2-1-2003

Reduction of a dislocation of the hip due to developmental dysplasia: Implications for the need for future surgery

Scott J. Luhmann
Washington University School of Medicine in St. Louis

George S. Bassett
Washington University School of Medicine in St. Louis

J. Eric Gordon
Washington University School of Medicine in St. Louis

Mario Schootman
Washington University School of Medicine in St. Louis

Perry L. Schoenecker
Washington University School of Medicine in St. Louis

Reduction of a Dislocation of the Hip Due to Developmental Dysplasia: Implications for the Need for Future Surgery

By Scott J. Luhmann, MD, George S. Bassett, MD, J. Eric Gordon, MD, Mario Schootman, PhD, and Perry L. Schoenecker, MD

Investigation performed at the Department of Orthopaedic Surgery, St. Louis Children's Hospital; Shriners Hospital for Children, St. Louis Unit; and Division of Health Behavioral Research, Departments of Pediatrics and Internal Medicine, Washington University School of Medicine, St. Louis, Missouri

Background: Recent reports on the treatment of a dislocation of the hip due to developmental dysplasia have documented conflicting data on the importance of the ossific nucleus in the development of postreduction ischemic necrosis. Delaying reduction until the ossific nucleus is present bypasses the time-period of maximal osseous remodeling of the hip, thereby possibly increasing the need for future operations. We hypothesized that hips with an ossific nucleus are more likely to have subsequent reconstructive procedures.

Methods: A retrospective review of the medical records at two tertiary-care children's hospitals was completed to identify all patients who had had reduction of a dislocation of the hip due to developmental dysplasia, performed between 1979 and 1993, when they were less than two years old. Patients were excluded if the medical records or radiographs were inadequate, the duration of follow-up was less than three years after the final reduction, a previous reduction had been performed at an outside facility, or the patient had a neuromuscular disease or a teratologic dislocation. We identified 124 patients (153 hips) who satisfied the criteria for inclusion. The average age at the time of the reduction was eleven months, and the average duration of follow-up was 7.2 years.

Results: Overall, fourteen of the sixty-three hips without an ossific nucleus had a reconstructive procedure: thirteen had a varus rotational osteotomy of the proximal part of the femur and one had a combined pelvic and varus rotational femoral osteotomy. Forty of the ninety hips with an ossific nucleus had a reconstructive procedure: twenty-seven had a varus rotational osteotomy, eight had a pelvic osteotomy, and five had a combined pelvic and varus rotational osteotomy ($p < 0.05$). In addition, secondary reconstructive procedures were performed in 17% (ten) of the fifty-nine patients who were less than six months old and in 35% (thirty-three) of the ninety-four patients who were at least six months old, which was a greater than twofold increase. The effect of age was further emphasized at the other age cutoff points.

Conclusion: Delaying the reduction of a dislocated hip until the appearance of the ossific nucleus more than doubles the need for future surgery to make the hip as anatomically normal as possible. Despite finding a slight increase in the rate of ischemic necrosis after reduction of the hips without an ossific nucleus, we advocate early reduction of a dislocation of a hip due to developmental dysplasia to optimize the development of the hip with the minimum number of operations.

Level of Evidence: Prognostic study, Level II-1 (retrospective study). See Instructions to Authors for a complete description of levels of evidence.

Recent reports have documented conflicting data on the importance of the presence of the ossific nucleus in the development of postreduction ischemic necrosis in dislocations due to developmental dysplasia of the hip[1-3]. The presence of the ossific nucleus has been theorized to confer protection against ischemic necrosis after reduction[1]. Animal studies have demonstrated that the presence of the ossific nucleus increases the stiffness of the femoral head, which hypothetically would reduce the compression of the vascular system of the femoral head at reduction[2]. In a previous report, we failed to identify an association between the status of the ossific nucleus and the prevalence of ischemic necrosis[3]. With

use of the criteria described by Bucholz and Ogden[4], the overall prevalence of ischemic necrosis in our patient population was 6% (nine of 153 hips). Ischemic necrosis developed in five (8%) of the sixty-three hips in which the ossific nucleus was absent and in four (4%) of ninety hips in which it was present ($p = 0.489$). Previous treatment with a Pavlik harness, preoperative use of traction, secondary reductions, and concomitant adductor tenotomies at the time of the reduction were not associated with postreduction ischemic necrosis.

A delay in the reduction of a dislocated hip, in order to visualize the ossific nucleus of the femoral head, could have a negative impact on the development of the hip. In a dislocated hip, the ossific nucleus in the femoral head may not be present until the patient is more than twelve months old. Maximal osseous remodeling of the hip occurs within the first year of life, and delaying reduction may increase the need for future operations in order to normalize the anatomy of the hip joint. If the remaining development of the acetabulum and the femoral head is estimated to be insufficient, secondary reconstructive procedures, such as a pelvic or femoral osteotomy, will be needed to correct residual hip dysplasia.

The purpose of this study was to analyze the association between the age of the patient as well as the status of the ossific nucleus at the time of reduction and the frequency of surgical procedures performed to correct the residual hip dysplasia after reduction of a dislocation due to developmental dysplasia. Our hypothesis was that more reconstructive procedures are needed to normalize the hip joint if the reduction is delayed.

Materials and Methods

A computer search was completed to identify all patients who had been managed because of developmental dysplasia of the hip at our two tertiary-care children's hospitals between January 1, 1979, and December 31, 1993. The medical records were reviewed to identify patients who were less than two years old when they underwent reduction of a dislocation of the hip that was due to developmental dysplasia. Patients were excluded if their medical records or radiographs were inadequate, the duration of follow-up was less than three years after the final reduction, a previous operative reduction had been performed at another medical center, or the dislocation was due to neuromuscular causes or was a teratological dislocation. Patients who had been previously managed with a Pavlik harness were not excluded from this analysis. The patient population in this study was previously analyzed to identify the status of the ossific nucleus and the development of postreduction ischemic necrosis[3].

We identified 124 patients with 153 dislocated hips who met the study criteria for inclusion. There were 117 girls and seven boys. The mean age at the time of the reduction was eleven months (range, one to twenty-four months). Eighty-four hips were in patients who were less than twelve months old at the time of the reduction, and sixty-nine hips were in patients who were more than twelve months old. The dislocations were unilateral in ninety-five patients (seventy-four left hips and twenty-one right hips) and bilateral in twenty-nine patients. Treatment with a Pavlik harness was documented in twenty-five of the 153 hip dislocations. The average duration of follow-up was 7.0 years for hips with the ossific nucleus and 7.5 years for those without it. Overall, the average duration of follow-up for the entire study population was 7.2 years (range, 3.0 to 16.3 years) after reduction.

A retrospective review of the medical charts and radiographs was completed by individuals who were not involved with the children's initial or subsequent care. The age at the time of reduction, the method of reduction, the use of preoperative traction, concomitant procedures at the time of reduction, and secondary operative procedures were documented for all eligible patients. Treatment algorithms and techniques for the management of dislocations due to developmental dysplasia of the hip have been previously reported[3]. All closed reductions were performed with the patient under general anesthesia to allow gentle reduction of the hip. Fluoroscopy was used in all hips, and arthrograms were additionally performed in hips that had an equivocal reduction or were poorly visualized with fluoroscopy. Eighty-one patients (65%; ninety-nine hips) with a safe zone of <30°, as described by Ramsey et al.[5], had a percutaneous adductor tenotomy. An open reduction was performed if the hip was unstable following the initial closed reduction or if a previous closed reduction had failed. Medial approaches were an option if the hip was reducible, but unstable, and the patient was less than one year old. An anterior approach was used for hips that were irreducible, after a previously failed closed or open reduction, or if the patient was more than one year old. In this study, a medial approach was used at the initial reduction in six hips. An anterior approach was used in eleven initial reduction attempts and in all twenty-six secondary and tertiary reductions. After the reduction (open or closed), all patients were managed with a one and one-half spica cast with careful molding over the posterior aspect of the greater trochanter with the hip in the so-called human position described by Salter et al.[6]. After July 1986, postoperative computerized axial tomography was used to confirm anatomic reduction of the hip in all patients. The hip was maintained in the initial cast between six and eight weeks. A second cast was generally used if concentric reduction of the hip joint was present. After cast removal, an abduction orthosis was used to maintain the hip at 60° of total abduction. The orthosis was worn until the hip development, as seen on serial radiographs, was considered to be normalized or until a secondary reconstructive procedure was performed. Failure of the reduction was defined as the lack of concentric reduction of the femoral head within the acetabulum at any time during treatment and included hips that had subluxated or had frank redislocation. Failure to maintain concentric reduction necessitated the use of an additional general anesthetic for open reduction of the hip through an anterior approach, with or without a concomitant varus rotational osteotomy of the proximal part of the femur (a varus rotational osteotomy). Reductions of dislocated hips were performed at the earliest time possible.

The primary indication for a varus rotational osteotomy

TABLE I Frequency of Reconstructive Procedures According to the Age at the Time of the Reduction

Age at Time of Reduction	No. of Hips That Had a Reconstructive Procedure	Age at Time of Reduction	No. of Hips That Had a Reconstructive Procedure	P Value*
<6 mo (n = 59)	10 (17%)	≥6 mo (n = 94)	33 (35%)	0.0154
<9 mo (n = 79)	12 (15%)	≥9 mo (n = 74)	31 (42%)	<0.01
<12 mo (n = 84)	13 (15%)	≥12 mo (n = 69)	30 (43%)	<0.01
<15 mo (n = 100)	20 (20%)	≥15 mo (n = 53)	23 (43%)	<0.01
<18 mo (n = 130)	26 (20%)	≥18 mo (n = 23)	17 (74%)	<0.01

*Chi-square test.

of the proximal part of the femur at the time of the reduction was the need to improve the stability of the reduction; the osteotomy was included in the analysis as a reconstructive procedure. To reduce the risk of development of ischemic necrosis, a varus rotational osteotomy was not performed, at the time of the reduction, to treat decompression of the femoral head.

Radiographs performed at the time of the reduction were used to determine the status of the ossific nucleus. The ossific nucleus had been absent in sixty-three hips and present in ninety hips. In patients who were less than twelve months old, the ossific nucleus had been absent in fifty-seven hips and present in twenty-seven hips. In patients who were more than twelve months old, it had been absent in six hips and present in sixty-three.

Five attending pediatric orthopaedic surgeons had been involved in all of the reductions and had used similar treatment algorithms and techniques. Secondary periacetabular pelvic osteotomies and varus rotational osteotomies were performed after documentation of inadequate remodeling of the hip joint so that the long-term prognosis of the joint would not be jeopardized. The use of reconstructive procedures, their type and timing, was determined by the attending physician. The primary indications for secondary reconstructive procedures were failure of the acetabulum to undergo progressive development after reduction to within normal limits (for a minimum of three years after the reduction) and subluxation of the hip joint. In hips with acetabular dysplasia, without subluxation, the decision for reconstructive surgery was made on the basis of the age of the patient, the appearance and morphology of the hip joint, and the site of primary osseous abnormality. The acetabular index was used to follow the development of the hip after the reduction. The guidelines for normal hip development were an acetabular index that was <25° at the age of one year, <20° between two and three years of age, <15° at six years of age, and <10° at ten years of age.

Statistical Methods

We used SAS software (Statistical Analysis System, Cary, North Carolina) to perform all analyses. Chi-square tests were used to statistically test the association between the number of reconstructive procedures and the age at which reduction was performed. For patients with bilateral involvement, each hip was considered an independent occurrence for purposes of the statistical analysis. A p value of ≤ 0.05 was considered significant.

Results

The mean age of the fifty-one patients (sixty-three hips) in whom the ossific nucleus was absent at the time of the reduction was six months (range, one to seventeen months), and the mean age of the seventy-three patients (ninety hips) in whom it was present was fourteen months (range, three to twenty-three months). One hundred and thirty-six (89%) of the 153 hips were initially managed with closed reduction, and seventeen were managed with open reduction. Of the 136 initial closed reductions, 112 had a successful result and twenty-four failed to maintain a concentric reduction. Of the seventeen initial open reductions, fifteen had a successful result and two failed. Overall, twenty-six hips (twenty-four that had a closed reduction and two that had an open reduction) resubluxated or redislocated after the initial reduction; twenty-four of them were successfully relocated at the second reduction, which was always an open procedure. Both hips that had two unsuccessful reductions were successfully reduced at the third reduction, which was an open procedure.

In the sixty-three hips without an ossific nucleus, fourteen (22%) had a reconstructive procedure; two hips had a varus rotational osteotomy at the time of the initial reduction, and twelve had a secondary osteotomy (eleven had a varus rotational osteotomy and one, a combined varus rotational and pelvic osteotomy). In the ninety hips with an ossific nucleus, forty (44%) had a reconstructive procedure; nine had a varus rotational osteotomy at the time of the primary reduction, and thirty-one had a secondary osteotomy. The secondary reconstructive procedures included eighteen varus rotational osteotomies, eight pelvic osteotomies, and five combined varus rotational and pelvic osteotomies. The rate of reconstructive procedures in the hips with an ossific nucleus was double that in the hips without an ossific nucleus ($p < 0.05$).

The effect of age at the time of the reduction was assessed with use of six, nine, twelve, fifteen, and eighteen months of age as cutoff points (Table I). A secondary procedure was performed in ten (17%) of the fifty-nine patients who were less than six months old compared with thirty-three (35%) of the ninety-four patients who were more than six months old. The

effect of age was further evaluated with use of nine, twelve, fifteen, and eighteen months of age as cutoff points. Older children were two to three times more likely than the younger children to have had a surgical reconstruction.

Statistical analysis was completed to identify whether any chronologic cutoff points would demonstrate an increase in the frequency of surgical procedures. Two chronologic cutoff points, six and eighteen months, were discovered. Ten (17%) of the fifty-nine hips in patients who were less than six months old had a reconstructive procedure, whereas thirty-three (35%) of the ninety-four hips in patients who were at least six months old had such a procedure. The second cutoff point, eighteen months, demonstrated similar findings. A comparison of the three age-groups (less than six months, six to seventeen months, and eighteen months or more) showed significant differences ($p = 0.0000001$) with respect to the frequency of surgical procedures.

The data were additionally analyzed to count concomitant operations, such as a varus rotational osteotomy and pelvic osteotomy, as two separate reconstructive procedures. The premise for this was based on the concept that more severely dysplastic hips would require osteotomies on both sides of the hip. However, when this analysis was completed, no new significant findings were demonstrated with respect to patient age or the status of the ossific nucleus.

Analysis of other factors, such as the side of the dislocation, treatment with a Pavlik harness, preoperative traction, unilateral compared with bilateral involvement, closed compared with open reduction, approach of the open reduction, and failed primary reduction, demonstrated no differences with respect to the frequency of reconstructive procedures.

Discussion

The long-term goal of the treatment of developmental dysplasia of the hip is an acetabulum and femoral head that are within the normal range of alignment at the completion of skeletal growth. Normal development of the hip joint is dependent upon many factors; however, the primary factor is concentric reduction of the femoral head within the acetabulum[7-13]. After reduction of the hip joint, long-term maintenance of the concentric reduction is essential to ensure continued development into the normal range[9,13]. In addition, a subluxated hip joint provides poor stimulation of the acetabulum to remodel the dysplasia toward normal alignment[14]. Interestingly, in our analysis, we did not find an increase in secondary reconstructive procedures, or an increase in ischemic necrosis[3], when the hips required a secondary reduction because of subluxation. Four (44%) of the nine hips with ischemic necrosis underwent a reconstructive procedure (a pelvic osteotomy and a varus rotational osteotomy in two hips each) compared with fifty-four (35%) of all 153 hips in this study. Because of the low frequency of ischemic necrosis in our patient population, we could not demonstrate whether it had an effect on the need for secondary reconstructive procedures.

The capacity of the acetabulum to resume normal growth after reduction is dependent not only on the age of the patient at reduction but also on the inherent remaining growth potential of the acetabulum[7]. The potential for growth and remodeling of the hip joint is maximal at birth and declines thereafter[8]. Lindstrom et al.[13] demonstrated that early treatment led to the best acetabular development, with the lowest acetabular indices in patients who were less than one year old and the highest in patients who were more than two years old. In general, the earlier the reduction of the hip the better its radiographic appearance, and hence the better its function[13,15-20]. Malvitz and Weinstein[15], in a report on the long-term results in 152 hips, found that the early reductions were associated with better functional results, less proximal growth disturbances, and fewer degenerative changes. Additionally, when the radiographic results were less than anatomic, function tended to deteriorate over time. Unfortunately, the age beyond which a dysplastic hip cannot be expected to return to within normal range is unknown[8,9,11,12,19-25]. Analysis of our data supports early reduction of a dislocation of the hip that is due to developmental dysplasia, thereby minimizing the need for future reconstructive procedures. Despite the findings of this analysis, the development of the acetabulum is most dependent on the concentric reduction of the femoral head within the acetabulum. The status of the ossific nucleus and the age of the patient at the time of the reduction most likely play a minor role in the development of the hip compared with that played by the location of the femoral head.

A review of the literature on developmental dysplasia of the hip demonstrated that the frequency of secondary reconstructive procedures after reduction has ranged from 38% to 80% in longer-term follow-up studies[10,14,15,26,27]. Powell et al.[28], in a study of forty-nine hips, reported that the overall frequency of secondary procedures was 67%. In that study, the rate of secondary procedures was 29% for patients who were less than twelve months old at the time of reduction, 49% for those who were twelve to twenty-four months old, and 79% for those who were more than two years old. Roose et al.[29], in a study of twenty-nine hips that had a medial open reduction, reported that the overall frequency of secondary procedures was 38%. The mean age of the patients who had not had a reconstructive procedure was 7.2 months at the time of the reduction, whereas the mean age of the patients who had a secondary surgery was sixteen months at the time of reduction. There is evidence in the literature that hips that are concentrically reduced earlier in life undergo fewer secondary reconstructive procedures to normalize the hip joint. Interestingly, our data demonstrated three significantly ($p < 0.05$) distinct age-groups: less than six months of age, six to seventeen months of age, and eighteen months of age or older. This finding most likely represents a continuum of the acetabular response to the reduction, with early reductions (those performed in patients who are less than six months old) associated with the best acetabular response; reductions in the six to seventeen-month age-group, with a moderate response; and those in the eighteen month or older age-group, with the least response[28]. The duration of follow-up for our patients ranged from three years to sixteen years and four months. A longer duration of follow-up will un-

doubtedly show an increase in the number of future operations for both groups. On the basis of our experience, we believe that it is unlikely that the relative difference between the groups will change enough to alter the findings of this analysis.

The ossific nucleus can usually be visualized in normal hips at around six to eight months of age[30]. However, in dislocated hips, the ossific nucleus may not be seen until up to seventeen months of age[3]. Delaying reduction until visualization of the ossific nucleus has been advocated as a way to minimize the risk of development of ischemic necrosis of the femoral head[1]. Our concern with this approach was that the delay would increase the need for secondary reconstructive procedures since the time of maximum acetabular remodeling would be bypassed. A delay in the reduction of a dislocated hip until the appearance of the ossific nucleus increased the frequency of reconstructive procedures in our patient population. Therefore, we advocate early reduction of a dislocation of the hip due to developmental dysplasia to optimize the development of the acetabulum and the femur with the minimum number of operative procedures. ■

Scott J. Luhmann, MD
J. Eric Gordon, MD
Perry L. Schoenecker, MD
Department of Orthopaedic Surgery, Washington University School of Medicine, One Children's Place, Suite 4S-20, St. Louis, MO 63110

George S. Bassett, MD
621 South Ballas Road, Suite 63B, St. Louis, MO 63141

Mario Schootman, PhD
Division of Health Behavioral Research, Departments of Pediatrics and Internal Medicine, Washington University School of Medicine, 4444 Forest Park, Suite 6700, St. Louis, MO 63110

The authors did not receive grants or outside funding in support of their research or preparation of this manuscript. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

References

1. **Segal LS, Boal DK, Borthwick L, Clark MW, Localio AR, Schwentker EP.** Avascular necrosis after treatment of DDH: the protective influence of the ossific nucleus. *J Pediatr Orthop.* 1999;19:177-84.
2. **Segal LS, Schneider DJ, Berlin JM, Bruno A, Davis BR, Jacobs CR.** The contribution of the ossific nucleus to the structural stiffness of the capital femoral epiphysis: a porcine model for DDH. *J Pediatr Orthop.* 1999; 19:433-7.
3. **Luhmann SJ, Schoenecker PL, Anderson AM, Bassett GS.** The prognostic importance of the ossific nucleus in the treatment of congenital dysplasia of the hip. *J Bone Joint Surg Am.* 1998;80:1719-27.
4. **Bucholz RW, Ogden JA.** Patterns of ischemic necrosis of the proximal femur in nonoperatively treated congenital hip disease. In: *The hip. Proceedings of the sixth scientific meeting of the Hip Society.* St. Louis: C.V. Mosby; 1978. p 43-67.
5. **Ramsey PL, Lasser S, MacEwen GD.** Congenital dislocation of the hip. Use of the Pavlik harness in the child during the first six months of life. *J Bone Joint Surg Am.* 1976;58:1000-4.
6. **Salter RB, Kostuik J, Dallas S.** Avascular necrosis of the femoral head as a complication of treatment for congenital dislocation of the hip in young children: a clinical and experimental investigation. *Can J Surg.* 1969; 12:44-61.
7. **Wedge JH, Wasylenko MJ.** The natural history of congenital disease of the hip. *J Bone Joint Surg Br.* 1979;61:334-8.
8. **Wedge JH, Wasylenko MJ.** The natural history of congenital dislocation of the hip: a critical review. *Clin Orthop.* 1978;137:154-62.
9. **Weinstein SL.** Congenital hip dislocation. Long-range problems, residual signs, and symptoms after successful treatment. *Clin Orthop.* 1992;281:69-74.
10. **Weinstein SL.** Natural history of congenital hip dislocation (CDH) and hip dysplasia. *Clin Orthop.* 1987;225:62-76.
11. **Harris NH.** Acetabular growth potential in congenital dislocation of the hip and some factors upon which it may depend. *Clin Orthop.* 1976;119:99-106.
12. **Harris NH, Lloyd-Roberts GC, Gallien R.** Acetabular development in congenital dislocation of the hip. With special reference to the indications for acetabuloplasty and pelvic or femoral realignment osteotomy. *J Bone Joint Surg Br.* 1975;57:46-52.
13. **Lindstrom JR, Ponseti IV, Wenger DR.** Acetabular development after reduction in congenital dislocation of the hip. *J Bone Joint Surg Am.* 1979;61:112-8.
14. **Kalamchi A, Schmidt TL, MacEwen GD.** Congenital dislocation of the hip. Open reduction by the medial approach. *Clin Orthop.* 1982;169:127-32.
15. **Malvitz TA, Weinstein SL.** Closed reduction for congenital dysplasia of the hip. Functional and radiographic results after an average of thirty years. *J Bone Joint Surg Am.* 1994;76:1777-92.
16. **Mankey MG, Arntz GT, Staheli LT.** Open reduction through a medial approach for congenital dislocation of the hip. A critical review of the Ludloff approach in sixty-six hips. *J Bone Joint Surg Am.* 1993;75:1334-44.
17. **Zionts LE, MacEwen GD.** Treatment of congenital dislocation of the hip in children between the ages of one and three years. *J Bone Joint Surg Am.* 1986;68:829-46.
18. **Castillo R, Sherman FC.** Medial adductor open reduction for congenital dislocation of the hip. *J Pediatr Orthop.* 1990;10:335-40.
19. **Ferguson AB Jr.** Primary open reduction of congenital dislocation of the hip using a median adductor approach. *J Bone Joint Surg Am.* 1973;55:671-89.
20. **Gibson PH, Benson MK.** Congenital dislocation of the hip. Review at maturity of 147 hips treated by excision of the limbus and derotation osteotomy. *J Bone Joint Surg Br.* 1982;64:169-75.
21. **Ishii Y, Ponseti IV.** Long-term results of closed reduction of complete congenital dislocation of the hip in children under one year of age. *Clin Orthop.* 1978;137:167-74.
22. **Mardam-Bey TH, MacEwen GD.** Congenital hip dislocation after walking age. *J Pediatr Orthop.* 1982;2:478-86.
23. **Schwartz DR.** Acetabular development after reduction of congenital dislocation of the hip. A follow-up study of fifty hips. *J Bone Joint Surg Am.* 1965; 47:705-14.
24. **Pemberton PA.** Pericapsular osteotomy of the ilium for treatment of congenital subluxation and dislocation of the hip. *J Bone Joint Surg Am.* 1965;47:65-86.
25. **Weinstein SL, Ponseti IV.** Congenital dislocation of the hip. *J Bone Joint Surg Am.* 1979;61:119-24.
26. **Weiner DS, Hoyt WA Jr, O'Dell HW.** Congenital dislocation of the hip. The relationship of premanipulation traction and age to avascular necrosis of the femoral head. *J Bone Joint Surg Am.* 1977;59:306-11.
27. **Kasser JR, Bowen JR, MacEwen GD.** Varus derotation osteotomy in the treatment of persistent dysplasia in congenital dislocation of the hip. *J Bone Joint Surg Am.* 1985;67:195-202.
28. **Powell EN, Gerratana FJ, Gage JR.** Open reduction for congenital hip dislocation: the risk of avascular necrosis with three different approaches. *J Pediatr Orthop.* 1986;6:127-32.
29. **Roose PE, Chingren GL, Klaaren HE, Broock G.** Open reduction for congenital dislocation of the hip using the Ferguson procedure. A review of twenty-six cases. *J Bone Joint Surg Am.* 1979;61:915-21.
30. **Pettersson H, Theander G.** Ossification of femoral head in infancy. I. Normal standards. *Acta Radiol Diagn.* 1979;20:170-9.