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Acute Slipped Capital Femoral Epiphysis: the Importance of Physeal Stability*

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ABSTRACT: To test the traditional classification system of slipped capital femoral epiphysis, we evaluated the presenting symptoms and radiographs of fifty-four patients and reclassified the slipped epiphyses as unstable or stable, rather than acute, chronic, or acute-on-chronic. Slips were considered to be unstable when the patient had such severe pain that weight-bearing was not possible even with crutches. Slips were considered to be stable when the patient could bear weight, with or without crutches.

We reviewed the records on fifty-five hips in which the slip would have been classified as acute because the duration of symptoms was less than three weeks; thirty of these were unstable and twenty-five were stable. All slips were treated with internal fixation. A reduction occurred in twenty-six of the unstable hips and in two of the stable hips. Fourteen (47 per cent) of the thirty unstable hips and twenty-four (96 per cent) of the twenty-five stable hips had a satisfactory result. Avascular necrosis developed in fourteen (47 per cent) of the unstable hips and in none of the stable hips. We were not able to demonstrate an association between early reduction and the development of avascular necrosis.

Slipped capital femoral epiphysis, a disorder affecting adolescents, traditionally has been classified on the basis of the duration of symptoms. A slip has been defined as acute when there was a sudden onset of usually severe symptoms and the symptoms were of less than three weeks' duration^{11,19}. Some authors^{8,11}, however, have used two weeks for this definition. Aadelen

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et al. stated that a gentle reduction, done with the patient under general anesthesia, must be at least partially successful for a slip to be defined as acute. A chronic slip has been characterized by the gradual onset and progression of symptoms for more than three weeks, without any sudden exacerbation. A combination of these two groups, or acute-on-chronic slips, has been characterized by the sudden exacerbation of symptoms due to acute displacement of an already chronically slipped epiphysis. More recently^{2,26}, the sudden onset of severe pain in the hip without radiographic signs of remodeling and new-bone formation at the epiphyseal-metaphyseal junction has been used as the definition of an acute slip and radiographic signs of periosteal new bone, of a chronic slip.

This classification is cumbersome and may mislead physicians since it does not include a consideration of the stability of the slipped epiphysis, although the acute and acute-on-chronic definitions suggest some degree of instability. The purpose of this study was to assess the acute component of a slip (characterized by a duration of symptoms of less than three weeks, regardless of whether the slip was acute or acute-on-chronic) and to determine if the outcome of treatment was related to stability. We believe that it may be more valuable to classify slipped capital femoral epiphyses as either stable or unstable, and that unstable slips may have a worse prognosis.

Previous investigators have reported that the time from acute slippage to reduction is important in the prevention of avascular necrosis^{1,5,10,16,22}. Some of the children in the present series were treated very soon after the time of presentation because of severe pain, but distance and socioeconomic variables often prevented patients from being seen immediately at a definitive treatment center. This variability in the time from the onset of symptoms to the time of treatment allowed us to compare the times to reduction as they correlated with the development of avascular necrosis.

Materials and Methods

We classified a slip as unstable if the child had such severe pain that walking was not possible even with crutches, regardless of the duration of the symptoms. We classified a slip as stable if walking and weight-bearing

were still possible, with or without crutches. We retrospectively reviewed the records of children who had had a slipped capital femoral epiphysis that had been treated initially with internal fixation at one of three centers: Children's Hospital of Michigan, C. S. Mott Children's Hospital, and the Texas Scottish Rite Hospital. The period of the review was 1976 to 1989, inclusive, for Children's Hospital of Michigan; 1975 to 1991, inclusive, for C. S. Mott Children's Hospital; and 1981 to 1991, inclusive, for the Texas Scottish Rite Hospital. Any child who had an underlying metabolic or endocrine disorder was excluded from the study. Fifty-five slips were included in the study.

We reviewed the charts to determine the age, sex, race, and weight of the child and the side of the slip. We classified the child as obese if the weight was more than two standard deviations above the mean for the chronological age, as determined with use of the National Center for Health Statistics percentiles¹³. We also recorded the duration of symptoms, any history of antecedent trauma, any prodromal symptoms (for the acute-on-chronic slips), and the times from the onset of symptoms to presentation and to the operation.

From the initial lateral radiograph, we calculated the degree of slip by subtracting the value for the Southwick head-shaft angle on the normal side from that on the side of the slipped epiphysis. If the hip was so painful that a lateral radiograph had not been made, we used the initial anteroposterior radiograph instead. We also measured the apparent joint space (the cartilage space) to determine if there was any narrowing, which indicates the presence of chondrolysis^{14,25}. Since Maurer and Larsen found that the apparent joint space of a normal hip is four to five millimeters and that it decreases to at least one-half of this width in children who have chondrolysis, we defined chondrolysis, for the purpose of this study, as a decrease in the apparent joint space of more than two millimeters from that of the contralateral hip. In the case of bilateral narrowing after a bilateral slip, chondrolysis was defined as a decrease in the joint space to a width of three millimeters or less¹⁴.

Internal fixation was used in all of the hips. In the early part of the series, multiple threaded Steinmann pins were used. Later, one or two cannulated screws, or one screw and one Steinmann pin, were used to engage the center of the capital femoral epiphysis with four or five of the screw-threads. The operative reports were reviewed to determine the number of pins used and if any attempts at reduction had been made. We found, however, that it was impossible to determine, from the operative notes, how mobile the epiphysis was, whether or not a formal reduction had been done (rather than a reduction having occurred because of the position of the patient on the operating table), or how gentle the reduction had been. Therefore, the effect of these variables could not be determined.

We reviewed the radiographs that were made im-

mediately after the operation to determine the degree of residual postoperative slip. Comparable preoperative and immediate postoperative radiographs were not available for seven hips. For these hips, the two most comparable radiographs were used. We calculated the amount of reduction (the degree of preoperative slip minus the degree of residual slip), when present, and expressed it as both magnitude (degrees) and percentage of reduction. The positions of the pins and screws were evaluated to determine whether or not any had penetrated the joint.

On the basis of the charts and radiographs from the latest follow-up evaluation, we determined the range of motion of the hip and whether there was any chondrolysis, pain, or postoperative complications. We also recorded the time of the first appearance of any avascular necrosis. The results were graded with use of the criteria of Aadelen et al. An excellent result meant that the patient had no limp, no pain, and a normal range of motion in the hip. A good result meant that the patient had no limp, no pain, and internal rotation beyond neutral but with a slight limitation. A fair result meant that the patient had no limp, no pain, and a slight limitation of abduction as well as internal rotation. A poor result meant that the patient had a mild limp; slight pain after strenuous exercise; and a slight limitation of internal rotation, abduction, and flexion. The result was considered a failure when the patient had a limp, pain on activity, and a marked limitation of motion that necessitated a reconstructive operation or when there were progressive radiographic changes in the hip. Excellent, good, and fair results were considered satisfactory and poor results and failures, unsatisfactory. Any hip in which avascular necrosis had developed was considered to be a failure. All of the children in this study had been followed for at least two years, except for the fourteen in whom avascular necrosis developed.

Statistical analysis was performed with the use of Systat version-5.1 software (Systat, Evanston, Illinois). To test for differences between groups of discrete data, the Fisher exact test was used for 2×2 analyses when the number in any cell was five or less, and the chi-square test with Yates correction was used for 2×2 analyses when the number in all cells was more than five. The Pearson chi-square test was used for analyses in any table that was larger than 2×2 . The two-tailed Student t test was used to test for significant differences between two groups of continuous data and analysis of variance was used to test for significant differences between three groups of continuous data. When the variances between groups of data were different, as evidenced by a significant probability ($p < 0.05$) of the Bartlett test for homogeneity of group variance, the two-tailed Welch separate-variances t test was used instead of the Student t test. For all statistical analyses, $p < 0.05$ was considered significant. It must be pointed out, however, that multiple analyses of the same data may

result in spurious significance. With the thirty-two comparisons in this study, the chance that at least one comparison may show a significant difference when, in reality, it is not significant, is $(1 - (1 - 0.05)^{32})$, or 81 per cent. Unexpectedly, all but one of the significant values of $p < 0.05$ in this study were actually $p < 0.005$. This decreases the risk of spurious significance to 15 per cent.

Results

There were fifty-five slips in fifty-four children; thirty slips were unstable and twenty-five were stable. Thirty-one of the slips were treated at the Texas Scottish Rite Hospital; eighteen, at Children's Hospital of Michigan; and six, at C. S. Mott Children's Hospital. Twenty-seven of the slips were in boys and twenty-eight, in girls. Thirty-two involved the left hip and twenty-three, the right hip. Thirty-eight were acute and seventeen were acute-on-chronic. Thirty-seven occurred in obese children and eighteen, in children who were not obese. There were fourteen mild, sixteen moderate, and twenty-five severe slips (according to the classification of Boyer et al.). Thirty-one slips occurred in non-Hispanic white children; twenty, in black children; and four, in Hispanic children.

When the groups from the three hospitals were compared, no significant differences were found with regard to the age ($p = 0.82$), sex ($p = 0.71$), or obesity ($p = 0.17$) of the patient; the severity of the slip in terms of magnitude ($p = 0.74$) or class⁷ ($p = 0.48$); or the duration of follow-up ($p = 0.30$). There was a difference in the proportion of stable and unstable slips at the three hospitals ($p < 0.001$): twelve stable and six unstable slips were treated in Detroit; no stable and six unstable slips, in Ann Arbor; and thirteen stable and eighteen unstable slips, in Dallas. (Three stable slips that had been treated in Ann Arbor were not included in the study because all had been treated with an open epiphyseodesis. After correction for these three, there was no significant difference in the proportion of stable and unstable slips between the three hospitals [$p = 0.15$]). There was a significant difference between the hospitals with regard to the race of the patient ($p < 0.0001$), with three white and fifteen black children from Detroit, five white children and one black child from Ann Arbor, and twenty-three white, four black, and four Hispanic children from Dallas. These racial differences reflect the ethnic distributions in the geographical locations.

Unstable Slips

There were thirty unstable slips in thirty patients. Twelve involved the right hip and eighteen, the left. The average age at the time that the patient was first seen was twelve years (range, ten to sixteen years). Eighteen children (60 per cent) were obese. In twenty-seven (90 per cent) of the children, the acute symptoms occurred as the result of a fall. There was an average of four days from the onset of the symptoms to the arrival at the hospital, four days (range, nine hours to twelve days)

from the arrival at the hospital to the operation, and eight days (range, fourteen hours to twenty-two days) from the onset of the symptoms to the operation. The average preoperative slip was 51 degrees (range, 23 to 70 degrees). No chondrolysis was apparent in any patient at the time of the arrival at the hospital.

Preoperative traction was used for twenty children, and it was not used for nine children. It is not known whether or not traction was used for one child. The traction was skeletal in six children: a pin was inserted in the distal part of the femur in four children and in the proximal part of the tibia in two. Skin traction was used for fourteen patients: Buck traction was employed for twelve children and Russell traction, for two.

There was a reduction — either intentional or unintentional — in twenty-six hips; it averaged 31 degrees (range, 10 to 68 degrees), or 61 per cent (range, 18 to 138 per cent) of the extent of the initial slip. Twenty-four of the reductions were closed and two were open. Both of the open reductions were performed when attempts at closed reduction had failed and the surgeon believed that additional reduction was necessary. Both children were black; one was a girl and one was a boy. The time from the onset of the symptoms to the operation was six days for both children. For the boy, the surgeon decided that the reduction was inadequate on the basis of intraoperative fluoroscopy and proceeded to immediate open reduction. No radiographs were kept, so the extent of the slip after the attempted closed reduction is not known. For the girl, the initial slip was 56 degrees and was unchanged after the closed reduction, which was done the day after the onset of the symptoms. The open reduction was performed six days after the onset of the symptoms and resulted in a 138 per cent reduction. There were no other features that distinguished these two hips from the twenty-four in which closed reduction was successful.

Six of the slipped epiphyses were fixed with a single screw; one, with a single pin; and twenty-three, with multiple pins or screws. Supplemental postoperative immobilization with a spica cast was used for the patient in whom the slip was fixed with a single pin. There were no postoperative infections.

The average duration of follow-up was three years (range, six months to eight years). In all hips that were included in the study but were followed for less than two years, avascular necrosis had developed by the time of the latest follow-up examination. There were fourteen (47 per cent) satisfactory results in the thirty unstable hips.

Stable Slips

There were twenty-five stable slipped epiphyses in twenty-four children. Eleven involved the right hip and fourteen, the left hip. The average age at the time of presentation was thirteen years (range, ten to fifteen years). Nineteen children (79 per cent) were obese. In

TABLE I
COMPARISON OF PATIENTS WHO HAD A STABLE SLIPPED CAPITAL FEMORAL EPIPHYSIS
WITH THOSE WHO HAD AN UNSTABLE SLIPPED CAPITAL FEMORAL EPIPHYSIS*

	Stable	Unstable	P Value
Age (yrs.)	13 ± 1.4	12 ± 1.5	0.34
Sex	12 F, 13 M	16 F, 14 M	0.90
Race†	10 W, 13 B, 2 H	21 W, 7 B, 4 H	0.07
Obesity (yes/no)	19/6	18/12	0.33
Side of slip	11 R, 14 L	12 R, 18 L	0.98
Trauma (yes/no)	6/19	27/3	<0.0001
Acute/acute-on-chronic	21/4	17/13	0.06
Severity of slip			
Mild/moderate/severe ⁷	12/7/6	2/9/19	0.001
Degrees	35 ± 21	51 ± 14	0.002
Duration of symptoms (days)	12 ± 6.1	4 ± 4.6	<0.0001
Time from presentation to operation (days)	2 ± 1.6	4 ± 3.8	0.004
Time from onset of symptoms to operation (days)	14 ± 6.3	8 ± 7.0	0.002
No. of pins or screws (1/≥2)	18/7	7/23	0.0008
Duration of follow-up (yrs.)	3 ± 0.8	3 ± 2.0	0.80
Avascular necrosis (yes/no)	0/25	14/16	0.0003
Result (satisfactory/unsatisfactory)	24/1	14/16	0.0003

*Continuous data are expressed as the average and standard deviation.

†W = non-Hispanic white, B = black, and H = Hispanic.

six hips (24 per cent), the symptoms occurred as the result of a fall. The average time from the arrival at the hospital to the operation was two days (range, one to seven days). The average time from the onset of the symptoms to the operation was fourteen days (range, four to twenty-eight days). The average preoperative slip was 35 degrees (range, 5 to 70 degrees). No chondrolysis was apparent in any patient at the time of presentation at the hospital.

Preoperative Buck traction was used for six of the children who had a stable slip. Seven of the slipped epiphyses were fixed with multiple pins and eighteen, with a single screw. There was reduction in only two hips; both reductions were closed. No child had postoperative immobilization in a cast. The average duration of follow-up was three years (range, two to five years). Twenty-four (96 per cent) of the results were satisfactory.

Comparison between the Stable and the Unstable Groups (Table I)

We first compared the difference between the outcomes of the stable slips and those of the unstable slips. There was a significant difference in the proportion of satisfactory to unsatisfactory results, with the stable group having 96 per cent satisfactory results and the unstable group, 47 per cent ($p = 0.0003$). This difference was largely due to the development of avascular necrosis: none of the patients in the stable group and fourteen (47 per cent) of the patients in the unstable group had avascular necrosis ($p = 0.0003$). For the unstable group, the average angle of slip was more severe (51 compared with 35 degrees in the stable group; $p = 0.002$), the average time from the onset of the symptoms to the operation was less (eight compared with fourteen days; $p = 0.002$), but the average time from the arrival at the hospital to the operation was more (four compared with

two days; $p = 0.004$). This reflects the difference in the average duration of symptoms between the unstable and the stable groups (four compared with twelve days; $p < 0.0001$). There were no significant differences between the stable and the unstable groups with regard to the age, sex, race, or obesity of the patient; the side on which the slip occurred; the proportion of acute or acute-on-chronic slips; or the duration of follow-up.

Avascular Necrosis

Avascular necrosis of the femoral head developed in fourteen children; all had an unstable slip. The avascular necrosis appeared an average of six months (range, three to eight months) after the operation. The only significant differences between the group in which avascular necrosis developed and those in the group in which it did not were the time from the onset of the symptoms to the operation and the time from the arrival at the hospital to the operation (Table II). The time from the onset of the symptoms to the operation averaged four days for the fourteen hips in which avascular necrosis developed and twelve days for those in which it did not ($p = 0.002$). However, there was no significant difference in the relative frequency of development of avascular necrosis in hips in which an urgent operation (performed twenty-four hours or less after the onset of the symptoms) had been done and in hips in which the operation had been done later (Fisher exact test, $p = 0.15$): avascular necrosis developed in four of the five hips that were operated on within twenty-four hours and in ten (40 per cent) of the twenty-five hips that were operated on after twenty-four hours. We were able to demonstrate a significant difference in the prevalence of avascular necrosis when the operation was done within forty-eight hours (seven of eight hips) and when the operation occurred after forty-eight hours (seven of

TABLE II
COMPARISON OF PATIENTS WHO HAD AN UNSTABLE SLIP WITH AVASCULAR NECROSIS
WITH THOSE WHO HAD AN UNSTABLE SLIP WITHOUT AVASCULAR NECROSIS*

	With Avascular Necrosis	Without Avascular Necrosis	P Value
Age (yrs.)	13 ± 1.5	12 ± 1.2	0.055
Sex	5 F, 9 M	11 F, 5 M	0.15
Race†	8 W, 4 B, 2 H	13 W, 3 B, 0 H	0.20
Obesity (yes/no)	6/8	12/4	0.16
Side of slip	5 R, 9 L	7 R, 9 L	0.94
Acute/acute-on-chronic	10/4	7/9	0.25
Severity of slip			
Mild/moderate/severe	1/4/9	1/5/10	0.98
Degrees	53 ± 13	50 ± 15	0.61
Duration of symptoms (days)	3 ± 3	5 ± 5.5	0.18
Time from presentation to operation (days)	2 ± 1.8	6 ± 3.8	0.0004
Time from onset of symptoms to operation (days)	4 ± 4.3	12 ± 7.1	0.002
Reduction (degrees/per cent)	29 ± 15/55 ± 23	33 ± 17/66 ± 34	0.48/0.38
Traction (None/skin/skeletal)	5/5/3	4/9/3	0.62
No. of pins or screws (1/≥2)	5/9	2/14	0.29
Duration of follow-up (yrs.)	3 ± 1.7	4 ± 2.1	0.16
Center (Detroit/Ann Arbor/Dallas)	4/2/8	2/4/10	0.49

*Continuous data are expressed as the average and standard deviation.

†W = non-Hispanic white, B = black, and H = Hispanic.

twenty-two hips) (Fisher exact test, $p = 0.012$).

The time from the arrival at the hospital to the operation averaged two days for the hips in which avascular necrosis developed and six days for the hips in which it did not ($p = 0.0004$). There were no significant differences between these groups with regard to the age, sex, race, or obesity of the patient; the side of the slip; the duration of the symptoms; the proportion of acute or acute-on-chronic slips; the severity of the slip (either in degrees or in terms of class⁷); the magnitude or percentage of reduction; the number of pins that were used for fixation; the use of preoperative traction; the hospital where the treatment was done; or the duration of follow-up (Table II).

Complications with the Hardware and Chondrolysis

Eight children had a complication that was directly related to the hardware. Five complications occurred early postoperatively: in three children, an internal fixation device penetrated the hip joint and in two, the pins exited the posterior part of the femoral neck and then re-entered the femur at the epiphysis. There were three late complications: one hip in which there was a stable slip had additional slippage after the initial internal fixation and, in two children, the epiphysis collapsed after the development of avascular necrosis, resulting in late penetration of the joint by the screws (chondrolysis subsequently developed in one of these children). In one other child, who had an unstable slip, chondrolysis and pain developed as a late complication, in the absence of avascular necrosis, and the most recent result was poor.

Discussion

In the past, the definition of an acute slip of the capital femoral epiphysis depended on the duration of

symptoms^{7,9,19}. This led to the classification of a subgroup called acute-on-chronic. Acute-on-chronic slips do not readily fall into either the acute or the chronic group, but they can readily be classified as being stable or unstable. A slip in a patient who has had symptoms for only one or two weeks may be stable; the child may have only vague symptoms and may be seen promptly by a physician, even though he or she is still able to bear weight. A slipped epiphysis is unstable if the hip is so painful that weight-bearing is not possible even with crutches. We encourage physicians, for the purpose of prognosis, to classify slipped capital femoral epiphyses according to stability rather than according to the duration of symptoms.

The reductions of the unstable slips in this study were often unintentional — that is, they occurred with the induction of anesthesia and the position of the patient on the operating table. It is for this reason that we used the word occurred, rather than performed, when discussing a reduction. It stands to reason that a stable slip will resist reduction and that an unstable slip can be reduced easily; a reduction occurred in twenty-six (90 per cent) of thirty unstable slips and in two (8 per cent) of twenty-five stable slips.

This series included acute slips that were treated solely with internal fixation. In most of the other series that we reviewed, the acute slips were treated with several methods^{1,5,10,11,16,23}, which makes comparisons between the studies difficult. Our rate of 47 per cent satisfactory results in the unstable group is worse than those in other series. Bishop et al. reported a 67 per cent rate of satisfactory results in fifteen acute slips. Orofino et al. reported a 64 per cent rate of satisfactory results in eleven acute slips. The unsatisfactory results in the present series were primarily due to avascular necrosis. The 47 per cent

rate of avascular necrosis in our unstable group was higher than that reported by Casey et al. (14 per cent), Aadelen et al. (18 per cent), Green et al. (10 per cent), and Bishop et al. (33 per cent) and is lower than that reported by Schein (55 per cent). We believe that the relatively high rate of 47 per cent is related to the classification system that we used; unstable slips indicate more risk of damage to the posterior retinacular vessels, which increases the frequency of avascular necrosis.

Our 96 per cent rate of satisfactory results in the stable group is similar to the results in many series of chronic slips treated with *in situ* methods^{2,4,7,9,15,17,21}.

The time at which avascular necrosis can be identified radiographically is also controversial. Avascular necrosis became apparent on the plain radiographs in our series three to eight months after the operation; this is longer than the eight-week interval noted by Bishop et al. but shorter than the one-year interval reported by Aadelen et al.

Aadelen et al. reported that no avascular necrosis occurred in their black or female patients. Bishop et al. and Orofino et al. described avascular necrosis in black patients. Five of our fourteen patients who had avascular necrosis were girls and four were black. It is apparent from this, and from other series^{6,20}, that black or female children who have an unstable slipped capital femoral epiphysis are not immune to avascular necrosis.

The relationship between the development of avascular necrosis of the femoral head and the time to reduction of a slipped epiphysis is controversial^{1,5,10,16,22}. Aadelen et al. could not draw any definite conclusions with regard to this relationship, but they did state that avascular necrosis did not develop in any hip in which the reduction had been performed within twenty-four hours after the onset of acute symptoms. Casey et al., however, discovered that in four of their five patients in whom avascular necrosis developed, a reduction had been performed within one week after the onset of symptoms; they postulated that the inflammatory effusion associated with an acute slip might have jeopardized an already tenuous blood supply. For the unstable slips in our series, we noted that the average time from the presentation at the hospital to the operation was two days for patients in whom avascular necrosis later developed and six days for those in whom it did not. Some have thought that preliminary traction may decrease the risk of avascular necrosis by gradually reducing the epiphysis, and that preliminary traction should be used before fixation^{10,19,23}. We noted no difference, however, in the results for the patients who were managed with or without preliminary traction, or in the results of the dif-

ferent types of traction that were used.

In an effort to minimize the risk of avascular necrosis, we are unable to recommend immediate reduction and internal fixation of unstable slips with the patient under general anesthesia. Our finding that the time from the onset of symptoms to the reduction of the slipped epiphysis was significantly less in the patients in whom avascular necrosis of the femoral head subsequently developed suggests, but does not prove, that early reduction is unwise. There is a possibility that these results are confounded by the shorter time to the operation in the patients who had the most severe unstable slips, which are associated with a higher rate of subsequent avascular necrosis. We did not find that an early operation reduced the frequency of subsequent avascular necrosis. Wolff et al. also believed that the interval from acute slippage to internal fixation is not as important for the prevention of avascular necrosis as was previously thought. However, we have a concern with regard to the cause-and-effect relationship in the clinical setting of significant findings in this retrospective study. Although we cannot prove it, we believe that the children who reached us and were treated with internal fixation early had a more severe form of the unstable slip that was associated with an even higher rate of avascular necrosis. This would explain our significant observation ($p = 0.0004$) that the time from presentation to the operation averaged two and six days for those who subsequently had and those who did not subsequently have avascular necrosis, respectively. We do not believe that, in the face of these concerns with regard to a cause-and-effect relationship, it would be proper to make recommendations for treatment.

We also were not able to demonstrate an association between the severity of a slip or the magnitude of a reduction and the frequency of avascular necrosis. The development of avascular necrosis has been associated with over-reduction. In one series, three of the five hips in which avascular necrosis developed had been over-reduced¹⁰, as were all five hips in another series⁶. Bishop et al. stated that over-reduction (or positioning of the capital femoral epiphysis in valgus angulation) indicates increased mobility of the epiphysis, more tearing of the capsule and retinacular vessels at the time of the slip, and more chance that avascular necrosis will develop. Only one hip in the present series had an over-reduction (138 per cent), but the result was excellent. We emphasize again that many of the reductions in our series occurred with induction of anesthesia and positioning of the patient on the table; a formal reduction maneuver was not attempted in most patients in this series.

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