteotomies were decided according to age, grade of dislocation, AI, and the intraoperative test of stability that was applied and the stable position for hip reduction was achieved to perform appropriate osteotomy.

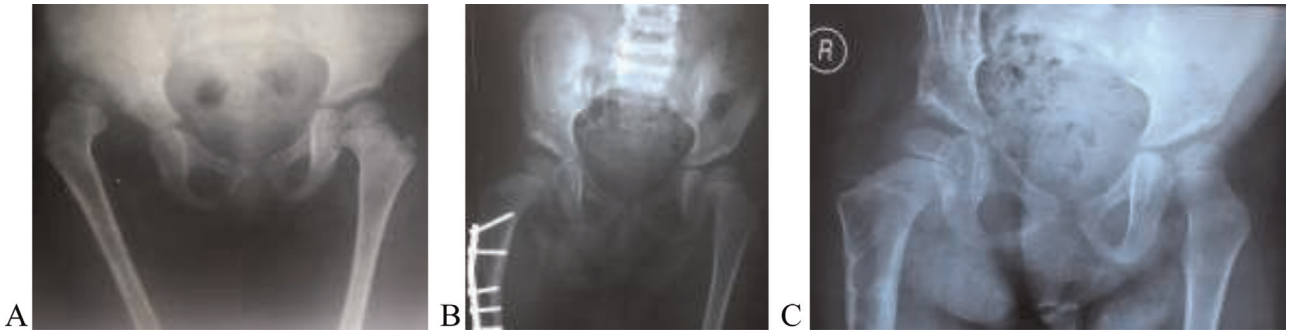
Many authors have reported the functional and radiographic results of a one-stage hip reconstruction for DDH. Karakas *et al.* [5] obtained 67% clinically and 65% radio graphically good or excellent results according to McKay and Severin classifications in 55 hips with a one-stage hip reconstruction. Forlin *et al.* [22] presented a series of 20 children (24 hips) with DDH treated by a one-stage hip reconstruction who were 4 and 12 years of age. They obtained excellent or good results in 17 (70%) of those hips according to the McKay and Severin classifications. The poor results were reported in patients older than 7 years at the time of hip reconstruction. Umer and Nawaz [3] presented a series of 23 patients (29 hips) treated by one-stage hip reconstruction. The average age of the patients was

Figure 7



A 3-year-old female child; she had left DDH. (a) Preoperative radiograph in anteroposterior (AP) view. (b) Early postoperative radiograph AP view after one-stage hip reconstruction revealed containment of the femoral head. (c) Final follow-up radiograph AP view 2 years postoperatively with excellent clinical and radiographic outcome. DDH, developmental dysplasia of the hip.

Figure 8



A 3 years and 5 months old female child; she had right DDH, (a) preoperative radiograph anteroposterior (AP) view. (b) Early postoperative radiograph AP view after one-stage hip reconstruction revealed containment of the femoral head. (c) Final follow-up radiograph AP view 2 years postoperatively with excellent clinical and radiographic outcome. DDH, developmental dysplasia of the hip.

6.84 years. The mean follow-up period was 19.6 months. Excellent or good results were achieved in 25 (86%) hips according to the McKay classification. Ganger *et al.* [23] obtained excellent or good results in 80% of hips after treatment by one-stage hip reconstruction according to the Severin classification. The mean follow-up period was 3.5 years. Galpin *et al.* [4] obtained good results in 75–85% of patients after radiographic and clinical evaluation. These previous studies have shown that the better results were obtained when the patients were younger at the time of surgery.

In this series, 36 hips with DDH in children 3–5 years old treated by one-stage operation showed that 31 (86.1%) hips achieved good or excellent results according to McKay clinical classification, and 30 (83.3%) hips achieved good or excellent according to Severin radiographic classification after a mean follow up of 3 years and 4 months. Our results were comparable to the results of the previous studies.

Many studies reported that AVN of the femoral head is one of the main complications associated with treatment of DDH. Our results revealed that four (11%) hips had a vascular necrosis according to the Bucholz and Ogden classification. Many authors reported that femoral shortening and adequate immobilization in the hip spica might avoid AVN [14,24]. In this study, femoral shortening and stable reduction during surgery and immobilization in hip spica in position 30° of flexion and 30° of abduction with 20° internal rotation for 12 weeks were required.

It is important that older children with DDH should be early diagnosed and managed by one-stage hip reconstruction for satisfactory results. Subluxation and residual acetabular dysplasia are inevitable complications during management of DDH. Many authors have reported that the incidence of AVN after open reduction is 0–8% [25–27]. Bilateral DDH, femoral head enlargement, increased anteversion, and inappropriate pelvic osteotomy are risky for subluxation and residual acetabular dysplasia [17,27,28].

In the present study, two (5.5%) patients had subluxation with residual acetabular dysplasia and required another surgical intervention. These complications occurred in patients with DDH Tonnis grade III. The results preposed that DDH Tonnis grade III was risky for residual acetabular dysplasia and subluxation after one-stage hip reconstruction. These complications may result from excessive compression of the femoral head on the edge of the acetabulum in patients with Tonnis grade III DDH. The excessive compression results in poor acetabular development and disposes the hip to residual acetabular dysplasia and subluxation after hip reconstruction. The data were comparable to the former studies [26,28].

Conclusion

DDH in older children is better to be treated with one-stage hip reconstruction operation, where adequate stable concentric reduction can be achieved, and this can result in remodeling of the acetabulum and stable concentric reduction of the dislocated hip. DDH Tonnis grade III is risky for residual acetabular dysplasia and subluxation after one-stage hip reconstruction.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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