DOI: https://doi.org/10.54393/pjhs.v7i4.3543

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 04 (April 2026)

Original Article

OPEN ACCESS

Outcome of Modified Salter Osteotomy in Improving Acetabulum Index of Developmental Dysplasia of the Hip with Age Group of 2-10 Years

Mehtab Ahmed[1*], Pervez Ali[1], Shazia Soomro[2], Abdul Ghaffar Jamali[1], Faique Ali[1] and Hassan Ahmed[1]

[1]Department of Orthopedic Surgery, Jinnah Postgraduate Medical Center, Karachi, Pakistan
[2]Department of Pediatrics, National Institute of Child Health, Karachi, Pakistan

ARTICLE INFO

Keywords:
Developmental Dysplasia of the Hip, Modified Salter Osteotomy, Acetabular Index, Pediatric Orthopedics

How to Cite:
Ahmed, M., Ali, P., Soomro, S., Jamali, A. G., Ali, F., & Ahmed, H. (2026). Outcome of Modified Salter Osteotomy in Improving Acetabulum Index of Developmental Dysplasia of the Hip with Age Group of 2-10 Years: Outcome of Modified Salter Osteotomy on Acetabular Index in Children Aged 2–10 Years. Pakistan Journal of Health Sciences, 7(4), 99-104. https://doi.org/10.54393/pjhs.v7i4.3543

***Corresponding Author:**
Mehtab Ahmed
Department of Orthopedic Surgery, Jinnah Postgraduate Medical Center, Karachi, Pakistan
mehtabahmeddahani@gmail.com

Received Date: 11th October, 2025
Revised Date: 3rd February, 2026
Acceptance Date: 11th February, 2026
Published Date: 30th April, 2026

ABSTRACT

The modified Salter osteotomy is a widely utilized surgical intervention for treating developmental dysplasia of the hip (DDH). **Objectives:** To assess the outcome of modified Salter osteotomy in improving the acetabular index (AI) in children with DDH aged 2-10 years. **Methods:** This observational cohort study was conducted at the Department of Orthopedics, JPMC, Karachi, from December 2024 to September 2025. Sixty children aged 2–10 years with DDH undergoing modified Salter osteotomy were included. Baseline demographics, clinical examination, and preoperative radiographs for AI were recorded. Outcomes included change in AI, radiological grading by Severin classification, and clinical results by Modified MacKay criteria at 3 and 6 months. Data were analyzed using SPSS version 26.0 with non-parametric tests, Chi-square/Fisher's exact test, and Kappa statistic, taking $p<0.05$ as significant. **Results:** In a total of 60 children, 12 (20.0%) were boys, and 48 (80.0%) were girls, with a median age of 7 (5.5–9) years, and BMI 25 (23.0–27.0) kg/m^2. The median AI decreased significantly from 39.00 (35.00–43.00) preoperatively to 21.00 (18.00–25.00) at 6 months ($p<0.001$). At 6 months, radiological outcomes were excellent in 24 (40.0%), good in 20 (33.3%), fair in 10 (16.7%), and poor in 6 (10.0%). Clinical outcomes were excellent in 22 (36.7%), good in 21 (35.0%), fair in 11 (18.3%), and poor in 6 (10.0%). Agreement between the two systems was substantial ($\kappa=0.71$, $p<0.001$). **Conclusions:** Modified Salter osteotomy resulted in a significant improvement in AI among children with DDH, accompanied by favorable radiological and clinical outcomes at six months.

INTRODUCTION

The modified Salter osteotomy is a widely utilized surgical intervention for treating developmental dysplasia of the hip (DDH). The modified Salter osteotomy is primarily aimed at correcting acetabular dysplasia and enhancing the biomechanical alignment of the hip joint in pediatric patients. If left untreated, DDH can lead to early degenerative changes, resulting in pain, restricted mobility, and the necessity for additional surgical interventions in adolescence or adulthood. In early childhood, the acetabulum is relatively malleable, and surgical correction can significantly reshape the hip socket [1]. No formal studies are available estimating the prevalence of DDH in Pakistan. Whatever local data exist, the incidence of DDH is estimated to be around 5/1000 hips [2]. A key indicator of acetabular dysplasia and treatment efficacy in DDH management is the acetabular index (AI), which measures the slope of the acetabular roof [3]. A high AI indicates insufficient acetabular coverage of the femoral head, increasing the risk of hip instability and progressive joint degeneration. Surgical procedures like the Salter osteotomy enhance acetabular coverage [3]. The traditional Salter osteotomy redirects the acetabulum by cutting through the ilium and rotating the acetabular fragment, utilizing a bone graft to improve coverage over

DOI: https://doi.org/10.54393/pjhs.v7i4.3543

the femoral head and reduce the acetabular index [4-6]. Modifications to the Salter technique have been developed to optimize surgical outcomes and minimize complications in pediatric orthopedic surgery [7, 8]. Baghdadi et al., in a clinical evaluation based on the Modified MacKay criteria, noticed that 30% of cases were rated as excellent, 52% as good, 14% as fair, and 4% as poor following the Salter technique in DDH [9]. The DDH can result in persistent acetabular dysplasia, hip instability, and early degenerative changes if not corrected during childhood. In children, pelvic osteotomies are often required to improve femoral head coverage and allow further acetabular remodeling. The modified Salter osteotomy is a commonly performed redirectional procedure aimed at correcting acetabular dysplasia, and improvement in AI is a key objective, a radiographic marker of treatment success. Although literature reports favorable outcomes after modified Salter osteotomy, local evidence in children aged 2–10 years remains limited, and radiographic outcome data are scarce in comparable settings

The modified Salter osteotomy has been mostly applied in developmental dysplasia of the hip, but a local assessment of its radiographic outcome, especially the increase in the acetabular index, in children as young as 210 years is scarce. The absence of outcome data tailored to the population poses a gap in the objective evaluation of the surgical success in similar contexts. This research aimed to determine the result of modified Salter osteotomy through the evaluation of the change in the acetabular index of children with DDH.

METHODS

This observational cohort study was conducted at the Department of Orthopedics, Jinnah Postgraduate Medical Centre (JPMC), Karachi, Pakistan, between December 2024 and September 2025. Ethical approval was granted by the Institutional Review Board of JPMC (letter number F.2-81/2024-GENL/166/JPMC). Informed written consents were sought from all study participants. The inclusion criteria were children of either gender, aged 2–10 years, diagnosed with DDH, and who underwent surgical intervention via modified Salter osteotomy. Children with neuromuscular disorders, syndromic etiologies of hip dysplasia, prior hip surgery, or incomplete medical records were excluded. DDH was defined as a developmental disorder of acetabular formation leading to hip instability and abnormal gait. Non-probability, consecutive sampling technique was adopted. A sample size of 60 was based on the WHO sample size calculator using an expected 4.0% frequency of poor outcomes in DDH [9], a 5% margin of error, and a 95% confidence level. At baseline, demographic data, including age, gender, and body mass index (BMI), were recorded. A detailed clinical examination was performed to assess hip stability, range of motion, and gait. Preoperative anteroposterior pelvic radiographs were obtained, and AI were independently measured by two radiologists to ensure interobserver consistency. Intraoperative details, including osteotomy technique, fixation type, and perioperative complications, were documented. All patients underwent Modified Salter Osteotomy performed by an experienced pediatric orthopedic surgeon following standard operative protocols. The primary outcome was improvement in AI, while secondary outcomes included radiological classification of hip morphology by the Severin grading system and clinical outcomes using the Modified MacKay criteria, both categorized as excellent, good, fair, or poor. The AI, defined as the angle between Hilgenreiner's line and a line drawn from the triradiate cartilage to the lateral edge of the acetabulum, was used as a quantitative radiographic measure of acetabular coverage. Severin's classification system grades hip morphology on postoperative radiographs according to acetabular development, congruency of the femoral head, and the presence of degenerative changes. Severin grades I and II, representing a normal or nearly normal hip joint with adequate acetabular coverage, were categorized as excellent or good outcomes. Grades III and IV, which indicate dysplastic hips with insufficient coverage but without frank dislocation, were considered fair outcomes, while grades V and VI, denoting subluxated or redislocated hips and advanced degenerative changes, respectively, were classified as poor outcomes. The Modified MacKay criteria provide a standardized framework for assessing postoperative hip function. The criteria take into account hip stability, range of motion, presence or absence of pain, gait quality, and limb length equality. Patients with full stability, a normal pain-free gait, and a full range of motion were classified as having excellent clinical outcomes. Those with minor limitations in movement or gait disturbances without significant pain were graded as good outcomes. Patients with moderate restriction of movement, limping, or discomfort were placed in the fair outcome category, while those with persistent instability, severe stiffness, painful gait, or marked functional limitation were graded as poor outcomes. Participants were followed at 3 months and 6 months postoperatively. At each follow-up, clinical outcomes were assessed using the Modified MacKay criteria, while serial radiographs were obtained for acetabular index measurement and graded according to the Severin classification. Outcome assessment was performed by clinicians blinded to the initial preoperative measurements to reduce assessment bias. The completeness of follow-up was ensured through scheduled hospital visits and reminder calls to caregivers, with any loss to follow-up recorded.

DOI: https://doi.org/10.54393/pjhs.v7i4.3543

All data were entered and analyzed using IBM-SPSS Statistics version 26.0. Categorical variables such as age group, gender, surgical side, BMI categories, and outcome grades were expressed as frequencies and percentages. Continuous variables, including the age, BMI, and AI, were assessed for normality using the Shapiro–Wilk test and were reported as median with interquartile range because the data were not normally distributed. The preoperative and postoperative AI were compared using the Wilcoxon signed-rank test for paired data. Radiological outcomes according to the Severin classification and clinical outcomes according to the Modified MacKay criteria were presented as categorical distributions, and agreement between the two outcome scoring systems was assessed using the Kappa statistic. Associations between outcome categories (excellent, good, fair, poor) and demographic or clinical variables were evaluated using the Chi-square test or Fisher's exact test where appropriate. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

In a total of 60 children, 12 (20.0%) were boys, and 48 (80.0%) were girls. The median age and BMI were 7 (5.5-9) years, and 25 (23.0-27.0) kg/m2, respectively. Surgical intervention was performed on the right side in 17 (28.3%), on the left side in 30 (50.0%), and bilaterally in 13 (21.7%) (Table 1).

Table 1: Characteristics of Children (n=60)

Characteristics		Frequency (%)
Age (Years)	2-5	21 (35.0%)
	>5 to 10	39 (65.0%)
Gender	Boy	12 (20.0%)
	Girl	18 (80.0%)
Surgical Site	Right	17 (28.3%)
	Left	30 (50.0%)
	Bilateral	13 (21.7%)
Body Mass Index (kg/m^2)	≤24	19 (31.7%)
	>24	41 (68.3%)

The AI showed a statistically significant improvement 6 months after modified Salter osteotomy, and the median preoperative AI was 39.0° (IQR 35.0–43.0), which decreased to 21.0° (IQR 18.0–25.0) at follow-up (p<0.001). Radiological outcomes at 6 months based on the Severin classification demonstrated that 24 (40.0%) hips were graded excellent, 20 (33.3%) good, 10 (16.7%) fair, and 6 (10.0%) were poor. Clinical outcomes at 6 months assessed using the Modified MacKay criteria showed that 22 (36.7%) hips were graded excellent, 21 (35.0%) good, 11 (18.3%) fair, and 6 (10.0%) were poor. Comparison of outcome systems demonstrated substantial agreement with a Kappa statistic of 0.71 (p<0.001) (Table 2).

Table 2: Cross-Comparison of Radiological (Severin) and Clinical (Modified Mackay) Outcomes After 6-Months (n=60)

Severin Classification	Modified MacKay Criteria			
	Excellent	Good	Fair	Poor
Excellent	18	4	2	–
Good	3	13	3	1
Fair	1	2	6	1
Poor	0	2	0	4

Radiological outcomes by the Severin classification showed that in children aged 2 to 5 years, 11 (45.8%) were excellent, 6 (30.0%) good, 3 (30.0%) fair, and 1 (16.7%) poor, while in those aged 6 to 10 years, 13 (54.2%) were excellent, 14 (70.0%) good, 7 (70.0%) fair, and 5 (83.3%) poor (p=0.484). Among boys, 7 (29.2%) were excellent, 4 (20.0%) good, and 1 (10.0%) fair, with no poor outcomes, whereas in girls, 17 (70.8%) were excellent, 16 (80.0%) good, 9 (90.0%) fair, and 6 (100%) poor (p=0.336). With respect to the surgical side, excellent outcomes were observed in 5 (20.8%) right-sided, 15 (62.5%) left-sided, and 4 (16.7%) bilateral hips, while poor outcomes were seen in 1 (16.7%) right-sided, 3 (50.0%) left-sided, and 2 (33.3%) bilateral hips (p=0.791). In the BMI ≤24 kg/m^2 group, 9 (37.5%) were excellent and 2 (33.3%) poor, compared with 15 (62.5%) excellent and 4 (66.7%) poor in the BMI >24 kg/m^2 group (p=0.733) (Table 3).

Table 3: Association of Radiological Outcomes (After 6 Months) Based on Severin Classification with Demographic and Clinical Variables (n=60)

Variables		Excellent, n (%)	Good, n (%)	Fair, n (%)	Poor, n (%)	p-value
Age (Years)	2 to 5	11 (45.8%)	6 (30.0%)	3 (30.0%)	1 (16.7%)	0.484
	>5 to 10	13 (54.2%)	14 (70.0%)	7 (70.0%)	5 (83.3%)	
Gender	Boy	7 (29.2%)	4 (20.0%)	1 (10.0%)	–	0.336
	Girl	17 (70.8%)	16 (80.0%)	9 (90.0%)	6 (100%)	
Surgery Side	Right	5 (20.8%)	7 (35.0%)	2 (20.0%)	1 (16.7%)	0.791
	Left	15 (62.5%)	8 (40.0%)	6 (60.0%)	3 (50.0%)	
	Bilateral	4 (16.7%)	5 (25.0%)	2 (20.0%)	2 (33.3%)	
Body Mass Index (kg/m^2)	≤24	9 (37.5%)	8 (40.0%)	2 (20.0%)	2 (33.3%)	0.733
	>24	15 (62.5%)	12 (60.0%)	8 (80.0%)	4 (66.7%)	

Chi-Square test applied

Clinical outcomes according to the modified MacKay criteria indicated that in children aged 2 to 5 years, 10 (45.5%) were excellent, 7 (33.3%) good, 3 (27.3%) fair, and 2 (33.3%) poor, whereas in those aged 6 to 10 years, 12 (54.5%), 14 (66.7%), 8 (72.7%), and 4 (66.7%) respectively were observed (p=0.734). In boys, 6 (27.3%) were excellent, 5 (23.8%) good, and 1 (9.1%) fair, with no poor outcomes, while in girls, 16 (72.7%) were excellent, 16 (76.2%) good, 10 (90.9%) fair, and 6 (100%) poor (p=0.357). Considering the surgical side, excellent outcomes were seen in 4 (18.2%) right-sided, 14 (63.6%) left-sided, and 4 (18.2%) bilateral hips, with poor outcomes in 1 (16.7%) right-sided, 3 (50.0%) left-sided, and 2 (33.3%) bilateral hips (p=0.380). In the BMI

DOI: https://doi.org/10.54393/pjhs.v7i4.3543

≤24 kg/m^2 group, 8 (36.4%) were excellent and 2 (33.3%) poor, compared with 14 (63.6%) excellent and 4 (66.7%) poor in those with BMI >24 kg/m^2 (p=0.940) (Table 4).

Table 4: Association of Clinical Outcomes (After 6 Months) Based on Modified Mackay Criteria with Demographic and Clinical Variables (n=60)

Variables		Excellent, n (%)	Good, n (%)	Fair, n (%)	Poor, n (%)	p-value
Age (Years)	2 to 5	10 (45.5%)	7 (33.3%)	3 (27.3%)	2 (33.3%)	0.734
	>5 to 10	12 (54.5%)	14 (66.7%)	8 (72.7%)	4 (66.7%)	
Gender	Boy	6 (27.3%)	5 (23.8%)	1 (9.1%)	–	0.357
	Girl	16 (72.7%)	16 (76.2%)	10 (90.9%)	6 (100%)	
Surgery Side	Right	4 (18.2%)	8 (38.1%)	2 (18.2%)	1 (16.7%)	0.380
	Left	14 (63.6%)	9 (42.9%)	7 (63.6%)	3 (50.0%)	
	Bilateral	4 (18.2%)	4 (19.0%)	2 (18.2%)	2 (33.3%)	
Body Mass Index (kg/m^2)	≤24	8 (36.4%)	8 (38.1%)	3 (27.3%)	2 (33.3%)	0.940
	>24	14 (63.6%)	13 (61.9%)	8 (72.7%)	4 (66.7%)	

Chi-Square test applied

DISCUSSION

The present study demonstrated a significant reduction in AI at six months after modified Salter osteotomy in DDH among children aged 2-10 years. Rehman and colleagues reported a reduction in mean AI from 32.25 ± 3.77° to 19.16 ± 5.25° at eight weeks following Salter osteotomy in children aged 18 months to 4 years, which was statistically significant (p<0.001) [10]. The larger reduction in AI observed in the present study may reflect the inclusion of older children up to 10 years, who presented with higher baseline AI values, thereby providing a greater potential for correction. Esmaeilnejad-Ganji *et al.* reported long-term outcomes of a modified Salter osteotomy in 90 hips with DDH, demonstrating a reduction in mean AI from 47.85° to 17.16° immediately postoperatively, with further remodeling leading to a mean AI of 11.24° at final follow-up [11]. The current study observed a similar significant reduction at six months, although the degree of correction was not as profound as reported in that study. The discrepancy likely reflects the relatively short follow-up duration in the present cohort, as long-term remodeling of the acetabulum is expected to enhance radiological improvement over time. Vasyl and Viktor, evaluating modified single pelvic osteotomy (SPO), also reported a reduction in AI from 39.5 ± 7° to 20.4 ± 5° at six months, with continued improvement to 14.5 ± 4° at longer follow-up [12]. Based on the Severin classification, the present study observed excellent or good radiological outcomes at six months. These results are in agreement with Baghdadi *et al.* who found radiological satisfaction rates of 86% and 85% in patients younger and older than three years, respectively, using the modified Severin score [9]. A study from Iraq reported good to excellent radiological outcomes in the majority of patients under six years of age undergoing Salter osteotomy, with minimal complications [13]. Mahmud and colleagues, who evaluated a triple procedure including open reduction, varus derotation femoral osteotomy, and acetabular osteotomy, demonstrated a reduction in mean AI from 48.55 ± 7.63 to 23.68 ± 2.93, with Severin excellent or good outcomes in 16 (72.7%) hips [14]. The comparable rates of radiological success between the two studies suggest that modified Salter osteotomy alone, when properly indicated, may provide outcomes equivalent to more extensive combined procedures. In contrast, the long-term study by van Stralen *et al.* highlighted that 8% of hips required total hip arthroplasty at a median of 22 years following Salter osteotomy, and that the occurrence of avascular necrosis (AVN) significantly influenced radiological outcomes [15]. Clinically, the modified MacKay criteria revealed excellent or good results in the vast majority at six months. This proportion is consistent with the 82–83% satisfactory clinical outcomes reported by Baghdadi *et al.* in both age groups [9]. Jasim similarly documented favorable functional recovery, particularly in younger children [13]. Esmaeilnejad-Ganji *et al.* found excellent or good clinical outcomes in 94.5% of hips at final follow-up after a newly modified Salter osteotomy [11]. The slightly lower proportion in the present study is likely due to the shorter follow-up period, as functional recovery in DDH patients continues to progress with rehabilitation and growth [16, 17]. In the present study, radiological and clinical outcomes did not differ significantly between age groups. Baghdadi *et al.* also found no significant differences between children under and over three years in terms of clinical and radiological satisfaction [9]. In contrast, Koroglu *et al.* demonstrated that children operated before the age of four years achieved superior clinical outcomes and lower rates of AVN compared with those operated later [18]. The findings of this study support the role of modified Salter osteotomy as a reliable intervention for DDH in children between 2 and 10 years, producing both significant radiographic correction and functional improvement [19-21]. The substantial agreement between radiological and clinical outcome measures underlines the importance of combined assessment in postoperative evaluation [22-24]. The evidence from this and related studies suggests that surgical correction yields high proportions of satisfactory outcomes across a broad age range, provided that careful patient selection and surgical expertise are ensured [25].

Several limitations should be acknowledged. The short follow-up duration of six months restricts the ability to assess long-term acetabular remodeling, functional recovery, and the risk of late complications such as AVN, redislocation, or early degenerative changes. The single-

DOI: https://doi.org/10.54393/pjhs.v7i4.3543

center design limits generalizability, and a multicenter collaborative approach would provide larger sample sizes and broader external validity. Moreover, the single-center study limits external validity; hence, multicenter research with a larger sample size and extended follow-up would be advised in the future to obtain stronger evidence and confirm the radiographic and clinical outcomes of modified Salter osteotomy.

CONCLUSIONS

The use of modified Salter osteotomy increased the acetabular index (AI) of children with developmental dysplasia of the hip (DDH) significantly. This was accompanied by positive radiological and clinical outcomes at six months after surgery. Also, it was observed that Co concordance between various assessment systems was high, which proves the validity of the surgical outcomes.

Authors' Contribution

Conceptualization: MA, PA
Methodology: MA, AGJ, FA, HA
Formal analysis: SS, AGJ, FA, HA
Writing and Drafting: MA
Review and Editing: MA, PA, SS, AGJ, FA, HA

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Xiao H, Tang Y, Su Y. Risk Factors of Developmental Dysplasia of the Hip in a Single Clinical Center. Scientific Reports. 2022 Nov; 12(1): 19461. doi: 10.1038/s41598-022-24025-8.

[2] Nawaz H. Developmental Dysplasia of the Hip-Where do we Stand? Journal of the Pakistan Medical Association. 2008; 58(1): 2.

[3] Chen X, Liu J, Xue M, Zou C, Lu J, Wang X *et al.* Risk Factors of Developmental Dysplasia of the Hip in Infants: A Meta-Analysis Based on Cohort Studies. Orthopaedics and Traumatology: Surgery and Research. 2024 Jun; 110(4): 1-11. doi: 10.1016/j.otsr.2024.103836.

[4] Sadat-Ali M. Developmental Dysplasia of the Hip in Saudi Arabia: Time to Wake Up. A Systematic Review (1980-2018). Open Journal of Epidemiology. 2020 Apr; 10(2): 125-131. doi: 10.4236/ojepi.2020.102011.

[5] Ionescu A, Dragomirescu MC, Herdea A, Ulici A. Developmental Dysplasia of the Hip: How Many Risk Factors are Needed? Children. 2023 May; 10(6): 968. doi: 10.3390/children10060968.

[6] Alshehri F and Almalki Y. Developmental Dysplasia of the Hip in Infants Younger than Six Months: Ultrasonographic Assessment in Relation with Risk Factors. International Journal of Health Sciences. 2023 Mar; 17(2): 37.

[7] Tao Z, Wang J, Li Y, Zhou Y, Yan X, Yang J *et al.* Prevalence of Developmental Dysplasia of the Hip in Infants: A Systematic Review and Meta-Analysis. Biomedical Journal Paediatrics Open. 2023 Oct; 7(1): 1-7. doi: 10.1136/bmjpo-2023-002080.

[8] Burkhart RJ, McNassor R, Acuña AJ, Kamath AF. Is Prematurity A Risk Factor for Developmental Dysplasia of the Hip? A Systematic Review and Meta-Analysis. Journal of Pediatric Orthopaedics B. 2023 Jul; 32(4): 305-311. doi: 10.1097/BPB.0000000000001021.

[9] Baghdadi T, Bagheri N, Khabiri SS, Kalantar H. The Outcome of Salter Innominate Osteotomy for Developmental Hip Dysplasia Before and After 3 Years Old. Archives of Bone and Joint Surgery. 2018 Jul; 6(4): 318.

[10] Shah MQ, Labib M, Iqbal MN, Qureshi BA. Role of Salter Osteotomy in Improving Acetabular Index of Developmental Dysplasia of the Hip Patients Measured by Radiography Pre-Op and Post-Op. Pakistan Armed Forces Medical Journal. 2025 Jan;75. doi: 10.51253/pafmj.v75iSUPPL-1.10462.

[11] Esmaeilnejad-Ganji SM, Esmaeilnejad-Ganji SM, Zamani M, Alitaleshi H. A Newly Modified Salter Osteotomy Technique for Treatment of Developmental Dysplasia of Hip That is Associated with Decrease in Pressure on Femoral Head and Triradiate Cartilage. BioMed Research International. 2019; 2019(1): 6021271. doi: 10.1155/2019/6021271.

[12] Vasyl S and Viktor F. Modified Salter Pelvic Osteotomy for the Developmental Dysplasia of the Hip Treatment. Acta Ortopédica Brasileira. 2023 Apr; 31: 1-4. doi: 10.1590/1413-785220233101e259040.

[13] Jasim DH. Outcome of Salter Osteotomy in Developmental Dysplasia of the Hip Patients Case Series. Academic International Journal of Medical Sciences. 2025 Sep: 1-10.

[14] Eren A, Pekmezci M, Demirkiran G, Cakar M, Guven M, Yazici M. Modified Salter Osteotomy for the Treatment of Developmental Dysplasia of the Hip: Description of a New Technique that Eliminated the Use of Pins for Internal Fixation. The Journal of Bone and Joint Surgery British Volume. 2007 Oct; 89(10): 1375-1378. doi: 10.1302/0301-620X.89B10.18704.

DOI: https://doi.org/10.54393/pjhs.v7i4.3543

[15] van Stralen RA, Colo E, Rutz E, Schreurs BW, Hosman AJ. Long-Term Results After Salter Innominate Osteotomy for the Treatment of Developmental Dysplasia of the Hip—Only 8% Rate of Total Hip Arthroplasty at a Median Follow-Up of 22 Years. Children. 2024 Dec; 11(12): 1525. doi: 10.3390/children11121525.

[16] Suvorov V and Filipchuk V. Salter Pelvic Osteotomy for the Treatment of Developmental Dysplasia of the Hip: Assessment of Postoperative Results and Risk Factors. Orthopedic Reviews. 2022 May; 14(3): 35335. doi: 10.52965/001c.35335.

[17] Forlin E, da Cunha LA, Figueiredo DC. Treatment of Developmental Dysplasia of the Hip After Walking Age with Open Reduction, Femoral Shortening, and Acetabular Osteotomy. Orthopedic Clinics. 2006 Apr; 37(2): 149-160. doi: 10.1016/j.ocl.2005.11.005.

[18] Köroğlu C, Özdemir E, Çolak M, Şensöz E, Öztuna FV. Open Reduction and Salter Innominate Osteotomy Combined with Femoral Osteotomy in the Treatment of Developmental Dysplasia of the Hip: Comparison of Results Before and After the Age of 4 Years. Acta Orthopaedica et Traumatologica Turcica. 2021 Jan; 55(1): 28. doi: 10.5152/j.aott.2021.17385.

[19] El-Sayed M, Ahmed T, Fathy S, Zyton H. The Effect of Dega Acetabuloplasty and Salter Innominate Osteotomy on Acetabular Remodeling Monitored by the Acetabular Index in Walking DDH Patients Between 2 and 6 Years of Age: Short-To Middle-Term Follow-Up. Journal of Children's Orthopaedics. 2012 Dec; 6(6): 471-477. doi: 10.1007/s11832-012-0451-x.

[20] Wada A, Sakalouski A, Nakamura T, Kubota H, Matsuo A, Taketa M *et al.* Angulated Salter Osteotomy in the Treatment of Developmental Dysplasia of the Hip. Journal of Pediatric Orthopaedics B. 2022 May; 31(3): 254-259. doi: 10.1097/BPB.0000000000000883.

[21] Kandil AE, Mohamed Saeed AB, El-Barbary H, Hegazi M, El-Sobky M. Salter Versus Dega Osteotomy After Open Reduction of Developmental Dysplasia of the Hip in Young Children. The Egyptian Orthopaedic Journal. 2013 Mar; 48(1): 80-87.

[22] Aldhoon M, Almarzouq A, ALRashdan DA, Altarawneh R, Otoum A, Ibrahim F. Salter Innominate Osteotomy for the Management of Developmental Dysplasia of the Hip in Children: Radiographic Analysis. Indian Journal of Orthopaedics. 2023 Jan; 57(1): 80-85. doi: 10.1007/s43465-022-00786-2.

[23] Aljanabi AS and Hakim WS. Clinical and Radiological Outcomes of Open Reduction Alone Versus Open Reduction with Pelvic Osteotomy for Developmental Dysplasia of the Hip in Children Over 1.5 Years of Age. Journal of Medicine and Life. 2023 Dec; 16(12): 1839. doi: 10.25122/jml-2023-0212.

[24] 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 Apr; 79(2): 159-165.

[25] Tejpal T, Shanmugaraj A, Gupta A, Horner NS, Simunovic N, Kishta W *et al.* Outcomes and Complications of Patients Undergoing Salter's Innominate Osteotomies for Hip Dysplasia: A Systematic Review of Comparative Studies. Journal of Hip Preservation Surgery. 2020 Dec; 7(4): 621-630. doi: 10.1093/jhps/hnab014.