

A Single Cannulated Screw for Slipped Capital Femoral Epiphysis

Pornchai Mulpruek, M.D., M.Ch.(Orth.) Chathchai Pookarnjanamorakot, M.D.,
Wichien Laohacharoensombat, M.D., and Chanyut Suphachatwong, M.D.,

Department of Orthopaedics, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand.

ABSTRACT

Slipped capital femoral epiphysis is rare in Asiatic Indonesian-Malays. Six children (8 hips) with this condition including four boys (average age, 12.9 years) and two girls (average age, 13 years), were treated with a single cannulated screw (7mm) fixation. Four out of 6 cases were acute on chronic and mild slips. In evaluating the position of the screw, six out of eight hips had intermediate scores (3-4 points) and the remaining two hips had unfavorable scores (5 points).

The average follow up period was 2.6 years (range, 1.8-3 years). None of the slips progressed after the operative fixation. The average time of physeal fusion was 14.5 months (range, 12-16.5 months). There was no evidence of avascular necrosis or chondrolysis in any cases. In the clinical evaluation, five hips had good results, two hips had fair results and one had poor result. Using Kruskal-Wallis one - way analysis, there were no statistically significant relationships between the screw position and either the time to physeal fusion ($p > 0.105$) or the clinical results ($p > 0.052$).

INTRODUCTION

Slipped capital femoral epiphysis is a disorder in which there is an acute or gradual disruption through the physeal plate. The main objective of treatment is to prevent further slippage and promote the premature physeal closure. Previously, in situ fixation with multiple pins had been widely accepted as the treatment for either acute or chronic slips¹⁻⁶. However, several authors have reported the problem of pin penetration and the development of chondrolysis and avascular necrosis⁷⁻¹⁵. Walters and Simon⁷ presented evidence that chondrolysis was related to persistent pin penetration which occasionally remained unrecognized on radiographs. To minimize those complications, a single screw fixation was firstly suggested by

Morrissy¹⁶ and O' Beirne, et al¹⁷. Later, several authors reported satisfactory results after fixation with a single cannulated screw¹⁸⁻²². In this study, the authors aim to review the use a single cannulated screw fixation for the treatment of slipped capital femoral epiphysis.

MATERIALS AND METHODS

The medical records and radiographic studies of 8 patients (12 hips) who had slipped capital femoral epiphysis, (treated at Ramathibodi hospital between 1990 and 1996) were reviewed. Six of 8 patients (8 hips) matched the criteria for using a single cannulated screw as the fixation of the slip.

The data obtained from the medical records and radiographs included the patient's age and sex, the duration of symptoms, the severity of the slip, the appearance of the contralateral hip, the presence and assessment of the endocrine disorders, the position of the screw, and the time to physeal fusion.

In regard to the duration of symptoms, the slips were classified as chronic (having symptoms for 3 weeks or more), acute (having symptoms for less than 3 weeks), or acute on chronic (having an exacerbation of symptoms on chronic cases). For the bilateral simultaneous involvement, the hip with the longest duration of symptoms was considered to be the first affected hip.

The severity of the slip was determined from the radiographs of the hips in anteroposterior and lateral views and classified as mild (less than 1/3 displacement of the epiphysis on the metaphysis), moderate (1/3 - 1/2 displacement of the epiphysis on the metaphysis), severe slip (displacement more than 1/2 of the metaphysis width). A hip was designated as a pre-slip if there were symptoms of hip pain but without radiographic slippage, with or without physeal widening.

The lateral head-shaft angle was measured on the frog leg lateral radiograph of the hip (Fig. 1).

Endocrine disorders were assessed by physical examination and the serum levels of thyroid hormone (T4, FT4, TSH), cortisol, prolactin, and insulin.

After the diagnosis was made, all of the patients were admitted to the hospital and kept in bed with skin traction. On the day after admission, the operation was performed on a fracture-table under fluoroscopic control. In 5 patients (5 hips) with acute or acute on chronic slips, one trial of closed reduction under general anesthesia prior to the fixation was performed. The technique used in reduction was gentle traction of the extremity and internal rotation of the hip as much as possible to achieve the normal position. Two of these 5 patients who later had pain in the contralateral hip and were designated as pre-slip had the in situ fixation. The other case with chronic slip also had the in situ fixation. For the technique of fixation, the guide-pin was introduced through a stab skin incision and advanced through the neck into the epiphysis. Several attempts were occasionally necessary to place the pin in the center of the femoral head and perpendicular to the physis. A single 7 mm cannulated screw was then placed over the guide-pin in all cases. All of the operations were performed by one of us (P. M.).

In regard to the postoperative evaluation, the position of the screw was measured from the anteroposterior and lateral radiographs by the method described by Aronson²⁰, Goodman, et al²². The screw was in position 1 when its central axis was over the central line of the femoral head or within a distance equal to 1/2 the diameter of the screw. The screw was in position 2 when the distance between its axis and the center line of the femoral head was

between 1/2 and 1 screw-diameter, and in position 3 when its axis was more than 1 screw-diameter from the central line of the femoral head (Fig. 2). For statistical analysis, each position of the screw in anteroposterior and lateral views was scored, for example, 1 for position 1. Thus, the best position in 2 planes equaled a screw position score of 2 points (1+1 points), intermediate scores equaled 3 to 4 points (1+2 or 2+2 points). An unfavorable position was scored 5 points (2+3 points), the worst position in both radiographs was scored 6 points (3+3 points).

Serial follow-up radiographs were evaluated for physeal closure and the time to fusion. Physeal fusion was determined to have occurred when more than 75% of the physis had undergone linear closure.

The lateral head-shaft angle was measured on the frog-leg lateral radiograph of the hips. This was done during the preoperative, postoperative, and follow-up periods to evaluate the severity of the slips and to measure the slip progression.

Chondrolysis was determined by using the criteria of Ingram et al²³ when the cartilage space measured three mm or less.

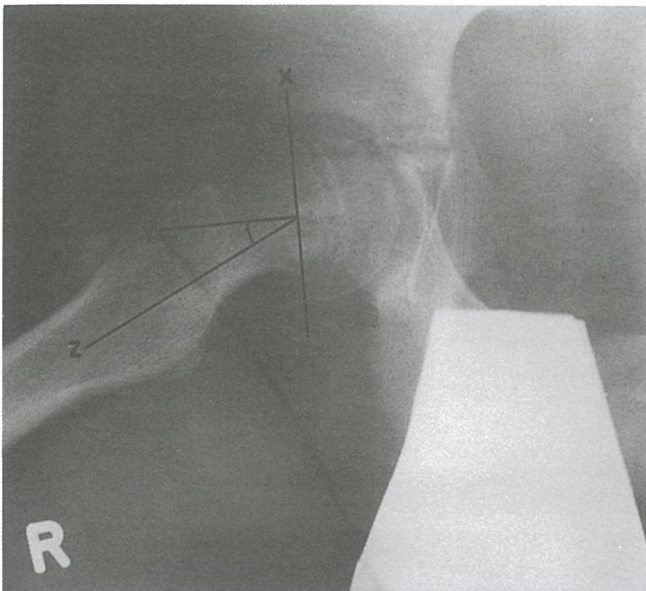


Fig. 1 The lateral head shaft angle is created by the intersection of a line drawn along the femoral shaft (Z) and a line (Y) perpendicular to a line drawn along the epiphyseal plate (X).

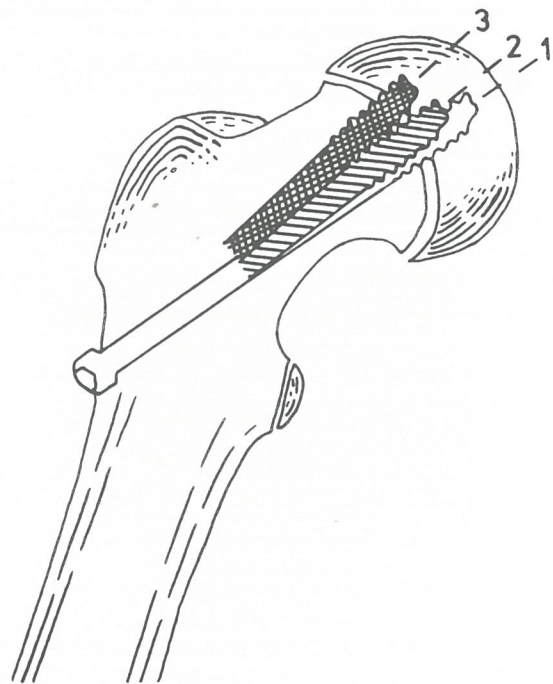


Fig. 2 Diagram showing the positions of the screw in the proximal part of the femur. In position 1, the central axis of the screw is located over the central line of the femoral head or within a distance equal to one-half the diameter of the screw; in position 2, the distance between the axis of the screw and the central line of the femoral head is equal to between one-half and one screw-diameter; and in position 3, the axis of the screw is located more than one screw-diameter from the central line of the femoral head.

At the time of the study the patients were recalled for clinical as well as radiographic evaluation of the hips. The results were classified as excellent, good, fair, poor, and failed according to the range of motion of the hip, limping, and pain as suggested by Heyman and Herndon²⁴. For an excellent result, the patient had to have a normal range of motion of the hip, no limp, and no pain. For a good result, slight limitation of internal rotation, no limp, and no pain; for a fair result, limitation of abduction and internal rotation but no pain or limp; for a poor result, slight limitation of abduction, internal rotation, and flexion, slight pain after strenuous exercise, and mild limp; and for a failure result, pain with activity, limp, and marked limitation of motion that would lead to a reconstructive procedure.

RESULTS

There were four boys (average age, 12.9 years) and two girls (average age, 13 years), giving a ratio of 2 to 1. Both hips were affected in two of six cases (33%). In one patient, the right hip alone was affected and in three, the left (Table 1). None of the patients had endocrine disorders in this study.

The most common clinical presentation was anterior thigh pain (5 cases). Only one case presented limping and groin pain. The duration of symptoms ranged from 2 to 40 weeks. Most of the patients had acute on chronic slips

(4 cases). On physical examination, various degrees of external rotation of the affected sides as well as the antalgic gait were noted in all cases. All of the patients had mild slips. Concerning the hip on the opposite sides in the cases with bilateral involvement, one asymptomatic case had limitation of internal rotation of the hip and the trethowan sign on radiographic evaluation (Fig.3). In the other case with bilateral involvement, the second groin pain developed nine months after the first hip and the radiographic study revealed the acute stage of mild slip.

In the postoperative evaluation of the screw position in 8 hips, most of the patients (6 hips) had intermediate scores (3-4 points) (Fig. 4) and the unfavorable position (5 points) was noted in two hips (Fig. 5). None of the patients had the best position of the screw (2 points). There was slight improvement of the lateral head-shaft angle on the immediate postoperative radiographs.

The average follow-up period was 2.6 years (range 1.8 - 3 years). None of the slips progressed after the operative fixation. There were no significant changes of the lateral head-shaft angle from the postoperative radiographs to the follow-up studies. The average time of physal fusion was 14.5 months (range 12 - 16.5 months) (Fig. 6). Clinical evaluation using the criteria of Heyman and Herndon (Table 2) at the time of the study, five hips had good results, two hips had fair and one hip had poor a result. Neither excellent nor failure result was observed. In the case with a poor result, there was only a slight limita-

Table 1. Patient data on admission

Case	Age	Gender	Side	Duration of symptom	Type of slip	Grade	Head shaft angle
1	13.4	M	R	3 Mo	AC	mild	28°
2	12.3	F	L	3 Mo	AC	mild	31°
3	13.8	F	R/L	2 Wk	A	mild/pre slip	31°/25°
4	13.2	M	L	10 Mo	C	mild	32°
5	11.8/12.7	M	R/L	4 Mo / 3 Wk	AC / A	mild/pre slip	34°/28°
6	13.4	M	L	6 Mo	AC	mild	30°

Table 2. Relationship between screw position, time to physal fusion and clinical results.

Case	screw position score / side	physal fusion (months)	clinical results
1	4 / R	12	fair
2	5 / L	12	fair
3	4 / R	14	good
	3 / L	14.5	good
4	5 / L	14	poor
5	4 / R	16.5	good
	4 / L	14.5	good
6	3 / L	14	good

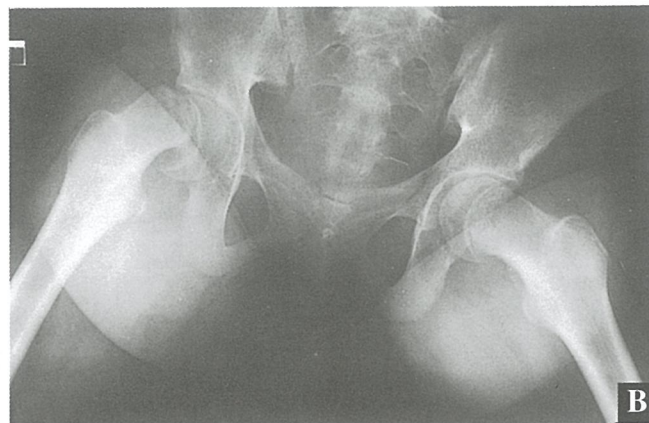
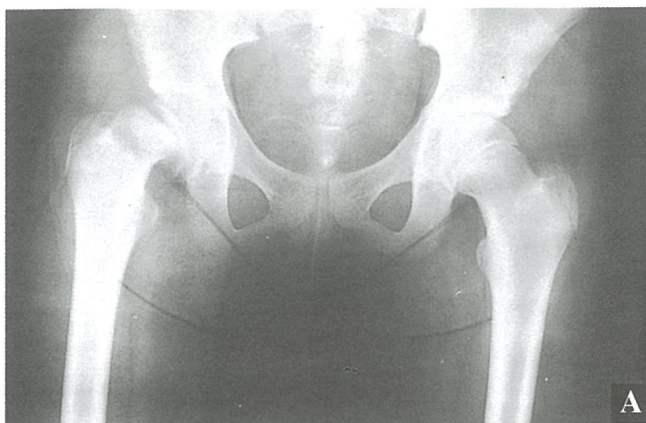


Fig. 3 (A-B) The radiographs of case No. 3, a female 13.8 years old, showed a mild slip of the right hip and asymptomatic pre-slip stage of the left hip.

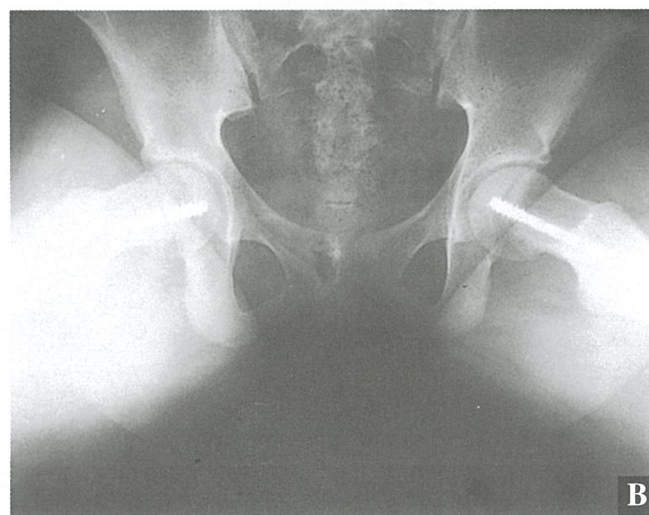
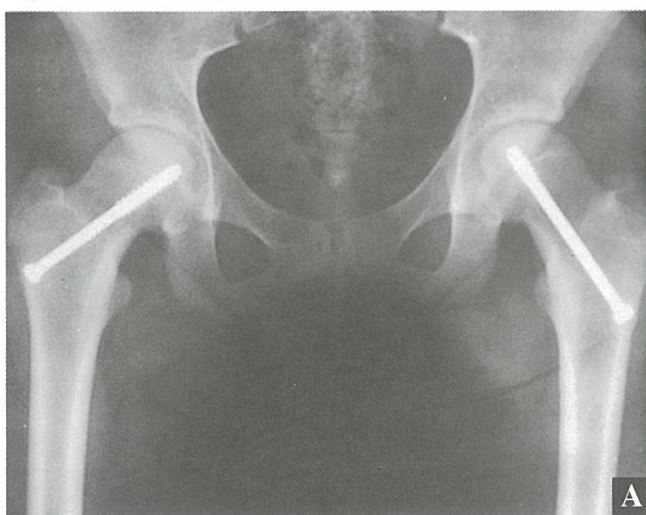


Fig. 4(A-B) The radiographs of case No. 3, showed the fixation with a single cannulated screw on each side. The screws on both sides were placed in position 2 on both anteroposterior (A) and lateral view (B), therefore were determined as intermediate score (4 points).

tion of the range of motion and a mild limp even though there was no pain with exercise.

There was no evidence of avascular necrosis and chondrolysis in any of the patients in this study. The screw position score was compared with the time to physeal fusion and with clinical result using the Kruskal-Wallis one-way analysis of variance. There was no statistically significant relationships of the screw position with either the time to physeal fusion ($p > 0.105$) or the clinical result ($p > 0.052$).

DISCUSSION

The aim of the treatment in slipped capital femoral epiphysis is to prevent further slippage and promote premature closure of the physis. Previously in situ fixation of the femoral head with multiple pins or screws is a well-known and commonly used method of treatment in mild

and moderated cases¹⁻⁶. However several authors have reported serious complications including penetration of the pin resulting in chondrolysis and avascular necrosis⁷⁻¹⁵. The prevalence of these complications has been reported to range from 4 to 55 percent and they have been associated with poor results^{9,10,12,18,19}. Theoretically, it is reasonable enough to assume that increasing the number of pins or screws will increase the chance of injuring the blood supply as well as penetration into the joint. Therefore, to prevent those complications a single screw fixation was first introduced by Morrisy¹⁶. Later several authors reported satisfactory results with a single cannulated screw with which the surgical technique is more practical than the previous type¹⁸⁻²¹.

Karol, et al²⁵, in an animal study, reported a 30% increase in stiffness with the double screw compared with single screw fixation. However, the authors recommended single screw fixation because the small gain in stiffness

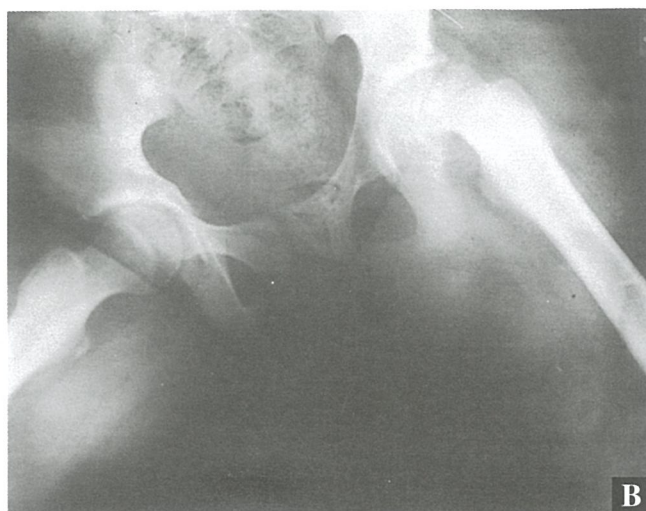
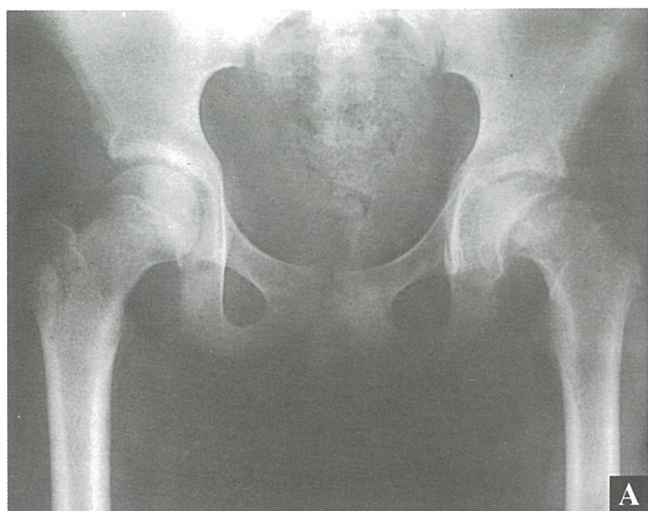


Fig. 5 (A-D) (A-B) The radiographs of case No. 2, a female 12.3 years old showed a mild slip of the left hip. The screw was placed in position 2 on anteroposterior (C) and position 3 on lateral view (D). The result was defined as unfavorable position (5 points).

did not offset the risk of complications. Kibiloski, et al²⁶, reported the slight differences in the rate of creep between double and single screw fixation for slipped capital femoral epiphysis when subjected to physiologic shear loads.

Slipped capital femoral epiphysis is rare in South East and East Asia. Loder²⁷ reported that the relative frequency compared with the white population was only 0.5 for the Asiatic Indonesian-Malays [Japanese, Chinese, Filipino, Thai, Vietnamese]. Therefore, in this study we present a small number of patients. Our previous study confirmed that obesity is the important factor related to the etiology²⁸. We also had satisfactory results with the single screw fixation including the cancellous and cannulated types. At the present time we use only the cannulated screw for fixation as the technique is much easier.

Physeal fusion was demonstrated in all of eight hips after fixation with a single cannulated screw. The diameter of the threads of the screws in our study was seven millimeters. The large size of the screw was chosen in order to obtain maximum stability of the slips. There were no significant changes of the lateral head-shaft angle when the postoperative radiographs were compared to the follow-up radiographs. The time to fusion averaged 14 months, which is longer than our previous report and in the literature²⁰⁻²². This is probably due to the rigorous criteria for fusion which was defined as more than 75 per cent physeal closure seen on both anteroposterior and frog - leg lateral radiographs. These results confirm that a single cannulated screw fixation is sufficient for prevention of further slippage and promotion of physeal closure.

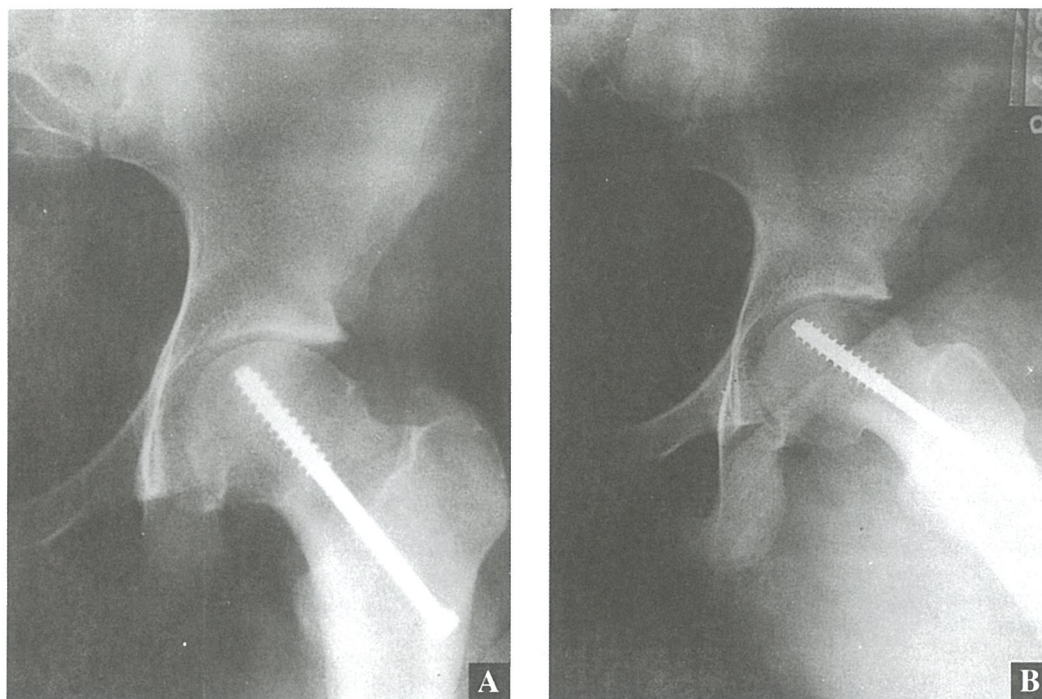


Fig. 6 (A-B) The anteroposterior (A) and lateral (B) radiograph of case No. 2 showed fusion of physeal plate.

It is accepted that to obtain the best result, the screw's central positioning as well as the perpendicular direction to the physeal are the main objectives of fixation. We were successful in placing the screw in the best position in only one hip. Most of the patients had intermediate scores (5 hips). The main reason is that the condition is rare and requires skill using the technique of fixation. As the slip occurs towards the posterior direction, the entry point of the screw is limited to only the anterior part of the neck. Therefore, this could be rather difficult for surgeons who had experience with this condition only once or twice a year. Nevertheless, from the clinical evaluation, there was only one case with a poor result. The relationship between screw position score and clinical results was not statistically significant ($p > 0.052$). This was probably due to the small sample size. Also, there were no statistically significant relationships between screw position and time to physeal closure ($p > 0.105$). From our study, we believe

that the placement of a single cannulated screw not more than one screw-diameter away from the center of the femoral head could give satisfactory results.

In conclusion, from our review, we had the satisfactory experience with a single cannulated screw fixation in the treatment of acute, acute on chronic and chronic, slipped capital femoral epiphysis. A single screw fixation could provide adequate epiphyseal stability as there was no further slip and physeal fusion occurred in all cases. There were no serious complications such as avascular necrosis, penetration of screw into the joint, or chondrolysis in this study.

ACKNOWLEDGEMENT

We wish to thank Ms. Kulsuda Jiamsuchon from the Statistical Unit, Ramathibodi Hospital, for her advice on analysis of the data.

REFERENCES

1. Schnute W. Slipped capital femoral epiphysis. Clin Orthop 1958 ; 11 : 63.
2. Newman PH. The surgical treatment of slipping of the upper femoral epiphysis. J Bone Joint Surg(Br) 1960; 42 : 280.
3. O' Brien ET, Fahey JJ. Remodelling of the femoral neck after in situ pinning for slipped capital femoral epiphysis. J Bone Joint Surg(Am) 1977; 59 : 62-8.
4. Boyer DW, Mickelson MR, Ponseti IV. Slipped capital femoral epiphysis. Long-term follow up of one hundred and twenty-one patients J Bone Joint Surg(Am) 1981 ; 63 : 85-95.
5. Kulick RG, Denton JR. A retrospective study of 125 cases of slipped capital femoral epiphysis. Clin Orthop 1982 ; 162 : 87-90.
6. Zahrawi FB, Stephens TL, Spencer GE, Clough JM. Comparative study of pinning in situ and open epiphysiodesis in 105 patients with slipped capital femoral epiphysis. Clin Orthop 1983 ; 177 : 160-8.
7. Walters R, Simon SR. Joint destruction : a sequel of unrecognized pin penetration in patients with slipped capital femoral epiphysis. In : The Hip. Proceeding of the eight open scientific meeting of the hip society. St. Louis : C.V. Mosby, 1983 : 145-64.
8. Cameron HU, Wang M, Koreska J. Internal fixation of slipped capital femoral epiphysis. Clin Orthop 1978 ; 137 : 148-53.
9. Bennet GC, Koreska J, Rang M. Pin placement in slipped capital femoral epiphysis. J Pediatr Orthop 1984 ; 4 : 574-8.
10. Greenough CG, Bromage JD, Jackson AM. Pinning of the slipped upper femoral epiphysis a trouble-free procedure ? J Pediatr Orthop 1985 ; 5 : 657-60.
11. Hagglund G, Hansson LI, Sandstrom S. Slipped capital femoral epiphysis in southern Sweden. Long term results after nailing / pinning. Clin Orthop 1987 ; 217 : 190-200.
12. Lehman WB, Menche D, Grant A, Pugh J. The problem of evaluating in situ pinning of slipped capital femoral epiphysis : an experimental model and a review of 63 consecutive cases. J Pediatr Orthop 1984 ; 4 : 297-303.
13. Reiley PM, Weiner DS, Gillespie R, Weiner SD. Hazards of internal fixation in the treatment of slipped capital femoral epiphysis. J Bone Joint Surg (Am) 1990 ; 72 : 1500-9.
14. Stambough JL, Davidson RS, Ellis RD, Gregg JR. Slipped capital femoral epiphysis : an analysis of 80 patients as to pin placement and number. J Pediatr Orthop 1986 ; 6 : 265-73.
15. Swiontkowski MF. Slipped capital femoral epiphysis. Complication related to internal fixation. Orthopedics 1983 ; 6 : 705-12.
16. Morrissey RT. In situ fixation of chronic slipped capital femoral epiphysis. In : Instructional course lecture. American Academy of Orthopaedic Surgery 1984 ; 33 : 319-27.
17. O' Beirne J, McLoughlin R, Dowling F, Forgarty E, Regan B. Slipped upper femoral epiphysis : Internal fixation using single central pins. J Pediatr Orthop 1989 ; 9 : 304-7.
18. Koval KJ, Lehman WB, Rose D, Koval RP, Grant A, Strongwater A. Treatment of slipped capital femoral epiphysis with a cannulated-screw technique. J Bone Joint Surg (Am) 1989 ; 71 : 1370-77.
19. Mann D, Waddington J. Slipped capital femoral epiphysis. Result of treatment with a single cannulated screw. Orthopedics 1989 ; 12 : 251-5.
20. Aronson DD, Carson WE. Slipped capital femoral epiphysis. A prospective study of fixation with a single screw. J Bone Joint Surg (Am) 1992; 74 : 810-9.
21. Ward WT, Stefkow J, Wood DB, Staniski CL. Fixation with a single screw of slipped capital femoral epiphysis. J Bone Joint Surg (Am) 1992; 74 : 799-809.
22. Goodman WW, Johnson JT, Robertson WW. Single screw fixation for acute and acute-on-chronic slipped capital femoral epiphysis. Clin Orthop 1996 ; 322 : 86-90.
23. Ingram AJ, Clarke MS, Clark CS Jr, Marshall WR. Chondrolysis complicating slipped capital femoral epiphysis. Clin Orthop 1982 ; 165 : 99-109.
24. Heyman CH, Herndon CH. Epiphysiodesis for early slipping of the upper femoral epiphysis. J Bone Joint Surg (Am) 1954 ; 539-54.
25. Karol LA, Doane RM, Cornicelli SF. Single versus double screw fixation for treatment of slipped capital femoral epiphysis : a biomechanical analysis. J Pediatr Orthop 1992 ; 12 : 741-45.
26. Kibiloski W, Doane RM, Karol LA, Haut RC, Loder RT. Biomechanic analysis of single versus double screw fixation in slipped capital femoral epiphysis at physiologic load levels. J Pediatr Orthop 1994 ; 14 : 627-30.
27. Loder RT. 47 co-investigators. The demographics of slipped capital femoral epiphysis. Clin Orthop 1996 ; 332 : 8-27.
28. Mulpruek P, Laohachareonsombat W, Mahachoklertwattana P, Pookarnjanamorakot C. Slipped capital femoral epiphysis in Ramathibodi hospital. J Med Assoc Thailand 1997 ; 80 : 447-53.