

Slipped capital femoral epiphysis: an analysis of treatment outcome according to physeal stability

Salah Fallath, MD; Merv Letts, MD

Introduction: Slipped capital femoral epiphysis (SCFE) is a common hip disorder in adolescents. Treatment can be associated with serious complications, mainly avascular necrosis (AVN). The objective of this study was to evaluate treatment outcomes and complications based on physeal stability at presentation. **Methods:** We reviewed retrospectively all children treated for SCFE from 1990 through 2000 at the Children's Hospital of Eastern Ontario, Ottawa. **Results:** Of a total of 87 patients (56 male) identified, 73 had slips classed as stable and 14, unstable; 42 involved the left side, 34 the right, and 19 were bilateral. Avascular necrosis (AVN) developed in 1 patient with a stable slip (morbidity 1.4%) and in 3 with unstable slips (21.4%; $p = 0.001$). Manipulative anatomical reduction was done in 11 cases (78.5%), all unstable slips. All slips complicated by AVN had been classified according to the traditional system as acute-on-chronic. Complication rates differed significantly between unstable slips (36%) and stable (20%). No statistically significant association was found between AVN and slip severity, time to fixation or use of reduction. **Conclusions:** The treatment of stable slips exhibits a lower incidence of AVN. These results nevertheless suggest that gentle reduction of unstable slips is safe and unaccompanied by an increase in complications.

Introduction : L'épiphysiolyse fémorale supérieure (EFS) est un trouble de la hanche courant chez les adolescents. Le traitement peut être associé à des complications graves, principalement la nécrose avasculaire (NAV). Cette étude visait à évaluer les résultats du traitement et les complications en fonction de la stabilité de l'épiphyse lorsque le patient s'est présenté. **Méthode :** Nous avons examiné rétrospectivement tous les enfants traités pour EFS de 1990 à 2000 au Centre hospitalier pour enfants de l'est de l'Ontario, à Ottawa. **Résultats :** Sur un total de 87 patients (56 de sexe masculin) identifiés, on avait classé 73 épiphysiolyse comme stables, et 14 instables. Il y en avait 42 du côté du gauche, 34 du côté droit et 19 des deux côtés. La nécrose avasculaire (NAV) a fait son apparition chez un patient dont l'épiphysiolyse était stable (morbidity de 1,4 %) et chez trois où elle était instable (21,4 %; $p = 0,001$). On a procédé à une réduction anatomique par manipulation chez 11 patients (78,5 %) dont l'épiphysiolyse était stable dans tous les cas. On avait classé toutes les épiphysiolyse qui avaient entraîné une complication causée par NAV en fonction du système traditionnel, soit aiguë-sur-chronique. Les taux de complication ont différé considérablement entre les épiphysiolyse instables (36 %) et stables (20 %). On n'a pas trouvé de lien statistiquement significatif entre la NAV et la gravité de l'épiphysiolyse, le temps nécessaire à la fixation ou le recours à la réduction. **Conclusions :** Le traitement des épiphysiolyse stables produit une incidence plus faible de NAV. Ces résultats indiquent néanmoins que la réduction en douceur des épiphysiolyse instables est sans danger et n'entraîne pas d'augmentation des complications.

Slipped capital femoral epiphysis is the commonest serious hip disorder in the adolescent. Its traditional classification is according to symptom duration. An acute slip has

symptoms that last less than 3 weeks; a chronic slip has a gradual onset and progression of symptoms, which last for longer than 3 weeks. A slip is designated acute-on-chronic when

symptoms are chronic for more than 3 weeks with a sudden acute exacerbation lasting less than 3 weeks.¹

Loder and colleagues² emphasized the importance of physeal stability at

Division of Pediatric Orthopaedics, Children's Hospital of Eastern Ontario, Ottawa, Ont.

Accepted for publication Dec. 15, 2003

Correspondence to: Dr. Merv Letts, Department of Surgery, Shaikh Khalifa Medical Center, PO Box 51900, Abu Dhabi, United Arab Emirates; fax 971 2 610 4962; letmer764@skmc.gov.ae

presentation by correlating it with outcome. A slip is considered to be stable if walking and weight-bearing are still possible, with or without crutches. If walking is impossible even with crutches, the patient has an unstable slip regardless of the duration of symptoms.

The purpose of this retrospective study was to evaluate and compare treatment outcomes of children presenting with a slipped capital femoral epiphysis, stable or unstable, at a major tertiary pediatric trauma centre.

Material and methods

We reviewed the records of all children treated for slipped capital femoral epiphysis in our institution between 1990 and 2000 (inclusive), identifying 87 patients with 106 slips.

Medical records were reviewed for demographic data at the time of the slip, including each child's age, sex, weight, injured side, history of trauma, weight-bearing status on arrival, duration of symptoms, and length of time from presentation to operation. From initial radiographs, the percentage of slip and slip angle were determined as described by Southwick.^{3,4} Operative reports were reviewed for the method and number of screws used for fixation, any manipulation attempted, and intra-operative complications.

Range of hip motion, patients' activity level, and any complaints (pain, limp or stiffness) were recorded from their latest follow-up. Radiographs from the latest follow-up were used to determine the presence of avascular necrosis (AVN) and chondrolysis, which was considered present if there was a joint space narrowing of 3 mm or less.⁵

For patients with AVN or who underwent reoperation for any reason, we reviewed immediate post-operative and subsequent radiographs, and recorded the time from initial operation to the identification of complications.

Statistical analysis was performed

with SPSS software, version 10.0. A 2-tailed Student's *t* test was used to quantify significant differences between 2 groups of continuous data. For 2 × 2 analyses when the number in any cell was 5 or less, we used Fisher's exact test to test differences between groups of discrete data, and the χ^2 test when the number in all cells was more than 5.

Results

Based on their ability to bear weight on arrival, 73 (84%) of the 87 patients with slipped capital femoral epiphysis had stable slips and 14, unstable (Table 1).² Boys (64% of the study group) had 56 slips (7 unstable) and girls, 31 (7 unstable). The right side was involved in 26 slips, and the left in 34; 19 were bilateral.

Three patients in our evaluation group had an underlying endocrine or genetic disorder: congenital adrenal hyperplasia, histiocytosis and Frohlich's syndrome, respectively.

Fourteen (16%) of the children presented with distal thigh or knee pain, in isolation or associated with hip and groin pain.⁶

Stable slips

There were 90 stable slips in 73 patients, of whom 49 (67%) were male (Table 1). Twenty involved the right hip, and 34 the left; 19 were bilateral. The average age at presentation was 12 years (range 5–17 yr); average weight was 73 kg. Eleven patients (15%) had a history of hip trauma before the onset of symptoms on that side. The period from symptom onset to surgical pinning averaged 3 months (range 3 d to 24 mo). According to the traditional classification system,⁵ 70 slips (78%) were chronic, 14 (16%) acute and 4 (4.4%) acute-on-chronic; 2 were pre-slips.

A single screw was used to fix a slipped epiphyses in 58 cases, a pair of screws in 29, and three Knowles pins in 2 cases. One slip occurred in a 5-year-old child with juvenile Scheurmann's syndrome (Fig. 1). Duration of follow-up averaged 2 years and 9 months (range 2–8 yr).

One patient with a stable slip developed AVN 15 months after fixation (Fig. 2). He had presented at age 14 with groin pain that had been present for 4 months but had worsened

Table 1

Comparison of data for patients having stable and unstable slips

Characteristics	Stable <i>n</i> = 73	Unstable <i>n</i> = 14	<i>p</i> value
Mean age (and range), yr	12.4 (5–17)	12.8 (10–16)	0.783
Males, no. (and %)	49 (67)	7 (50)	0.238
Females	24 (33)	7 (50)	
Mean weight, kg	73.2	67.5	0.796
Slip occurred on right side, cases	20	6	0.487
Left side	34	8	
Bilateral	19	0	
Mean follow-up (and range), mo	33 (24–96)	35 (24–72)	0.654
Trauma, no. of cases (and %)	11 (15)	11 (78.6)	0.036
Complications, no. (and %)	15 (20)	5 (36)	0.030
Avascular necrosis, no. (and %)	1 (1.4)	3 (21.4)	0.001
Range of motion, degrees			
Flexion	120	108	0.008
Extension	-0.14	2	0.004
Abduction	46.9	29.5	0.641
Internal rotation	24.4	22.3	0.745
External rotation	57.4	49.6	0.002

over the preceding week. His grade II slip was initially fixed with 2 cannulated screws, which were changed to a single screw in the first postoperative day because of joint penetration by 1 of the screws. The avascular area was limited to the anterolateral area of the femoral epiphysis (Fig. 2).

Unstable slips

There were 14 unstable slips in 14 patients; 7 were males. The side affected and other data are presented in Table 1. In 11 cases (79%), acute symptoms occurred as the result of a fall. Seven slips were acute and 7 were acute-on-chronic, according to the older classification system.

Two days was the average period from the onset of acute symptoms to arrival at the hospital (range 1–3 d); average time from presentation to operation was 28 hours (range 3.5–72 hr). There was a reduction of the slip in 11 hips (79%): 2 spontaneous (14%) and 9 by manipulation (64%). Three were pinned *in situ* with no reduction. Three of the slipped epiphyses were fixed with 2 Knowles pins, 1 with 2 cannulated screws and 10 with a single cannulated screw.^{2,7}

No child was immobilized in a cast after the operation. The average duration of follow-up was 35 months (range 24–72 mo).

Four of the children, 2 females and 2 males, developed AVN (Fig. 3).

Three of those 4 patients underwent gentle reduction intraoperatively with hip flexion, internal rotation and extension, whereas the fourth patient had her slip reduced with the application of skin traction (Table 2).^{2,5}

Comparison between the stable and the unstable groups

As indicated in Table 1, group differences for patient age, sex and weight were not significant ($p > 0.05$). The same was true for the side affected by the slip and the duration of follow-up. There was also no significant difference in number of screws used for fixation, or in slip severity (mild, moderate or severe).

Differences between the groups were significant for postoperative flexion, extension and external rotation, with the stable group achieving a better range of motion. Applying the traditional classification to the 2 groups also showed a significant difference between the stable and the unstable groups ($p = 0.002$): although most slips in the stable group were chronic (70 cases, 78%), none were chronic in the unstable group (50% acute and 50% acute-on-chronic). Four slips in the stable group were acute-on-chronic, 1 of which had AVN (Table 2).

AVN developed in 1 stable slip and 3 unstable slips with a statistically significant difference between

the 2 groups ($p = 0.001$).

An association was found between the traditional classification and the development of AVN ($p = 0.001$; correlation coefficient -0.352). Whether stable or unstable, all the hips that developed this complication were acute-on-chronic, with an average of 30 hours between presentation in the emergency department and the operation. No significant correlation was found in either group between AVN and the degree of displacement, nor between AVN and surgical delay from either symptom onset or emergency-room presentation (Table 2).¹

The average duration of symptoms was 3 months in the stable group and 1.5 months in the unstable group, with no statistical difference between the 2 groups ($p = 0.115$). The time from the arrival at hospital to the operation averaged 29 hours (3.5–72 h).^{8,9}

Repinning was required for 4 slips, 2 stable and 2 unstable slips. The stable slips that required repinning were due to a joint penetration in 1 case that was later complicated by AVN, and the second repinning was for a patient who had a grade I slip that was fixed with 2 pins, and 3 months postoperatively, radiographs revealed further slippage compared with the immediate post-operative x-ray. The child was not complaining of any pain at that time.¹⁰



FIG. 1. Radiograph of the hips of a 5-year-old boy with Scheuchmann's syndrome, illustrating widened physis in the anteroposterior view (upper x-ray) and grade I slips bilaterally on the frog-leg view (lower x-ray).

Two unstable slips required repositioning. One patient fixed with a single screw experienced continued slippage. The other, fixed with 2 screws, occurred in a patient with growth hormone deficiency. Despite good initial positioning, follow-up radiographs 10 months postoperatively showed the screws out of the epiphysis because of continued physal growth.

Chondrolysis developed in 1 unstable slip fixed with 2 screws that had no evidence of joint penetration on the follow-up radiographs or at the time of fixation. The joint space narrowing was evident on x-ray 1 year postoperatively; the patient had symptoms for 1 day and was operated upon within 5 hours after presentation. The patient is now asymptomatic with full range of motion at the most recent follow-up (3 yr postoperative).^{5,11}

One patient in the stable group was found to have some lucency around the screw 24 months after fixation, for which the screw was removed.^{12,13} There was no evidence of infection.

Other complications that we encountered were trochanteric bursitis in 1 child, limb length discrepancy of less than 2 cm in 5 (stable slips), and the head of the screw broke at the time of screw removal in 1 child. Of the 87 patients, 36 underwent screw removal.

The overall complication rate was higher in the unstable group (36%) versus stable group (20%) with a statistically significant difference between the 2 groups ($p = 0.030$).

Discussion

Development of AVN remains a devastating and disconcerting complication. Loder and coauthors² reported an AVN rate of 47% for unstable slips; in our series, it was much lower (21%). With stable slips, Loder's group had satisfactory results in 96% of their cases and no AVN, whereas

we had 1 case of AVN (1.4%). When slipped capital femoral epiphysis is classified according to physal stability, the correlation of acute/unstable slips with osteonecrosis was very good.¹⁴

Placement of pins in the antero-lateral portion of the epiphysis has been reported to increase the risk of AVN,^{11,15} and our 1 case of AVN was probably pin-induced.

Maeda and colleagues¹⁶ and other clinicians^{8,9} have suggested that in unstable slips the vascular damage occurs at the time of injury, before reduction, and that the reduction

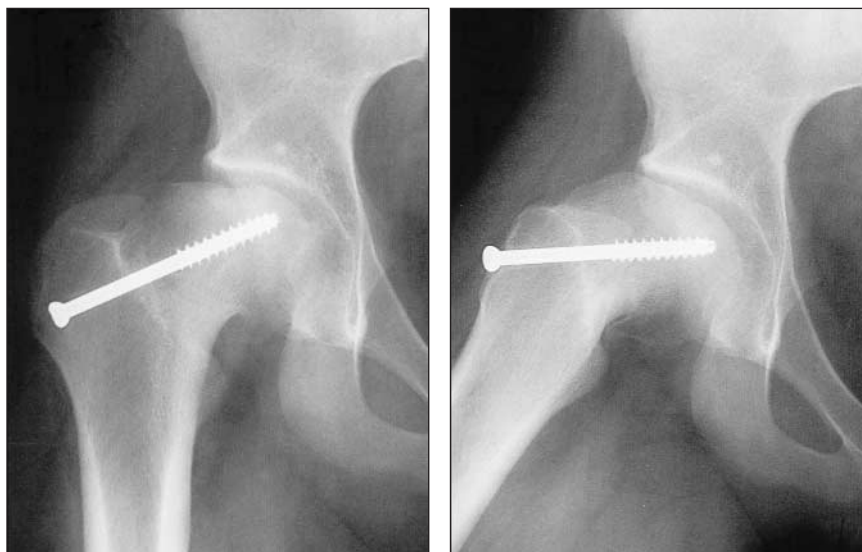


FIG. 2. Radiographs of a 14-year-old boy with a stable slip. The 2 cannulated screws were changed to 1 screw the day after the first operation because of joint penetration. The radiolucent area involves the anterolateral area of the head on both the anteroposterior (left x-ray) and frog-leg lateral (right x-ray) views.



FIG. 3. Left, a radiograph of a child with bilateral slipped capital femoral epiphysis, stable on the child's left and unstable on the right, who developed AVN. Right, a radiograph taken after removal of the right screw, 2 years later.

Table 2

Descriptions of the 4 patients who developed postoperative avascular necrosis

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4
Age at presentation	14 years	12 years	13 years	10 years
Sex	Male	Female	Male	Female
Side of slip	Right	Right	Right (of bilateral slips)	Left
Type of slip	Stable	Unstable	Unstable (left slip, stable)	Unstable
Grade	Moderate	Mild	Moderate	Mild
Time from presentation to operation	28 hours	72 hours	19 hours	36 hours
Manipulation	No	Yes	Yes	Yes, with skin traction
No. of screws	2 cannulated	1 ASINS	1 cannulated	1 cannulated
Range of motion, degrees				
FFD / forward flexion	0/85	10/110	0/120	30/60
Abduction /adduction	40/40	20/25	30/15	30/10
Internal/external rotation	20/70	-5/30	10/30	0/45
Postoperative pain	Limping, no pain	Pain, stiffness	Minimal pain	Walking with crutches
Degree of avascular necrosis	Lateral aspect of head	Advanced OA changes	Flat head with sclerosis	Advanced OA changes
Additional procedures	2 screws changed to a single screw, 1 day later	Proximal femoral triplane osteotomy	At fixation of left slip 2 yr postop, this screw was backed out a few turns because of head collapse	Derotation osteotomy of femoral diaphysis

FFD = fixed flexion deformity; OA = osteoarthritic; postop = postoperatively

does not necessarily contribute to the risk of AVN. We would concur with their view. Indeed, 1 patient in our series with an unstable slip was anatomically reduced in bed with Buck's traction while awaiting surgery, but nevertheless later developed total head AVN.

Ratney and associates¹⁵ also believe that a gentle reduction will not cause AVN and that the previously reported association of AVN with the reduction of the slipped epiphysis may be due to the confounding effect of the severity of the slip, in that a patient who had a severe slip may be more likely to have a reduction.

Although the number of patients in our unstable group was small, no correlation was found between AVN and reduction, timing of the reduction or severity of the slip. All 4 patients who developed AVN in our series (1 with a stable slip and 3 with unstable) were acute-on-chronic in the traditional classification.

It has been reported that AVN develops in unstable slips only.^{2,17} Our patient with the stable slip who developed AVN had a mild slip that

was fixed *in situ*; he had had hip pain for 4 months that was exacerbated by a minor fall 1 week before presentation. We changed this patient's fixation to a single screw the day after his operation because of joint penetration; the avascular area was localized to the antrolateral area of the epiphysis, and AVN was probably secondary to a pinning complication.

The transient penetration of the joint in that patient was unassociated with chondrolysis.¹⁸ In 4 other patients, transient penetration of the joint was noted and corrected during the procedure, with none exhibiting any symptoms or signs of chondrolysis. Our 1 case of chondrolysis did not have pin penetration and within 1 year recovered complete range of motion.

Slip progression secondary to continued physeal growth resulted in the epiphysis growing off the pins in 3 patients (1 in the stable and 2 in the unstable group). Their slip progression required repinning.¹⁰

The youngest patient in our group (5 years old) had bilateral slips; the right side was pinned and the left,

closely observed. Both joints had favourable outcomes.

This retrospective study of 114 slipped capital femoral epiphyses showed no association between the severity of the slip, the time to operation and the development of AVN. The case of avascular necrosis in the stable slip could have been related to the operative fixation. Gentle manipulative reduction appears to be a safe procedure that does not contribute to the development of AVN.

Acknowledgement: The authors are very appreciative of the secretarial support of Ms. Sue Ziebel in the typing of the drafts of this paper.

Competing interests: None declared.

References

1. Fahey JJ, O'Brien ET. Acute slipped capital femoral epiphysis. Review of the literature and report of ten cases. *J Bone Joint Surg Am* 1965;47:1105-27.
2. Loder RT, Richards BS, Shapiro PS, Reznick LR, Aronson DD. Acute slipped capital femoral epiphysis: the importance of physeal instability. *J Bone Joint Surg Am* 1993;75:1134-40.

3. Southwick WO. Treatment of severely slipped upper femoral epiphysis by trochanteric osteotomy. *AADS Instruct Course Lect* 1972;21:200.
4. Salvati EA, Robinson JH Jr, O'Down TJ. Southwick osteotomy for severe chronic slipped capital femoral epiphysis: results and complications. *J Bone Joint Surg Am* 1980;62:561-70.
5. Ingram AJ, Clarke MS, Clarke CS Jr, Marshall WR. Chondrolysis complicating slipped capital femoral epiphysis. *Clin Orthop* 1982;165:99-109.
6. Matava MJ, Patton CM, Luhmann S, Gordon JE, Schoenecker PL. Knee pain as the initial symptom of slipped capital femoral epiphysis: an analysis of initial presentation and treatment. *J Pediatr Orthop* 1999;19:455-60.
7. Kibiloski LJ, Doane RM, Karol LA, Haut RC, Loder RT. Biomechanical analysis of single- versus double-screw fixation in slipped capital femoral epiphysis at physiological load levels. *J Pediatr Orthop* 1994;14:627-30.
8. Loyd RD, Evans JP. Acute slipped capital femoral epiphysis. *South Med J* 1975;68:857-62.
9. Peterson MD, Weiner DS, Green NE, Terry CL. Acute slipped capital femoral epiphysis: the value and safety of urgent manipulative reduction. *J Pediatr Orthop* 1997;17:648-54.
10. Denton JR. Progression of a slipped capital femoral epiphysis after fixation with a single cannulated screw: a case report. *J Bone Joint Surg Am* 1993;75:425-7.
11. Tudisco C, Caterini R, Farsetti P, Potenza V. Chondrolysis of the hip complicating slipped capital femoral epiphysis: long-term follow-up of nine patients. *J Pediatr Orthop B* 1999;8:107-11.
12. Maletis GB, Bassett GS. Windshield-wiper loosening: a complication of *in situ* screw fixation of slipped capital femoral epiphysis. *J Pediatr Orthop* 1993;13:607-9. Comment, 1994;14:549-50.
13. Morrissy RT, Busch MT. Windshield-wiper loosening: a complication of *in situ* screw fixation of slipped capital femoral epiphysis [letter]. *J Pediatr Orthop* 1994;14:549-50.
14. Morrissy RT, editor. *Slipped capital femoral epiphysis*. No. 23 of Monograph Series. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2002.
15. Rattey T, Piehl F, Wright JG. Acute slipped capital femoral epiphysis: review of outcome and rates of avascular necrosis. *J Bone Joint Surg Am* 2002;78:398-402.
16. Maeda S, Kita A, Funayama K, Kokubun S. Vascular supply to slipped capital femoral epiphysis. *J Pediatr Orthop* 2001;21:664-7.
17. Kallio PE, Mah ET, Foster BK, Paterson DC, LeQuesne GW. Slipped capital femoral epiphysis: incidence and clinical assessment of physeal instability. *J Bone Joint Surg Br* 1995;77:752-5.
18. Zionts LE, Simonian PT, Harvey JP Jr. Transient penetration of the hip joint during *in situ* cannulated-screw fixation of slipped capital femoral epiphysis. *J Bone Joint Surg Am* 1991;73:1054-60.

THE MACLEAN-MUELLER PRIZE

Attention: Residents and surgical department chairs

Each year the *Canadian Journal of Surgery* offers a prize of \$1000 for the best manuscript written by a Canadian resident or fellow from a specialty program who has not completed training or assumed a faculty position. The prize-winning manuscript for the calendar year will be published in an early issue the following year, and other submissions deemed suitable for publication may appear in a subsequent issue of the Journal.

The resident should be the principal author of the manuscript, which should not have been submitted or published elsewhere. It should be submitted to the *Canadian Journal of Surgery* not later than Oct. 1.

Send submissions to: Dr. J.P. Waddell, Coeditor, *Canadian Journal of Surgery*, Division of Orthopaedic Surgery, St. Michael's Hospital, 30 Bond St., Toronto ON M5B 1W8.

