

# Outcomes of A Single-Stage Triple Procedure for The Treatment of Developmental Dysplasia of the Hip in Children of Walking Age.

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## Authorship and Contribution Declaration

Each author of this article has encountered all 04 criterions of authorship:

1. Commencement and design of the study, attainment of data, or analysis and interpretation of information.
2. Drafting the manuscript or rewriting it censoriously for important intellectual content.
3. Providing concluding endorsement of the version for publication.
4. All authors have settled to be answerable for all aspects of their research work

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## ABSTRACT

**Objective:** To evaluate the radiographic and functional outcomes of treating DDH in ambulatory children using single-stage triple surgery, combined with open reduction, femoral varus derotational osteotomy and Salter's innominate osteotomy.

**Methodology:** The Department of Orthopaedic Surgery of the Sheikh Khalifa Bin Zayyad Al Nayyan Medical Complex Quetta conducted this descriptive study between January 2017 and December 2020. The study included of 60 patients (96 hips) aged between 18 months and 8 years who were diagnosed with DDH. Severin's classification was applied to assess radiologic outcomes, while McKay's criteria were used to evaluate clinical outcomes.

**Results:** The majority of patients (58.3%) of this study had hips with severe dysplasia (Tönnis Grade IV) preoperatively, with a mean age of 4.6 years. The final procedures performed were Salter's innominate pelvic osteotomy in 84 hips (87%), Pemberton osteotomy in 8 hips (8.3%), and Chiari's salvage procedure in 4 hips (4.1%). According to McKay's criteria, the postoperative results were excellent in 45 patients, good in 8 patients and fair in 5 patients. Radiographically, 84 hips had a type I and 10 hips a type II of the Severin classification.

**Conclusions:** In particular, severe DDH with walking age group is best treated by single-stage triple procedure. This method yields excellent to good functional and radiographical results. Early recognition and treatment also continue to be important aspects in managing challenging dysplastic hips.

**Keywords:** Congenital Hip Dislocations, Hip Dislocations, Congenital, One stage triple procedure, salter's innominate osteotomy.

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## INTRODUCTION

Developmental dysplasia of the hip (DDH) refers to a range of hip abnormalities, including dislocated, subluxated, or dysplastic hips with an abnormal acetabulum. This term, which changed the formerly common "Congenital Dysplasia of the Hip," better reflects the developmental nature of the disorder<sup>1-3</sup>. DDH is characterized by an immature, shallow acetabulum that may be associated with subluxation or dislocation of the femoral head. The severity of the DDH ranges from mild instability to complete

dislocation, leading to significant functional impairment if left untreated. The congruent stability of the femoral head within the acetabulum decides the proper hip development in children; if instability persists by the time a child begins walking, the normal development of the hip will be affected<sup>4-6</sup>.

Early diagnosis and treatment are crucial for achieving the best possible functional outcomes. However, the early detection of DDH remains a challenge in many regions, particularly in areas where healthcare facilities are limited, screening programs are lacking, and cultural practices such as

swaddling are prevalent<sup>7-9</sup>. In such settings, DDH is often diagnosed late, typically when children begin to walk and exhibit a limp. Even when DDH is identified early, it is sometimes improperly managed by traditional healers or through non-standard medical practices. Subsequently, numerous cases present at an older age, necessitating more complex surgical interventions due to adaptive shortening of the extra-articular soft tissues, acetabular dysplasia, and increased femoral anteversion<sup>10-12</sup>.

Pelvic osteotomy is often required in case of persistent acetabular dysplasia when acetabular deficiency is severe. The purpose of this procedure is to reposition the acetabulum so that more of the femoral head is covered and therefore the function and stability of the joint are improved. In contrast, femoral osteotomy promotes the reduction of the hip joint while reducing the risk of osteonecrosis from intraarticular pressure by relieving hip joint stress. It also helps to shorten a femur and to decrease abnormal excessive femoral anteversion which is quite common to young untreated DDH<sup>13-15</sup>. To correct these clinical situations in older children with persistent acetabular dysplasia, the objectives become the postponement or prevention of the development of the osteoarthritis and the endoprosthesis of the hip in childhood<sup>16-18</sup>.

Salter's innominate osteotomy is a method used to redirect the acetabulum which has been widely accepted in treatment of late-presenting DDH. This method led to a 92% rate of good or excellent radiographic results, by Salter initially<sup>19</sup>. Nowadays, open reduction combined with Salter's osteotomy is gaining popularity for the treatment of DDH in a complete one-stage procedure particularly happening late after walking years. Nevertheless, multiple factors can impact the outcomes of Salter's osteotomy: age at time of treatment; open reduction required or not; past hip treatments and whether it is bilateral.<sup>20</sup>

When femoral anteversion is severe or femoral shortening is required to aid in the reduction of the dislocated hip, Femoral Varus Derotational Osteotomy (VDRO) is recommended. VDRO is especially helpful in easing hip joint stress, which lowers the likelihood of osteonecrosis, a dangerous side effect of DDH treatment. To maximise hip stability and function, this operation is frequently paired with other treatments, such as pelvic osteotomy or capsulorraphy<sup>19-20</sup>. When there is significant laxity in the hip joint after reduction, capsulorraphy—tightening of the joint capsule—is recommended. In older kids or those with severe

types of DDH, this surgery is crucial for preserving hip stability and preventing redislocation<sup>20</sup>.

Even though these surgical procedures are effective, treatment timing remains crucial. It is recommended that DDH be detected and treated during the initial stages of life. In order to reduce complications and enhance results, treatment should be started as soon as possible, ideally before the child turns four years old, if early detection is missed<sup>18-20</sup>. In older children, especially those beyond the walking age, treatment typically involves more extensive surgery due to the aforementioned complications. Without added procedures, such as femoral or pelvic osteotomy, achieving a normal hip in adulthood is unlikely<sup>17-20</sup>.

In regions where early detection of DDH is limited and challenging, such as in parts of South Asia, the diagnosis is often delayed until significant deformities have developed. Maternity homes do not have screening programs and home births are more common which prolongs this delay. Cultural customs like swaddling also play a part in the delayed presence of DDH. Inadequate treatment by non-specialists frequently results in less than ideal outcomes even in cases where a diagnosis is made early<sup>19-20</sup>. For many children in these areas to achieve acceptable hip function major surgical procedures such as femoral and pelvic osteotomies are necessary.

With clearly defined disease conditions, ages and treatments received, this study sought documentation of the outcomes of a group of late-diagnosed DDH patients. We also analysed factors associated with osteonecrosis and the overall outcomes following treatment, particularly focusing on the role of femoral shortening with derotation and Salter's innominate osteotomy in achieving optimal results. Given the challenges in early detection and proper management in our region, this study contributes valuable insights into the management of DDH, especially in children presenting after the "golden period" of treatment.

**Objective:** The aim of this study is to evaluate the radiographic and functional outcomes of a one-stage triple procedure (open reduction, femoral varus derotational osteotomy, and Salter's innominate osteotomy) for the treatment of developmental dysplasia of the hip in children of walking age.

## METHODOLOGY

This descriptive study was conducted at the Department of Orthopaedic Surgery, Sheikh Khalifa

Bin Zayyad Al Nayyan Medical Complex, Quetta, spanning from January 1, 2017, to December 31, 2020.

The study included 60 patients (96 hips), from children aged 18 months to 8 years who were diagnosed with developmental dysplasia of the hip (DDH), encompassing both genders. Individuals who did not have syndromic diseases or neuromuscular abnormalities and who had not received DDH treatment before were eligible. The exclusion criteria included individuals who were younger than 18 months or older than 8 years those with neuromuscular disorders those with syndromic syndromes like Arthrogryposis multiplex congenita those who had previously received DDH therapy elsewhere and those who were contraindicated for the triple procedure.

To gather data, radiological examinations and clinical evaluations were used. According to McKay's criteria, clinical evaluations covered pain, limping, and range of motion. Anteroposterior and frog-lateral plain X-ray images of the pelvis were used for radiological examinations. Before surgery, Tönnis grading was applied, and postoperative evaluation was conducted using Severin's classification. A proforma was used to collect all the data.

Data analysis was done with SPSS 16.0. Severin's criteria were used for radiological results and McKay's criteria for clinical outcomes evaluation in the analysis. To evaluate radiography results, the acetabular index (AI) and center-edge angle (CEA) were evaluated.

The iliofemoral technique, sometimes referred to as the Smith-Petersen approach, is utilised to enter the acetabulum in order to execute osteotomies and open reductions. The anterior superior iliac spine (ASIS) to the greater trochanter is where a curved incision is made at the start of treatment in order to access the anterior hip joint. A meticulous dissection is performed to preserve key anatomical features focusing on the femoral head and hip joint capsule. As soon as the appropriate exposure is obtained joint reduction and osteotomy is performed. Correct alignment and structural stability are ensured by layer-by-layer closure of the incision. When hip dysplasia necessitates more complex care the Summerville method may be employed. This involves making a posterior or posterior-lateral incision depending on the hips location and the surgeon's judgment. To improve covering of the femoral head the acetabulum is reshaped and repositioned using

an osteotomy after the femoral head and acetabulum are carefully exposed. After the acetabulum is fixed in place using K-wires, the closure is performed and the necessary postoperative care protocols are carried out.

For patients with an acetabular index (AI) greater than  $40^\circ$  Salter's Innominate Osteotomy is recommended. The innominate bone is exposed by a curved incision made above the iliac crest reflecting the periosteum of the iliac crest and the abdominal muscles. A wedge osteotomy of the innominate bone is then performed to realign the acetabulum. The osteotomy is secured with K-wires to maintain the acetabulum's new position and the incision is covered in layers. The hip joint capsule is opened by a linear incision made along the acetabular edge (inverted T-shaped incision), which later on is concluded with capsuloraphy is to increase the stability of the hip joint. Subsequently a suture technique that reinforces the joint and reduces laxity is used to repair and tighten the capsule.

Femoral shortening and derotation osteotomy (VDRO) is advised to rectify excessive femoral anteversion and enhance stability respectively. In this technique the proximal femur is exposed subperiosteally following a lateral incision over the femur. Distal to the lesser trochanter a transverse osteotomy is carried out and the femur is shortened by realigning the femoral shaft and excising extra bone. By rotating the distal component until the patella faces forward femoral anteversion can be corrected. Femoral head concentrically decreases with appropriate alignment following osteotomy site stabilization with a dynamic compression plate or other fixation methods.

In order to maintain stability and alignment and immobilize the hip joint postoperatively, involves the use of a hip spica cast. The hip joint is placed in a  $90^\circ$ – $100^\circ$  flexion and  $40^\circ$ – $55^\circ$  abduction posture with neutral internal rotation when the cast is applied. This position is maintained for three months, with frequent changes made if necessary. Follow-up care includes monthly visits for the first three months, followed by visits every three months up to one year. During these follow-ups, clinical evaluations and radiographs of the pelvis are conducted to monitor Tönnis grading, acetabular index, center-edge angle, and any signs of avascular necrosis (AVN).

**Classification Systems  
McKay's Clinical Criteria:**

Grade	Rating	Description
I	Excellent	Stable painless hip; Negative Trendelenburg sign; Full range of motion (ROM)
II	Good	Slight limp; Slight reduction in ROM
III	Fair	Positive Trendelenburg sign; Moderate limp; Limited ROM
IV	Poor	Positive Trendelenburg sign. Unstable and/or Painful hip;

**Severin's Radiographic Classification for Postoperative Outcome:**

Class/ Grade	Description	Centre-Edge Angle (Degrees)
I	Normal appearance	≥15(5-13 Years) ≥20(>14 Years)
II	Mild deformity of femoral head, neck or acetabulum	≥15(5-13 Years) ≥20(>14Years)
III	Dysplasia/ moderate deformity	<15(5-13 Years) <20(>14 Years)
IV	Subluxation of femoral head	-
V	Articulation of femoral head with false acetabulum	-
VI	Redislocation	-

**Tönnis Classification (Preoperative):**

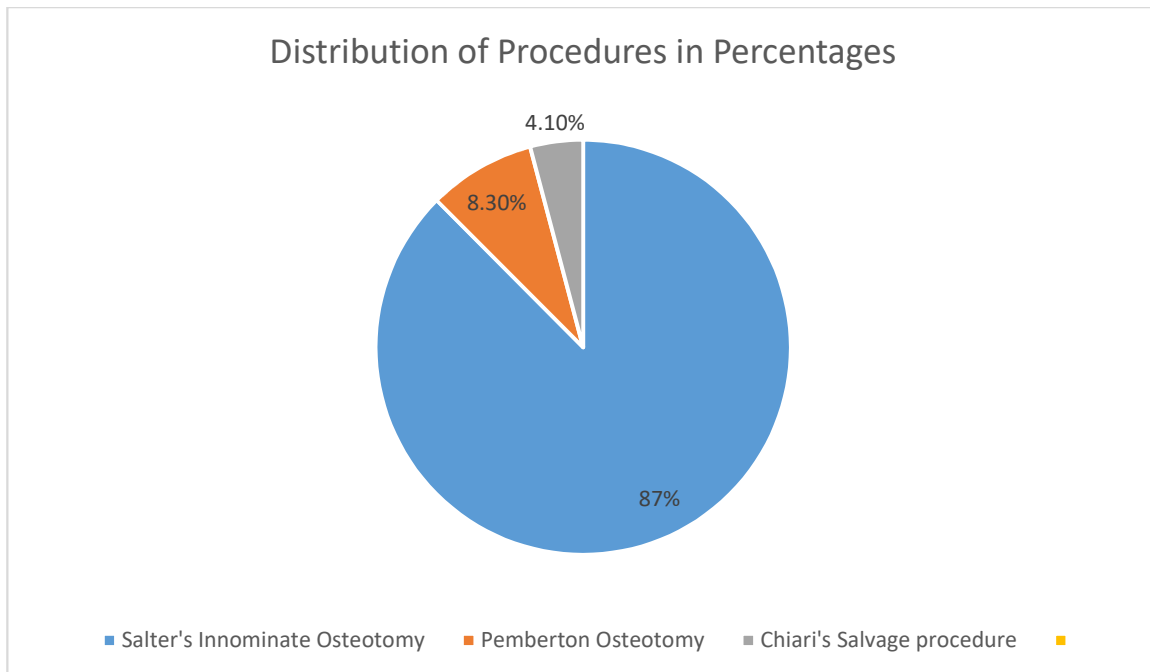
Grade	Criteria
<b>I</b>	Capital femoral epiphysis medial to Perkins line
<b>II</b>	Capital femoral epiphysis medial to Perkins line but below the level of the superior acetabular rim
<b>III</b>	Capital femoral epiphysis at the level of the superior acetabular rim
<b>IV</b>	Capital femoral epiphysis below the level of the superior acetabular rim

**RESULTS**

In present study we included 60 patients with DDH comprising of 96 Hips, where male and female distribution were 20 (33%) and 40 (66%), respectively. As for the hip laterality, 9 (15%) patients involved Right side and 7 (11.6%) patients involved left side, while 44 (73.4%) patients were affected bilaterally. The Pre-operative Tönnis Grading was observed as 8 (8.3%) patients falling in Grade I, 12 (12.5%) patients in Grade II, 20 (20.8%) patients in Grade III, and 56 (58.3%) patients in Grade IV of

DDH. Mean age of patients was 4.6 years, ranging from 1.6 years to 8 years. Functional outcomes according to Modified McKay's criteria observed as 45 patients as Excellent, 8 patients as Good, 5 patients as Fair and 2 patients as Poor results. Radiological outcomes according to Severin's criteria were recorded as 84 patients as type I, 10 patients as type II, 2 patients as type III, while there were no patients falling in type IV, type V or type VI categories.

Procedure	Number of Hips	Percentage
Salter's Innominate Osteotomy	84	87%
Pemberton Osteotomy	8	8.3%
Chiari's Salvage Procedure	4	4.1%



## DISCUSSION

For walking-age children with developmental dysplasia of the hip (DDH), a single-stage triple procedure consisting of open reduction, femoral shortening and derotation, and Salter's innominate osteotomy has shown to be a successful treatment approach. Our study demonstrates that this comprehensive approach yields favourable clinical outcomes. According to McKay's criterion, there were notable advancements, with many patients achieving excellent or good outcomes. Less pain less limping and more mobility are the results of this. This aligns with additional studies demonstrating the effectiveness of the surgery in symptom reduction and hip function restoration<sup>16</sup>.

Severin's categorization radiographic assessments confirm the advantageous outcomes of this surgical approach. A slight acetabulum and femoral head deformity was present in most patients or they appeared normally. These results demonstrate how well the procedure fixes the anatomical abnormalities connected to DDH. The observed increases in the center-edge angle and acetabular index provide more evidence that the procedure was successful in realigning the femoral head and optimizing acetabular coverage. These outcomes align with larger studies that highlight the benefits of a single-phase approach<sup>17</sup>.

Studies have indicated that the implementation of a combination strategy can mitigate patient trauma and expedite recuperation times by

decreasing the quantity of surgeries needed. In addition, the integrated design of this procedure facilitates a more comprehensive repair of femoral and acetabular abnormalities which is necessary to achieve long-term stability and function<sup>19</sup>.

While these are encouraging results it is important to remember that issues such as avascular necrosis or persistent dysplasia may still exist. To ensure the long-term efficacy of treatment for osteonecrosis symptoms radiographic assessments and ongoing surveillance are required. All things considered the single-stage triple treatment is a good way to treat DDH offering significant improvements in radiographic and clinical outcomes and adhering to established guidelines for hip dysplasia orthopaedic surgery<sup>20</sup>.

The current study set out to assess the effectiveness of a single-stage triple surgery in treating walking-age children with hip developmental dysplasia (DDH). In total 96 hips were involved in the trial which included 60 participants. As expected given the higher prevalence of DDH in women the gender distribution was skewed toward females with 20 (33%) and 40 (66%) percent female patients respectively.

The laterality distribution showed that only 15% and 11.6 % of cases involved the right and left hips respectively with the majority of cases (73.4%) being bilateral. This higher than average rate of bilateral involvement is consistent with earlier DDH studies which typically show bilateral cases<sup>17</sup>.

In terms of the severity of the disease, the pre-operative Tönnis grading showed that a sizable percentage of hips were categorised as Tönnis Grade IV, which denotes severe dysplasia. The decision to perform the triple procedure in all instances was likely influenced by the severity of the condition, as this technique is frequently reserved for more severe cases that necessitate simultaneous treatment of femoral and acetabular abnormalities.

In a total of 84 hips (87%), Pemberton osteotomy was performed on 8 hips (8.3%), while Chiari's salvage operation was performed on 4 hips (4.1%) of the surgical procedures. Salter's innominate osteotomy is widely accepted as a successful treatment for paediatric acetabular dysplasia. In a small percentage of cases, the use of Pemberton and Chiari methods suggests a customised strategy based on the unique anatomical requirements of the patient.

According to modified McKay's criteria, post-operative functional outcomes were mostly outstanding (45 patients) and good (8 patients), with only a small percentage of patients having fair (5 patients) or poor (2 patients) results. These results demonstrate that most patients experienced excellent function restoration following the single-stage triple surgery. These conclusions were corroborated by radiological results, which were assessed using Severin's criteria. Of the hips, 84 were classified as type I and 10 as type II, showing acceptable acetabular development following surgery.

Severin's classification does not include type IV, V, or VI outcomes, indicating that the surgical methods used were effective in avoiding serious problems or persistent malformations. Considering the large number of patients with advanced pre-operative Tönnis grades, this result is very noteworthy.

## CONCLUSION

In summary, open reduction combined with femoral varus derotational osteotomy and Salter's innominate osteotomy is a single-stage triple procedure that is very effective in managing developmental dysplasia (DDH) in walking-age children, especially when severe dysplasia is present, and reduces the risk of AVN. The noteworthy percentage of good and positive results, both radiologically and functionally, highlights the importance of this all-encompassing surgical strategy in handling complex DDH cases. Treating DDH in these patients effectively requires an early diagnosis and management.

## Limitations:

In order to further analyse these findings and investigate the long-term implications of this approach, it is imperative that future research incorporates larger cohort studies and extended follow-up periods.

## Ethical Considerations:

Ethical standards were followed in the study, guaranteeing voluntary participation, informed consent, and confidentiality. Before starting the data collection process, permission was obtained from the appropriate institutional review board.

## Conflict of Interest: None

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## Disclaimer: None

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