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Treatment of Slipped Upper Femoral Epiphysis with In-Situ Pinning

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ABSTRACT

Background: There is no absolute agreement on how to best treat slipped capital femoral epiphysis (SCFE). Different clinical presentations, different classifications, and different surgical procedures that have been described led to disagreements and different trends. At the moment, there are no recommendations based on facts. Different surgeries can be broken down into fixation in place, compensatory osteotomies, and direct corrections of the deformity at the head-neck junction.

Objective: This study aimed to assess the outcomes of patients with mild to moderate slipped capital femoral epiphysis treated with in situ pinning.

Patients and methods: A prospective study on eighteen patients (23 hips), with mean age of 13.11 ± 1.53 years, presented with mild to moderate SCFE, in situ fixation was used to treat them. Patients with mild to moderate slipped capital femoral epiphysis confirmed clinically and radiologically. Pre-slip and bilateral cases in the high-risk patients were included. Patients with severe SCFE were excluded.

Results: There was a significant relationship between outcome and complications where all patients with fair outcomes were complicated and all those with excellent outcomes were uncomplicated.

Conclusion: Treatment with in situ pinning for pre slip and slipped capital femoral epiphysis that were mild to moderate was taken into account as an effective method in treatment and gave good results with a low complication rate.

Keywords: Slipped capital femoral epiphysis, Pinning in situ, Surgical hip dislocation.

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is the most prevalent hip problem in teenagers. It is the posterior and inferior slippage of the proximal femoral epiphysis on the metaphysis (femoral neck) (growth plate) [(1)]. The term slipped capital femoral epiphysis is a misnomer because the femoral epiphysis retains its normal connection within the acetabulum. The femoral neck and shaft shift upwardly and anteriorly relative to the femoral epiphysis [(2)]. The prevalence of SCFE is 3-10/100,000, the boy/girl ratio is 1.4/1, and it's more common in blacks. The most common age is 10-16 [(3)].

Most are "idiopathic." Atypical SCFEs are caused by endocrine (hypothyroidism, panhypopituitarism) or renal failure. Radiotherapy, osteodystrophy, and mechanical factors that increase stress on the growth plate such as obesity and trauma **[(4)]**.

Clinically, the patient presents with limping and externally rotated limb with possible shortening, and discomfort that is only marginally confined to the knee, thigh, hip, or groin. Rarely, they have a history of trauma [(1)]. Plain x-rays of both hips (anteroposterior/ lateral views) are used to confirm the diagnosis [(5)].

Due to either the atypical presentation, such as knee discomfort, or the chronic nature of the presentation, the diagnosis is frequently delayed or ignored. There is a link between delayed diagnosis and greater complication rates [(1)].

The treatment of this pathology is operative. In situ pinning is the currently recommended procedure for hips with mild to moderate SCFE, and it typically produces positive functional and radiological results. Treatment for hips with severe SCFE involves a modified Dunn technique [(2)].

The purpose of in situ pinning is to fix the epiphysis and prevent further slippage. This technique has good long-term results [(6)]. It's a safe and simple technique. It prevents problems like chondrolysis, avascular necrosis, and femoroacetabular impingement [(7)].

As a result, we sought to assess the outcomes of patients with mild to moderate slipped capital femoral epiphysis treated with in situ pinning.

PATIENTS AND METHODS

A prospective study on eighteen patients (23 hips), between 10 and 16 years of age, presented with mild to moderate SCFE, were treated with in situ fixation at Zagazig University Hospitals, during the period from December 2021 to May 2022.

All patients were followed up for 6 months. Patients with mild to moderate slipped capital femoral epiphysis confirmed clinically and radiologically, pre-slip and bilateral cases in the high-risk patient were included. Patients with severe SCFE were excluded.

Preoperative assessment:

- **History:** Complete history: age, gender, weight, and height. The presence of hip or knee pain, the affected side (right or left), and whether it is unilateral or bilateral. Symptoms persistence. Ability to bear

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weight, history of recent trauma, previous medical history, as well as any medications the patient is currently taking and family history, particularly of metabolic or endocrine disease.

- **Examination:** A general physical examination was performed, as well as a full hip and knee examination, to determine the patient's body mass index (BMI) = weight/square of height by meter (Kg/m^2).

Laboratory investigation: All patients had a full preoperative routine lab investigation before surgery.

Radiological assessment: Standard radiography, Plain x-ray of both hips (anteroposterior/frog-leg lateral views).

Surgical technique:

The patient was positioned on the fracture table. Under general or spinal anesthesia, the affected leg was held in extension, the patella facing anteriorly, and the limb in neutral to slight internal rotation and slight abduction. In two hips of unstable slips, the epiphysis was reduced to some extent in this position. No further efforts for reduction, internal rotation of the affected limb just until the patella becomes neutral. The contralateral limb was positioned in wide abduction and extension in traction or flexed and abducted to clear it from the lateral fluoroscopic view.

The C-arm fluoroscope was confirmed to be working well and the femoral epiphysis was visible on both AP and lateral views. The ideal placement of a single cannulated screw was close to the center of the capital epiphysis and perpendicular to the physis. Because of the typical posterior displacement of the femoral epiphysis on the neck, the entry point of the guidewire was located on the anterior base of the femoral neck. The exact location varied with the severity of the slip. In 8 hips of moderate slips, the entry point was farther anteriorly, and in 11 hips of mild slips, 4 cases pre-slip, the entry point was on the lateral femoral cortex.

The position and direction of the guidewire were identified under fluoroscopy on both the AP and lateral views. Marked on the patient's skin by placing a free guidewire against the skin, the intersection of these two lines indicates the proper point of insertion of the guide wire (triangulation technique).

A stab incision in the skin was made at this point. The guide wire was inserted and pushed into the base of the femoral neck. The location and orientation of the guide wire were confirmed fluoroscopically. The guidewire was advanced into the epiphysis, aiming at the center of the femoral head on both fluoroscopic views to a level within 5 mm of the subchondral bone without penetrating the joint space. In 2 hips of unstable SCFE, second guide pin was placed in the posterior-inferior aspect of the femoral epiphysis. If the location of the guide wire was not ideal, it could be repositioned or temporarily left in place as a guide for the insertion of the second guide wire in the proper position. The guidewire was measured with the cannulated depth gauge instrument and a screw of appropriate length was selected. The bone was drilled and tapped with cannulated instruments advanced over the guidewire.

Several fluoroscopic checks (AP and lateral) were made during drilling and tapping. The screw was inserted over the guidewire and advanced until five threads engaged the epiphysis. After satisfactory placement of the screw had been confirmed, the guidewire was removed. We do not try to achieve compression between the femoral cortex and the threads of the screw, and the screw head was not left protruding more than a few millimeters, because it may irritate the soft tissues and cause symptoms. A stab incision was closed with absorbable subcutaneous and skin sutures.

A sterile dressing was placed over the wound. The limb was released from traction and the hip was placed through a range of motion and careful assessment to ensure that the screw did not penetrate the joint space.

In cases of bilateral slips, positioning and draping procedures were usually staged side by side.

Postoperative Management:

- We examined the surgical site on the first post-operative day. We allowed partial weight bearing with crutches for stable SCFE as soon as the patient was comfortable, which was usually within 24 hours of surgery. Weight bearing was prohibited for 6 weeks in patients with unstable SCFE.
- The stitches were removed two weeks after surgery.
- Crutches should be used for partial weight bearing for the first 6 weeks.
- Athletic activities were permitted after three months, but vigorous sports and activities were prohibited until the physis was closed.

All patients were monitored in the outpatient clinic as follows:

- The stitch was removed after 2 weeks of monitoring.
- Follow up of the patient clinically and radiologically after 3 and 6 months.

Follow up:

We assessed the patient in the follow-up:

- **Clinical evaluation:** The clinical outcomes were assessed using the **Modified Harris Hip Score [8]**, which includes the following items:

- **Radiological evaluation:**

Anteroposterior and frog-leg lateral views of the pelvis and both hips were taken after surgery and looked at two weeks, every month until three months, and then at three and six months. All radiographs were looked at to measure the Southwick angle before and after surgery and to look for signs of osteonecrosis, such as increased density of the femoral head followed by its eventual collapse.

Ethical Approval:

After explanation of the all rights, an informed consent was signed by each patient before participation in this study. Before conducting the study, an ethical approval was taken by The Institutional Review Board of Faculty of Medicine, Zagazig University. The conduction of the current study was matched with the Declaration of Helsinki Guidelines for Human Research.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 20.0 software was used. Qualitative data were expressed as numbers and percentages and continuous quantitative data were represented as mean and standard deviation. The following tests were used to see if differences were significant: Chi-square test for difference and association of qualitative variables (X^2) and t-test, paired by paired t. P value at 0.05 for significant results and 0.001 for highly significant results for differences between quantitatively independent groups.

RESULTS

Patient demographics:

This study included 18 patients with an age range of 10 to 16 years, and a mean age of 13.11 ± 1.53 years. Males represented 66.7% of them. Their body mass index (BMI) ranged from 23 to 32 kg/m^2 with a mean of 26.7 kg/m^2. As regards the side of lesion, thirteen patients (72.2%) of them had unilateral lesions and the remaining four patients had bilateral lesions (27.8%).

Twenty-three limbs were included; 52.2% of them were right-sided lesions. As regards the stability of slip, 91.3% were stable and 8.7% were unstable.

Regarding the degree of slip, about 48% of patients had a mild slip, 34.8% had a moderate slip, and 17.4% had pre slip (Table 1).

Table (1): Distribution of the studied patients according to baseline data

	N=18	%
Gender:		
Female	6	33.3%
Male	12	66.7%
Age (year):		
Mean ± SD	13.11± 1.53	
Range	10 – 16	
BMI		
Mean ± SD	26.65± 3.01	
Range	23 – 32	
Laterality:		
Bilateral	5	27.8%
Unilateral	13	72.2%
Side:	**N=23**	
Left	11	47.8%
Right	12	52.2%
Stability:		
Stable	21	91.3%
Unstable	2	8.7%
Degree of slip:		
Pre slip	4	17.4%
Mild	11	47.8%
Moderate	8	34.8%

On preoperative radiographs, there were 4 preslip (17.4 %), 11 mild (47.8%) and 8 moderate (34.8%) SCFE. The mean pre-operative Southwick angle was 26.1± 10.4. At the last follow-up, the mean Southwick angle was 26.7±11.02. Only one hip of moderate slip showed progression of 12 degrees and further slippage was prevented in 22 hips (95.7%). In our series, there were no cases of chondrolysis or avascular necrosis at the last follow-up. We evaluated the clinical results of the study using a modified Harris Hip score, 69.6% had an excellent outcome, 21.7% had a good outcome, and 8.7% showed a fair outcome (table 2).

Table (2): Distribution of the patients according to postoperative modified Harrison score

	N=23	%
Score:		
Fair	2	8.7%
Good	5	21.7%
Excellent	16	69.6%

Complications

In our series, one hip had slip progression (4.3%), after 6 months of follow up, the case was moderate slip, stable type, known case of hypothyroidism, Southwick angle progressed from 32 to 43 degrees and the patient was planned for revision. Two hips had impingement (8.7%), after 6 months of follow up, the two hips were moderate type. Twenty hips (87.0%) had no radiological evidence of any possible other complications, such as hardware failure or the presence of signs of osteonecrosis (Table 3).

Table (3) Distribution of the hips according to complications:

	N=23	%
Complications:		
No	20	87.0%
Impingement	2	8.7%
Slip progression	1	4.3%

There was a non-significant statistically relationship between the outcome and either age, gender, or body mass index (table 4).

Table (4): Relation between postoperative outcome by mHHS-8 and demographic data

Parameter	mHHS-8			Test	
	Fair N=2 (%)	Good N=4(%)	Excellent N=12(%)	χ^2/F	p
Gender:					
Female	0 (0%)	1 (25%)	5 (41.7%)	1.398	0.237
Male	2 (100%)	3 (75%)	7 (58.3%)		
Age (year), Mean ± SD	12.0 ± 2.83	13.75±0. 96	13.08 ± 1.51	0.864	0.441
BMI (kg/m^2), Mean ± SD	30.5 ± 0.71	26.0 ± 0.95	26.44 ± 3.14	1.949	0.169

There was a non-significant statistically relation between the outcome and either side or stability. There was a significant relationship between outcome and degree of slip where all patients with fair outcomes had a moderate slip (Table 5).

Table (5): Relation between postoperative outcome by mHHS-8 and disease-specific data

Parameter	mHHS-8			Test	
	Fair	Good	Excellent	χ^2	p
	N=2 (%)	N=5(%)	N=16(%)		
Side:					
Right	1 (50%)	1 (20%)	10 (62.5%)	1.163	0.281
Left	1 (50%)	4 (80%)	6 (37.5%)		
degree of slip:					
pre slip	0 (0%)	2 (40%)	2 (12.5%)	MC	<0.001**
Mild	0 (0%)	0 (0%)	11 (68.8%)		
Moderate	2 (100%)	3 (60%)	3 (18.8%)		
Stability:					
Unstable	1 (50%)	0 (0%)	1 (6.2%)	1.88	0.17
Stable	1 (50%)	5 (100%)	15 (93.8%)		

There was a significant relationship between outcome and complications where all patients with fair outcomes were complicated and all those with excellent outcomes were uncomplicated (table 6).

Table (6): Relation between postoperative outcome by mHHS-8 and complications

Parameter	mHHS-8			Test	
	Fair	Good	Excellent	χ^2	p
	N=2 (%)	N=5(%)	N=16(%)		
Complications: Absent	0 (0%)	4 (80%)	16 (100%)	13.025	<0.001**
Present	2 (100%)	1 (20%)	0 (0%)		

There was a non-significant relationship between complications and age, gender, or body mass index (table 7).

Table (7): Relation between complications and demographic data

	Complications			
	Absent N=15 (%)	**Present N=3 (%)**	**χ^2/t**	p
Gender:				
Female	5 (33.33%)	1 (33.3%)	Fisher	0.515
Male	10 (66.66%)	2 (66.66%)		
Age (year)				
Mean ± SD	13.27 ± 1.44	12.33 ± 2.08	0.963	0.35
BMI (kg/m^2)				
Mean ± SD	26.35 ± 2.96	29.0 ± 2.65	-1.46	0.159

There was a significant relationship between the outcome and the initial slippage degree**.** While, there was non-significant relation between outcome and either side, stability (table 8).

Table (8): Relation between complications and disease-specific data

	Complications		**Test**	
	Absent N=20 (%)	**Present N=3 (%)**	**χ^2**	**p**
Side:				
Right	9 (45%)	2 (66.7%)	Fisher	0.59
Left	11 (55%)	1 (33.3%)		
Laterality:				
Unilateral	12 (80%)	1 (33.3%)	Fisher	0.172
Bilateral	3 (20%)	2 (66.7%)		
Degree of slip:				
pre slip	4 (20%)	0 (0%)		
Mild	5 (25%)	0 (0%)	0.546	0.46
Moderate	11 (55%)	3 (100%)		
Stability:				
Unstable	19 (95%)	2 (66.7%)	Fisher	0.249
Stable	1 (5%)	1 (33.3%)		

DISCUSSION

In our study, there were 23 SCFE hips. 11 hips (47.8%) had mild slip, and 8 hips (34.8%) had moderate slip, while 4 hips (17.4%) had pre-slips. They were fixed in place with pins. There were 16 patients who had stable SCFE fixed with a single screw, and two patients who had unstable SCFE were fixed with two screws. The patient's ages ranged from 10 to 16 years old, with the majority being males (66.7%), while females were 33.3%. The left side was in 11 hips (47.8%) of the cases, and the right side in 12 hips (52.2%), with bilateral involvement in 5 cases (27.8%).

Erden *et al.* [3] found that the age ranged from 10 to 16 years old. Bilateral involvement in SCFE was around 20-25% [3]. According t**o Loder *et al.*** [9] age ranged from 8 to 15 years old, and bilaterality ranged from 18 to 50%. In our study, the male to female ratio was 2:1, which agrees with the previous reports of **Song *et al.*** [10], which showed a ratio with variations from 1.1:1 up to 4.1:1. **Lehmann *et al.*** [11] found that SCFE affects males more than females and found an overall male-to-female ratio of 1.65:1.

The current study revealed that 87% of the studied patients had no complications, and 13% had a complication. There was a significant relationship between outcome and initial slippage degree, where all patients with fair outcomes had a moderate slip.

Macía-Villa *et al.* [12] reported 91%-95% success using the technique of in situ fixation with a single screw in mild and moderate SCFE. **Nectoux *et al.*** [13] suggest that the functional prognosis of cases of SCFE treated with in situ pinning is directly proportional to the initial slippage degree. Regarding the number of screws used for fixation, we used in our study one screw fixation for stable SCFE (21 hips) and two screw fixations for unstable SCFE (2 hips), which agrees with **Kishan *et al.*** [14] who supported the use of 2 screws in acute or unstable SCFE fixation. With more screws, there is a greater chance that one will accidentally go into the joint. This needs to be weighed against the biomechanical benefit of two screws.

Santili *et al.* [15] reported that effectiveness of in situ fixation using single/double screws both in stable or unstable SCFE found no difference, and slippage progression did not exceed 10 degrees.

Amara *et al.* [16] reported that the complication of using more than one screw can penetrate the joint cavity if the slip angle is more than 60 degrees.

In our study, we used screws that were partially threaded**. Samelis *et al.* [17]** found that non-threaded pins can move, which can cause slips to happen again. Thin pins can get bent. The implant may leave the femoral neck and go into the posterior-superior part of the femoral head. At this point, the epiphysis's blood vessels that bring food to it could be hurt. If the femoral neck keeps growing, the epiphysis may separate from a pin that doesn't have threads and slide further down the femoral neck.

Regarding slip progression, in our study, occurred only in one case (4.3%) with moderate slip. **Carney *et al.* [18]** found that 20% of the time, slippage got worse after a single cannulated screw was used to fix the bone in place. On the postoperative frog-leg lateral radiograph, the progression of the slip seemed to be inversely related to the number of screw threads that are engaged in the epiphysis. It seems right to say that the screw should be tightened until five threads touch the epiphysis.

In our study, we found impingement in 2 hips (8.7%) with moderate slip, and no avascular necrosis or chondrolysis were seen. **Samelis *et al.* [17]** found that depending on how bad the fall was, FAI becomes painful months or years after surgery because of permanent damage to the labrum and/or articular cartilage. FAI is a strong possibility in any hip that has slipped and has limited internal rotation (100) at 90° of flexion or can't bend more than 90°. All serious slips are made worse by this interference, as are 50% of moderate slips and 33% of mild slips. Labral lesions show up between the 10th and 3rd hour of the acetabulum 6 to 12 months after the start of the slip.

CONCLUSION

Our study supported evidence that treatment with in situ pinning for pre-slip, mild and moderate slipped capital femoral epiphysis is considered an effective method in treatment and gives good results with a low complication rate. However, it highlights the fact that increasing the initial slippage degree is more likely to generate a poorer outcome.

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