Outcome of Closed Reduction of Developmental Dysplasia of Hip Before First Year of Age, A Retrospective Cohort Study, Saudi Arabia

Fahad AlShayhan (Fahadshayhan@gmail.com)
King Saud University
Abdulmonem Alsiddiky
King Saud University
Raghad Barri
King Saud University

Research Article

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Abstract

Background: Developmental dysplasia of hip (DDH) management is challenging hence there is no fixed rules or radiographic criteria to assess and manage DDH. There are many treating modalities including closed reduction, open reduction, skin traction, hip Spica and many others. This study is to assess the outcome of closed reduction in patients below 12 months of ages.

Method: A retrospective study among patients with DDH who underwent closed reduction before the first year of age in a major referral medical center. The study included 100 patients and 168 hips. Average of follow up period was 5.97 years (±3.01). Couple of variables were measured in AP x ray of pelvis to assess the outcome of closed reduction.

Results: Most of the hips were grade 1 and 2 according to the IHDl (International hip dysplasia institution) classification. Significant improvement in the acetabular index post closed reduction. In addition to the normalizing of CE angle's values. Also, majority of hips were severin's class 1 and 2 which were associated with good outcome.

Conclusion: Safe closed reduction in patients with DDH below one year of age had a great outcome, less AVN, less growth complications and decrease the need of future open reduction.

Introduction

Developmental dysplasia of the hip (DDH) is a structural abnormality involving the hip joint that's range from deviation in normal hip to developmental hip dysplasia \(^{(1,2)}\). The DDH includes partial dislocation (subluxation), complete dislocation and acetabular dysplasia \(^{(3)}\). The original term (congenital dysplasia of the hip) CDH used to describe only the congenital type that the infant born with. However, the new term DDH included hip dysplasia or dislocation which develops after the delivery of normal infant \(^{(4)}\).

DDH has a wide optional treatment modality depend on the patient age and severity of the dislocation, including the closed reduction and manipulation under anesthesia. Closed reduction is commonly used method to treat DDH before the child is able to walk due to its high success rate \(^{(5)}\). However, the overuse and wrong utilization of this treatment modality may result in long term complication \(^{(6)}\).

The outcome of DDH treatment has improved significantly over the past 30 years \(^{(7)}\). But, delayed diagnosis and thus treatment lead to less predictable outcome of reduction and more challenging hip to reduce \(^{(6)}\).

Despite the high percentage of successful closed reduction, some complications could appear with follow up. Avascular necrosis was reported by 35% of whom underwent closed reduction which this may lead to femoral head deformities, leg length discrepancy and other consequences that will affect joint function and therefore his daily activities \(^{(8,9)}\). Redislocation, residual subluxation and persisting
acetabular dysplasia are other complications could occur from closed reduction\(^{(5,10)}\). Explanation of these complications could be from improper concentric reduction by the surgeon\(^{(9)}\).

Detecting abnormalities or unimproved hips early post closed reduction and surgical intervention is important to avoid long term complications\(^{(11)}\). Age of the patient at reduction, gender of the patient, side, grade of displacement, acetabular index (AI), center-edge angle of Wiberg (CE), Reimer’s index (RI), center-head discrepancy distance (CHDD), orientation of sourcil and performing adductor tenotomy are factors which may predict the outcome of closed reduction\(^{(9,11,12,13,14)}\). Radiographic results are associated with the outcome of closed reduction\(^{(6)}\). Our aim is to assess the outcome of hips underwent closed reduction before age of one year. The study was approved by the Intuitional Review Board in the College of Medicine.

**Methodology**

A total of 168 hips of patients diagnosed with developmental dysplasia of the hip (DDH) and treated with closed reduction technique under general anesthesia. All patient had hip adductor tenotomy, placed on hip Spica/cast. Quality of closed reduction intra op was assessed using the hip arthrogram and fluoroscopy. Total duration of immobilization was 7.5 months including 12 weeks of hip spica, 6 weeks broomstick, 12 week of abduction splint. Patients with neuromuscular disorders, teratological dislocations or inadequate follow up radiographs were excluded as well as patients with irreducible hips that needed open reduction initially. Ethical approval was obtained from institutional review board at medical college, King Saud University.

The mean age at the time of the diagnosis was 4.92 months (Range 0:11, ±2.49). The average follow-up period was 5.97 years (±3.01). Hips were divided in two groups according to the age of the patient at reduction: In Group 1 there were 91 hips reduced from 1 to 6 months of age, while in Group 2 there were 77 hips reduced from 7 to 12 months of age. The International hip dysplasia institution (IHDI) displacement method of classification was used as it is considered as a reliable method and is more widely applicable than the Tönnis method as it can be applied even when the ossification center is absent\(^{(15)}\). The IHDI Classification grades severity from Grade 1 as the mildest type to Grade 4 as the most severe type of hip dislocation. Also, orientation of sourcil after reduction was measured in three different categories which were horizontal, oblique and vertical. Accordingly, center-edge angle of Wiberg (CE), Reimer’s index (RI) and center-head discrepancy distance (CHDD) were calculated and recorded for each hip. Smith’s c/b ratio was calculated by measuring the lateral placement of the medial corner of the upper femoral metaphysis in relation with Perkin’s line\(^{(13)}\). Post reduction avascular necrosis (AVN) was recorded and classified. Finally, hips were grouped according to modified Severin classifications, and pre and post reduction acetabular index values (AI) were measured\(^{(11)}\).

SPSS software, version 23 (SPSS Inc., Chicago, Illinois, USA) was used for data entry and analysis. All analyses were carried out at a significance level of 0.05. Chi square test was used for categorical
variables followed by post hoc analysis using the adjusted residual values, while continuous variables associations were examined using independent t-test and One-way ANOVA.

**Results**

The mean age of the patients at time of reduction was 6.31 months (Range 0:12, ±2.74). There were a total of 144 female and 24 male hips included in the study analysis. From a total of 168 hips, according to International Hip Dysplasia Institute displacement classification (IHDI) (Table 1), 29 hips (17.2%) was classified as Grade I, 76 hips (45.2%) as Grade II, 51 hips (30.4%) as Grade III and 12 hips (7.1%) as Grade IV(15). The acetabulum was evaluated according to the acetabular index value. The mean pre reduction acetabular index value was 38.56° (±9.59°). In Group 1 based on age of the patient at reduction, the mean pre reduction acetabular index value was 38.58° (±6.45°), while 38.54 (±8.75°) in Group 2. There was not significant statistical difference between both groups in AI values at that stage (p-value = 0.67). AI value improvement was calculated from post reduction results to score a mean of 18.24 (±3.65) in Group 1 and 18.27 (±3.69) in Group 2, and no significant statistical difference between both groups in AI values at that stage (p-value = 0.74). Also, it is important to note that gender did not have any significant association with AI values (p-value = 0.19).

According to smith the c/b ratio in normal hips ranges from 0.60 to 0.85 (13). Before reduction the average c/b ratio was 0.97 (±0.179) in Group 1 and 0.98 (±0.670) in Group 2. These was not significant statistical difference between both groups at that stage (p-value = 0.14). Post reduction average c/b ratio was 0.76 (±0.05) in Group1 and 0.74 (±0.22) in Group 2. After testing both groups, no significant statistical difference between both groups in c/b ratio post reduction (p-value = 0.274). Moreover, CE-angle was negative in all hips before reduction, however, post reduction, it improved to reach a mean of 37.97° (±8.71°) in Group 1 and 38.90° (±7.71°) in Group 2. The independent t-test showed that no significant statistical difference between both groups in CE-angle post reduction (p-value = 0.65). Finally, it is important to note that gender did not have any significant association with either c/b ratio or CE-angle (p-values: 0.175 and 0.290, respectively).

Last post reduction radiographs of the patients were graded according to modified Severin's classifications (Table 2) (11). From the 168 hips in this study, 143 (85.1%) were classified in Severin's group Ia, 14 (8.3%) in group II, 2 (1.2%) in group III, 8 (4.8%) in group IVa and 1 (0.6%) in group VI. Using the chi-square test, there was no significant difference between Group 1 and 2 in Severin's groups according to anatomical results (p-value = 0.540). This is justified by observing and comparing the percentages for both age groups based on age: in group 1, 81 hips were classified in group Ia, while 9 were classified in group II, while in group 2, 61 hips were classified in group Ia while 5 were classified in group II. Further to note that a statistical significant association was calculated using chi-square test between Severin classifications and orientation of sourcil after reduction (p-value = 0.0001). As horizontal orientation of the sourcil were most likely associated with being classified in Group Ia according to Severin's classifications. Moreover, hips in groups Ia and II were significantly associated with lower Reimer's index percentage values with means of 0.121 and 0.124 respectively and a p-value = 0.0001.
The mean acetabular index before reduction in cases with good results (according to Severin's classification) was 38.43° (±11.27°). On the contrary, the mean acetabular index before the treatment in cases with poor results (according to Severin's classification) was 42.29° (±6.27°). Using One-way ANOVA, a statistically significant difference was calculated between these results (p-value = 0.021). Regarding avascular necrosis, there were a total of 11 hips developed postoperative AVN and 157 hips did not have signs of postoperative AVN. There was no statistically significant in the association between age group or gender with AVN (p-values: 0.295 and 0.171, respectively). Moreover, there was no statistically significant difference between the AI index before reduction and avascular necrosis (p-value = 0.270).

A statistically significant different was calculated, using chi-square test, between AVN and anatomical Severin's classification (p-value = 0.0001). In other words, not developing AVN will most likely yield better results. Moreover, there was a significant association between IHDI displacement classification and AVN (p-value = 0.038).

**Discussion**

This study was designed to study outcome of closed reduction of 168 hips for patients with DDH before age of 12 months, majority of hips (83.3%) showed successful outcome with no signs of AVN and patients didn't need further surgeries after following up the results. According to Severin's classification (Table 3) most of hips (93.4 %) were classified as good result (Grade 1a and 2), and (6.6%) were classified as unsatisfactory [13].

In addition, smith c/b ratio which is basically ratios to describe the anatomical relationship in pelvis and femur, was measured also in all cases pre and post reduction and showed significant improvement and normalization of the values (below 0.8) [13]. CE angel indicates the femoral head in relation to the acetabulum and the development of its roof, which was monitored postoperative and showed great improvement and continued to improve throughout the post reduction period.

Although with satisfactory post reduction acetabular index values ranging between (18.24-18.27) in all patients and using Severin's classification (Table 3), class I and II hips were accepted as good results, while the remaining classifications were considered as poor outcomes [8], few patients which represents 6 % ended up with poor outcome including AVN following the closed reduction. It was previously identified that the age at onset of initial treatment and degree of dislocation (according to tonnis classification) were a major risk factors for AVN, but gender, laterality, age, adductor tenotomy and the use of abductor brace were not recognized as risk factors [8]. Moreover most of the patients whom ended up by satisfactory outcome, were between horizontal and oblique in regard of orientation of sourcil with RI less than 33% as also observed in Zhe Fu study [14].

Subluxation of hip diagnosed based on Reimer’s index >33%, it provides a reliable measurement of subluxation severity [14]. Zhe fu et al. found that 26/30 hips with high RI associated with unsatisfactory
Severin’s grades (14). This study revealed a significant association between low RI and satisfactory Severin’s grades (I & II). It was found that the incidence of AVN among hips underwent closed reduction before age of 12 months range from 8.3-47% (5, 6, 7, 8, 11, 16). Current study found that AVN occurred among 12 hips (7.1%). Brougham et al found previously no significant association between age, gender and incidence of AVN, whereas Mathew et al. found significantly male at higher risk to develop AVN compared with female (8,16). Similarly, this study found no significant relation between gender, age with incidence of AVN. Chango et al. found significantly that incidence of AVN associated with unsatisfactory Severin grades (17). This study found a very significant association between Severin classification and AVN. This study have found that 22 hips (13.1%) underwent a secondary operation. AVN found among 8/22 of operated hips.

**Conclusion**

Most of hips (83.3%) had a successful outcome, free of AVN with follow up and didn’t underwent any further procedures for DDH. Safe closed reduction in patients with DDH below one year of age had a great outcome, less AVN, less growth complications and decrease the need of future open reduction. Horizontal orientation of sourcil associated significantly with satisfactory results. Lower reimer’s index associated significantly with better outcome. Mean AI found to be significantly lower among hips that found to have good outcome compared with the group who had a poor outcome. IHDI displacement classification found to be a significant predictor of AVN in the future among hips undergoing closed reduction.

**Declarations**

**Ethics approval, consent to participate:**

Ethical approval was obtained from institutional review board at medical college, King Saud University (14/2/2018 – Reference number 18/0153/IRB). Informed consent was obtained from legal guardian of each patient.

**Guidelines:**

All patient underwent standardize closed reduction under general anesthesia, adductor tenotomy and hip arthrogram with fluoroscopy to ensure quality of reduction. All patients placed on hip spica and total duration of immobilization is 7.5 months as following (12 weeks of hip spica, 6 weeks broomstick, 12 week of abduction splint).

**Consent for publication:**

No applicable.

**Availability of data and materials:**
The datasets used and analysed during the current study available from the corresponding author on reasonable request.

**Competing interests:**

The authors declare that they have no competing interests.

**Funding:**

Deanship of Scientific Research, King Saud University.

**Authors' contributions:**

Fahad AlShayhan (Study design, Performed measurements, Manuscript preparation). Abdulmonem AlSiddiky (Formulating research question, study design, revising the manuscript and statistical analysis). Raghad Barri (Study design, Performed measurements, Manuscript preparation).

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If any of the sections are not relevant to your manuscript, please include the heading and write 'Not applicable' for that section.

**References**


Tables

Table 1 International Hip Dysplasia Institute displacement classification:
<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>the H-point is at or medial to the P-line.</td>
</tr>
<tr>
<td>II</td>
<td>the H-point is lateral to the P-line and at or medial to the D-line.</td>
</tr>
<tr>
<td>III</td>
<td>the H-point is lateral to the D-line and at or inferior to the H-line</td>
</tr>
<tr>
<td>IV</td>
<td>the H-point is superior to the H-line</td>
</tr>
</tbody>
</table>

*H-line is Hilgenreiner’s line drawn through the top of the tri-radiate cartilages bilaterally.*

*P-line is Perkin’s line drawn perpendicular to the H-line at the super lateral margin of the acetabulum.*

*D-line is diagonal line drawn 45 degrees from the junction of H-line and P-line.*

*H-point is the midpoint of the superior margin of the ossified metaphysis.*

**Table 2 Relationship between station of the hip at reduction and anatomical results:**

<table>
<thead>
<tr>
<th>Station</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-1)</td>
<td>16</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(0)</td>
<td>107</td>
<td>87</td>
<td>11</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>(+1)</td>
<td>42</td>
<td>40</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(2)</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**AVN**

<table>
<thead>
<tr>
<th>AVN</th>
<th>No</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>157</td>
<td>87</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

*AVN Avascular necrosis*

**Table 3 Modified Severin’s Classification of hips** (11):
<table>
<thead>
<tr>
<th>Radiographic appearance</th>
<th>Center edge angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Normal</td>
<td>CE angle &gt;19°, age 6-13 years</td>
</tr>
<tr>
<td></td>
<td>CE angle &gt;25°, ≥ 14 years</td>
</tr>
<tr>
<td>1b Normal</td>
<td>CE angle 15° - 19°, age 6-13 years</td>
</tr>
<tr>
<td></td>
<td>CE angle 20° - 25°, ≥ 14 years</td>
</tr>
<tr>
<td>2 Moderate deformity of the femoral head or neck or acetabulum, but otherwise as group 1a or 1b</td>
<td></td>
</tr>
<tr>
<td>3 Dysplastic but without subluxation</td>
<td>CE angle &lt;15°, age 6-13 years</td>
</tr>
<tr>
<td></td>
<td>CE angle &lt;20°, ≥ 14 years</td>
</tr>
<tr>
<td>4a Subluxation</td>
<td>Moderate, CE angle ≥ 0°</td>
</tr>
<tr>
<td>4b</td>
<td>Sever, CE angle &lt; 0°</td>
</tr>
<tr>
<td>5 Femoral head articulates with a secondary acetabulum in the upper part of the original acetabulum</td>
<td></td>
</tr>
<tr>
<td>6 Redislocation</td>
<td></td>
</tr>
</tbody>
</table>

*Center-edge angle of Wiberg (CE angle)*