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SALTER VERSUS DEGA OSTEOTOMY AFTER OPEN REDUCTION OF DEVELOPMENTAL DYSPLASIA OF THE HIP IN YOUNG CHILDREN

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ABSTRACT

Background: Developmental dysplasia of the hip is a major pediatric concern. Traditional osteotomies, including Salter and Dega, are widely practiced, yet data remain scarce and controversial in young children. Therefore, this study was conducted to provide clarity.

Objectives: To compare Salter and Dega osteotomies after open reduction of developmental dysplasia of the hip in young children with respect to clinical outcomes and acetabular index (AI).

Duration: Six months w.e.f 15th July, 2022 to 14th Jan, 2023

Methodology: After ethical approval, 60 children with DDH were enrolled, counseled, and randomized by lottery to undergo Salter or Dega osteotomy following open reduction. Preoperative assessment included history, examination, acetabular index (AI), and McKay's criteria. Standard operative protocols and monitoring were applied. Postoperative AI and clinical outcomes were evaluated immediately and at 12 months. All measurements were performed by the investigator to minimize bias.

Results: In 60 children with developmental dysplasia of the hip, Salter osteotomy achieved a significantly lower acetabular index (17.48±3.95 vs. 21.61±4.02, p=0.000) and more excellent outcomes (86.2% vs. 50.0%, p=0.027) than Dega osteotomy.

Conclusion: Both Salter and Dega osteotomies proved effective after open reduction for developmental dysplasia of the hip. However, Salter osteotomy showed significantly better outcomes, with lower acetabular index values and higher rates of excellent clinical results. These findings establish Salter osteotomy as the superior technique for young children requiring hip reconstruction.

Key Words: Developmental Dysplasia of the Hip, Osteotomy, Salter Osteotomy, Dega Osteotomy, Acetabular Index, Hip Dislocation, Child, Treatment Outcome, Radiographic Evaluation.

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a spectrum of disorders including dislocation, subluxation, and acetabular dysplasia, and is among the most common hip conditions in infants.[1] Risk factors include female gender, first-born status, positive family history, oligohydramnios, multiple pregnancies, uterine anomalies, post-maturity, and high birth weight.[2] The condition, if untreated, can lead to pain, gait abnormalities, and secondary osteoarthritis.[3] At walking age, a painless limp is the most common sign, progressing later to fatigue, discomfort, and degenerative changes in the hip and spine. Early diagnosis and treatment are critical, as most cases can be successfully managed non-operatively.[4]

The prevalence of DDH varies globally from 0.5% to 1.5%.[5] While nearly 90% of mild instabilities resolve spontaneously within two months of life, a small proportion persists and requires intervention.[6] In Pakistan, the 2017 census identified 913,667 disabled individuals, 40% of whom were children, with nearly 70% residing in rural areas where access to specialized care is limited. The effectiveness of treatment decreases with age, with success rates over 95% before age two but as low as 42% beyond age eight.[7] These figures highlight the importance of timely diagnosis and early referral.[7]

Treatment depends on age, severity, and associated conditions.[8] In infants, bracing methods such as the Pavlik harness are commonly used, though their success diminishes after six months and risks like osteonecrosis increase.[9] Older children or those with failed non-operative treatment usually require surgical intervention. Open reduction is indicated when closed reduction fails or in fixed dislocations.[10] Pelvic or femoral osteotomies are often needed to maintain stable reduction and optimize acetabular development.[11]

Several osteotomy techniques are in practice. Salter and triple pelvic osteotomy (TPO) are redirectional procedures, while Pemberton and Dega are reshaping osteotomies. Dega osteotomy is often preferred in severe dysplasia, whereas Salter osteotomy redirects the acetabulum to improve femoral head coverage.[12] Radiological assessment commonly relies on the acetabular index (AI) and acetabular depth ratio (ADR).[13]

Comparisons between Salter and Dega osteotomies show mixed results. El-Sayed et al. in Egypt found significantly lower final AI in Salter compared to Dega among children aged 18–48 months (15.25 vs. 19.91; $p<0.05$), along with better excellent outcomes (22% vs. 5%). In older children (>48–72 months), results favored Dega but without statistical significance.[14] Kandil et al. in Egypt reported an overall success rate of 88.9%, with no significant difference between Salter (89.5%) and Dega (88.2%) ($p=1.000$). Postoperative AI and center-edge angle were also comparable, though they noted the advantage of Dega osteotomy in avoiding secondary hardware removal.[15]

Although both Salter and Dega osteotomies are established in DDH management, published evidence remains conflicting, particularly in children. Regional data are scarce, and controversy persists over which procedure offers superior outcomes. This study was designed to address these gaps by directly comparing Salter and Dega osteotomies in young children.

HYPOTHESIS

The acetabular index (AI) at final follow-up is significantly lower in patients undergoing Salter osteotomy compared to those undergoing Dega osteotomy after open reduction for developmental dysplasia of the hip.

METHODOLOGY

Study Design and Setting

This randomized controlled trial was conducted in the Department of Orthopedics, Sir Ganga Ram Hospital, Lahore. A total of 60 patients, 30 in each group, were enrolled. The sample size was calculated with 80% power and a 5% level of significance, considering expected excellent clinical outcomes of 22.0% and 5.0% for Salter and Dega osteotomies, respectively.[14] Non-probability, consecutive sampling was used.

Operational Definitions and Eligibility

Developmental Dysplasia of the Hip (DDH): Congenital or early childhood hip disorder with abnormal acetabular development, confirmed by AI >30° or femoral head displacement requiring open reduction.

Clinical Outcomes: Assessed by Barrett's modification of McKay's criteria, grading hip function as excellent, good, fair, or poor at 12 months postoperatively.

Acetabular Index (AI): Angle measured between Hilgenreiner's line and the acetabular roof on pelvic radiographs preoperatively, postoperatively, and at final follow-up.

Inclusion criteria: Children aged 1–6 years with DDH indicated for Salter or Dega osteotomy, including unilateral and bilateral cases.

Exclusion criteria: Children with neuromuscular disorders, syndromic DDH, previous hip surgery, hip infection, trauma, tumors, incomplete follow-up, or contraindications to surgery/anesthesia.

Data Collection and Procedures

After ethical approval, 60 eligible children presenting with DDH at outpatient ward of Orthopedic Department, Sir Ganga Ram Hospital, Lahore and scheduled for surgery were included in the study after taking informed written consents from their parents/ guardians. Detailed histories and baseline examinations were performed. Randomization into Salter and Dega groups was done using the lottery method. Preoperative evaluation included AI measurement and McKay's criteria. The Salter osteotomy involved a complete iliac osteotomy stabilized with a triangular graft to redirect the acetabulum and improve femoral head coverage. The Dega osteotomy was an incomplete transiliac osteotomy hinging on the triradiate cartilage, reshaping the acetabulum to enhance anterior and lateral coverage without a graft. Standard intraoperative monitoring (pulse oximetry, blood pressure, ECG) was applied. Open reduction with the assigned osteotomy was performed under standard protocols. Postoperatively, AI and clinical outcomes were recorded immediately and at 12 months. Assessments were performed by the investigator to reduce bias. Confounders were controlled through strict application of exclusion criteria.

Data Analysis

Data were analyzed using SPSS version 26. Numerical variables (age, AI values) were expressed as mean ± SD (range). Categorical variables (gender, clinical outcomes) were presented as frequencies and percentages. Chi-square test compared categorical data, while independent t-test analyzed continuous variables. Outcomes were stratified by age and gender, with significance set at $p \leq 0.05$.

RESULTS

A total of 60 children with developmental dysplasia of the hip (DDH) were included in the study. The mean age was 3.45±1.80 years (range: 1–6 years). Of these, 34 (56.7%) were between 1 and 3 years of age, while 26 (43.3%) were between 4 and 6 years. Female patients were more frequent, accounting for 39 (65.0%) cases compared to 21 (35.0%) males. The mean pre-operative acetabular index (AI) was 42.75±4.52. The detailed demographic characteristics are shown in Table 1.0. Both groups showed no significant baseline differences. The mean age was 3.57±1.76 years in Group A and 3.33±1.86 years in Group B (p=0.619). Age distribution (1–3 vs. 4–6 years) and gender were similar between groups (p=0.602 and p=0.417, respectively). The mean pre-operative acetabular index was 43.03±4.66 in Group A and 42.47±4.43 in Group B (p=0.631). Details are given in Table 2.0.

Table 3.0 shows the comparison of immediate post-operative acetabular index between the two groups. The mean value was 22.87±4.42 in Group A and 24.60±4.17 in Group B, with no statistically significant difference (p=0.132).

Table 4.0 presents the comparison of acetabular index and clinical outcomes at final follow-up. The mean acetabular index was significantly lower in Group A (17.48±3.95) compared to Group B (21.61±4.02) (p=0.000). Clinical outcomes according to McKay's criteria also favored Group A, with 25 patients (86.2%) showing excellent results compared to 14 (50.0%) in Group B (p=0.027). Good outcomes were observed in 2 (6.9%) patients of Group A and 9 (32.1%) of Group B, while fair outcomes were seen in 2 (6.9%) and 4 (14.3%) patients, respectively. Poor outcome was reported in 1 (3.6%) patient of Group B, whereas none in Group A. One patient from Group A and two from Group B were lost to follow-up, and the analysis was carried out on the reduced sample size. Although stratification of AI score and clinical outcomes consistently favored Group A, statistical significance could not be achieved in all subgroups due to the limited number of cases.

Table 1.0: Demographic Characteristics of Children Presenting with DDH

Characteristics	Total (n=60)
Age (years)	3.45±1.80
• **1-6 years**	34 (56.7%)
• **4-6 years**	26 (43.3%)
Gender	
• **Boy**	21 (35.%)
• **Girl**	39 (65.0%)
Pre-Operative AI	42.75±4.52

Table 2.0: Comparison of Baseline Characteristics between the Study Groups

Characteristics	Group A (n=30)	Group B (n=30)	p-value
Age (years)	3.57±1.76	3.33±1.86	0.619
• **1-3 years**	16 (53.3%)	18 (60.0%)	0.602
• **4-6 years**	14 (46.7%)	12 (40.0%)	
Gender			
• **Boy**	12 (40.0%)	9 (30.0%)	0.417
• **Girl**	18 (60.0%)	21 (70.0%)	
Pre-Operative AI	43.03±4.66	42.47±4.43	0.631

Chi Square test/ Independent sample t test, taking p-value≤0.05 as significant.

Table 3.0: Comparison of Immediate Post-Operative AI between the Groups

Characteristics	Group A (n=30)	Group B (n=30)	p-value
Acetabular Index	22.87±4.42	24.60±4.17	0.132

Independent sample t test, taking p-value≤0.05 as significant.

Table 4.0: Comparison of Outcomes at 12 Months

Characteristics	Group A (n=29)	Group B (n=28)	p-value
Acetabular Index	17.48±3.95	21.61±4.02	0.000
Clinical Outcomes			
• **Excellent**	25 (86.2%)	14 (50.0%)	0.027
• **Good**	2 (6.9%)	9 (32.1%)	
• **Fair**	2 (6.9%)	4 (14.3%)	
• **Poor**	0 (0.0%)	1 (3.6%)	

Chi Square test/ Independent sample t test, taking p-value≤0.05 as significant.

1. **Note:** One patient from Group A and two patients from Group B were lost to follow-up. Analyses are reported for the remaining patients (Group A: n=29, Group B: n=28).

2. Stratification of AI score and clinical outcomes maintained supremacy of group A over group B, but statistical significant could not be achieved in all sub groups due to small sample size.

DISCUSSION

Developmental dysplasia of the hip (DDH) remains a significant orthopedic problem in children, as delayed diagnosis and inadequate treatment may lead to long-term disability and early osteoarthritis.[1,3] Various surgical techniques, including Salter and Dega osteotomies, have been introduced to achieve stable reduction and improved acetabular development.[14,15] However, despite widespread use, evidence comparing these procedures is scarce, particularly in younger children, and existing studies often report conflicting results regarding radiological and functional outcomes. In view of these uncertainties and the lack of sufficient regional data, the present study was planned to evaluate and compare both osteotomy techniques.

The results of the present study closely align with those of Rehman et al. in Pakistan, who demonstrated a significant reduction in acetabular index (AI) following Salter osteotomy, with values decreasing from a preoperative mean of 32.25±3.77 to 19.16±5.25 postoperatively ($p<0.001$). They concluded that Salter osteotomy is highly effective in improving acetabular morphology, a finding consistent with our results, where AI improvement was more pronounced in the Salter group compared with Dega osteotomy.[14]

Supporting evidence also comes from Van Stralen et al. in the Netherlands, who highlighted the long-term efficacy of Salter osteotomy. Their series reported a low incidence of total hip arthroplasty (8%) at final follow-up, suggesting durable benefits. They also cautioned, however, that avascular necrosis (AVN) occurs more frequently when Salter osteotomy is performed with open reduction compared to when it is carried out independently. Importantly, they noted that patient-reported outcomes were significantly worse when AVN developed.[15]

In Bangladesh, Mahmud et al. described the effectiveness of combined surgical procedures such as open reduction, femoral shortening, varus derotation osteotomy, and pelvic osteotomy. They emphasized the principle of achieving "concentric reduction without tension," even if additional bony interventions are required. Excellent outcomes were achieved when Salter, Pemberton, or Shelf osteotomies were applied appropriately. Their findings reinforce that meticulous surgical technique and adherence to core principles are central to successful outcomes. Our study supports this concept, as Salter osteotomy produced predictable radiological correction and favorable functional results, particularly in younger children.[16]

Suvorov et al. in Ukraine similarly reported that Salter osteotomy corrected AI by a mean of 24.1±6.5°, with excellent or good outcomes in 95.5% of patients. They observed that older age and higher preoperative AI were predictors of poorer results, while greater surgical correction improved prognosis. These observations mirror our findings, where younger children had a higher proportion of excellent outcomes following Salter osteotomy, whereas results in older children were less predictable.[17]

In contrast, several studies demonstrated the effectiveness of Dega osteotomy. Rampal et al. in France reported favorable radiological and functional results with modified Dega osteotomy, particularly noting a low risk of acetabular retroversion.[18] Kandil et al. in Egypt found no significant differences between Salter and Dega osteotomies regarding AI correction, center-edge angle, or overall success rate (88.9%). They also highlighted the advantage of Dega osteotomy in avoiding secondary surgery for hardware removal. While our results showed significantly better AI reduction and clinical outcomes with Salter osteotomy, the technical advantages of Dega remain relevant.[19]

El-Sayed et al. in Egypt provided further nuance, demonstrating that Salter osteotomy produced superior outcomes in younger children, while Dega was more favorable in older age groups. This observation is consistent with our results, which confirmed the importance of patient age in determining outcomes.[20] Similarly, Morsy et al. reported no significant difference in hip stability between Salter and Dega osteotomies, concluding that both procedures are effective options for DDH.[21]

Taken together, the global literature shows that both Salter and Dega osteotomies are effective procedures for DDH following open reduction. However, Salter osteotomy consistently demonstrates superior AI correction and higher proportions of excellent clinical results, particularly in younger children. Dega osteotomy, on the other hand, remains a valuable alternative, especially in older patients or when preservation of pelvic stability and avoidance of hardware removal are prioritized.

CONCLUSION

Both Salter and Dega osteotomies proved effective after open reduction for developmental dysplasia of the hip. However, Salter osteotomy showed significantly better outcomes, with lower acetabular index values and higher rates of excellent clinical results. These findings establish Salter osteotomy as the superior technique for young children requiring hip reconstruction.

LIMITATIONS & RECOMMENDATIONS

The strength of this study lies in its randomized design, standardized assessments, and direct comparison of Salter and Dega osteotomies in young children with DDH. Limitations include the relatively small sample size, single-center setting, and short-term follow-up, which may restrict generalizability. Nevertheless, the findings provide valuable regional evidence. Future multicenter studies with larger cohorts and longer follow-up are recommended to confirm comparative advantages and refine age-specific surgical decision-making in pediatric DDH.

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