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Challenges in the Management of Developmental Hip Dysplasia in Walking Children A Cross-Sectional Study

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ABSTRACT

Infantile Developmental Dysplasia of the Hip (DDH) poses unique diagnostic and treatment difficulties as it relates to a diagnosis made in walking age children as compared to that of infants. As complications from lack of a timely report often produce unpredictable results and more complex treatment regimes.

Primary Purpose: To direct an assessment of the challenges faced with reference to clinical criteria, types of available treatments, and how such treatment is subsequently assessed; specifically concerning DDH in patients aged 12-60 months, who present for treatment at Al Hussain Teaching Hospital in Samawa, Al-Muthanna.

Study Methodology: The 78 DDH children were recruited for the purpose of a two-year cross-sectional study and accordingly, they were divided into groups based on Tönnis classification of severity, age at presentation, and how the DDH was treated. The patients' clinical evaluations were done using Modified McKay criteria, and the treatment evaluation results were determined by using X-rays of each patient. The study data was analyzed using the SPSS version 26.

Results and Findings: The majority of the study participants were female (89.7%), and their average age at presentation was 22.4 ± 11.6 months (mean). Approximately two-thirds of the study group of children (62.8%) were brought to the hospital for treatment after the age of 18 months. The types of treatment provided to the study participants were Closed Reduction (41.0%), Open Reduction (47.4%), and Pelvic Osteotomy (11.5%). Avascular Necrosis (21.8%), Redislocation (15.4%), and Residual Dysplasia (28.2%) were identified as complications. Satisfactory results were noted to occur in 56.4% of the kids treated. When analyzing outcomes according to treatment modality it was found that there are statistically significant differences in both treatment outcomes ($p=0.003$) and Complication Rates and ages at presentation ($p<0.001$).

Conclusion: Managing DDH in children who have become walking creates many treatment challenges that are caused by both the high complication rate as well as variable treatment outcomes. The identification of DDH at an earlier age (less than 18 months) can be facilitated by better screening practices in conjunction with the establishment of standardized treatment protocols to enhance the likelihood of achieving the best possible outcomes and reduce overall morbidity in this fragile population.

Keywords: Developmental dysplasia of the hip; walking child; late presentation; open reduction; complications; avascular necrosis; outcomes.

INTRODUCTION

Developmental dysplasia of the hip (DDH) is the most common congenital musculoskeletal disorder in children; it encompasses a spectrum of hip abnormalities, ranging from mild acetabular dysplasia to complete hip dislocation [1,2]. The estimated incidence of DDH varies significantly across populations, ranging from 1.5 to 20 cases per 1000 live births. Certain ethnicities and geographic areas are associated with much higher rates of DDH than others [3,4]. To effectively provide preventive orthopedic support, neonatal screening programs are essential because early identification and treatment during the first year of life typically provide excellent results through simple interventions, such as the Pavlik harness [5].

Children may be identified with DDH through an established screening process after they have achieved independent walking. Previous diagnostic challenges of identifying DDH and treatment of DDH can significantly complicate any therapeutic approach provided to walking children with established DDH [6,7]. Compared to the infant group diagnosed with DDH, the walking child group (generally defined as children who are over the age of 12 months and have achieved independent ambulation) presents an entirely different clinical scenario. The adaptive capacity of the acetabulum, the deformation of the femoral head, the thickening of the capsular structures, and the visual inspection of the surrounding soft tissue collectively indicate a history of adaptive changes that may complicate future therapies and diminish therapeutic responses [8].

Compared with infants, the pathoanatomy of late-presenting DDH differs significantly. To prevent concentric reduction into the acetabulum, the femoral head may be severely malformed, flattened, and enlarged. The acetabulum itself undergoes progressive dysplastic changes, becoming anteverted and shallow, with a hypertrophied limbus that may impede reduction [9,10]. Additionally, an hourglass deformity that hinders attempts at reduction is created when the iliopsoas tendon contracts and may indent the medial joint capsule. While the transverse acetabular ligament may tighten and narrow the inferior acetabular opening, the ligamentum teres frequently becomes hypertrophic and fills the acetabulum [11].

Painless limping, leg-length discrepancy, restricted hip abduction, a positive Trendelenburg gait in unilateral cases, and a distinctive waddling gait in bilateral involvement are typical clinical presentations in walking children [12]. In the walking child group, radiological evaluation is crucial, whereas in infants, clinical examination may be sufficient for diagnosis. While advanced imaging modalities such as arthrography, computed tomography, and magnetic resonance imaging may be required for surgical planning, plain radiography provides vital information on the degree of displacement, acetabular development, and femoral head morphology [13].

Compared to infants, treatment approaches for DDH in walking children are significantly more intricate and intrusive. Although feasible in certain situations, closed reduction has a much lower success rate than open reduction. It is associated with a higher risk of complications, particularly avascular necrosis of the femoral head [14,15]. To address soft-tissue barriers to reduction, such as the release of the iliopsoas tendon, excision of the hypertrophic ligamentum teres, and removal of the inverted limbus, many patients in this age group require open reduction. Medial, anterior, and anterolateral approaches are among the surgical techniques described; each has unique benefits and drawbacks [16].

Additionally, to achieve hip stability and support normal development, children presenting

after 18 months of age frequently require procedures beyond simple reduction. To reduce strain on the neurovascular structures and lower the risk of avascular necrosis, femoral shortening may be necessary [17, 18]. Redirecting the acetabulum and providing sufficient coverage of the femoral head often necessitates pelvic osteotomies, such as Salter innominate osteotomy, Pemberton acetabuloplasty, or Dega osteotomy. The patient's age, the degree of dysplasia, and the particular anatomical deficiencies present all influence the choice of osteotomy [19, 20].

The treatment of late-onset DDH is complex, even when performed with the best surgical methods. The worst potential outcome is avascular necrosis (AVN) of the femoral head, which can occur in anywhere from ten to sixty percent of patients, depending on the population and treatment course [21,22]. The Kalamchi and MacEwen Classification System is often used to grade AVN severity, with the more severe grades showing worse long-term prognosis [23]. In addition to AVN, further impaired function with leg-length discrepancy, stiffness, redislocation, residual dysplasia, and early onset degenerative joint disease during adulthood can also be serious complications of late-onset DDH [24].

Children with DDH who can walk develop a range of interrelated and multifactorial conditions. Age at initial presentation is one of the most robust predictors of outcome; older patients have a greater likelihood of having complications and worse functional outcomes [25,26]. The degree of severity of the dislocating event at the time of presentation, as evaluated with the IHDI or Tönnis grading systems, is another factor related to treatment complexity and prognosis [27]. Other complicating factors include bilateral involvement of the hips, prior failed attempts at treatment, and the presence of associated conditions such as traumatic dislocation or neuromuscular disorders, all of which complicate the management of children with DDH [28].

In developing nations, the late presentation of DDH remains a major problem due to poor access to quality medical care. Barriers to early diagnosis include the absence of adequate neonatal screening, the lack of awareness by healthcare providers and parents, cultural factors, the remoteness of villages from healthcare providers, and limited access to pediatric orthopedic services [29,30]. Thus, a large number of children with DDH will not start walking until they are over two years of age, and the treatment will be more difficult and the outcomes less well defined. Developing effective strategies to improve DDH care will require an understanding of the unique challenges and outcomes experienced by children with DDH in developing countries.

Iraq, like many developing countries, faces significant challenges in managing DDH due to the limitations of its healthcare system; the long-term effects of ongoing socioeconomic problems; and the large numbers of people displaced from their homes as a result of military conflict. Many of the residents of Al-Muthanna Governorate in southern Iraq, which is centered around the city of Samawa, are rural and do not have access to the full range of tertiary care for pediatric orthopedic problems. Al Hussain Teaching Hospital is the primary referral center for pediatric orthopedic care in Al-Muthanna governorate and has a catchment area of roughly 800,000 residents.

To date, there has been little published literature from Iraq regarding the unique challenges, treatment strategies, and treatment outcomes associated with late-presenting DDH in the pediatric population. Most research conducted to date has focused on infantile DDH or has been conducted in tertiary institutions located in Baghdad, which does not necessarily reflect

the reality of the situation in rural areas. Thus, the objective of this study was to perform a comprehensive review on the presentation, treatment choices, complications and results associated with the management of DDH in an ambulatory population of children at our institution in order to identify gaps in knowledge and to contribute to the available literature on this complex condition.

METHODOLOGY

Study Design and Setting

Over 24 months, from March 2018 to March 2020, this cross-sectional analytical study was conducted at the Department of Orthopedic Surgery at Al Hussain Teaching Hospital, Samawa, Al-Muthanna Governorate, Iraq. The primary referral center for Al-Muthanna governorate and its environs, Al Hussain Teaching Hospital is a 400-bed tertiary-care facility with a well-established pediatric orthopedic unit that handles approximately 1,200 pediatric cases annually. Before enrollment, all participating children's parents or legal guardians provided informed written consent, and the institutional ethics committee reviewed and approved the study protocol.

Selection of Patients

All children who visited our facility during the study period and were diagnosed with developmental dysplasia of the hip comprised the study population. Children aged 12-60 months at the time of presentation, a confirmed diagnosis of DDH based on clinical and radiological criteria, unilateral or bilateral hip involvement, and parents who provided informed consent for participation were strict inclusion criteria. Children younger than 12 months or older than 60 months at presentation, secondary hip dislocations caused by infectious arthritis, skeletal dysplasias, or neuromuscular disorders, teratologic hip dislocations present at birth, prior surgical intervention for DDH at another facility, incomplete medical records or radiographic documentation, and patients lost to follow-up before a six-month post-treatment evaluation were among the exclusion criteria.

Clinical Evaluation

All patients underwent a complete clinical assessment by the orthopedic team. The evaluation included a detailed medical history (including gestational and birth history), family history of DDH, risk factors (such as breech presentation or firstborn status), and developmental status (particularly the child's age at first walking). Additionally, gait pattern (Trendelenburg gait in unilateral cases or waddling gait in bilateral cases), leg length discrepancy (using the block test as well as tape measure from ASIS to medial malleolus) and range of hip motion, with particular emphasis on the limitation of abduction, presence of a Galeazzi sign indicating femoral shortening and evaluation of hip stability using the Barlow and Ortolani manoeuvers, if appropriate, were all documented as part of the physical examination. Particular emphasis was placed on identifying associated musculoskeletal abnormalities and evaluating overall development.

Radiological Assessment.

Each subject had a standard anteroposterior (AP) radiograph of the pelvis taken with the hips in the anatomical position (neutral rotation) and in full abduction (maximal abduction). Various criteria were assessed, including: acetabular index (AI)–the angle formed by Hilgenreiner's line and the superior border of the acetabulum–the center-edge angle of Wiberg when the

ossification center of the femoral head developed enough; continuity of Shenton's line; degree of displacement of the femoral head, determined using percentage of uncoverage; and evaluation of severity of sublaxation and/or dislocation based on the Tönnis grading scale (Grade I indicates subluxation; Grade II indicates high dislocation of femoral head opposed to acetabulum; Grade III indicates dislocated acetabulum; Grade IV indicates completely dislocated with superior and lateral displacement). For some patients, additional imaging was then done. These consisted of hip arthrography performed under general anesthesia to determine the ability to reduce and/or detect barriers to reduction (inverted limbus, constricted capsule, or interposed soft tissue); Computerized Tomography (CT) with 3D reconstruction performed for surgical planning for complex cases; and Magnetic Resonance Imaging (MRI) of the soft tissue-anatomy/cartilaginous structures when necessary.

Protocols for Treatment

Patient age, the degree of dislocation, and institutional protocols established by expert consensus and literature review were taken into consideration when making treatment decisions. Initial treatment for children with Tönnis grade I or II, aged 12 to 18 months, involved preliminary traction using Bryant's or modified Bryant's skin traction for 2 to 3 weeks, followed by an attempt at closed reduction under general anesthesia. To verify concentric reduction and find any obstructions, arthrography was used. A hip spica cast was used to keep the hip in a stable position, which is usually the human position with 90–100 degrees of flexion and 40–50 degrees of abduction, if a successful closed reduction was accomplished with the hip stable in the safe zone (less than 60 degrees of flexion and adequate abduction without excessive force). Under anesthesia, the cast was changed every six weeks for a total of twelve weeks.

Open reduction was used for children who were older than 18 months, had Tönnis grade III or IV dislocation, or had unstable or unsuccessful closed reduction. The patient's age and anatomical factors were considered when selecting the surgical technique. The anterolateral approach (Smith-Petersen) was used for the majority of patients over 18 months and for those requiring concurrent femoral shortening. In contrast, the medial approach was used in a few cases involving children under 18 months. Transection of the iliopsoas tendon, excision of the hypertrophic ligamentum teres and pulvinar, division of the transverse acetabular ligament, and removal of the inverted limbus were all part of open reduction. In children older than 24 months, or in cases in which pre-reduction traction revealed significant soft-tissue tension, a femoral shortening osteotomy was performed. Depending on the degree of femoral head displacement, the shortening was 1.5–2.5 cm. In cases with substantial residual acetabular dysplasia, pelvic osteotomy was added; in our institution, Salter innominate osteotomy is the preferred procedure. Depending on the procedures carried out, post-operative immobilization in a hip spica cast was maintained for eight to twelve weeks.

Monitoring and Evaluation of Results

Each patient underwent routine clinical and radiological evaluations at predetermined intervals: immediately after reduction or surgery, six weeks after cast change, three months after cast removal, six months, and one year after treatment. A minimum follow-up period of 6 months was required for inclusion in the outcome analysis. The modified McKay criteria, which categorize results as excellent (no limp, negative Trendelenburg sign, full range of motion, no leg length discrepancy), good (slight limp, slight decrease in range of motion, minimal leg

length discrepancy less than 1.5 cm), fair (moderate limp, positive Trendelenburg sign, mild limitation of motion, leg length discrepancy 1.5-3 cm), or poor (severe symptoms, marked limitation of motion, persistent dislocation, or severe leg length discrepancy). The evaluation of acetabular development using serial acetabular index measurements, the shape and development of the femoral head, the presence and degree of avascular necrosis using the Kalamchi and MacEwen classification, and the preservation of concentric reduction were all part of the radiological outcome assessment.

Complications were methodically documented and categorized as either late (occurring after three months) or early (occurring within three months). Avascular necrosis of the femoral head identified by radiographic changes such as increased density, fragmentation, or growth disturbance; redislocation defined as loss of concentric reduction requiring revision surgery; residual dysplasia with persistent acetabular index greater than usual for age; infection, including deep and superficial wound infection; nerve injury, particularly femoral and obturator nerve palsy; and stiffness with significant range of motion limitation affecting function were among the specific complications that were monitored.

Gathering Information and Statistical Evaluation

The data collected in this study consisted of demographic information, clinical presentation, radiological parameters and treatment modalities, as well as complications and outcomes. The raw data were entered into Microsoft Excel 2019, then analyzed with the Statistical Package for the Social Sciences (SPSS) version 26.0. Categorical variables were reported as frequency/percentage, while continuous variables were summarized as mean + standard deviation, median (interquartile range) or both where appropriate. The chi-square test or Fisher's exact test were employed for categorical variables, whereas the independent t-test or Mann-Whitney U test were compared for continuous variables based on the distribution of the data and size of the sample. A Pearson's or Spearman's correlation coefficient analysis to evaluate the relationships between variables was also done where appropriate. Finally, a multivariate logistic regression analysis will ultimately be used to determine independent predictors of complications and poor outcome measures. For the purposes of this study, a p-value of < 0.05 will be considered statistically significant.

RESULTS

Over the 24-month study period, 78 children who met the inclusion criteria and had developmental dysplasia of the hip were enrolled. Table 1 displays the study population's clinical and demographic features. At presentation, the average age was 22.4±11.6 months, with a range of 12-58 months. With 70 patients (89.7%) being girls and only eight patients (10.3%) being boys, there was a clear female predominance, resulting in an 8.75:1 female-to-male ratio. Fifty-four patients (69.2%) had unilateral involvement, of whom 35 (64.8%) had left hip involvement. Twenty-four patients (30.8%) had bilateral involvement.

Positive family history was found in 18 patients (23.1%), breech presentation in 27 cases (34.6%), and firstborn status in 42 patients (53.8%). According to age group distribution, 29 patients (37.2%) were aged 12-18 months, 32 (41.0%) 19-36 months, and 17 (21.8%) 37-60 months. According to the Tönnis classification, most patients had moderate to severe displacement, with 12 hips (11.8%) grade I, 38 hips (37.3%) grade II, 35 hips (34.3%) grade III, and 17 hips (16.7%) grade IV.

Table 1: Demographic and Clinical Characteristics (N=78)

Variable	Category	n (%)
Gender	Female	70 (89.7%)
	Male	8 (10.3%)
Age at presentation	12-18 months	29 (37.2%)
	19-36 months	32 (41.0%)
	37-60 months	17 (21.8%)
Laterality	Unilateral	54 (69.2%)
	Bilateral	24 (30.8%)

The treatment modalities used and their outcomes are summarized in Table 2. 32 patients (41.0%) underwent closed reduction attempts, and 19 (59.4%) achieved stable reductions. Thirty-seven patients (47.4%) underwent open reduction; 28 (75.7%) used the anterolateral approach, and 9 (24.3%) used the medial approach. In 18 patients (48.6% of open reduction cases), femoral shortening osteotomy was combined with open reduction. Nine patients (11.5%) with significant residual acetabular dysplasia following reduction underwent pelvic osteotomy, specifically Salter innominate osteotomy.

Table 2: Treatment Modalities (N=78)

Treatment Modality	n (%)
Closed reduction	32 (41.0%)
Open reduction - Anterolateral	28 (35.9%)
Open reduction - Medial	9 (11.5%)
Femoral shortening + Open reduction	18 (23.1%)
Pelvic osteotomy (Salter)	9 (11.5%)

Among patients examined in the study, complications were most commonly observed in 51 patients (65.4%). Complications have been presented in detail with further information about Avascular necrosis (AVN), which was noted to be the most common complication with 17 patients (21.8%) diagnosed with this; 6 patients had Kalamchi Grade 1 AVN, 7 had Kalamchi Grade 2 AVN, three had Kalamchi Grade 3, and 1 had Grade 4 AVN. Twelve patients (15.4%) also presented with Redislocation that required revision surgery. The remaining patients presented with residual Dysplasia; 22 (28.2%) had residual Dysplasia and elevated acetabular index. Other complications observed included: 4 patients (5.1%) with superficial wound infections, two patients (2.6%) with transient nerve Palsy, and eight patients (10.3%) with significant hip stiffness. The statistical analysis indicates that presenting Age had a statistically

significant association with the overall occurrence of Complications in the study population, as those who presented over 24 Months of age were found to have a statistically higher occurrence of both AVN and Redislocation compared to those who were younger than 24 months ($P < 0.001$).

Table 3: Complications (N=78)

Complication	**n (%)**
Avascular necrosis (total)	17 (21.8%)
Redislocation	12 (15.4%)
Residual dysplasia	22 (28.2%)
Infection (superficial)	4 (5.1%)
Nerve palsy (transient)	2 (2.6%)
Hip stiffness	8 (10.3%)

Table 4 displays functional outcomes at a minimum 6-month follow-up. According to the modified McKay criteria, 18 patients (23.1%) achieved excellent results, 26 patients (33.3%) achieved good results, 21 patients (26.9%) achieved fair results, and 13 patients (16.7%) achieved poor results. Forty-four patients (56.4%) had overall satisfactory results (excellent or good). Open reduction in conjunction with femoral shortening produced better results than closed reduction alone in older children, according to statistical analysis, which also showed a significant correlation between treatment modality and functional outcomes ($p=0.003$). Furthermore, poor outcomes were strongly correlated with the presence of complications, particularly AVN and redislocation ($p < 0.001$).

Table 4: Functional Outcomes (N=78)

Outcome (Modified McKay)	**n (%)**
Excellent	18 (23.1%)
Good	26 (33.3%)
Fair	21 (26.9%)
Poor	13 (16.7%)
Satisfactory (Excellent + Good)	**44 (56.4%)**

DISCUSSION

Managing developmental dysplasia of the hip (DDH) in walking children is one of the most challenging aspects of pediatric orthopaedic practice. DDH has a complicated pathoanatomy, complex treatment requirements, a high rate of associated complications, and uncertain results in the long term. A study of 78 children treated at Al Hussain Teaching Hospital in a regional area of Iraq over two years provides essential insight into the management of late-presenting DDH, particularly when access to early screening and specialist paediatric orthopaedic care may be limited. The study highlighted many important issues that require further discussion.

The demographics of our patient cohort are consistent with literature-specified patterns. The predominant excess (89.7%) of females in this series reflects the higher incidence of DDH being established as a female condition because of greater ligamentous laxity, likely due to influence from maternal relaxin hormone and genetic factors [31,32]. Our female-to-male ratio of 8.75:1 is greater than the typical reported range of 4:1 to 6:1. This could be indicative of either actual variability in disease occurrence among regions, or the fact that we were preferentially receiving referrals for more severe cases that necessitated tertiary care. In comparison to certain large case series, we did not evaluate statistically left-sided predominance (64.8%) in unilateral cases, but it's consistent with trends observed in many studies. The increased prevalence of left-sided cases is believed to correlate with the more common left occipitoanterior fetal presentation limiting abduction of the left hip [33].

Perhaps the most serious finding of our study is the significantly late presentation (mean of 22.4 months) with 62.8% of patients seen after 18 months of age. The delayed presentation of patients demonstrates a breakdown in screening and early identification systems in this region and is in stark contrast to what is possible in babies when identified and treated promptly. In accordance with international standards, infants determined to possess increased risk factors should be screened using ultrasound in addition to regular follow-up appointments and universal screening procedures at birth [34]. However, the establishment of such programs depends upon the presence of a strong healthcare system, qualified personnel, and knowledge on the part of parents regarding resources for detection and treatment, all of which are likely to be absent from resource-poor regions. Studies conducted in developing nations consistently demonstrate considerably later ages of presentation than their counterparts in developed nations as a result of traditional swaddling practices, absence of comprehensive screening programs, delays in medical consultation and insufficient access to healthcare due to socio-economic factors [29, 30].

Depending on the patient's age and degree of dislocation, our institution's treatment strategy varied: in 41% of cases, closed reduction was attempted; in 47.4% of cases, open reduction was necessary. This distribution reflects the fact that many walking children have established pathoanatomical changes and soft-tissue obstacles that render closed methods ineffective for their treatment. Our series' closed reduction success rate of 59.4% attaining stable reduction is comparable to documented success rates of 40–70% in age groups that are comparable [14,35]. Closed reduction in walking children, however, carries inherent risks and necessitates careful patient selection, precise technique, and close monitoring to identify early signs of complications, especially avascular necrosis [15].

In nearly half of the patients in our series, open reduction was the cornerstone of care. There

are proponents of both anterior and medial surgical approaches, and the choice remains a subject of debate. In 75.7% of open reductions, particularly in children older than 18 months, we primarily used the anterolateral approach because it allows concurrent femoral shortening when necessary and provides excellent exposure of soft-tissue obstacles, such as the iliopsoas tendon, capsule, and limbus [16]. Theoretically, avoiding the abductor muscles and possibly lowering AVN rates are two benefits of the medial approach, which is used in confident younger children. However, it provides limited visualization and cannot address associated femoral or acetabular deformities. To relieve soft-tissue tension and potentially reduce the risk of AVN, femoral shortening was performed in 23.1% of our patients, primarily those older than 24 months or with significant dislocations [17,18].

Our study's high complication rate, which affected 65.4% of patients, highlights how difficult it is to treat late-presenting DDH. Due to its potentially catastrophic long-term effects on hip growth and function, avascular necrosis, which occurs in 21.8% of cases, is the most feared complication. Our AVN rate falls within the broad range of 5–60% reported in the literature for walking children with DDH; variations may be attributable to treatment approaches, AVN diagnostic criteria, age at treatment, and the degree of displacement [21, 22, 36]. AVN has a multifactorial etiology that may include direct vascular injury during surgery, excessive pressure on the femoral head from an unremodeled acetabulum or tight soft tissues, and disruption of the blood supply during reduction [37].

15.4% of our patients experienced relocation, which required revision surgery and put these kids at greater risk for complications and additional anesthetic and surgical risks. Inadequate initial reduction, neglect of acetabular dysplasia, early removal of the spica cast, or gradual displacement in children with neuromuscular imbalance are the usual causes of relocation. Risk factors for redislocation include being older than 24 months at treatment, having a high-grade initial dislocation, having insufficient acetabular coverage, and having soft tissue interposition [38, 39]. In addition to identifying potential areas for improvement in surgical technique, postoperative immobilization protocols, and follow-up care, our comparatively high redislocation rate may be attributable to the majority of late presenters with severe pathology in our series.

At medium-term follow-up, 28.2% of our patients had residual dysplasia, which is characterized by a persistent elevation of the acetabular index above age-appropriate limits. Significant residual dysplasia is associated with an increased risk of early-onset osteoarthritis in adulthood. It may necessitate additional surgical intervention, although some degree of acetabular remodeling can be anticipated after concentric reduction, particularly in younger children [40]. Age at reduction, the quality of reduction, the length of concentric containment, and potentially personal biological factors all influence the degree of acetabular remodeling. Although the best time and kind of osteotomy are still being researched, pelvic osteotomy during open reduction or as a staged procedure can improve acetabular coverage and possibly improve long-term outcomes [19,20].

At least six months after treatment, only 56.4% of patients with infant developmental dysplasia of the hip (DDH) who met the modified McKay criteria reached satisfactory functional outcomes. This represents the lowest satisfaction rate to date when compared to 70%-90% satisfaction ratings seen for the same patient population treated for DDH. Therefore, early detection programs will play an important role in demonstrating the difference in outcomes

between patients with early-presenting DDH compared to those who present with late symptoms. Our data demonstrate successful assessment of outcome for patients treated for DDH over the medium term but do not predict how hips will perform, or how potential for the development of degenerative changes may arise from that time until decades later [24,41]. Furthermore, there are long-term studies that demonstrate that some patients may have satisfactory hips during childhood but develop premature osteoarthritis as they enter their adolescent to adult years [42]. The factors that influence this scenario include the presence of avascular necrosis (AVN), residual dysplasia, inability to achieve an incongruent reduction, and biomechanical aspects.

In addition, our statistical correlations will help provide useful information for counseling and clinical decision-making regarding optimal treatment protocol for patients with DDH. Our data also indicated that there is a strong correlation ($p < 0.001$) between age of presentation for treatment of DDH and rate of complications. Therefore, each month that passes before treatment will only complicate the success of treatment and worsen the overall prognosis for the patient. There is also a significant correlation ($p=0.003$) between the type of treatment and level of function achieved, suggesting that proper technique and selection of surgical procedures will result in optimal results. However, the best course of action for each patient is still being researched [25,26,27].

Several limitations were identified with the current study.Due to its relatively brief minimum follow-up time of six months, we feel that this duration does not provide adequate time for evaluating outcomes relating to long-term effects of developing Osteoarthritis or requiring salvage procedures. However, this time can be used to evaluate the incidence of immediate complications and an individual's early functional status. The short time frame for follow-up also precludes any investigation into trends in presentation patterns or results over time due to its cross sectional design. Therefore, while these results likely provide some insight into how DDH is managed by similar regional centres in Iraq and other developing countries, there are limitations to how generalizable they can be because of the single centre design. Additionally, while the number of patients studied is appropriate for a regional centre, the limited sample size restricts statistical power when conducting multivariate models and performing subgroup analyses to identify independent predictors for outcomes.

Despite these limitations, this study has helped to establish basic priorities for generating higher levels of care and illustrates the validity of using real-life data to evaluate the challenges associated with treating late-presenting DDH patients in resource-poor environments. In order to prevent late presentations of DDH, the implementation of universal newborn screening programs; provision of training for primary healthcare practitioners regarding clinical examination techniques for DDH; the creation of public health campaigns to increase parental awareness; and improving access to ultrasound for high-risk newborns is essential [43]. In addition, establishing standardised treatment protocols based upon both age and severity of presentation will provide the best possible chance to maximise outcomes and minimise complications associated with the treatment of children who do present at later ages despite these screening efforts. It is also expected that by leveraging shared resources and knowledge, the development of regional centres dedicated to the treatment of complex DDH cases will lead to improved surgical outcomes. To facilitate the identification and management of complications, and to collect outcome data to support future practices, the establishment of

comprehensive long-term follow-up protocols with extended,repeated surveillance is also initipated to satisfactorily evaluate complications and collect outcomes for those patients who are identified late [44].

In conclusion, even though the surgical care provided to these children is of the highest standard, the issues presented with managing HDH in children who have begun walking, is an extremely difficult challenge both clinically and mathematically, due to the large number of complications associated with this condition, and causing unpredictable outcomes. The overwhelming majority of the clinical population presented to this study was late presenters, revealing a reflection on the systemic problems associated with Early Detection & Screening that require targeted resource distribution and the formulation of healthcare policy initiatives. The best chance for success in the children that are diagnosed with this complication late in life is through meticulous, individualised plans of treatment selection and the implementation of quality surgical techniques and thorough follow up, however, families must also be informed of the high risk and limitations associated with treating DDH at that time. The ultimate management of this condition must always be through prevention via early detection; this reemphasises the need for the implementation of universal newborn screening programs and better access to paediatric orthopaedic fàclities in underserved communities.

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