RESEARCH ARTICLE

CYPRUS
JOURNAL OF MEDICAL SCIENCES

DOI: 10.4274/cjms.2023.2023-47
Cyprus J Med Sci 2023;8(5):328-333

One-Stage Combined Surgical Treatment of Developmental Dysplasia of the Hip in the Children Aged Over 18 Months

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Abstract

BACKGROUND/AIMS: This retrospective study aimed to evaluate the early-term radiological and functional outcomes of one-stage combined surgical treatment in children aged over 18 months with developmental dysplasia of the hip (DDH).

MATERIALS AND METHODS: Thirty-two (32) patients (44 hips) with DDH were included in the study. The Tönnis classification system was used to assess the pre-operative dysplasia grade of the hips. The acetabular index (AI) was measured on AP pelvic radiographs performed preoperatively and at the last control examination. Radiological evaluation was performed according to Severin's criteria, whereas modified McKay's criteria were applied for clinical evaluation. Kalamchi and MacEwen's criteria were preferred for the evaluation of avascular necrosis (AVN).

RESULTS: The mean preoperative AI value of the hips was 44.7±5.0°, whereas that value at the last control AI was 23.5±3.7° ($p<0.001$). According to Tönnis classification, 10 hips were type II, 11 hips were type III, and 23 hips were type IV among 44 hips. According to the modified McKay criteria, excellent clinical results were obtained in 39 (88.7%) hips, good in 4 (9%) hips, and fair in 1 (2.3%) hip. According to Severin's criteria, class 1 radiological results were obtained in 29 (66%) hips, class 2 in 13 (29.5%) hips, and class 3 in 2 (4.5%) hips. The evaluation based on Kalamchi and MacEwen's criteria revealed AVN in 8 (18.2%) hips.

CONCLUSION: Combined surgical procedures involving pelvic and femoral osteotomy with open reduction are effective in the management of DDH in children over 18 months of age. In addition, femoral derotation osteotomy is necessary for stable reduction in children after walking age.

Keywords: Acetabular anteversion, children, derotation osteotomy, femoral anteversion, hip dysplasia, pemberton pericapsuler osteotomy, salter innominate osteotomy, treatment

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a disease that manifests itself with various abnormalities ranging from mild dysplasia to significant dislocation.[1] DDH treatment is determined by the age of the patient, and the best results are obtained if treatment is started at an early age. The main goal of treatment is to achieve concentric reduction of the hip joint at the earliest possible age. Because the development of the hip slows down after 4 years of age, treatment should be started before 4 years of age if possible.[2] As age advances in DDH, treatment interventions become more complex, complication rates increase, and treatment success decreases.

Performing open reduction, pelvic, and femoral osteotomy (varization, derotation, and shortening) operations together is called one-stage combined surgical intervention. These are the most common surgical procedures implemented for realignment of the hip for treating children with high hip dislocation aged over 18 months.

Pemberton pericapsular osteotomy (PPO) and Salter innominate osteotomy (SIO) are the most preferred types of pelvic osteotomy

To cite this article: Türközü T. One-Stage Combined Surgical Treatment of Developmental Dysplasia of the Hip in the Children Aged Over 18 Months. Cyprus J Med Sci 2023;8(5):328-333

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Received: 18.04.2023
Accepted: 26.09.2023

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for treating DDH of the early childhood age. SIO is a redirectional osteotomy, whereas PPO is a reshaping osteotomy type, and they are preferred depending on the morphology of the acetabulum. In most patients with DDH, acetabular insufficiency is usually anterior, and both osteotomies increase anterior acetabular coverage. However, PPO provides more anterior coverage than SIO.[3,4]

Femoral shortening should be performed in high hip dislocations where reduction cannot be achieved and in conditions where tight reduction occurs to prevent the development of avascular necrosis (AVN).[5] Although DDH is associated with increased femoral anteversion, some studies have shown no difference in femoral anteversion compared with normal hips, whereas other studies have demonstrated an increase in anteversion.[6-8] Therefore, there is still no consensus on whether femoral derotational osteotomy is necessary for the treatment of DDH.

In patients with DDH, the femoral neck-shaft angle is usually normal. Although many authors have emphasized in the past that coxa vara formation due to varus osteotomy contributes to the stable reduction of the hip, coxa vara is a deformity and cannot be accepted as a functional position.[9,10] It leads to limb shortness, lateralization of the femoral shaft, shift of the mechanical axis toward the medial aspect of the knee, and consequent mechanical complications in the knee. Hence, variation osteotomy is usually not preferred.[11,12] This retrospective study evaluated the early-term radiological and functional outcomes of one-stage combined surgical treatment in children aged over 18 months with DDH.

MATERIALS AND METHODS

This study was approved by the Van Yüzüncü Yıl University Non-Invasive Clinical Research Ethics Committee (approval number: 2023/01-12, date: 20.01.2023).

Patients with DDH aged 18 months who were treated by a single surgeon in the orthopedics and traumatology clinic of a tertiary health center between 2018 and 2022 were retrospectively screened. The study included patients who underwent one-stage combined surgical treatment. Patients treated with isolated pelvic or femoral osteotomy, hip dysplasia that developed secondary to neuromuscular disease, and patients who did not come for follow-up examinations were excluded from the study. Demographic data, clinical evaluations, and radiological results of the patients were obtained from medical records. The Tönnis classification system was used to assess the pre-operative dysplasia grade of the hip.[13] Acetabular index (AI) values were measured on AP pelvic radiographs performed preoperatively, postoperatively, and at the last control examination. Radiological evaluation was performed according to Severin's criteria, whereas clinical evaluation was performed according to modified McKay's criteria.[14,15] Kalamchi and MacEwen's criteria were preferred for the evaluation of AVN, which is one of the commonly seen complications.[16]

Surgical Method

The surgery was initiated with adductor tenotomy. The Bikini approach was used for open reduction, capsulorrhaphy, and pelvic osteotomy. A second separate lateral incision was made in the proximal thigh for femoral shortening and/or femoral derotation. To increase the coverage of the femoral head, SIO was applied to the acetabulum with spherical and anterolateral insufficiency, whereas PPO was applied to the shallow and ellipsoid acetabulum.[17]

To obtain maximum joint compliance, the necessity of derotation osteotomy was evaluated in the flexion, abduction, and internal rotation positions in the reducible hips. Femoral shortening osteotomy was performed on irreducible hips or those with tight reduction. To determine the amount of derotation before femoral osteotomy, two pieces of Kirschner wires were sent to the femur from the distal and proximal of the osteotomy line parallel to the operating table. For shortening and/or derotation osteotomy, the femur was transversely osteotomized from the subtrochanteric region.

After femoral osteotomy and shortening for high hip dislocations, the hip joint was reduced using a Kirschner wire in the proximal femur like a joystick, and the proximal fragment was internally rotated until maximum compliance between the acetabulum and femoral head. After the distal fragment was positioned with the patella facing up, the angle between the two Kirschner wires was determined as the amount of derotation. The amount of shortening was determined as the amount of overlap of the distal fragment on the proximal fragment when the hip was in the reduced position after osteotomy and longitudinal traction was applied from the knee level, and the distal fragment was shortened (Figure 1).

After performing derotation and/or shortening, the osteotomy region was fixed with a 4-hole 1/3 semitubular plate. Varization osteotomy was applied in none of the patients. Capsulorrhaphy was performed after the reduction. For preserving the reduction, the patients were implemented spica cast with hips at 30° flexion, 30° abduction, and neutral rotation. All hips underwent CT for postoperative reduction

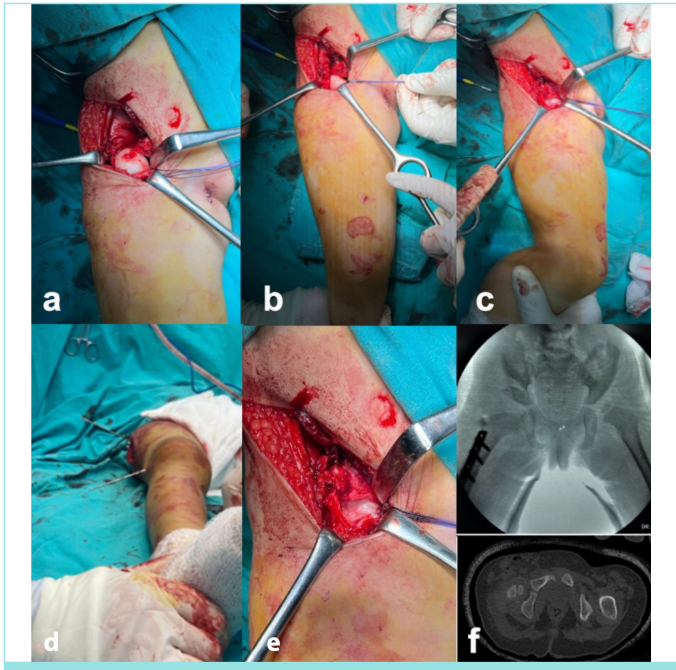

Figure 1. a) View of aspheric femoral head after capsulotomy, b) After pelvic osteotomy, the view of joint incompatibility while the leg is in flexion, abduction, and neutral rotation, c) the joint appears to be maximally compatible when the leg is in flexion, abduction, and internal rotation, d) determination of the degree of derotation between two Kishner wires after femoral osteotomy, e) the appearance of the joint after fixation of the osteotomy area with a semitubular plate after derotation, f) postoperative pelvic X-ray and CT image of the patient.

control. After 6 weeks of follow-up in spica cast, a full-time abduction orthosis was administered for 6 weeks. Rehabilitation was initiated 3 months after surgery to reduce joint stiffness.

Statistical Analysis

SPSS 26.0 software was used for statistical analysis. The mean, standard deviation, median, minimum, maximum, frequency, and percentage values were used in the descriptive statistics of the data. The distribution of the variables was measured using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used in the analysis of quantitative independent data. The chi-square test was used in the analysis of qualitative independent data, and Fisher's exact test was used when the chi-square test conditions were not met. A paired t-test was used to evaluate the difference between the pre-operative AI (AI1) and the final control AI (AI2). P-values <0.05 were considered significant.

RESULTS

The study included 44 hips from 32 patients. Of the patients, 29 (90.6%) were female and 3 (9.4%) were male. Bilateral DDH was present in 12 patients, 21 (47.7%) had right hip involvement, and 23 (52.3%) had left hip involvement in 32 patients. The mean age at surgery of the patients was 31.2±11.1 months, and the mean follow-up duration was 25.6±11.6 months. The demographic data of the patients are presented in Table 1.

The mean AI1 value of the hips was 44.7±5.0° whereas that AI2 value was 23.5±3.7°. The mean postoperative improvement in the AI1-AI2 was 21.2±6.6° and statistically significant (p<0.001) (Table 1).

According to Tönnis classification, 10 hips were type II, 11 hips were type III, and 23 hips were type IV among 44 hips (Table 2). To increase acetabular coverage, 12 (27.3%) hips were reconstructed with SIO and 32 (72.7) hips were reconstructed with PPO. Femoral derotation osteotomy was performed in 44 (100%) hips, whereas 33 (75%) hips were applied femoral shortening. The mean derotation angle was 22.6±3.9° (Table 1). The correlation between Tönnis hip type and degree of derotation was significant (p<0.01). In other words, it was observed that the amount of derotation increased as the Tönnis grade increased.

According to the modified McKay criteria, excellent clinical results were obtained in 39 (88.7%) hips, good in 4 (9%) hips, and fair in 1 (2.7%) hip (Table 3). In the evaluation of the last control radiographies according to Severin's criteria, class 1 radiological results were obtained in 29 (65.9%) hips, class 2 in 13 (29.5%) hips, and class 3 in 2 (4.5%) hips (Table 4).

Evaluation of the last control radiography based on Kalamchi and MacEwen's criteria revealed that no AVN was present in 36 (81.8%) hips, whereas AVN was present in 8 (18.2%) of 44 hips. There was type I AVN in 5 hips and type III AVN in 3 hips. The types and rates of AVN are presented in Table 5 in detail.

Redislocation and subluxation were not observed in any hip. The allergic reaction developed due to the cotton under the cast in the postoperative 2nd week. The cast was removed, hip reduction was preserved in the abduction orthosis, and cast was reapplied after recovery of the skin lesions. In another patient, superficial wound site infection was detected in the surgical site of femoral osteotomy and was treated with antibiotherapy.

Preoperative, early term, and postoperative recent control images of two patients with excellent outcomes and without AVN are presented in Figure 2, 3.

Table 1. Demographic data and radiological evaluation of the hips (n=44)

	Patient data
Age (months)	31.2±11.1
Follow-up time (months)	25.6±11.6
Preoperative acetabular index (degrees)	44.7±5.0
Follow-up acetabular index (degrees)	23.5±3.7
Tönnis radiological classification (n, %)	
- Type I	-
- Type II	10 (22.7)
- Type III	11 (25)
- Type IV	23 (52.3)
The type of pelvic osteotomy (n, %)	
- Salter	12 (27.3)
- Pemberton	32 (72.7)
Femoral deoration osteotomy (n, %)	44 (100)
Femoral shortening (n, %)	33 (75)
Deoration degrees	22.6±3.9

Table 2. DDH types according to Tönnis classification

Grade	Criteria	Number	Percentage (%)
Type I	Femoral capital epiphysis medial to Perkins line and below Hilgenreiners line	-	-
Type II	Epiphysis below the Hilgenreiners line but lateral to Perkins	10	22.7
Type III	Epiphysis lateral to the Perkins line at the level of the acetabular margin	11	25
Type IV	Epiphysis lateral to the Perkins line and above the acetabular rim	23	52.3

DDH: Dysplasia of the hip.

Table 3. Results of clinical assessments according to modified McKay's criteria

Grade	Rating	Description	Number	Percentage (%)
1	Excellent	Painless, stable hip; no limp; more than 15° internal rotation	39	88.7
2	Good	Painless, stable hip; slight limp or decreased motion; (-) Trendelenburg's sign	4	9
3	Fair	Minimum pain, moderate stiffness, (+) Trendelenburg's sign	1	2.3
4	Poor	Significant pain	-	-

DISCUSSION

This study revealed that satisfactory clinical (97.7%) and radiological (95.5%) outcomes were obtained in the early-term follow-up of one-stage combined surgical treatment in children aged over 18 months with DDH. In the literature, excellent and good outcomes according to McKay's clinical grading as well as class 1 and 2 outcomes according to Severin's radiological grading are interpreted as "satisfactory outcome". Many authors have reported satisfactory radiological and clinical outcomes of one-stage combined surgical treatment with varying rates in the past (Table 6).[4,5,18-21]

Among the studies conducted in similar mean age with the present study, Aly[12] detected radiologically 100% and clinically 80.5% satisfactory outcomes in the early-term follow-up. From studies with middle-term follow-up, Mazloumi et al.[20] reported radiologically 88.8% and clinically 75% satisfactory outcomes, whereas Zimri et al.[21] denoted radiologically 75.5% and clinically 90.6% satisfactory outcomes. Although the success rate of the combined surgical treatment of DDH reached 80-90% in the literature, this rate has decreased with longer duration follow-up. In a study with a long-term follow-up, the researchers reported radiologically 75.8% and clinically 72.7% satisfactory outcomes.[22] This study included early-term (25.6±11.6) follow-up, and we obtained radiologically 95.5% and clinically 97.7% satisfactory outcomes.

Table 4. Results of radiological assessments according to Severin's criteria

Class	Description	Number	Percentage (%)
1	Normal hips	29	66
2	Concentric reduction of the hips with moderate deformity of the femoral neck, head or acetabulum	13	29.5
3	Dysplastic hips without subluxation	2	4.5
4	Subluxation	-	-
5	Head articulating with a secondary acetabulum in the upper part of the original acetabulum	-	-
6	Redislocation	-	-

Table 5. Avascular necrosis of femoral head assessments according to the Kalamchi-MacEwen criteria

Grade	Description	Number	Percentage (%)
Type I	Changes affecting the ossific nucleus but resulting in an essentially normal head at final follow-up	5	11.4
Type II	Type I + Lateral physical damage resulting in coxa valga	-	-
Type III	Type I + Central physical damage resulting in coxa breva	3	6.8
Type IV	Total damage to the head and physis resulting in deformity of the femoral head and neck	-	-

Figure 2. a) Pre-operative radiograph of a 23-month-old female patient, b) postoperative 6th month radiograph of the patient, and c) 26th month radiograph of the patient without AVN with excellent results.

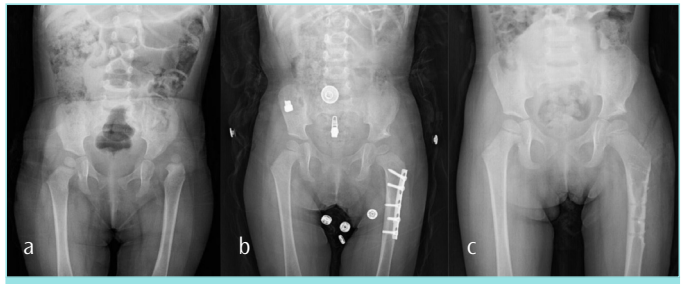

Figure 3. a) Pre-operative radiograph of a 19-month-old female patient with left DDH, b) postoperative 8th month radiograph of the patient who was treated with open reduction, PPO, and femoral shortening-derotation, c) 24-month radiograph of the patient with excellent results.

Table 6. Different rates of radiological and clinical results by many authors in the literature

Study	Hip number	Mean surgery age (year)	Follow-up time (year)	Severin (class 1+2)	Mckay's (excellent and good)	Complication
Vallamshetla et al.[18]	18	5.9	6.10	100%	100%	1 hip AVN, 1 hip redislocation
Umer et al.[19]	29	6.8	1.5	65.5%	86.2%	1 hip AVN
Mazloumi et al.[20]	36	3.8	7.6	88.8%	75%	3 hips with AVN, 2 hips subluxated, and 1 hip redislocated
Zimri et al.[21]	213	3.3	8	75.5%	90.6%	AVN and redislocation 3 cases (1.40%)
Aly[12]	20	3.8	3.8	100%	80.5%	1 hip AVN
Bhatti et al.[4]	82	-	3	85.4%	-	8 hip AVN, 2 hip subluxation

Salter, Pemberton, and Dega osteotomies are the most widely known of the various pelvic osteotomy methods for increasing the coverage of the femoral head in the surgical treatment of DDH.[23-27] Abdullah et al.[28] treated 34 hips with SIO and 8 hips with dega osteotomy out of 42 hips. In that study, the determination of the pelvic osteotomy type was based on AI values and the surgeon's experience. In addition, Mazloumi et al.[20] treated 29 hips with SIO and 7 hips with PPO in their series involving 36 hips, and they selected the type of pelvic osteotomy according to femoral head size and acetabular capacity. In this study, 12 (27.3%) hips were reconstructed with SIO, whereas PPO was applied in the reconstruction of 32 (72.7%) hips. The type of pelvic osteotomy was selected by evaluating the intraoperative acetabular morphology.

Abdullah et al.[28] performed femoral shortening and derotation in 40 of 42 hips (41 Tönnis type IV hips, 1 Tönnis type II hip) and detected subluxation in 2 hips and AVN in 1 hip. Ertürk et al.[29] performed femoral shortening and derotation in all the hips in their series involving 49 hips (33 Tönnis type IV hips, 16 Tönnis type III hips) and detected redislocation in 1 (2%) hip and AVN in 16 (32.6%) hips. According to Tönnis classification, 23 (52.3%) hips were type IV, 11 (25%) hips were type III, and 10 (22.7%) hips were type II in the present study. In this study, we performed shortening and derotation in all type IV and type III hips (except one type III hip). In contrast, we performed only derotation in all type II hips. We discovered no redislocation or subluxation in any of the cases according to our early-term follow-up.

The general consensus on the treatment of DDH is the necessity of absolute concentric reduction between the femoral head and acetabulum. The affected acetabulum in DDH has not normal acetabular anatomy; therefore, it is not like a normal acetabulum even after pelvic osteotomy. In addition, difficulties are experienced in achieving concentric reduction because the sphericity of the femoral head is lost (femoral head flattening) in high hip dislocations.[30,31] The contact area between the femoral head and acetabulum increases when pelvic osteotomy is performed.[32] This contact area between the femoral head and acetabulum is further increased with derotation osteotomy. The author's opinion is that femoral derotation should be performed even if there is no real increase in femoral anteversion to achieve maximum compliance between the dysplastic acetabulum with abnormal acetabular anteversion and the dysmorphic and aspheric femoral head.

AVN remains the most frequently observed complication for treating DDH. Many studies have demonstrated that the development of AVN depends on numerous factors such as patient age at presentation, treatment type, and severity of dysplasia. Ning et al.[27] reported AVN with a rate of 27.4% in a large case series including 864 hips in which they performed one-stage combined surgery and associated advanced age at surgery and high Tönnis grade with increased severity of osteonecrosis. In this study, AVN was in 8 (18.1%) of 44 hips according to the Kalamchi-MacEwen criteria. There was type I AVN in 5 hips and type III AVN in 3 hips. The rate of clinically significant AVN (Kalamchi-MacEwen type II, III, IV) was 6.8%. All hips with type III AVN consisted of Tönnis type IV hips. In addition, 2 hips were reconstructed with Pemberton osteotomy, and 1 hip was reconstructed with Salter osteotomy. The mean age was 43 months.

This study is different from other studies with respect to postoperative management. We preferred the spica cast in flexion, abduction, and neutral rotation because we derotated all the hips. Regardless of pelvic osteotomy type (Salter and Pemberton), we considered full-time immobilization for 12 weeks (6 weeks in spica cast, 6 weeks in brace) to be adequate. Bhuyan[30] performed spica cast in slight flexion, abduction, and internal rotation positions after open reduction, Salter osteotomy, and femoral shortening-derotation (range 20°-30°) on 30 hips and immobilized the hips for a total of 12 weeks (6 weeks in cast, 6 weeks in brace). On the other hand, Ertürk et al.[29] applied full-time immobilization for 12 weeks (6 weeks in spica cast, 6 weeks in brace) and part-time immobilization for 6 weeks on 49 hips in which open reduction, Salter osteotomy, and femoral shortening-derotation.

The author has attributed the radiological and clinical results obtained from this study as satisfactory and the absence of complications that require secondary surgery, such as redislocation and subluxation, to the selection of the pelvic osteotomy type according to the acetabular morphology, implementation of femoral derotation procedure with varying degrees (to achieve the maximum compliance of hip joint), and realization of the surgical procedure by a single experienced surgeon.

Study Limitations

This study has some limitations. First, this was a retrospective study with a relatively small number of patients. Second, only the early results of the surgical procedure were reported in the study. Mid- and long-term results should also be evaluated. Third, the study represents only one physician's experience without a comparative study.

CONCLUSION

Combined surgical procedures involving pelvic and femoral osteotomy with open reduction are effective in the management of DDH in children over 18 months of age. In addition, femoral derotation osteotomy is necessary for stable reduction in children after walking age.

MAIN POINTS

- Combined surgeries are an effective procedure in the treatment of DDH in children over 18 months of age.
- Femoral derotation osteotomy is required for stable reduction in children after walking age.
- There is no need for varus osteotomy for stable reduction.

ETHICS

Ethics Committee Approval: This study was approved by the Van Yüzüncü Yıl University Non-Invasive Clinical Research Ethics Committee (approval number: 2023/01-12, date: 20.01.2023).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

DISCLOSURES

Financial Disclosure: The author declared that this study had received no financial support.

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