



## Slipped Capital Femoral Epiphysis: Functional and Radiological Outcome of In-situ Fixation and Sub Capital Osteotomy in a Total of 56 Hips with Midterm Follow Up

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**Received:** August 22, 2023

**Published:** December 02, 2023

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### Abstract

**Background:** Treatment of SCFE has remained controversial since long time. Slipped capital femoral epiphysis (SCFE) can be treated by a variety of methods with the method of in situ pinning being most commonly used for mild to moderate cases. More recently, the Safe Surgical Hip Dislocation procedure consisting of capital realignment had been popularized as a treatment method for severe cases of SCFE. The purpose of this article is to evaluate the differences between treatment methods in terms of complication rate, and functional outcomes.

**Methods:** All patients treated for SCFE with in situ fixation or sub capital osteotomy at our institute were included. Preoperative slip degree was measured radiographically and post operative correction was determined using Southwick angle. Clinical outcome was measured by clinical examination and evaluation based on Harris hip scoring and HOOS scoring system. 45 patients with 56 slips filled out the questionnaires for Harris hip score and Hip Dysfunction osteoarthritis Outcome Score (HOOS).

**Results:** Patients with mild to moderate and stable slips operated with in situ pinning and patients with severe, unstable slips operated with sub capital osteotomy by anterior approach at our institute had good scores on HOOS and Harris Hip Scoring system and had good radiological outcome and an acceptable complication rate. In both the groups we had 12.5% of patients with complication. AVN rates of 5.35% (3/56) overall and 11.5% (3/26) in sub capital osteotomy group was found.

**Conclusion:** In situ pinning and sub capital osteotomy gives good result with low complication rate. Thus in situ pinning is a good method for treatment of stable SCFE and sub capital osteotomy for severe slips.

**Keywords:** Slipped Capital Femoral Epiphysis; Insitupinning; Subcapitalosteotomy; Anterior Approach; Avn; Impingement; Chondrolysis; Osteoarthritis; Implant Failure

### Introduction

Slipped capital femoral epiphysis (SCFE) is one of the most common hip disorder in adolescents, with slippage of metaphysis in anterior and superior direction [5]. It occurs mostly in children 9-16 years [1,2]. The prerequisite factors are obesity, male gender and endocrine abnormalities [3,4]. In 1993, Loder, et al. [6] proposed a classification based on the stability of the physis. And clinical symptoms, in which the stable slips; weight bearing and ambulation are possible, and the unstable slips in which these are not possible, with or without crutches. The severity of the slip is determined by using the Southwick (SW) angle. Angles are classified as severe, at > 50 degree, moderate at 30 to 50 degrees and mild below 30 degrees respectively. Thus the severity of slips is in particularly important for selecting surgical treatment.

Out of the various treatments options of SCFE and the vast literature on them concludes two primary treatment strategies available, one as *in situ* fixation and other as sub capital osteotomy [4,11,12,15,16].

Presently, *in situ* fixation is considered the gold standard for mild and moderate slips, with intent to prevent further slippage and sub capital corrective osteotomy for severe slips to restore the hip anatomy and avoid complications [8].

Unstable and severe slips seem to be a candidate for anatomic reduction methods. Unstable SCFEs have a much higher incidence of avascular necrosis (up to 50% in some series) compared to stable SCFEs (almost 0%)<sup>6</sup> due to difficulty in re alignment. In addition to the severe deformity which predisposes them for a high AVN rate.

The sub capital osteotomy by a Ganz surgical dislocation of the hip [20,21] has been shown to restore the normal anatomy of the hip without disturbing the blood supply of the femoral head [14]. But there is a conflicting result by both the posterior and anterior approaches. Thus we would like to report our outcomes in mid-term 2-5 year follow up. We assessed the rate of complications, degree of reduction, radiological changes, and range of movement of the hip and functional outcome.

## Materials and Methods

We retrospectively reviewed the medical records and radiographs of 45 patients diagnosed with SCFE and having a follow up of minimum 2 years to 5 years. We evaluated 56 hips in 45 patients (including bilateral hips involvement in 11 patients); majority of our patients were males numbering 36 (80%) and 9 (20%) were female with male: female ratio of 4:1. The distribution of age groups in our study ranged from minimum age of 11 years and maximum age of 19 years (mean age 14.22 years, SD-2.12).

Depending on stability and chronicity of symptoms they were operated with *in situ* pinning or subcapital osteotomy by anterior approach. The stability was purely determined on the ability of the patient to ambulate, as described earlier.

30/56 (53.57%) were stable hips out of which 24 were operated with *in situ* pinning or a closed procedure and 6 cases were operated with open subcapital osteotomy.

The remaining 26/56 (46.42%) were unstable hips out of which 6 were operated with *in situ* pinning or a closed procedure and 20 cases were operated with subcapital osteotomy (Table 1).

Out of 56 hips evaluated 25/56 were acute symptoms out of which 15 were operated with *in situ* pinning or a closed procedure and 10 cases were operated with open subcapital osteotomy.

Out of 56 hips evaluated 31/56 were chronic symptoms out of which 15 were operated with *in situ* pinning or a closed procedure and 16 cases were operated with open subcapital osteotomy.

Preoperative slip degree was taken for all patients as per the pre operative X Ray.

There were 25 mild cases, 18 moderate cases and 13 severe cases out of 56 hips with mean pre operative slip of 39.86 degree. Southwick angle at the end of one year post operatively gave us the slip degree correction. (Table 2).

Patients were not excluded if they had pre-existing avascular necrosis (AVN), nor if they had undergone previous pinning of the hip. Both procedures were performed by a single surgeon.

Out of total 56 hips 30 (53.57%) hips were treated with *in situ* pinning and 26 (46.43%) hips were treated with osteotomy at sub capital levels, by an anterior approach.

We clinically examined the patients and the Harris Hip Score (HHS) and Hip Dysfunction Osteoarthritis Outcome Score (HOOS) was recorded and the hip range of motion (ROM) were recorded in all patients postoperatively at three, six, and 12 months.

HOOS is a scoring instrument with five sub scores on pain, mechanical symptoms, difficulties in activities of daily living, sports, and quality of life [19]. The HOOS is completed for the affected hip.

We rated hip function with the Harris hip score (HHS) [20], which has a range from 0 points (maximum disability) to 100 points (no disability). In the present study, a HHS score of <70 is Poor result, 70 - 89 Fair to Good results and 90 points or above was classified as an excellent clinical result.

When the patients had bilateral SCFE they filled two different forms for both the hips. Statistical Analysis of the data was done by Microsoft excel software and SPSS software.

## Results

Out of 56 hips we achieved a near normal functional outcome at the end of one year post operatively with mean flexion = 97.77 (SD 16.80) in *in situ* pinning group and 93.00 (SD 17.72) in sub capital osteotomy group. (p value = 0.309) Mean extension = 24.97 (SD 4.16) in *in situ* pinning group and 23.92 (SD 3.86) in sub capital osteotomy group. (p value = 0.335) Mean Abduction 28.60 (SD 11.98) in *in situ* pinning group and 25.46 (SD 13.24) in sub capital osteotomy group. (p value = 0.360) Mean Adduction 23.37 (SD 6.54) in *in situ* pinning group and 19.92 (SD 8.16) in sub capital osteotomy group. (p value = 0.091) Mean Internal rotation 36.47 (SD 6.380) in *in situ* pinning group and 34.58 (SD 6.36) in sub capital osteotomy group. (p value = 0.273) Mean External rotation 33.57 (SD 10.41) in *in situ* pinning group and 30.58 (SD 10.39) in sub capital osteotomy group. (P value = 0.288).

Also radiologically we had an excellent result with slip degree correction as shown below - (Table 3).

On examining clinically out of total 56 hips 7 had complications (7/56 (12.55%)) like AVN, impingement Osteoarthritis, Chondroly-

	In situ pinning	Osteotomy	Total
Stable	24	6	30/56 (53.57%)
Unstable	6	20	26/56 (46.42%)

**Table 1:** Distribution of patients as per Loders Classification depending on surgery performed.

Surgery	Slip Degree Group			Total
	≤ 30 mild	31 - 50 moderate	> 50 severe	
In Situ	25	5	0	30
Osteotomy	0	13	13	26
Total	25	18	13	56

**Table 2:** Distribution of patients as per Preoperative slip degree depending on surgery performed.

Slip degree score	Number of patients	Southwick angle at 12 months		p-value
		Mean	SD	
≤ 30	25	12.56	2.19	0.038
31 - 50	18	10.46	3.04	
> 50	13	10.57	3.67	

**Table 3:** Distribution of patients as per pre operative slip degree and post operative South wick angle at 12 months.  
p-value < 0.05 (Significant) ANOVA test used.

Complication	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Overall total %	Total % in in situ pinning	Total % in sub capital osteotomy
Chondrolysis	+	+	+	+	-	-	-	7.14 % (4/56)	10%	3.8%
CAM	-	+	-	-	-	-	-	1.78% (1/56)	3.3%	0%
Osteoarthritis	-	+	-	+	-	-	-	3.57% (2/56)	3.3%	0%
Implant breakage	+	-	+	-	-	-	-	3.57% (2/56)	6.6%	0%
AVN	-	-	-	-	+	+	+	5.35% (3/56)	0%	11.5%

**Table 4:** Various types of Complications in two surgical groups.

sis, Implant breakage. On further detailing these involved 2 stable slips with acute duration of symptoms, one operated with *in situ* pinning and having mild degree of slip while the other was operated with a sub capital osteotomy procedure having moderate slip degree. Rest of the five patients who had complications post operatively belonged to the unstable category, 4 had acute duration of symptoms out of which two were operated with *in situ* innning while other two were operated with sub capital osteotomy. There was one patient with chronic symptoms and was operated with sub capital osteotomy procedure.

Patients treated with *in situ* pinning one patient had chondrolysis and implant breakage after 1 year. Second one had CAM lesion with chondrolysis followed by osteoarthritis Third one had chondrolysis and implant breakage. This suggests a 10% rate of chondrolysis in *in situ* pinning and 3% rate of osteoarthritis and 3.3% rate of femur acetabular impingement 6.6% rate of implant breakage. (Table 4).

In patients treated with sub capital osteotomy 4 patients had complications. Out of 26 hips 3 cases had AVN in hips operated with subcapital osteotomy (3/26 hips) incidence of 11.5%. And one case presented at 6 months with Chondrolysis. There was no FAI seen in patients treated with subcapital osteotomy. (Table 4).

Complications addressed in *in situ* pinning cases were by implant removal in cases of chondrolysis, and also for implant failure cases.

Salvage procedures performed in cases with complications of AVN, are as mentioned Out of the three cases, in first case implant removal was done as the patient had stiff hip and had lost to follow up. In the second case An additional surgery in the form of pelvic supportive osteotomy was done at the trochantric level to provide an acceptable range of motion. The third case had a partial AVN with restricted range of abduction and externalrotation, thus to give good range of motion single screw was removed and now the patient has good range of motion.1 case operated with subcapital osteotomy presented with Chondrolysis at 6 months, was operated again for hardware removal but eventually had signs of early osteoarthritis of the hip joint at 1 year.

Hip osteoarthritis outcome scores showed good to fair outcomes except in patients with complicated cases which had restricted ROM. (Table 5).

Type of surgery	N	HOOS		p-value
		Mean	SD	
<i>In Situ</i>	30	62.07	14.89	0.001*
Osteotomy	26	76.31	14.18	

**Table 5:** Distribution of patients as per Hip Dysfunction Osteoarthritis Outcome score.

\*Significant (p-value < 0.05) Unpaired t-test used.

Harris hip score shows significant improvement in functional activities of patients operated with sub capital osteotomy, even when compared to the functional outcomes of *in situ* pinning patients (Table 6).

Type of surgery	N	Harris Hip Score		p-value
		Mean	SD	
<i>In Situ</i>	30	93.1	6.94	0.962
Osteotomy	26	93.19	7.53	

**Table 6:** Distribution of patients as per Harris Hip score.  
p-value > 0.05 (Not significant) Unpaired t-test used.

The *in situ* studies corroborates with our studies of *in situ* pinning, thus to conclude sub capital osteotomy can be very well addressed by an anterior approach with a favorable long term result.

Discussion

This study investigates the clinical and radiological outcome after *in situ* pinning and sub capital osteotomy procedure in a group

of 56 hips operated at our institute in the duration of 5 years with minimum follow up of 2 years.

In our study mild and moderate slips were operated with *in situ* pinning as done by many other studies [617,14,17,27]. Showed no significant differences in clinical outcome. Studies suggest that *in situ* fixation of higher-grade (severe) SCFE had a low surgical risk [14], as they highly rely on the potential of the neck to remodel. However the remodeling potential remained controversial as<sup>15</sup>, despite remodeling, the head-neck offset will remain abnormal likely to cause femoroacetabular impingement. *In situ* pinning had complications of impingement, chondrolysis and implant breakage.

There were 6 unstable hips treated with *in situ* pinning with no AVN opposed to studies such as done by Souder, *et al.* (2014) [28] who had 43% AVN in unstable hips treated with *in situ* pinning. There was no AVN was seen in cases operated with *in situ* pinning with regards to our expertise in this procedure and maybe lesser duration of follow up. Till now we had One case of Osteoarthritis (3.3%) in a short follow up period as opposed to Hagglund, *et al.* [5]. who reported OA in 24% of the hips treated with pinning *in situ* and Hansson, *et al.* [17] who reported 31% of the hips with OA results in chronic slips after pinning *in situ*, with longer follow up period than our study. Thus a longer follow up is required to rule out more cases of OA. Osteotomy at sub capital levels done for severe slips also had excellent outcomes except for few complications like AVN (11.5%), Chondrolysis (3.8%).

In case of subcapital osteotomies, done at the apex of deformity maximum correction of deformity can be achieved but with higher chances of AVN as the manipulation of the slip was in close proximity to the retinacular vessels .The osteotomies preformed at lower level at the base of neck or subtrochanteric level had less chances of AVN with lesser degree of deformity correction as the site of osteotomy is farther from the apex of deformity and the capsule is not disrupted but leading to FAI, Osteoarthritis [18].

The numerous techniques used by different surgeons to preserve the blood supply of head and prevent AVN had been tried, out of which Ganz safe surgical dislocation [16] gained a recent importance as it involved hip exposure with protection of posterior vascular retinacular tissue, thus claiming to prevent AVN, however at our institute the subcapital osteotomies were performed by an anterior approach and we were able to preserve the blood supply to the head .The anterior approach reduced the tamponade effect by draining the accumulated intracapsular hematoma and by sub capital osteotomy we were able to shorten the neck which avoided kinking of posterior vessels during reduction, thus preserving the blood supply to the head .

Publications [15] from the inventor's institute of safe surgical dislocation showed 0 percent AVN but 7.5% implant failure. However there was a selection bias, as intraoperative drilling of the head was done before including the cases in the study. Other centers have also tried Safe Surgical Dislocation approach, but with varying rates of AVN and implant failure rates. AVN rates in other studies ranging from minimum 3% to 43% [21]. Other studies had implant failure rate from 0% to 15% [22] but in our study we tend to possess zero cases of implant failure and 11.5% cases of AVN. Also in our study we got 3% chondrolysis in comparison to 20% chondrolysis as seen by Lawane., *et al.* (2009). In comparison to the above studies our group scored better in terms of implant failure, as we had no complications of the same, 3% chondrolysis as opposed to other studies; and we had 11.5% AVN which is a comparable rate with the centers that performed Safe surgical dislocation. We had zero cases of FAI opposed to other studies who had a longer follow up period as compared to our study [22]. Other studies showed 2.5% to 4%. Lawane., *et al.* had 4% FAI, Ziebarth., *et al.* had 2.5% FAI, Sankar., *et al.* (2013) had 3.7% FAI. Further follow up is required to rule out Cases of FAI, if any.

With regards to other studies we also restored acceptable postoperative ROM [15,23,24,25,26].

On radiographic evaluation, in our study the Preoperative slip angle ranged from 14 to 80 with mean of 39.86. Postoperative slip ranged from 12.2 to 28 with mean of 5.6, mean correction of 29.78.

In Ziebarth., *et al.* study [15] preoperative slip angle ranged from 34 to 70 with mean of 45.6, postoperative slip angle ranged from 1 to 20 with mean of 8.6, mean correction of 37. In Huber., *et al.* [24] study preoperative slip angle ranged from 19 to 77 with mean of 44.9, postoperative slip angle ranged from 18 to 25 with mean of 5.2, mean correction of 39.7. In Slongo., *et al.* [23] study preoperative slip angle ranged from 39 to 57 with mean of 47.6, postoperative slip angle ranged from 3.5 to 6 with mean of 4.6, mean correction of 43. In Novais., *et al.* [26] study preoperative slip angle ranged from 54 to 81 with mean of 65, postoperative slip angle ranged from 6 to 23 with mean of 16.

This reveals that our mean correction of slip angle is comparable to other studies done by Safe surgical dislocation.

We evaluated the postoperative clinical outcome by use of two scoring system. This helped us to compare our results with the results of other published studies, which use the same scoring system. The HHS in our series had a mean of 93.1 (SD 6.94) in the *in situ* pinning group and a mean of 93.19 (SD 7.53) in the sub capital osteotomy group with non-significant p value (P value 0.962). The

mean postoperative HHS in Ziebarth., *et al.* [15] study was 99.6, in Huber., *et al.* [24]. study mean of 97.8, and in Slongo., *et al.* [23] study with mean of 99.

In comparison to other studies our mean HHS was slightly lower due to involvement of more chronic cases (55.35%) which had slight persistent postoperative pain and limited ROM due to muscle weakness. This may improve on long-run follow up with come back of the patients to their full activity and restoration of full muscle power.

Harris hip score was good to excellent in 89.5% cases in our study.

HOOS scores were scored for different grades of slip and surgeries performed. Mean of 62.07 (SD 14.89) in *in situ* pinning group and in sub capital osteotomy group with mean of 76.31 (SD 14.18) There was a significant differences in HOOS sub-scores between hips with mild or moderate slip operated with *in situ* pinning or severe slips operated with sub capital osteotomy with p value (P value 0.001). This shows a comparable results to other studies [27].

## Conclusion

Hips with mild and moderate SCFE treated with *In situ* pinning and severe SCFE treated with Sub capital Osteotomy using anterior approach had favourable functional and radiological outcome, with an overall complication rate of 12.55%. The complication rate of AVN in sub capital osteotomy done by anterior approach is 11.5% suggesting the anterior approach technique to be as efficient as SSD as far as the functional outcome, radiological outcome and complication rate is concerned.

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