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ORIGINAL ARTICLE

Assessing Avascular Necrosis Risk and Outcomes after Open Reduction for Developmental Dysplasia of the Hip in Children in Pakistan

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ABSTRACT

Background: Developmental dysplasia of the hip (DDH) is a common pediatric orthopedic condition that, if untreated, can lead to long-term disability. Open reduction is often required in late-presenting cases but carries the risk of avascular necrosis (AVN) of the femoral head.

Objectives: This study aims to assess the incidence, risk factors, and outcomes of AVN in children undergoing open reduction for DDH in Pakistan.

Methods: This retrospective observational study was conducted at Shahid Hussain Orthopedic and General Hospital, Timergara during December 2022 to May 2023. A total of 95 children (aged 12 months to 6 years) who underwent open reduction for DDH were included in the study. Patient demographics, surgical details, post-operative care, and follow-up data were collected. AVN incidence was determined using the Salter and Kalamchi classification, while functional outcomes were evaluated using the Modified McKay criteria.

Results: AVN was identified in 24 patients (25%). Age at surgery above three years, prolonged immobilization (>8 weeks), and the medial surgical approach were associated with a higher incidence of AVN. Functional outcomes were significantly better in patients without AVN, with 95% achieving excellent or good results compared to 75% in those with AVN (p=0.01). Radiographic outcomes also showed a higher incidence of residual hip dysplasia in AVN patients, with 35% classified as Severin IV.

Conclusion: It is concluded that AVN is a major complication following open reduction for DDH, with a significant impact on functional and radiographic outcomes. Early intervention, careful surgical technique selection, and optimized post-operative management can help reduce AVN risk.

Keywords: Developmental dysplasia of the hip, avascular necrosis, open reduction, pediatric orthopedics, hip dysplasia, Pakistan.

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a congenital or developmental condition affecting the hip joint, where the femoral head is improperly aligned with the acetabulum. It includes a range of abnormalities, from mild instability to complete hip dislocation. DDH is one of the most common pediatric orthopedic disorders, with an estimated prevalence of 1 to 2 cases per 1,000 live births[1]. If not diagnosed and treated early, it can lead to long-term complications such as early-onset osteoarthritis, gait abnormalities, chronic pain, and functional disability. Early detection and treatment are essential to prevent long-term disability. In infants, non-surgical methods such as the Pavlik harness are generally effective[2]. However, in children diagnosed after the walking age or those in whom conservative treatments fail, surgical intervention becomes necessary[3]. Open reduction surgery is commonly performed in late-presenting DDH cases to reposition the femoral head within the acetabulum and restore hip stability and function. While this procedure is effective, it carries the risk of complications, among which avascular necrosis (AVN) of the femoral head is the most serious. Avascular necrosis occurs when the blood supply to the femoral head is disrupted, leading to ischemic bone necrosis, collapse, and eventual joint deformity[4]. In the context of DDH treatment, AVN can result from excessive pressure on the femoral head, prolonged immobilization, or damage to the vascular supply during surgery[5]. The severity of AVN varies, with some cases resolving over time, while others progress to severe femoral head deformity, leading to joint dysfunction and early arthritis[6]. The incidence of AVN following open reduction for DDH varies widely across studies, with reported rates ranging from 5% to 60%, depending on factors such as surgical approach, age at surgery, and post-operative immobilization techniques[7]. In Pakistan, where delayed diagnosis of DDH is common due to the lack of neonatal screening programs, many children undergo open reduction at older ages, increasing the risk of AVN and poorer surgical outcomes[8]. However, there is limited local data on the prevalence, severity, and long-term impact of AVN in children undergoing open reduction for DDH in Pakistan. There is a significant gap in research on DDH and its surgical outcomes in Pakistan. The lack of national screening programs and delayed diagnosis contribute to a higher proportion of children requiring surgical intervention[9]. Additionally, variations in surgical techniques, post-operative care, and rehabilitation protocols further influence outcomes. Understanding the risk factors, incidence, and severity of AVN following open reduction in Pakistani children is essential for optimizing treatment strategies and improving patient care[10].

Objective: This study aims to assess the incidence, risk factors, and outcomes of AVN in children undergoing open reduction for DDH in Pakistan.

METHODOLOGY

This is a retrospective observational study was conducted at Shahid Hussain Orthopedic and General Hospital, Timergara during December 2022 to May 2023. A total of 95 patients, all of whom underwent open reduction for developmental dysplasia of the hip were included in the study. The age range of patients is between 12 months and 6 years at the time of surgery. Patients diagnosed cases of developmental dysplasia of the hip requiring open reduction, children aged between 12 months and 6 years at the time of surgery, and those with complete medical records and radiographic follow-up for at least 12 months post-surgery were included in the study. Patients with incomplete follow-up data, prior surgical interventions for developmental dysplasia of the hip, or those with congenital syndromes or neuromuscular conditions affecting hip development were excluded.

Data Collection: All patients underwent open reduction surgery, with variations in surgical approach based on the severity of

dislocation. Post-operatively, patients were immobilized using hip spica casting for a duration determined by the surgeon. Patient demographics, including age, gender, and the side affected, were recorded. Surgical details such as the approach used, duration of immobilization, and any additional procedures performed were documented. Radiographic evaluation was done using pre- and post-operative X-rays to assess changes in hip joint alignment. The incidence and severity of avascular necrosis were classified using the Salter and Kalamchi classification system. Functional outcomes were assessed using the Modified McKay criteria to evaluate post-operative hip function.

Data Analysis: Data were analyzed using SPSS v21. Descriptive statistics were used to determine the incidence of avascular necrosis among the study population. Comparative analysis was performed to evaluate differences in outcomes between patients with and without avascular necrosis.

RESULTS

The study included a total of 95 patients, with a mean age of 3.2 ± 0.98 years at the time of surgery. The majority were female (65%), and the right hip was more commonly affected (60%) than the left (40%), with 11% presenting bilateral cases. The mean follow-up duration was 18 months, and pre-operative hip stability was observed in 45% of patients.

Table 1: Demographic and Baseline Values of Patients

Parameter	Value
Total Patients	95
Mean Age at Surgery (years)	3.2±0.98
Female (%)	62 (65%)
Male (%)	33 (35%)
Right Hip Affected (%)	57 (60%)
Left Hip Affected (%)	38 (40%)
Bilateral Cases (%)	10 (11%)
Mean Follow-up Duration (months)	18
Pre-operative Hip Stability (%)	45%

Avascular necrosis (AVN) was observed in 24 out of 95 patients, accounting for 25% of the total cases. Among these, Grade I was the most common (42%), followed by Grade II (33%), Grade III (17%), and Grade IV (8%).

Table 2: Incidence of Avascular Necrosis (AVN)

AVN Classification	Number of Patients	Percentage (%)
Total AVN Cases	24	25%
Grade I	10	42%
Grade II	8	33%
Grade III	4	17%
Grade IV	2	8%

The analysis of risk factors for avascular necrosis (AVN) showed that patients undergoing surgery after the age of 3 years had a significantly higher incidence of AVN (35%) compared to those operated on earlier (15%), with a p-value of 0.02. Similarly, prolonged immobilization beyond 8 weeks was associated with an increased AVN rate (40% vs. 18%, p = 0.03). The use of the medial surgical approach also showed a higher AVN occurrence (30% vs. 18%), though this was not statistically significant (p = 0.08).

Table 3: Risk Factors for AVN

Risk Factor	No AVN (%)	AVN (%)	p-value
Age at Surgery > 3 years	15%	35%	0.02
Immobilization > 8 weeks	18%	40%	0.03
Medial Surgical Approach	18%	30%	0.08

Among patients immobilized for less than 6 weeks, only 10% developed AVN, while those immobilized for 6–8 weeks had an 18% AVN rate. However, the AVN incidence rose significantly to 40% in patients immobilized for more than 8 weeks. These findings suggest that prolonged immobilization may be a major risk factor for AVN development post-surgery.

Table 4: Post-Operative Immobilization Duration and AVN Incidence

Immobilization Duration	Total Patients	AVN Cases (%)
<6 weeks	20	2 (10%)
6-8 weeks	50	9 (18%)
>8 weeks	25	10 (40%)

Patients who underwent surgery after the age of 3 years had a higher AVN incidence (35% vs. 15%, p = 0.02), and those immobilized for more than 8 weeks also had an increased risk (40% vs. 18%, p = 0.03). While the medial surgical approach was linked to a higher AVN rate (30% vs. 18%), this association was not statistically significant (p = 0.08). Functional outcomes were significantly better in the no-AVN group, with 95% achieving excellent or good results compared to 75% in AVN cases (p = 0.01). Radiographic outcomes (Severin I-II) were also markedly better in patients without AVN (80% vs. 25%, p = 0.001), highlighting the detrimental impact of AVN on both functional and radiographic recovery.

Table 6: Comparison of Outcomes Between Patients With and Without Avascular Necrosis

Parameter	No AVN (n=71)	AVN (n=24)	p-value
Age at surgery > 3 years	15%	35%	0.02
Immobilization > 8 weeks	18%	40%	0.03
Medial surgical approach	18%	30%	0.08
Excellent/Good Functional Outcome	95%	75%	0.01
Radiographic Outcome (Severin I-II)	80%	25%	0.001

DISCUSSION

This study aimed to evaluate the risk of avascular necrosis and its impact on surgical outcomes in children undergoing open reduction for developmental dysplasia of the hip in Pakistan. The findings indicate that avascular necrosis is a significant post-operative complication, affecting 25% of the patients. Several risk factors, including older age at surgery, prolonged post-operative immobilization, and surgical approach, were found to influence the incidence of avascular necrosis. The results suggest that delaying surgical intervention beyond three years increases the likelihood of avascular necrosis[11]. This aligns with previous studies, which indicate that younger patients generally have a better capacity for femoral head remodeling and revascularization. Late-presenting developmental dysplasia of the hip remains a challenge in Pakistan due to the lack of neonatal screening programs, delayed diagnosis, and limited access to specialized pediatric orthopedic care[12]. As a result, many children undergo open reduction at an age when the femoral head is more susceptible to ischemic damage. Post-operative immobilization duration was also identified as a significant factor. Patients who were immobilized for more than eight weeks had a higher incidence of avascular necrosis compared to those who were immobilized for a shorter period[13]. Prolonged immobilization may increase joint stiffness and restrict blood flow to the femoral head, leading to ischemic damage. These findings emphasize the importance of optimizing post-operative rehabilitation protocols to balance hip stability and early mobilization, thereby minimizing the risk of avascular necrosis[14].

The surgical approach was another variable influencing the development of avascular necrosis. The medial approach was associated with a higher risk compared to the anterior and anterolateral approaches. This may be due to the increased likelihood of disturbing the vascular supply of the femoral head when using the medial approach. Although this difference was not statistically significant, it suggests that careful surgical technique selection can play a role in reducing the incidence of avascular necrosis[15]. The functional and radiographic outcomes further highlight the negative impact of avascular necrosis. Patients without avascular necrosis demonstrated significantly better hip function, as indicated by higher excellent and good outcome scores on the Modified McKay criteria[16]. In contrast, those who developed avascular necrosis had a higher percentage of fair and

poor functional outcomes. Similarly, radiographic analysis using the Severin classification showed that a higher proportion of patients with avascular necrosis had residual hip dysplasia and joint deformities, increasing the likelihood of long-term complications such as early-onset osteoarthritis and reduced mobility[17]. These findings underscore the need for strategies to minimize the risk of avascular necrosis in children undergoing open reduction for developmental dysplasia of the hip. Early diagnosis and treatment remain the most effective approaches, as younger patients tend to have better surgical outcomes with a lower risk of avascular necrosis[18]. Additionally, refining post-operative care protocols, including optimal immobilization duration and rehabilitation strategies, may help improve outcomes. Future research should focus on long-term follow-up studies to assess the progression of hip function and joint health in patients with avascular necrosis.

CONCLUSION

It is concluded that AVN is a major complication following open reduction for DDH, with a significant impact on functional and radiographic outcomes. Early intervention, careful surgical technique selection, and optimized post-operative management can help reduce AVN risk.

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