RESEARCH ARTICLE

# The Outcome of Salter Innominate Osteotomy for Developmental Hip Dysplasia before and after 3 Years Old

Taghi Baghdadi, MD; Nima Bagheri, MD; Seyyed Saeed Khabiri, MD; Hadi Kalantar, MD

*Research performed at Joint Reconstruction Research Center, Imam Khomeini Hospital Complex ,Tehran University of Medical Science, Tehran, Iran*

*Received: 30 June 2017* *Accepted: 02 October 2017*

## Abstract

**Background:** Developmental dysplasia of the hip (DDH) is one of the most important and challenging conditions in the field of pediatric orthopedics; if not diagnosed and treated in time, it would lead to remarkable morbidity. Methods of treatment based on the patient's age can vary. The aim of this study is to compare the outcomes of Salter osteotomy surgery in two groups of patients under and over three years old.

**Methods:** In this retrospective study, medical records of patients who had undergone innominate Salter osteotomy, within the past ten years, due to non-pathological DDH were collected. Mean follow up of all patients is 70.28 months (min=25, max=118).

**Results:** Seventy patients were selected including 85 operated hips. Radiological satisfaction based on modified Severin score system rate was 86% and 85% for lower three years old group and second group, respectively. In clinical assessment, it was found that results in 82% of the patients under 3 years old and 82.9% of patients older than three years old were satisfactory. There was no statistically significant difference between the two groups based on Modified MacKay criterion.

**Conclusion:** Results in both groups of patients under and over 3 years old were found satisfactory. Difference in patient satisfaction rates based on clinical and radiological outcomes was not statistically significant between the two groups. It should also be noted that complications such as redislocation and deep wound infection would cause poor clinical and radiological outcomes.

**Keywords:** Assessment, Congenital, Hip dysplasia, Older children, Outcome, Salter osteotomy

## Introduction

Developmental dysplasia of the hip (DDH) is one of the most important and challenging conditions in the field of pediatric orthopedics; if it is not diagnosed and treated in time, it leads to remarkable rate of morbidity, including progressive damage and defective development of the acetabular cavity (1-6).

Since the etiology of DDH has been poorly understood, early diagnosis and effective treatment to prevent the progressive deleterious nature of this disease is of particular importance (7). Major treatment options focus on decreasing the pressure on the joint by putting femoral head in acetabular cavity

***Corresponding Author:*** Seyyed Saeed khabiri, Department of Orthopedic Surgery ,Taleghani Hospital, Faculty of Medicine, Kermanshah University of Medical, Kermanshah, Iran
Email: saeed.khabiri@gmail.com

THE ONLINE VERSION OF THIS ARTICLE
ABJS.MUMS.AC.IR

(8). In children younger than 18 months, non-surgical treatment options seem to have better outcomes, but in children over this age surgical intervention to maintain appropriate articular surface is required (4). Overall, in older children or patients with higher grade of the disease, surgical treatments have better outcomes and mainly concentrate on increasing the coverage of femoral head in acetabulum with or without osteotomy or femoral shortening. The optimal age or age limit to perform Salter osteotomy is controversial (9).

The aim of this study is to compare the outcomes of surgery in two groups of patients under and over age 3, who underwent Salter innominate osteotomy with or without femoral shortening.

## Materials and Methods

In this retrospective study, medical records of patients who had undergone Salter osteotomy surgery (with or without femoral shortening) for ten years (2004 to 2014) in Imam Khomeini Hospital complex, Tehran, Iran, were reviewed. A total of 309 patients with DDH were selected according to our inclusion criteria. Patients with definite diagnosis of the disease and no prior operation were considered for this study . Considering exclusion criteria, cases with other comorbidities such as cerebral palsy, arthrogryposis, myelomeningocele, were excluded from the study remaining 210 subjects for the final analysis. Seventy-three of the subjects had surgery over 3 years of age and the rest had undergone operations before the age of 3 years. We randomly selected thirty-five cases at the age of over 3 years and fifty cases at the age of less than 3 years. 32 cases older than 3 years (3 bilateral) and 38 patients in the group of under 3 years (including fifteen subjects with bilateral DDH) had complete follow-up records and were finally included in the study. Mean follow-up of all patients is 70.28 months (min = 25 months, max=118 months). Type of surgery for each patient, patient's age at the time of diagnosis, gender, level of pain, limping degree, and decreased range of motion of the hip joint were recorded on a data sheet. Patients were invited for follow-up physical examination and control radiographs of pelvic were obtained. The following parameters were also recorded: number of months from surgery, pain and limping degree and limb length discrepancy. Clinical assessment was based on Modified MacKay scoring system and radiologic assessment was done by modified Severin radiographic criteria. All analysis was performed with IBM SPSS Statistics version 19.0; T-test and chi-square tests were used for continuous and categorical variables , respectively. *P values* of less than 0.05 were regarded as statistically significant.

## Results

A total of seventy patients were ultimately selected, in whom 85 hips had prior surgery (15 patients had bilateral DDH). Patients were divided into two groups, thirty-eight patients (fifty hips) were on the first group of children who were less than 3 years old, and the second group included 32 patients (35 hips) over 3 years old. 13 patients were male while 57 cases were female (total of 70 patients). Among them, 38 patients (54%) had left hip involvement, 17 patients (24%) had right side involvement and 15 (22%) had bilateral involvement [Table 1].

In the first group, among 15 patients with bilateral hip dislocation, there were 1 boy and 14 girls. All girls with bilateral involvement were over 3 years old. The mean age of patients at the time of surgery was 34 months (18-64) with a mean age of 24.7 months in the first group and 47.5 months in the second group.

The mean age at last follow-up was 7.7 years and 10.09 years for the first and second group. Duration of follow-up in both groups was calculated and recorded as 68 and 73.5 months for the first and the second group, respectively. No significant difference was found.

Patients' Clinical status and radiologic evaluations were assessed. All patients in this study had undergone Salter osteotomy and 40 hips (47%) had undergone femoral osteotomy as well. 7 patients were under 3 years (8%) and 33 patients (38%) were over three

**Table 1. Petients demographic information**

| | | Group 1 | Group 2 | Total | *P value* |
|---|---|---|---|---|---|
| **Surgery age mean(month)** | | 24.7 | 47.5 | 34.12 (18-64) | 0.001 |
| **Last visit mean age(year)** | | 7.7 | 10.1 | 8.71 (5-13) | 0.001 |
| **Mean follow up duration(month)** | | 68 | 73.57 | 70.18 (25-118) | 0.311 |
| **Gender** | Boy | 4 | 9 | 13 / 70 | |
| | Girl | 34 | 23 | 57 | |
| **Surgery side** | Left | 19 | 19 | 38 (54%) | |
| | Right | 7 | 10 | 17 (24%) | |
| | Bilateral | 12 | 3 | 15 (22%) | |
| **Femoral shortening** | | 7 | 33 | 40 (47%) | |

**Table 2. Patients Radiologic Index**

| | Pre op AC.index | Post op AC.index | Delta | Final CEA |
|---|---|---|---|---|
| **Group 1 (SD)** | 39.5 (4.07) | 20.72 (3.8) | 18.8 (5.03) | 25.52 (8.75) |
| **Group 2 (SD)** | 38.9 (3.2) | 22.3 (4.3) | 16.6 (4.76) | 23.26 (9.31) |
| **Total (min-max)** | 39.31 (32-49) | 21.28 (12-29) | 17.93 (8-28) | 24.59 (6-47) |
| ***P value*** | 0.472 | 0.083 | 0.048 | 0.263 |

**Table 3. Patients Severin Radiologic Scoring System**

| | | Group 1 | Group 2 | *P value* |
|---|---|---|---|---|
| **Excellent** | IA | 31 (62%) | 22 (62.9%) | |
| **Good** | IB | 6 (12%) | 7 (20%) | |
| | II | 6 (12%) | 1 (2.9%) | |
| **Fair** | III | 4 (8%) | 5 (14.3%) | |
| **Poor** | IV | 0 (0%)0 | 0 (0%) | |
| | V | 0 (0%) | 0 (0%) | |
| | VI | 3 (6%) | 0 (0%) | |
| **Satisfaction** | | 43 (87%) | 30 (85%) | >0.05 |
| **Unsatisfaction** | | 7 (13%) | 5 (15%) | |

years old.

In radiological evaluation of patients in the first group, mean preoperative and postoperative acetabular index was 39.5 (SD: 4.07) and 20.72 (SD: 3.8), respectively. This is indicative of 18.8 (SD: 5.03) change in mean acetabular index. While in the second group, the mean preoperative acetabular index was 38.9 (SD: 3.2) and mean post-operative acetabular index was 22.3 (SD: 4.3) with a mean difference of 16.6 (SD: 4.46).

The acetabular index was improved in both groups, but there was no statistically significant difference in mean acetabular index before and after the surgery. (*P: 0.472* and *P: 0.083*, respectively) However, in the first group despite statistically significant reduction of acetabular index the change was not clinically significant (*P: 0.048*) [Table 2].

Radiological evaluation on control pelvic X-rays, showed average Central Edge Angle in the first group as 25.52 (SD: 8.75) and in the second group as 23.26 (SD: 9.31). This difference was not statistically significant (*P: 0.263*).

Based on Severin radiological subjective scoring system, there were 30 hips (60%) in the first group, which were considered as excellent, 13 hips (26%) good, 4 hips (8%) fair and 3 hips (6%) poor. In the second group, 22 hips (62%) were considered excellent, 8 hips (22%) good, 5 hips (14.3%) fair and no poor hips. Therefore, satisfaction rate of 86% was calculated in the first group, while in the second group it was 85%. There was no statistically significant difference between the two groups considering Severin radiological subjective criteria (*P >0.05*) [Table 3].

In clinical evaluation of patients based on Modified MacKay criteria, in the first group 15 hips (30%) were considered as excellent, 26 hips (52%) were good, seven hips (14%) fair and 2 cases (4%) poor, while in the second group, 8 patients (23%) were considered as excellent, 21 patients (60%) were good, 4 patients (11.4%) fair and 2 patients (5.7%) poor. Based on Modified MacKay Criteria, results in 82% of the patients in the first group and 82.9% of subjects in the second group were satisfactory. There was no statistically significant difference between the two groups based on Modified MacKay criteria (*P>0.05*) [Table 4].

In the follow up, we had 13 cases of Avascular Necrosis of femoral head (15%) while 9 of them were children under 3 years and the rest of them were above 3 years old. Based on Kalamchi and MacEwen's classification, 4 patients were categorized in class I, 2 in class II, 1 in class III, and 6 in class IV of femoral head avascular necrosis. All 6 patients in class 4 were under 3 years old [Table 5].

Among our patients, 2 cases had infection, which

**Table 5. Patients Kalamchi and MacEwen's classification**

| | Group 1 | Group 2 | Total |
|---|---|---|---|
| **Class I** | 3 | 1 | 4 |
| **Class II** | 0 | 2 | 2 |
| **Class III** | 0 | 1 | 1 |
| **Class IV** | 6 | 0 | 6 |
| **Total** | 9 | 4 | 13 |

**Table 4. Patients modified Mac-kay scoring system**

| | Group 1 | Group 2 | *P value* |
|---|---|---|---|
| **Excellent** | 15 (30%) | 8 (23%) | |
| **Good** | 26 (52%) | 21 (60%) | |
| **Fair** | 7 (14%) | 4 (11.4%) | |
| **Poor** | 2 (4%) | 2 (5.7%) | |
| **Satisfaction** | 41 (82%) | 29 (83%) | >0.05 |
| **Unsatisfaction** | 9 (18%) | 6 (17%) | |

were treated with debridement but their condition eventually led to AVN. Two patients in the first group had re-dislocation and were classified in poor groups, based on both radiological and clinical criteria.

## Discussion

Early diagnosis and treatment of DDH could significantly reduce long term complications of the disease (10). Review of literature showed that a large proportion of the studies addressing surgical treatment of DDH, has been conducted in developing countries including India, China and Egypt. The goal of treatment in patients with prolonged undiagnosed disease is to achieve a concentric reduction level of femoral head and acetabulum, which is appropriate for functional weight-bearing (9). Another goal is to reduce undesirable complications such as dislocation and subluxation of the hip joint (11).

Various studies have shown non-surgical treatment as skin traction and close reduction for prolonged DDH have high rates of complication, and surgical management would be eventually required (12-14). Mehmet Bulut et al. have shown in their study that treatment of the disease with only soft tissue is associated with high rates of complications and is not recommended (15). In our study, we studied patients above the age of 18 months with diagnosed DDH who underwent Salter osteotomy with or without femoral shortening. A Spica cast had been applied for all operated patients and remained in place for 8 weeks.

Studies have shown that Salter osteotomy clearly improves radiological criteria such as acetabular index postoperatively (16). There is controversy about the age limit for this operation (9). However, in his original article, Salter considered the method appropriate for patients within 18 months to 6 years of age (17). Ryan et al. reported one stage operation (open reduction + innominate osteotomy +/- femoral osteotomy) on children within 3 to 10 years of age has been reported with satisfactory acetabular remodeling and functional outcomes (8). Nakamura et al. performed similar study and found the comparable result with follow up duration as 10 to 23 years in their study (18).

In our study, based on Severin radiologic criteria, satisfaction rate among patients was 86%, and the difference between the two groups of patients was not statistically significant as observed by other studies (19-21).

Based on clinical criteria, patient satisfaction rate was 84%, and difference between two groups was not statistically significant, as reported in other studies (19-21).

Complications in our patients included 13 hips with AVN. We found no significant rate difference between two groups, (11% and 18%). Based on Kalamchi and MacEwen's classification, 6 patients were categorized in class IV of femoral head avascular necrosis, all 6 patients in class 4 were under 3 years old and two hips belonged to a bilateral DDH case. From this group, 6 cases with class IV AVN, 2 were diagnosed with post-operative redislocation and 2 with deep infection. There were two cases of redislocation in our study. Different dislocation rates of 4.5%, 5%, 24% and 64% have been reported in the literature and all have been associated with more complications, including AVN and low satisfaction. Both cases of redislocation in our study had underwent open reduction and Spica cast for 3 months (9, 23-27).

We found no scientific reason of the high-observed rate of class IV AVN in children under 3 years old.

The main limitation of this study is that it is a retrospective study and the data collection and recording may be impaired due to many factors and a prospective study must be performed to reclaim more reliable results. The other limitation is that we are not able to come to any conclusion about long term results as the time of our follow up is not long enough. There might be significant difference in quality of life and radiologic scores between the two groups in adult hood. Finally, patients had been admitted to a referral and training hospital and different surgeons had performed desired operations.

In our study, performing Salter osteotomy with or without femoral shortening to avoid complications has identical satisfactory results in both children over and less than 3 years old. There is no significant difference between these two groups based on clinical and radiological assessments. This operation is essential in prevention of early onset osteoarthritis and could have important social and economic benefits.

DDH is a disease in which timely diagnosis

and treatment reduce its associated long-term complications. We studied complication rate and surgical outcome in children with prolonged, undiagnosed DDH. The results in both groups of patients aged under and over 3 years who underwent Salter innominate osteotomy with or without femoral shortening were found satisfactory. Patient satisfaction difference rate, based on clinical and radiological outcomes, was not statistically significant between the two groups. It should also be noted that complications such as redislocation and deep infection result in poor clinical and radiological outcomes.

The authors declare no source of funding.

The authors declare no conflicts of interests.

Taghi Baghdadi MD
Nima Bagheri MD
Hadi Kalantar MD
Joint Reconstruction Research Center, Tehran University of Medical Science, Tehran, Iran

Seyyed Saeed Khabiri MD
Kermanshah University of Medical Science, Kermanshah, Iran

## References

1. Novacheck TF. Developmental dysplasia of the hip. Pediatr Clin North Am. 1996; 43(4):829-48.
2. Dezateux C, Rosendahl K. Developmental dysplasia of the hip. Lancet. 2007; 369(9572):1541-52.
3. Suzuki S. Deformity of the pelvis in developmental dysplasia of the hip: three-dimensional evaluation by means of magnetic resonance image. J Pediatr Orthop. 1995; 15(6):812-6.
4. Altay M, Demirkale I, Senturk F, Firat A, Kapicioglu S. Results of medial open reduction of developmental dysplasia of the hip with regard to walking age. J Pediatr Orthop Part B. 2013; 22(1):36-41.
5. Vafaee AR, Baghdadi T, Baghdadi A, Jamnani RK. DDH epidemiology revisited: do we need new strategies? Arch Bone Jt Surg. 2017; 5(6):440.
6. Graf R. Is DDH still a problem? Arch Bone Jt Surg. 2014; 2(1):2-3.
7. Feldman DS. How to avoid missing congenital dislocation of the hip. Lancet. 1999; 354(9189): 1490-1.
8. Ryan MG, Johnson LO, Quanbeck DS, Minkowitz B. One-stage treatment of congenital dislocation of the hip in children three to ten years old. Functional and radiographic results. J Bone Joint Surg Am. 1998; 80(3):336-44.
9. Abdullah ES, Razzak MY, Hussein HT, El-Adwar KL, Abdel-Razek Youssef A. Evaluation of the results of operative treatment of hip dysplasia in children after the walking age. Alexandria J Med. 2012; 48(2):115-22.
10. Terjesen T. Dysplasia of the contralateral hip in patients with unilateral late-detected congenital dislocation of the hip: 50 years' follow-up of 48 patients. Bone Joint J. 2014; 96(9):1161-6.
11. Kothari A, Grammatopoulos G, Hopewell S, Theologis T. How does bony surgery affect results of anterior open reduction in walking-age children with developmental hip dysplasia? Clin Orthop Relat Res. 2016; 474(5):1199-208.
12. Mardam-Bey TH, MacEwen GD. Congenital hip dislocation after walking age. J Pediatr Orthop. 1982; 2(5):478-86.
13. Zionts LE, MacEwen GD. Treatment of congenital dislocation of the hip in children between the ages of one and three years. J Bone Joint Surg Am. 1986; 68(6):829-46.
14. Terjesen T, Horn J. Have changes in treatment of late-detected developmental dysplasia of the hip during the last decades led to better radiographic outcome? Clin Orthop Relat Res. 2016; 474(5):1189-98.
15. Bulut M, Gürger M, Belhan O, Batur OC, Celik S, Karakurt L. Management of developmental dysplasia of the hip in less than 24 months old children. Indian J Orthop. 2013; 47(6):578-84.
16. Kotzias Neto A, Ferraz A, Bayer Foresti F, Barreiros Hoffmann R. Bilateral developmental dysplasia of the hip treated with open reduction and Salter osteotomy: analysis on the radiographic results. Rev Bras Ortop. 2014; 49(4):350-8.
17. Salter RB, Dubos JP. The first fifteen year's personal experience with innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. Clin Orthop Relat Res. 1974; 98(1):72-103.
18. Nakamura S, Ninomiya S, Takatori Y, Morimoto S, Umeyama T. Long-term outcome of rotational acetabular osteotomy: 145 hips followed for 10-23 years. Acta Orthop Scand. 1998; 69(3):259-65.
19. Erturk C, Altay MA, Yarimpapuc R, Koruk I, Isikan UE. One-stage treatment of developmental dysplasia of the hip in untreated children from two to five years old. A comparative study. Acta Orthop Belg. 2011; 77(4):464-71.
20. Tezeren G, Tukenmez M, Bulut O, Percin S, Cekin T. The surgical treatment of developmental dislocation of the hip in older children: a comparative study. Acta Orthop Belg. 2005; 71(6):678-85.

21. Tukenmez M, Tezeren G. Salter innominate osteotomy for treatment of developmental dysplasia of the hip. J Orthop Surg. 2007; 15(3):286-90.
22. Yagmurlu MF, Bayhan IA, Tuhanioglu U, Kilinc AS, Karakas ES. Clinical and radiological outcomes are correlated with the age of the child in single-stage surgical treatment of developmental dysplasia of the hip. Acta Orthop Belg. 2013; 79(2):159-65.
23. Ganger R, Radler C, Petje G, Manner HM, Kriegs-Au G, Grill F. Treatment options for developmental dislocation of the hip after walking age. J Pediatr Orthop Part B. 2005; 14(3):139-50.
24. Raiman A. Comments on the contribution: F. Grill and B. Frischhut: "Results of treatment of chronic congenital hip dislocation after learning to walk. Z Orthop Ihre Grenzgeb. 1992; 130(3):251.
25. Ruszkowski K, Pucher A. Simultaneous open reduction and Dega transiliac osteotomy for developmental dislocation of the hip in children under 24 months of age. J Pediatr Orthop. 2005; 25(5):695-701.
26. Mazloumi SM, Ebrahimzadeh MH, Kachooei AR. Evolution in diagnosis and treatment of Legg-Calve-Perthes disease. Arch Bone Jt Surg. 2014; 2(2):86-92.
27. Vafaee AR, Baghdadi T, Baghdadi A, Jamnani RK. DDH epidemiology revisited: do we need new strategies? Arch Bone Jt Surg. 2017; 5(6):440-2.