Acetabular Remodeling after Closed Reduction of Developmental Dysplasia of the Hip

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Abstract

Objectives: This study aims to assess the radiographic development of the acetabulum after closed reduction of developmental dysplasia of the hip in patients with different follow-up periods.

Methods: The authors undertook a retrospective review of clinical records and radiographs of children who were diagnosed with developmental dysplasia of the hip and underwent closed reduction (mean age at closed reduction: 8.6 months) at King Khalid Civil Hospital, Tabuk, Saudi Arabia. Patients with a follow-up period <12 months were excluded from the study. Acetabular index angles for anteroposterior pelvic radiograph before treatment and at the final follow-up were used to assess acetabular development. Patients were divided into four groups according to the follow-up period and then the acetabular index was compared.

Results: A total of 64 dislocated hips of 40 patients were included in the study. The average follow-up period was 33.9 months (range: 12–82 months). Mean acetabular index before closed reduction was 34.37° (range: 25–46°), whereas the mean acetabular index after closed reduction was 23.8° (range: 10–37°). All groups showed improvement in the acetabular coverage and the acetabular index was significantly higher in groups with a longer follow-up period.

Conclusions: This study found that successful closed reduction of congenitally dislocated hips within the recommended age results in better acetabular development (coverage) and this improvement is more evident in patients with a longer follow-up period. Further studies can consolidate these results and help define the criteria for deciding early acetabuloplasty.

Keywords: Acetabular index, acetabular remodeling, closed reduction, developmental dysplasia of the hip

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a condition in which there is an aberrant development of the acetabulum and proximal femur, resulting in instability of the hip. In general, the prevalence of DDH is about 1 in 100 newborns with instability to 1–1.5 dislocations per 1000 newborns.¹ In Saudi Arabia, DDH is a common orthopedic problem faced by almost every pediatric orthopedic surgeon in Saudi Arabia.²⁻⁴ For example, in...
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A study that investigated the incidence of hip instability over >10 years in newborns in Al-Khobar, Saudi Arabia, it was found that of the 30,651 live births, 4.3/1000 had unstable hips.[3]

The treatment of choice depends on the age at diagnosis. Although closed reduction along with spica casting is considered the standard method for children presenting at 4–12 months of age, their success rates vary.[5‑9] The primary objective of this treatment is to obtain and maintain early concentric and stable reduction of the hip in atraumatic fashion so that the cartilaginous surface of the femoral head is in contact with the cartilaginous floor of the acetabulum, which is important for correcting acetabular dysplasia.[6‑13] However, the acetabular development is not predictable and not always satisfactory with this method.[14,15] Therefore, this study aims to elucidate the effectiveness of successful closed reduction on the development of the dysplastic acetabulum when congruous, accurate and concentric reduction is obtained early and is maintained throughout growth.

METHODS

The authors retrospectively reviewed the records and X-rays of all children who presented with DDH at King Khalid Civil Hospital, Tabuk, Saudi Arabia, and underwent closed reduction between January 2008 and November 2014. The inclusion criteria were all DDH patients aged 4–15 months who underwent closed reduction with spica casting as well as those who underwent closed reduction after reduction could not be achieved by the Pavlik harness.

In general, after successful closed reduction, the reduced hips are immobilized in hip spica cast in the human position, with the criterion for successful reduction being a concentrically reduced cartilaginous femoral head with <4-mm medial dye pooling [Figure 1].[6,16,17] After 6 weeks, the reduction and stability of the hips are examined under fluoroscopy and the spica cast is changed to bilateral cylinder cast with abduction bar if the hips are stable in extension; otherwise, another hip spica cast is re-applied. The assessments are repeated at 6-week intervals until the hips become stable and a sufficient acetabular coverage is seen in the X-ray or until operative correction of the acetabular coverage is indicated.[6,17]

This study excluded all cases with a follow-up period of <12 months after closed reduction as well as where hips failed to maintain in concentric reduction (i.e., re-dislocated and needed open reduction), hips developed avascular necrosis, hip with closed triradiate cartilage and those with inadequate information and X-rays. The study set the minimum follow-up period to be 12 months because it has been shown that there is rapid acetabular development within this time frame.[13]

With respect to measurement tools, although there are several radiographic measurement tools for evaluating acetabular dysplasia before and after treatment, acetabular index (AI) is most commonly used.[8,9,11‑13,16,18‑20] Therefore, the authors used AI as a measuring tool in this study. In nondysplastic hips, AI is <20° after the age of 2 years. Therefore, an AI of <20° was considered as the benchmark for determining success of DDH treatment in this study.[13] The dysplastic hips were categorized into four groups according to the follow-up period and the mean AI before and after treatment and the mean AI correction was calculated for each group. A single observer (one of the co-authors) assessed the AI measurements from the initial radiographs and the most recent X-rays using Hilgenreiner’s method.[21] Improvements in acetabular coverage were statistically analyzed using SPSS version 20 (SPSS Inc., Chicago, IL, USA).

Ethical approval for this study (No. 3/52) was obtained from the Directorate of Health Affairs, Ministry of Health, Tabuk, Saudi Arabia, in 2015.

RESULTS

The authors reviewed the records and X-rays of 73 DDH patients who were managed by closed reduction. All these patients had presented with DDH at >4 months of age and had directly undergone closed reduction, except one patient
who had presented with DDH at birth and undergone treatment with the Pavlik harness that had failed.

Seven hips of four patients were excluded from this study because they were re-dislocated after closed reduction (and subsequently underwent open reduction) as well as one patient with bilateral avascular necrosis was also excluded from this study; there were no cases that needed acetabuloplasty alone. Another 28 patients were excluded from the analysis of this study because of incomplete data. Therefore, eventually, only 40 patients with 64 dislocated hips (having adequate data and X-rays) fulfilled our inclusion criteria. Of these, 35 were female and 5 were male patients, and dislocation was unilateral in 16 patients and bilateral in 24 patients. The mean age at closed reduction was 8.6 months (range: 5–15 months). Six patients (15%) were aged <6 months at the time of closed reduction, 28 patients (70%) were aged 6–12 months and 6 patients (15%) were aged >12 months. The average follow-up period was 33.9 months (range: 12–82 months).

The mean AI before closed reduction was 34.37° (range: 25–46°), whereas the mean AI after closed reduction was 23.8° (range: 10–37°; P = 0.032). Figures 2a and b represent one such improvement in AI. The mean AI for undislocated hips was 22° (range: 18–30°) at initial prereduction X-rays and 19.5° at the final X-ray (range: 15–26°). The mean AI before and after treatment and the mean AI correction for each of the four aforementioned groups are shown in Table 1.

It was found that the final acetabula AI with longer follow-up showed better correction (P = 0.016) as well as groups with longer follow-up period had more hips with AI <20° at the final X-rays (P = 0.001).

**DISCUSSION**

This study shows that in DDH patients who undergo closed reduction, the acetabular coverage (AI) satisfactorily improves after a minimum follow-up period of 12 months, provided that congruous, accurate and concentric reduction is obtained early and is maintained throughout growth. Although improvements in the AI of hips were observed in all follow-up groups, it was more evident in groups with longer follow-up periods (i.e., Groups 3 and 4 with follow-up periods of 3–7 years).

Several studies have previously demonstrated favorable outcomes using closed reduction for the treatment of DDH. For example, Li et al. reported that in the 12 months after closed reduction had been carried out, the acetabulum in the dysplastic hips developed more rapidly than that of the normal hips (i.e., physiological development).[13] Harris et al. found that, if congruity is attained and maintained without deformation of the femoral head by the primary manipulation, 95% of hips would not need acetabuloplasty if the patient admitted is aged ≤4 years or if congruity is attained in the functional position before the age of 4 years.[10] Another study observed significant and continuing improvement of the AI between 2 and 8 years after reduction was performed.[10] However, despite the recommendation of early concentric reduction for DDH, the acetabular development was not predictable and not always satisfactory.[12,14,18] Nevertheless, the current study demonstrates satisfactory acetabular development.

According to Tasnavites et al.[12] and Schwartz,[28] maximum acetabular remodeling mainly occurs within 2–3 years after treatment and subsequently slows down. This is in contrast to our findings, wherein acetabular development continued even 3–7 years after treatment. Our results are consistent

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**Table 1:** Distribution of patients according to periods of follow-up and the acetabular index before and after closed reduction

| Patient group | Follow-up period (average) | Number of patients (number of hips) | Mean initial AI | Mean final AI | Mean correction of AI | Number of hips with >15° correction by the final follow-up (%) | Number of hips with AI <20° at the final follow-up (%) |
|---------------|---------------------------|-------------------------------------|----------------|--------------|----------------------|-------------------------------------------------------------|-----------------------------------------------------|
| Group 1       | 12–17 m (13 m)            | 15 (24)                             | 38°            | 28.4°        | 9.6°                 | 4 (16.6)                                                    | 2 (8)                                               |
| Group 2       | 18–35 m (24.5 m)          | 9 (16)                              | 32°            | 23.3°        | 8.7°                 | 4 (25)                                                      | 3 (18.7)                                           |
| Group 3       | 36–59 m (48.8 m)          | 8 (12)                              | 30.68°         | 20.25°       | 10.43°               | 4 (33)                                                      | 6 (50)                                              |
| Group 4       | 60–82 m (68 m)            | 8 (12)                              | 34°            | 18.7°        | 15.1°                | 8 (66)                                                      | 8 (66)                                              |

AI – Acetabular index
with that of Harris\cite{Harris1979} and Lindstrom et al.,\cite{Lindstrom2003} who found that the acetabular coverage continues to develop even after 5 years of follow-up.

It may be argued that, although the current study’s results show acetabular coverage improvement is most significant in those with ≥5-year follow-up period (i.e., Group 4), the corrections observed could possibly have happened earlier itself. However, the authors believe that the large number of hips showing significantly lesser AI corrections in Groups 1 and 2 (i.e., <3 years of follow-up period) indicate that these corrections only happened later. According to Schwartz,\cite{Schwartz2012} acetabuloplasty should be indicated for those who have an AI of >25° at 2 years after closed reduction; however, in contrast, our results demonstrate the importance of a longer follow-up of DDH patients treated by closed reduction.

Although it would be ideal to assess the success of closed reduction when all patients reach skeletal maturity,\cite{Smith2003} in the current study, the authors were able to compare acetabular development after closed reduction in different groups of patients with short- and mid-term follow-up periods using AI, as it has also been demonstrated to be a sensitive tool for assessing acetabular development after DDH treatment.\cite{Smith2003,Al‑Umran2012}

The main limitation of this study is the small number of patients and number of hips analyzed for each follow-up group, which was also because several patients were lost to follow-up, and thus there is a possible lack of statistical power in this study to detect differences between groups. Therefore, the authors recommend that large-scale studies are needed to validate the results of this study. Subsequently, if the findings of this study are validated in large-scale studies, the authors recommend that the criteria for deciding early acetabuloplasty should be redefined.

**CONCLUSIONS**

This study shows that successful closed reduction of congenitally dislocated hips within the recommended age results in better acetabular development (coverage), which is more evident in patients with longer follow-up periods (≥4 years) after closed reduction.

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**Conflicts of interest**

There are no conflicts of interest.

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