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Document heading.

Outcome of Salter Osteotomy in DDH Patients Case Series

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Abstract:

Backgrounds: Developmental dysplasia of the hip (DDH) is a disorder of abnormal development resulting in dysplasia and possible subluxation or dislocation of the hip secondary to capsular laxity and mechanical factors.

Objective: To assess Clinical and radiological outcome of Salter osteotomy in ddh patient. **Methods:** The study is a Prospective descriptive analysis study involving 12 patients (1 males, 11 females) conducted in Karbala Governorate, Iraq, at Imam Al-Hussain Medical City and Imam Al-Hassan Al-Mujtaba Hospital from January 01, 2023, to January 01, 2025. Patients diagnosed with DDH and who underwent Salter osteotomy were included. Data collection was done through paper questionnaires focusing on age, sex, delivery mode, disease bilaterality, acetabular index, Modified McKay criteria, and postoperative complications (infection, redislocation, AVN). Ethical approval was granted by the research committees, ensuring patient confidentiality. Statistical analysis utilized descriptive statistics (frequency and percentage). **Results:** The study included a total of 12 participants, with 9 participants (75.0%) being under 2 years of age and 3 participants (25.0%) being over 2 years. Among these participants, 11 were female (91.7%) and 1 was male (8.3%). In terms of bilaterality, 6 participants (50.0%) had unilateral conditions left, 3 participants (25.0%) had bilateral conditions, and the remaining 3 participants (25.0%) had unilateral right conditions. Regarding delivery mode, 6 participants (50.0%) were delivered via cesarean section, while the other 6 (50.0%) were delivered through normal vaginal delivery.

Conclusions: In this study conclude Salter osteotomy in patient with DDH under six years old dilver good to excellent clinical and radiological outcome.

Introduction

Developmental dysplasia of the hip (DDH) is a disorder of abnormal development resulting in dysplasia and possible subluxation or dislocation of the hip secondary to capsular laxity and mechanical factors [1]. DDH vary in severity and may affect one or both hips. Diagnosis Typically, the condition is diagnosed not long after birth through physical examination (barlow test and ortonali test) and through imaging studies such as ultrasound or X-rays. Untreated, DDH can lead to chronic pain, limping, and other mobility problems later in life, so early detection is extremely important , So that screening of gynecologist and pediatrician and referral to orthopedic surgeon on suspicion [2] Risk factors for multiple DDH are a family history of DDH, breech presentation and female sex, because there are more affected girls , overcrowded like twin [3].

Other causes such as oligohydramnios (too little amniotic fluid) inhibit movement of the fetal position in the uterus and some postnatal practices like swaddling can increase the chances of a baby getting DDH. If left untreated and undiagnosed, DDH may result in a variety of complications such as weakness, deformity and early-onset OA in adulthood related to instability and abnormal loading of the hip joint. Clinical presentation of DDH might vary by age of presentation; in neonates, clinical presentation might be a click or “clunk” on examination of the hip, leg length asymmetry or decreased range of motion at the affected hip. Bigger children might present with gait disturbances, a limp and/or anisomelia [4].

The treatment of DDH is defferent dependent on the duration of diagnosis as well as the severity of the disease. In children below six months of age nonoperative treatment, for example immobilizing the hip joint in the correct position with a pavlic harness is typically implemented [5].

These methods use soft braces to maintain the hip flexed and abducted in a stable position to allow normal growth. If the Pavlik harness is unsuccessful in maintaining the hip in this position, the next treatment option would be using an Abduction brace. If that also fails, a closed reduction procedure is performed. Finally, if these conservative treatments fail, surgical intervention may be required. A Salter osteotomy is one of the most practical strategies of surgical treatment aimed at the repositioning of the acetabulum in relation to the femur head [6].

Salter osteotomy technique is implemented to turn the acetabulum to provide additional coverage on the femur head and achieve even a stronger degree of joint stabilization. Surgery is done to cut through the front of the pelvic bone (the innominate bone) and allow the acetabulum to become more useful. This is a process that restores hip joint symmetry and prevents dislocation and arthrotic development. Salter osteotomy is most effective in children of age below 6 years as the hip is the part that grows best after the operation [7].

Patients with DDH undergoing Salter osteotomy achieve tremendous effectiveness as far as joint stability, pain and functional movements [8,9]. It is clear that the primary therapeutic effect of the procedure is the correction of acetabular dysplasia, the most important part of which is DDH. This process realigns the hip, and does not cause additional dislocations by moving the 3 acetabulum in such a way that it encloses the femur head. This therapy plays a pivotal role in the long-term alleviation of pain and in lowering the chances of secondary arthritis that is a frequent occurrence in the case of untreated progressive DDH [8]. Salter Ostotomy also has the advantage that it stops premature hip radiological changes, without leading to osteoarthritis. Increasing the congruence of the joint will stop the abnormal wear of cartilage and degeneration of the hip. This in fact, significantly delays or prevents

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the development of arthritis of the hip in many people, which is a common sequela in people with DDH which is untreated, or which does not undergo surgery at a young age [9]. Furthermore, the procedure has long-term benefits and as a result of hip function, most patients are able to return to their previous activity level with decreased pain and improved mobility [10].

Aim of Study: To assess Clinical and radiological outcome of Salter osteotomy in ddh patient.

Methodology:

Sampling Method

A study comprising of 12 patients (1 males and 11 females) conducted in Kerbala Governorate, Iraq, at Imam al-hussain medical City and Imam al-Hassan al-Mujtaba Hospital, from January 01, 2023, to January 01, 2025. Patients were included if they were diagnosed with DDH and underwent Salter osteotomy.

Data Collection: Data were collected by paper questionnaires seeking information on age, sex, mode of delivery (normal vaginal delivery or caesarean section) and other clinic features (bilaterality of the disease, AI before and after surgery, Modified McKay criteria for the postoperative assessment). The questionnaires also inquired as to existences of the complications such as the infection, the redislocation or AVN after the operation.

Inclusion Criteria:

- Patients With Hip DDH: 12 patients with developmental dysplasia of the hip DDH.
- Patients have Salter osteotomy from January 01, 2023, to January 01, 2025.
- Participants By which patients were included Males and female patients under sixth years only.

Exclusion Criteria:

- Patients with major co-morbidities (neurological conditions) are likely to influence the outcomes of surgery.

Operative Procedure

Position: Supine

Incision: Curved or straight incision centered over the anterior superior iliac spine (ASIS) and extending distally toward the lateral aspect of the patella.

Surgical Steps (in DDH context):

1. Skin and subcutaneous tissue dissection:

Identify and protect the lateral femoral cutaneous nerve.

2. Interval Between Muscles:

- The true interval is between the tensor fascia lata (TFL) laterally and sartorius medially.
- Incise the fascia lata, retract TFL laterally and sartorius/rectus medially.

3. Exposure of Hip Capsule:

- Detach the rectus femoris origin (direct head) if needed.

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- The iliopsoas may also be released or retracted.
- Expose the anterior hip capsule; perform a capsulotomy (usually Tshaped).

4. Open Reduction:

- Identify obstacles: ligamentum teres, pulvinar, hypertrophied capsule, transverse acetabular ligament.
- Remove interposed tissues and reduce the femoral head into the acetabulum.

5. Capsulorrhaphy: Tighten the capsule to maintain stability.

6. Close in layers: Pelvic osteotomy (Salter) was done through the anterior incision of open reduction. Salter osteotomy was done in 12 hips. Salter osteotomy was completed by a gigli saw and the graft was taken from the iliac crest.

DDH Types According to Tonnis Criteria

Grade I: Capital femoral epiphysis medial to Perkins.

Grade II: Capital femoral epiphysis medial to Perkins.

Grade III: Capital femoral epiphysis at the level of the superior acetabular rim.

Grade IV: Capital femoral epiphysis above the level of the superior acetabular rim.

McKay's Criteria for Clinical Evaluation of Results.

Grade I: Excellent – Painless, stable hip; no more than 15 degrees of rotation.

Grade II: Good – Stable hip with mild limitation of range of motion.

Grade III: Fair – Minimum pain, some stiffness; positive Trendelenburg's sign.

Grade IV: Poor – Significant pain.

Ethical approval was issued by the research committee of Imam Al-Hussain Medical City and Imam Al-Hassan AlMujtaba Hospital; thus confidentiality of patient data was maintained by not including any personal identifying information at the time of data collection.

Statistical Analysis: The data analysis was conducted using SPSS version 26 and Excel 2013. The clinical characteristics and surgical outcomes of the patients were summarized using descriptive statistics, such as frequency and percentage.

Results:

Table 1: This table presents the demographic distribution of 12 participants categorized by age and gender. Regarding age, the majority of participants (75.0%) were under 2 years of age, while 25.0% were above 2 years. In terms of gender, 91.7% of the participants were female, and only 8.3% were male.

Table 1: Demographic Characteristics of Participants:

		N	%
Age	Above 2 years	3	25.0%
	Below 2 years	9	75.0%
	Total	12	100.0%
Gender	Female	11	97.7%
	Male	1	8.3%
	Total	12	100.0%

Table 2: This table shows the distribution of 12 participants categorized by bilaterality and delivery mode. For bilaterality, half of the participants (50.0%) had unilateral (left) conditions, 25.0% had bilateral conditions, and the remaining 25.0% had unilateral (right) conditions. Regarding delivery mode, 50.0% of participants were delivered via cesarean section (CS), while the other 50.0% were delivered through normal vaginal delivery (NVD).

Table 2: Distribution of Participants by Bilaterality and Delivery Mode:

		N	%
Bilaterality	Bilateral	3	25.0%
	Unilateral (Left)	6	50.0%
	Unilateral (Right)	3	25.0%
	Total	12	100.0%
Delivery Mode	CS	6	50.0%
	NVD	6	50.0%
	Total	12	100.0%

Table 3: The mean acetabular index decreased from 36.6 preoperatively to 19.2 immediately after surgery, and further to 15.7 at one year, indicating sustained improvement in acetabular development.

Table 3: Acetabular Index Mean:

Acetabular Index Mean	Mean
Pre operation	36.6%
Direct post operation	19.2%
1 year post operation	15.7%

Table 4: This table presents the pre-operative Tonnis classification of 12 participants. Among the participants, 66.7% were classified as Type 3, 25.0% as Type 2, and 8.3% as Type 4.

Table 4: Distribution of Participants Based on Tonnis Classification Pre-Operative:

Tonnis Classification Pre-Operative	N	%
Type 2	3	25.0%
Type 3	8	66.7%
Type 4	1	8.3%
Total	12	100.0%

Table 5: This table shows the postoperative evaluation of 12 participants based on the Modified McKay Criteria. According to the criteria, 58.3% of participants were excellent. 41.7 % of participants had good outcomes, while 0.0 % had poor and fair outcomes. 10.0 % of participants required Proximal Femur Osteotomy.

Table 5: Postoperative Evaluation Based on Modified McKay Criteria and Surgical Outcomes:

		N	%
Modified McKay Criteria		7	58.3%
		5	41.7%
		0	0.0%
		0	0.0%
		12	100.0%
Proximal Femur Osteotomy		1	10.0%
Need for Another Surgery (K-wires Removal)	Yes	12	100.0%

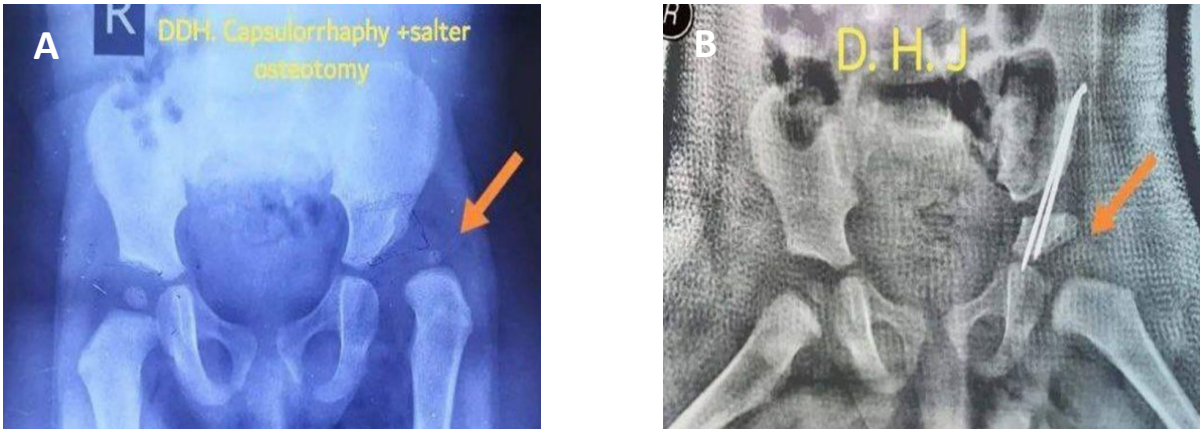

Figure 1 A, B: 2 years female patient with capsulorraphy and Salter osteotomy immediately after surgery.

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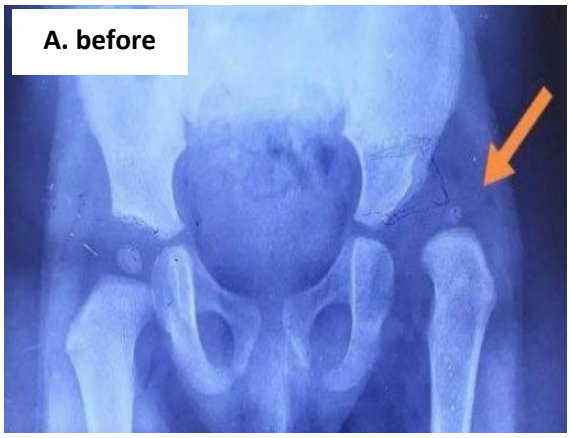

Figure 2 A, B: Post-spica outcomes following open reduction and pelvic osteotomy in a 2-year-old female patient with developmental dysplasia of the hip (DDH).

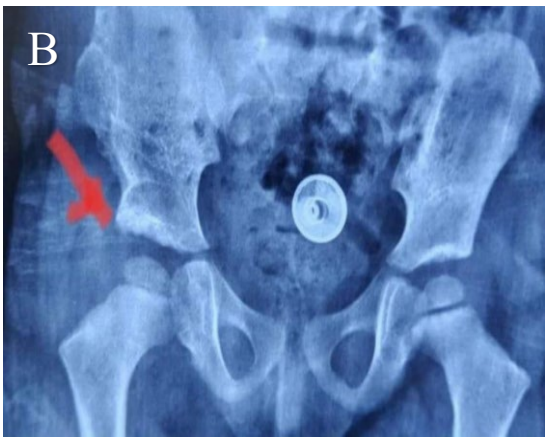

Figure 3 A, B: Eighteen-month postoperative outcomes following salter osteotomy for DDH in a same child.

Discussion.

In the present study, the majority of participants were under the age of 2. This is consistent with common clinical patterns in developmental dysplasia of the hip (DDH), where early surgical intervention leads to significantly better outcomes, particularly in younger patients. Hip joint is more flexible in young children, and this gives it a better chance of remodelling after surgery. These results are all in line with van Stralen et al. (2024) [11], who also highlight the advantages of surgical intervention in younger children, particularly in case of operations such as Salter Osteotomy. They have indicated in their study that the hip joint of younger children has more potential of recovery and hence more successful in the long run [11].

Most of the participants in the current research were female, which was in line with the already established pattern that DDH is prevalent in females. Female anatomy and hormonal differences could be the cause of the higher susceptibility of hip joint instability. This result is consistent with the report obtained by Rehman et al. (2025) [12], who also demonstrated that DDH was higher in females within their cohort. They also underline their study that females, in their early case, are more likely to have

better outcomes of the Salter Osteotomy since their hip joints are more flexible, which enables them to remodel better and be more stable after the procedure. The incidence of complications in the future and the likelihood of a successful outcome can be enhanced with an early surgical intervention of female infants [12].

Most of the subjects in this study were found to have unilateral left sided DDH which is typical in the clinical practice. The findings given by Suvorov and Filipchuk (2022) [13] also indicated a greater incidence of unilateral DDH and especially on the left side and noted that cases of unilateral DDH usually have a favorable prognosis. Unilateral character of the condition is usually simpler to treat on an isolated basis and the current project indicated that Salter Osteotomy is very efficient in treating unilateral cases, particularly unilateral cases located on the left. This result confirms that Salter Osteotomy is effective in unilateral situations to enhance the coverage of acetabular and increase the stability of the joint (Suvorov and Filipchuk, 2022) [13].

The participants were also divided into cesarean section (CS) and normal vaginal delivery (NVD). The importance of delivery mode in the development of DDH has been controversial. Nonetheless, the researchers conducted by Tushar et al. (2021) [14] did not find any significant relations between the mode of delivery and the occurrence or severity of DDH. Their examination maintained that additional elements, including heredity and intrauterine placement, have a larger contribution to DDH development. The current research results, which reveal a parity between cesarean and vaginal births, also confirm this conclusion, and it is possible that, although the mode of delivery is a certain factor, it is not the major one in the determination of DDH [14].

Most of the cases showed significant and permanent increase in the acetabular index, the mean index decreasing in preoperative state (36.6) to postoperative (19.2) and to 15.7 at 1 year follow-up. This stable decrease is a sign of the short-term mechanical correction of the acetabulum that is attained by surgery and of the biological remodeling of the acetabulum during the long run. These results are consistent with those of Tushar et al. (2021) [14] who found out that the majority of patients who underwent Salter pelvic osteotomy showed a considerable improvement in acetabular morphology that persisted afterwards. This result was reported by the authors to have been caused by the redirecting of the acetabular roof, instead of covering the femur head better, it triggers 16 physiological acetabular development, which leads to long-term congruency and stability of the joints [14]. Most of the subjects in the current study were categorized as Tonnis Type 3 that is severe DDH. It was also found by Suvorov and Filipchuk that a high prevalence of severe DDH cases is observed in patients in the conditions of Salter Osteotomy (2022) [13]. In their work, they stressed the fact that Salter Osteotomy is especially helpful with severe cases because it re-aligns the acetabulum, enhancing the coverage of the femural head and stabilization of the joint. These findings are supported by the present study because most of the Type 3 cases experienced a marked improvement in hip functioning and stability after the Salter Osteotomy. These findings demonstrate the relevance of early intervention in severe DDH cases since the intervention produces a significant effect on joint positioning and avoids additional worsening [13].

The majority of participants demonstrated excellent to good outcomes, with no cases of poor or fair results. These findings align with Tushar et al. (2021) [14], who reported high success rates and minimal complications following Salter Osteotomy. Their study indicated that most patients achieve excellent or good results, particularly in severe DDH cases, and that the procedure is highly effective in improving hip function and joint stability. The present study also found that the rate of complications was minimal, with no cases of infection, redislocation, or avascular necrosis (AVN). However, Proximal femur

osteotomy was a percentage 9% while kwire removal due to all patients (100%), which is consistent with the findings of Tushar et al. (2021), who noted that some patients may need supplementary interventions for optimal results. The need for these additional procedures does not diminish the overall success of surgery 17 but highlights the importance of personalized treatment and follow-up care to address any challenges during recovery [14]. Furthermore, the findings of Jagadesh et al. (2018) [15], who studied the outcomes of late-presenting DDH cases, also support the present study. Their research found that Salter Osteotomy is effective even in late-presenting cases, providing good functional outcomes with minimal complications. The absence of major complications in the present study, such as AVN or infection, supports the safety of Salter Osteotomy, as highlighted by Jagadesh et al. (2018) [15].

Conclusion and Recommendations:

Conclusion

This paper concludes that Salter osteotomy in children with developmental dysplasia of the hip (DDH) less than one year old years old yielded good to excellent clinical and radiological outcomes.

Recommendations

Ongoing Care: Surveillance and follow-up visits are required regularly to oversee the recovery and identify complications on time, including infection or redislocation.

Rehabilitation: An organised rehabilitation program must be provided to aid recovery, regain function and minimise the development of long term joint issues.

Long-Term Follow-Up: The optimal monitoring is more than two years, during which the patients can be observed to assess the sustainability of the outcomes of the surgical procedure and detect the occurrence of late complications, such as avascular necrosis (AVN). Follow-up is critical to enable prompt identification and control of this type of problem.

Greater populate: Future research can include larger and more representative groups to enhance the dependability and the applicability of the results.

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