Chondrolysis, Osteonecrosis, and Slip Severity in Patients with Subsequent Contralateral Slipped Capital Femoral Epiphysis

By Yakup Yildirim, MD, Severino Bautista, MD, and Richard S. Davidson, MD

Investigation performed at Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

Background: Prophylactic pinning of the radiographically and clinically normal contralateral hip in a patient with a unilateral slipped capital femoral epiphysis remains controversial. The purpose of this study was to identify the prevalence of chondrolysis and osteonecrosis and the degree of slip severity in contralateral hips with a subsequent slipped capital femoral epiphysis to determine whether the outcome or complications on the contralateral side were greater than the risks of prophylactic pinning.

Methods: The medical records of the patients operated on between 1993 and 2003 at a single hospital for treatment of a slipped capital femoral epiphysis were retrospectively evaluated. The severity and the chronicity of the slips were graded. Only children who initially had had a unilateral slip and had been followed for a minimum of twenty-four months or until skeletal maturity were included in the analysis for detection of a subsequent contralateral slip. Patients with more than twelve months of follow-up were included in the analysis for detection of osteonecrosis and chondrolysis.

Results: Two hundred and twenty-seven patients had a unilateral slipped capital femoral epiphysis at the time of the primary admission. A subsequent slip developed in the contralateral hip of eighty-two children (36%) within a mean of 6.5 months. Eighteen of the contralateral slips were of moderate or severe severity, with a potential for a poor outcome due to a risk of osteoarthritis in the future. Osteonecrosis or chondrolysis, each an established complication with a poor long-term prognosis, developed in five of the patients with a subsequent contralateral slip.

Conclusions: The high prevalence of a subsequent contralateral slip (36%) and the potential complication (high slip severity) and established complications (osteonecrosis and chondrolysis) related to the contralateral slip indicate that prophylactic pinning of the contralateral hip in a patient with a unilateral slipped capital femoral epiphysis is safer than and preferable to observation and symptomatic treatment.

Level of Evidence: Prognostic Level IV. See Instructions to Authors for a complete description of levels of evidence.

The prevalence of bilateral slipped capital femoral epiphysis has been reported to range between 40% and 80%[1]. This wide range may be related to the variability in the radiographic criteria used to evaluate the hips[2], the duration of the follow-up period[3], and the age of the patient at the time of diagnosis[4]. Bilateral slipped capital femoral epiphysis may present either as a primary bilateral slip (simultaneous slips) or as a later contralateral slip (subsequent slip). The reported frequency of a subsequent, contralateral slip during the remaining growth period has ranged between 25% and 40%[5-7]. There is controversy regarding the advisability of prophylactic pinning of the radiographically and clinically normal contralateral hip in patients with a unilateral slip. Proponents of prophylactic pinning have argued that slipped capital femoral epiphysis is a disease of the physes that places the patient at substantial risk for a subsequent, contralateral slip until physeal closure occurs[1,6,8,9]. Bilateral slipped capital femoral epiphysis was found in 67% of the patients in the study by Hägglund et al., who proposed prophylactic pinning of the contralateral hip in patients presenting with a unilateral slip[3].

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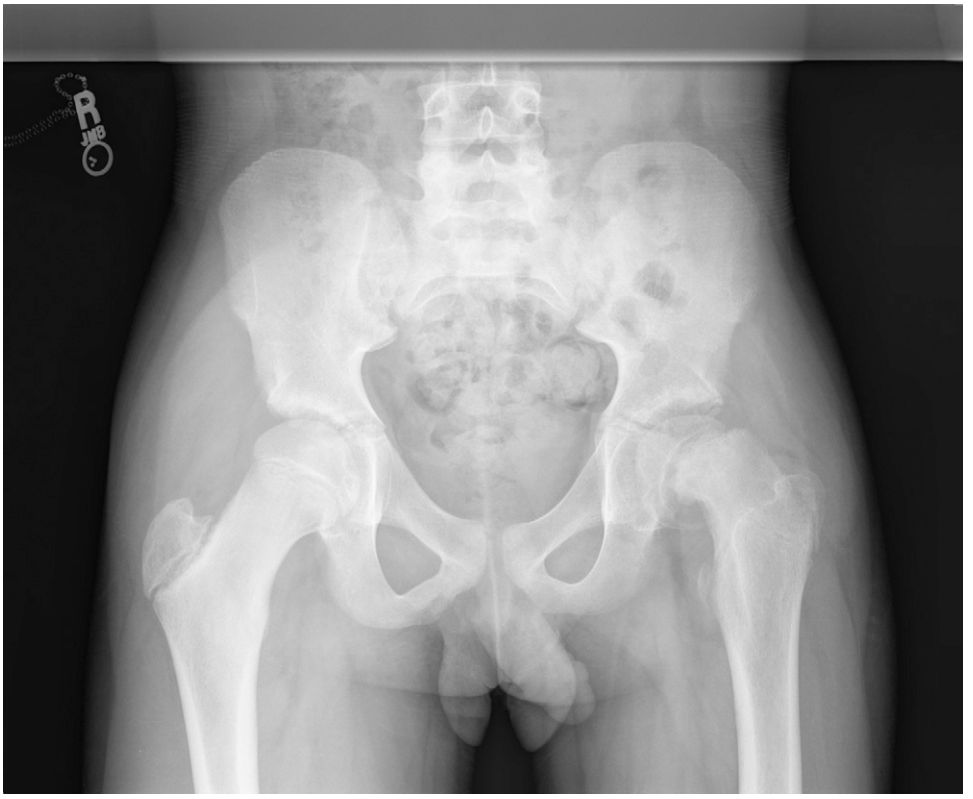

Fig. 1-A

Figs. 1-A and 1-B The sequence of sequential bilateral slipped capital femoral epiphysis in a patient.

Fig. 1-A Slipping of the left hip (right side of the radiograph).

Billing and Severin identified rates of bilaterality in patients with slipped capital femoral epiphysis of up to 80% when they were followed beyond maturity[2]. The subsequent slipped capital femoral epiphysis does not appear to have a benign natural history, as Hägglund et al. reported that 53% of second slips recognized during adolescence were associated with osteoarthritic changes during a period of long-term follow-up[6]. Jensen et al. reported mild osteoarthritis in one of nine hips in which a subsequent slip was detected during adolescence and severe osteoarthritis in two[10].

Opponents of prophylactic pinning argue that the procedure is unnecessary in most cases[10,11], and they have advocated close observation to detect a subsequent slip at an early phase, before it progresses to a more severe grade. The results on long-term follow-up of chronic slipped capital femoral epiphysis are favorable provided that displacement is mild and remains so. Castro et al. reported that, since the majority of the sequential slipped capital femoral epiphyses in their patients were detected and treated early, close follow-up rather than prophylactic pinning was more advisable[11]. However, if the prevalence of subsequent, contralateral slipping is high and if the outcome or complications associated with the subsequent slip are substantially greater than the risks of prophylactic pinning, then simultaneous pinning of the radiographically and clinically normal hip as well as the slipped capital femoral epiphysis may be appropriate. The treatment of slipped capital femoral epiphysis must be aimed at preventing a moderate or severe slip of the epiphysis and minimizing the risk of osteonecrosis and chondrolysis, which are the most serious complications[3,12], as the long-term outcome of slipped capital femoral epiphysis is directly related to the slip severity[13] and the presence or absence of osteonecrosis and chondrolysis[14-16].

The purpose of the current study was to evaluate the risk of unfavorable results (osteonecrosis, chondrolysis, and a severe slip, which can lead to later degenerative arthritis) in a large series of contralateral slipped capital femoral epiphyses in children who initially presented with a unilateral slipped capital femoral epiphysis.

Materials and Methods

We performed a retrospective review of the records of all patients with a slipped capital femoral epiphysis treated between 1993 and 2003 at a single hospital. Patients who had an endocrine or metabolic disease, had simultaneous bilateral involvement, or had been treated elsewhere for an initial slip were excluded. A complete set of radiographs made at the time of presentation was a criterion for inclusion. Only children who initially had had a unilateral slip and had been followed for a minimum of twenty-four months or until skeletal maturity (defined as fourteen years old for girls and sixteen years

Fig. 1-B
Slipping of the right hip (left side of the radiograph) after pinning of the slip in the left hip.

old for boys) were included[17] in the analysis for detection of a subsequent, contralateral slip.

In this study, the surgeons stabilized all slipped capital femoral epiphyses with either a single or a double 7.3-mm cannulated screw. The acute slips were stabilized with the patient either on a fracture table with the lower limb internally rotated or on a standard operating room table with the patella forward. Image intensification was used in all cases. In no case was a slipped capital femoral epiphysis reduced or manipulated. Any change in the position of the slipped capital femoral epiphysis occurred incidentally during the positioning of the patient. As the chronic slips did not move during treatment (presumably they were stable), the hip was positioned with the patella facing forward for ease of pinning under image intensification without manipulation. Postoperatively, all patients were instructed to use partial weight-bearing on the operatively treated lower limb for six weeks.

The medical records provided information on gender, age, and the chronicity of the slip. The chronicity was classified as acute, acute-on-chronic, or chronic. The slip was considered to be acute if the symptoms had been present for three weeks or less, acute-on-chronic if sudden acute pain had occurred after the symptoms had been present for more than three weeks, and chronic if the symptoms had been present for more than three weeks.

All preoperative and follow-up radiographs were reviewed to determine the grade of the slip and the presence or absence of complications (osteonecrosis and chondrolysis). The grade of the slip was defined as mild (<30°), moderate (30° to 50°), or severe (>50°) on the basis of the lateral head-shaft angle described by Southwick[18].

Patients who had been followed for more than twelve months were included in the analysis to detect complications. Chondrolysis was defined as a decrease in the joint space to a width of ≤3 mm[19], and radiographic evidence of osteonecrosis included collapse and sclerosis of the femoral head[20].

The age of the patients as well as the grade and chronicity of the slips were compared among the unilateral slips, first-side (index) slips in the patients with a bilateral slip, and the subsequent, contralateral slips in those with a bilateral slip. Statistical analysis was performed with analysis of variance (for the age comparison) and the chi-square test (for the chronicity and grade comparisons). P values of 0.05 were considered to be significant.

Results

The database of 520 patients diagnosed with slipped capital femoral epiphysis was initially evaluated. At the time of the primary admission, 331 patients had a unilateral slip and 189 had a bilateral slip. After exclusion of the patients with a

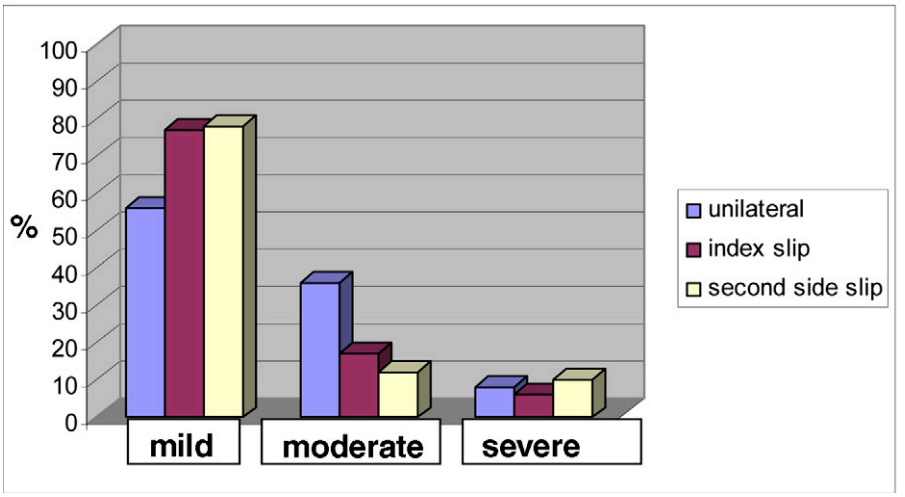

Fig. 2

Distribution (percentages) of the severity grades of the unilateral slips in the patients with no subsequent contralateral slip; the first-side (index) slips in the patients with a subsequent, contralateral slip; and the second-side slip in those with a subsequent, contralateral slip.

unilateral slip who had been lost to follow-up, had not reached skeletal maturity at the time of the last radiograph, or had been followed for less than two years, 227 patients (147 boys and eighty girls) with a unilateral slipped capital femoral epiphysis remained; these patients had been followed for an average of 26.4 months. A subsequent slip developed in the contralateral hip of eighty-two of these patients (forty-eight boys and thirty-four girls). The slip in the contralateral hip was detected at a mean of 6.5 months (range, one to twenty-five months) after the time of the initial presentation (Figs. 1-A and 1-B). There were no documented cases of pin penetration into the hip joint at the time of surgery.

The average age at the time of the initial presentation was thirteen years (range, nine to sixteen years) for the patients with a unilateral slipped capital femoral epiphysis in whom a subsequent, contralateral slip did not develop and 11.2 years (range, seven to fifteen years) for those in whom a subsequent slip did develop. This difference was significant ($p < 0.05$).

In the group without a subsequent slip, thirty-six (25%) of the index unilateral slips were acute, seven (5%) were acute-on-chronic, and 102 (70%) were chronic, and none of these designations changed during the follow-up period. In the group with a subsequent, second-side slip, twenty-three (28%) of the index unilateral slips were acute, six (7%) were acute-on-chronic, and fifty-three (65%) were chronic. On the contralateral side, sixty-two subsequent slips (76%) were acute, three (4%) were acute-on-chronic, and seventeen (21%) were chronic. There was no difference with regard to chronicity between the unilateral slipped capital femoral epiphyses in the patients without a subsequent slip and the index slipped capital femoral epiphysis in the patients who did have a subsequent, contralateral slip; however, both differed with regard to chronicity from the subsequent, contralateral slips, which were more likely to be acute ($p < 0.05$). Unfortunately, insufficient data were available in the charts to classify the slipped capital femoral epiphyses as *stable* or *unstable,* terms that have been shown to correlate better with the risk of osteonecrosis than the older terms *acute* and *chronic.*

There were eighty-one (56%) mild, fifty-two (36%) moderate, and twelve (8%) severe unilateral slipped capital femoral epiphyses in the patients who did not have a subsequent slip. In the group that did have a subsequent slip, sixty-three (77%) of the index unilateral slips were mild, fourteen (17%) were moderate, and five (6%) were severe, whereas sixty-four (78%) of the subsequent, second-side slips were mild, ten (12%) were moderate, and eight (10%) were severe (Fig. 2). The grades of severity were similar between the index slipped capital femoral epiphyses and the subsequent, contralateral slips in the group with a subsequent slip; however, both differed with regard to the grades of severity from the unilateral slipped capital femoral epiphyses in the group without a subsequent slip ($p < 0.05$).

Of the patients in whom the unilateral slipped capital femoral epiphysis was not followed by a second slip, 114 had been followed for more than one year (average, 33.2 months). Thirteen (11%) of these 114 children had a major complication: osteonecrosis of the femoral head was identified in eleven and chondrolysis, in two. The average intervals between the operation and identification of osteonecrosis and chondrolysis were 170 days (range, fifteen to 377 days) and ninety-five days, respectively. Of the patients who had a subsequent, contralateral slipped capital femoral epiphysis (with an average age of 11.7 years at the time of the second slip), fifty-eight were followed for more than one year (average, thirty-two months) after diagnosis of the second slip. There were five complications (9%): one patient had osteonecrosis (Fig. 3), and four had chondrolysis. All of the patients in whom

Fig. 3

Development of femoral head osteonecrosis in the left hip of a patient with a subsequent slip of the capital femoral epiphysis in that hip.

chondrolysis developed had a severe slip, and the patient in whom osteonecrosis developed had an unstable slip. The average interval between the operation and the development of chondrolysis was 119 days (range, forty-five to 194 days) in this group.

A poor outcome was identified in nineteen (23%) of the contralateral hips with later slipped capital femoral epiphysis, as determined by including all of those with a moderate or severe slip and/or established osteonecrosis or chondrolysis. A complication (osteonecrosis) developed in only one patient with a mild slip.

Discussion

The treatment of the radiographically and clinically normal contralateral hip in a child who has a unilateral slipped capital femoral epiphysis is controversial. Patients who are first seen with a unilateral slipped capital femoral epiphysis are at a 2335-times greater risk for the development of a contralateral slip than are those who have never had a slip[11]. This indicates that the initial and the subsequent, contralateral slipped capital femoral epiphyses are probably not independent events. The reported rates of a subsequent, contralateral slipped capital femoral epiphysis being detected during adolescence range between 25% and 40%[1,5,7], and evaluation of the forty-five studies in which the investigators categorized bilateral slipped capital femoral epiphysis as either simultaneous or subsequent revealed that 66% of the cases of bilateral slipped capital femoral epiphysis were the result of a subsequent, contralateral slip[11]. This high risk and the noted association between unilateral and subsequent, contralateral slipped capital femoral epiphysis validate the need to consider prophylactic pinning of the contralateral hip. Although the epidemiology of a subsequent, contralateral slip has been evaluated in detail, few authors have specifically addressed the complications related to the subsequent development of a contralateral slipped capital femoral epiphysis.

In a sensitivity analysis, Kocher et al. found that if the risk of the development of a contralateral slipped capital femoral epiphysis is believed to exceed 27%, then rational decision-making would favor prophylactic pinning[21]. In the current study, 36% of the patients with a unilateral slipped capital femoral epiphysis had a subsequent, contralateral slip. The reported time between the diagnoses of first and second slips of the capital femoral epiphysis has ranged from 0.8 to 1.3 years[6,9,22]. Jerre et al. found twenty-six months to be the maximum interval between the diagnoses of first and second (contralateral) slips[23]. Castro et al. reported that 88% of the subsequent slips in their study developed within eighteen months after the diagnosis of the first-side slipped capital femoral epiphysis[11]. The mean interval was 6.5 months in our study. On the basis of these reports, we believe that the duration of follow-up in the current study was sufficient for most of the subsequent slips to be diagnosed. Further follow-up might have identified an even higher prevalence of subsequent, contralateral slipped capital femoral epiphysis.

The long-term prognosis of undiagnosed subsequent, contralateral slipped capital femoral epiphysis is not always fair. Hägglund et al. recommended fixation of both hips at the time of the initial presentation in all children with a unilateral slip[6] on the basis of their finding that 14% (thirty-two) of the children in their series who had a unilateral slip had a subsequent, contralateral slip. Moderate-to-severe osteoarthrosis

had developed in ten of the hips by the time of the most recent follow-up examination. They also found that 51% of the hips that had appeared normal at the time of physeal closure had a tilt deformity suggestive of a previous slip. Jerre et al. reported that 25% of patients who had a subsequent, contralateral slipped capital femoral epiphysis had the development of osteoarthrosis in that hip[23].

Long-term studies have confirmed that the outcome of a slipped capital femoral epiphysis is directly correlated with the severity of the slip[13,15,24]. After a mean follow-up period of 5.9 years, Rattey et al. concluded that the Iowa hip score and the severity of the degenerative changes were related to the severity of the slip and that malunion of a slipped capital femoral epiphysis would have long-term consequences[25]. Carney et al. demonstrated that the natural history of a mild slipped capital femoral epiphysis treated with in situ fixation is good, whereas moderate and severe slipped capital femoral epiphyses are associated with the earlier development of degenerative joint disease, even after in situ fixation[13]. In another study, Carney and Weinstein found that all patients with moderate or severe slipped capital femoral epiphysis had evidence of degenerative joint disease after a mean follow-up period of forty-one years[24]. Because of similarly unfavorable outcomes in association with moderate and severe slips, Loder et al. combined these two groups, creating two categories of slip severity: mild and moderate/severe[15]. In the current study, after exclusion of four patients with a severe slipped capital femoral epiphysis in whom complications (osteonecrosis and chondrolysis) had already developed, there remained fourteen hips with a subsequent, contralateral slipped capital femoral epiphysis that was moderate or severe. Although osteonecrosis and chondrolysis are the problems seen in the early period after the slip[16], the major late problem of arthritis is often not seen until middle age[3]. Combination of the cases with established complications and those with a high-grade slip reveals that nineteen patients (23%) with a contralateral slipped capital femoral epiphysis in our series are at risk for a poor long-term outcome. In a decision analysis study, Kocher et al. reported the probability of osteonecrosis to be 0.2% and the probability of chondrolysis to be negligible after prophylactic in situ pinning of the contralateral hip[21]. Emery et al. evaluated ninety-five hips that had been treated prophylactically with multiple pins and reported that four pins had penetrated the articular cartilage[26]. Despite this finding, neither chondrolysis nor osteonecrosis was detected after a mean of twenty-two months of follow-up. Also, Seller et al. did not report any complications such as osteonecrosis or chondrolysis after a minimum duration of follow-up of one year after prophylactic pinning of the contralateral hip in patients with a slipped capital femoral epiphysis[27]. Since the complication rate following prophylactic pinning is lower than the potential and established risks of a subsequent slip, prophylactic pinning of the contralateral hip appears to be safer than observation and symptomatic treatment.

Opponents of prophylactic pinning have recommended frequent follow-up examinations of the contralateral hip until closure of the growth plate begins[5,7,11]. However, regular follow-up may not always be possible and effective for early detection of the contralateral slip. Stasikelis et al. reported that, despite all efforts to encourage routine follow-up visits, only seven of twenty children who eventually had a contralateral slipped capital femoral epiphysis had been seen at the specified intervals from the time of presentation until the subsequent, contralateral slip was detected[9], and 20% of the patients had an asymptomatic contralateral slipped capital femoral epiphysis that was detected on follow-up screening radiographs. Jensen et al.[10] and Hägglund et al.[6] also reported that close follow-up was not sufficient to prevent the development of a slipped capital femoral epiphysis of the contralateral hip in children who had a unilateral slip and concluded that depending exclusively on regular follow-up visits to decrease the severity of a subsequent, contralateral slip would not be feasible.

The two most common complications in patients with slipped capital femoral epiphysis are osteonecrosis and chondrolysis[3,28]. The reported rate of osteonecrosis has ranged between 3% and 47% and the reported rate of chondrolysis has ranged between 1% and 40%, depending on the series[29]. Although the rate of chondrolysis in our patients who had a subsequent, contralateral slip (four of fifty-eight; 7%) seems to be high, it falls within the normal range reported by Lubicky[16]. In the current study, we could not identify any cases of pin penetration on any of the intraoperative radiographs or in any of the operative notes.

Both osteonecrosis and chondrolysis usually appear, clinically or radiographically, during the first year after the operation[16]. According to Loder et al., osteonecrosis and chondrolysis develop between three and eight months after surgical treatment[14]; therefore, our follow-up interval of at least one year should have been sufficient to identify most such complications in our study group. In the current study, osteonecrosis or chondrolysis developed in 11% of the patients with a unilateral slipped capital femoral epiphysis and no subsequent slip and 9% of the hips in the group with a subsequent, contralateral slipped capital femoral epiphysis.

We compared parameters in the group of 145 children in whom a contralateral slipped capital femoral epiphysis never developed with those in the group of eighty-two patients in whom a subsequent, contralateral slip did develop. Those in whom a contralateral slip developed were significantly younger at the time of the initial slip. Loder et al. reported a mean age of twelve years for children in whom a subsequent, contralateral slipped capital femoral epiphysis developed and a mean age of thirteen years for those in whom one did not develop[5], a difference that also was significant ($p = 0.002$). In that study, the duration of symptoms prior to treatment was similar between the unilateral slipped capital femoral epiphyses in the patients who did not have a subsequent, contralateral slip and the index-side slipped capital femoral epiphyses in the patients who did have a subsequent, contralateral slip. Chronic slipped capital femoral epiphysis predominated in both groups. In a meta-analysis, Castro et al.[11] reported the percentages of acute, acute-on-chronic, and chronic slips as 18%, 7%, and 75%, respectively,

values consistent with our findings for the timing of the slips. Compared with the study by Castro et al., more of the patients in our series had an acute subsequent, contralateral slip, suggesting that they may have sought medical help for the contralateral slipped capital femoral epiphysis earlier. In a multicenter study by Loder, the average duration of symptoms prior to presentation of a unilateral slipped capital femoral epiphysis (3.9 months) was longer than that prior to presentation of a subsequent, contralateral slipped capital femoral epiphysis (three months)[30]. Proper education and the experience of the first slipped capital femoral epiphysis may be factors that shortened the duration of symptoms before presentation of the subsequent, contralateral slipped capital femoral epiphysis.

The high frequency of subsequent, contralateral slipped capital femoral epiphysis and the 23% risk of established and potential complications (osteonecrosis, chondrolysis, and osteoarthritis) in the contralateral hips with a subsequent slip in our series suggest that prophylactic pinning of the contralateral hip in a patient with unilateral slipped capital femoral epiphysis may be safer and preferable to observation and symptomatic treatment. In a decision model, Schultz et al.[31] found that treatment of the contralateral hip with prophylactic pinning is beneficial with regard to the long-term outcome of that hip. Pinning the unslipped hip is technically easy and can be done at the same time as the operation on the primary side[6]. Prophylactic pinning diminishes the need for repeated radiographic examination during the remaining growth period[1], allows the patient to be more active without constant fear of a sequential slip[32], and eliminates the small risks associated with a second administration of anesthesia. Operative procedures such as proximal femoral osteotomy, total hip arthroplasty, lateral shelf acetabuloplasty, and hip arthrodesis that are required to salvage the hip after such complications as osteonecrosis may also be avoided by prophylactic pinning[29]. ■

Yakup Yildirim, MD
SOYAK Yenisehir Selale Evleri B1 Daire 9, Umraniye, Istanbul, Turkey.
E-mail address: yakup_69@hotmail.com

Severino Bautista, MD
2776 Sagebrush Circle, Apartment 103, Ann Arbor, MI 48103

Richard S. Davidson, MD
Division of Pediatric Orthopaedic Surgery, The Children's Hospital of Philadelphia, 34th Street and Civic Center Boulevard, Philadelphia, PA 19082

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