Acetabular Development in Developmental Dysplasia of the Hip
A Radiographic Study in Anatomically Reduced and Uncomplicated Hips

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Abstract

The objective of this prospective, controlled study was to assess the radiographic course of acetabular development in developmental dysplasia of the hip (DDH). The study consisted of 14 patients (mean age at operation, 12 months; range, 6 to 18 months) from a large, prospective series diagnosed with unilateral DDH and treated by a soft tissue surgical procedure via the posteromedial approach. All patients had intraoperative radiographic anatomic reductions, did not have any type of complication during follow-up, and were followed until at least 10 years of age. Unaffected contralateral hips were used as controls. The acetabular angle of Sharp (AA) was measured to determine acetabular development. Mean follow-up was 112 months. A significant difference (p < 0.005) was observed between the mean AA values of affected and unaffected hips at operation and at the first three follow-up visits (mean age was 24, 41, and 56 months, respectively). This significant difference was not present (p > 0.05) at the latest two follow-up visits (mean age was 90 and 124 months, respectively). It can be concluded that a marked radiographic improvement in acetabular slope occurs within 1 year postoperatively. This improvement continues slowly during the childhood period, and the acetabulum attains previously determined normal AA values at nearly 7 to 8 years of age for those patients whose dysplastic hips were anatomically reduced at less than 18 months of age and for those who did not experience complications during follow-up.

The primary treatment objective for developmental dysplasia of the hip (DDH) in children is to make the hip as anatomically normal as possible for prevention of further degenerative joint disease at maturity. This can only be done by performing and maintaining an anatomic reduction and avoiding proximal femoral growth disturbance. These prerequisites provide an optimal environment for adequate acetabular and proximal femoral development.1,2 There is no definitive rule or set age as to when a dysplastic hip will return to normal radiologically following a treatment modality. This seems to depend on several factors, such as the age of the patient at the time of reduction, the adequacy of the reduction, and the remaining growth potential of the acetabular cartilage and proximal femur.2

The aim of this prospective, controlled study was to assess the course of acetabular development following anatomic reduction by comparing the radiographic results of the affected and unaffected contralateral hips of patients who were younger than 18 months of age at surgery and who were treated by a soft tissue surgical procedure due to unilateral DDH.

Methods

Between December 1993 and December 2004, 375 developmentally dysplastic hips of 291 consecutive children (18 months of age or younger) were treated by the investigators, using the same surgical algorithm.3 Following routine adductor longus and iliopsoas tenotomies using Ferguson’s posteromedial approach,4 hip joint arthrography was performed. If an arthrographically documented anatomic reduction could be obtained, the operation was ended. Otherwise, through the same incision, the inferomedial hip
joint capsule was opened, the ligamentum teres was excised, and the transverse acetabular ligament was sectioned to obtain an anatomic reduction during the same operative session. The hips were then immobilized in a bilateral hip spica in the human position for 3 months, and a full-time abduction brace was applied for an additional 3 months. In order to assess the normal course of acetabular development, radiological records of all patients were reviewed. The patients included in the study were those who had unilateral DDH, received complete radiological follow-up until they were at least 10 years old, did not have any type of avascular necrosis of the femoral head during the follow-up period, and had both an intact Shenton’s line and a center-edge angle of Wiberg greater than 15° at the latest follow-up. Fourteen patients (13 females and 1 male), who had not received any type of prior conservative treatment, met this strict inclusion criteria.

The acetabular angle of Sharp (AA) was used as the determinant of acetabular development. The angle was measured in affected and unaffected hips at operation and at five follow-up visits made at selected age intervals (2 years, 3 to 4 years, 4 to 6 years, 6 to 9 years, and 10 to 12 years). Mean age of the patients at operation and at first, second, third, fourth, and fifth follow-up visits were 12, 24, 41, 56, 90, and 124 months, respectively. All measurements were made by the first investigator using the same pencil and goniometer. The measurements of affected hips were taken first, and those of the unaffected hips were taken 3 weeks later. One measurement for each hip was made by the same observer, as AA is reported to have acceptable levels of intraobserver and interobserver reliabilities. AA values at different age groups were considered as normal or pathologic according to the classification system of Tönnis and colleagues. The paired t-test was used for comparison of the mean AA values of the affected and unaffected hips at different time intervals; a p value < 0.05 was the level of significance.

Results
Age of the included patients at operation ranged from 6 to 18 months, with an average of 12 months. The affected hip was the right hip in eight patients and the left hip in six patients. Preoperative dislocation grade, according to the Tönnis classification system, was grade 2 in eight hips, grade 3 in five, and grade 4 in one.

An anatomic reduction was obtained in all hips in the present study, without opening the hip joint capsule. Mean follow-up was 112 months (range, 103 to 125 months). Preoperative AA values were greater than or equal to 53° (moderately or extremely pathologic) in all affected hips and less than or equal to 50° (normal) in all unaffected hips. A statistically significant difference was observed between the mean AA values of the affected and unaffected hips at the time of operation and at the first three follow-up visits. However, this difference could not be detected at the latest two follow-up visits (Fig. 1). At the latest follow-up, AA values were within normal limits (less than or equal to 49°), according to the previously determined values for the ages of 10 to 11 years in all affected and unaffected hips (Fig. 2).

Discussion
There are two shortcomings of the present study. First, the patient sample was small due to inclusion of the limited number of patients who had unilateral DDH. However, the patient sample size could have been larger if bilateral cases operated on during the same time interval could have been included in the study. Secondly, none of the included patients could be followed until skeletal maturity had occurred, but at the latest follow-up, all of them were between 10 and 11.5 years of age. The results obtained at an average follow-up period of nearly 9.5 years can be taken into consideration, as the course of acetabular development can be understood in most of the cases by this time. However, the risk of a failure in acetabular development from 10 to 11 years of age to skeletal maturity should be kept in mind. We certainly believe that a study including a higher number of skeletally mature patients will provide a better understanding of the natural history of acetabular development in anatomically reduced and uncomplicated dysplastic hips.

If a radiographically documented anatomic reduction is not obtained and maintained in DDH, the risk of complications such as residual hip dysplasia, redislocation, and severe types of proximal femoral growth disturbance may significantly increase. Besides this, proximal femoral growth disturbance may have adverse effects on acetabular
growth and development, even if the hip has initially been reduced anatomically.\textsuperscript{1,9,10} Harris and coworkers\textsuperscript{11} stated that 95% of the anatomically reduced and uncomplicated hips would develop normally. In our series, all the hips were initially reduced anatomically. Therefore, among the anatomically reduced hips, we only included those that did not have any postoperative complications for better understanding of the natural history of acetabular development. We think that this fact is the most powerful aspect of the present study, as this prerequisite has not been a criteria or part of previous studies assessing the natural history of acetabular development.

There seems to be controversy about unaffected contralateral hips representing the control group in assessing acetabular development in DDH.\textsuperscript{12,13} In the present study, all of the unaffected contralateral hips were initially considered normal, according to the previously determined AA values.\textsuperscript{1} We believe that one of the best ways to compare the outcomes with a control group in DDH is to use the unaffected hips of the same patients as controls; therefore, bilateral cases were not included in the present study.

It has been commonly reported that the most significant improvement in the acetabular index could be detected within one year following reduction.\textsuperscript{1,10,12-17} The findings of the present study revealed that nearly 50% of the improvement in AA following anatomic reduction was observed within the first postoperative year. It has been stated also that if a marked acetabular development could not be detected within 1 year following reduction, the risk for development of further acetabular dysplasia increased.\textsuperscript{15,17} Mid-term follow-up studies have affirmed that the acetabulum has considerable potential for development until a child is 5 to 10 years of age.\textsuperscript{10,11,13,18,19} In long-term follow-up studies, it has been noted that the acetabular index continued to improve until skeletal maturity in the hips of those who were reduced at nearly 1 year of age.\textsuperscript{14,20} It also has been stated that hips that did not have marked acetabular development after 10 years of age will probably undergo further acetabular dysplasia.\textsuperscript{21,22} On the other hand, Kim and associates reported that the remodeling capacity of the acetabulum in dysplastic hips could not be expected after 4 to 5 years of age when certain abnormal conditions existed persistently.\textsuperscript{17} In the present study, it was seen that the affected hips, treated at nearly 1 year of age, gradually, had almost the same AA values as the unaffected contralateral hips at 7 to 8 years of age, and this similarity continued.
to be present when the patient reached 10 to 11 years of age.

Conclusion
The results of this study may provide some useful knowledge in clinical practice although it has some previously mentioned shortcomings. We can say that if a dysplastic hip is anatomically reduced when the patient is less than 18 months of age, and this anatomic reduction is maintained without the occurrence of any type of avascular necrosis of the femoral head, a considerable improvement in AA (nearly 6° to 7°) can be expected by 1 year postoperatively, and a slow but continuous improvement in acetabular development can occur during childhood. The age limit when AA will acquire previously reported normal values seems to be 7 to 8 years in such hips. We can suggest that, if a considerable improvement in AA cannot be observed by 1 year postoperatively or an abnormal AA persists after 7 to 8 years of age, the surgeon should be on the alert for a possible further development of acetabular dysplasia and consider performing an osteotomy to reorient the acetabulum in such hips.

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Disclosure Statement
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