

Slipped Capital Femoral Epiphysis in Adolescents: Functional Outcomes and Return to Physical Activity after Surgical Treatment

Vasileios GIOVANOULIS^a, Christos KOUTSERIMPAS^b, Angelo V. VASILADIS^c, Nikolaos LEPIDAS^d, Sarah CARVILLE^a, Sarah BOULCOURT^e, Brice ILHARREBORDE^a, Anne-Laure SIMON^a

^aDepartment of Pediatric Orthopaedic Surgery, Robert Debré University Hospital, Assistance Publique des Hôpitaux de Paris (AP-HP), Paris, France

^bDepartment of Orthopaedics and Traumatology, “251” Hellenic Air Force General Hospital of Athens, Greece

^cSports Trauma and Orthopaedic Department, St. Luke's Hospital, Thessaloniki, Greece

^d2nd Orthopedic Department, “Panagiotis & Aglaia Kyriakou” Children Hospital, 11527 Athens, Greece

^ePlateforme d'Analyse de la Marche (PAM), Robert Debré University Hospital, Assistance Publique des Hôpitaux de Paris (AP-HP), Paris, France

ABSTRACT

Background: Slipped capital femoral epiphysis (SCFE) represents a relatively common hip disorder in adolescents. The present retrospective study analyzes the correlation between age, severity of the slip and physical stability and the functional outcomes, as well as the ability to return to previous physical activity (PA) of patients surgically treated with either pinning in situ (PIS) or the modified Dunn (MD) procedure (anatomical reduction of the slipped epiphysis).

Methods: The present research is a retrospective observational study of patients surgically treated for SCFE from 2010 to 2015. The sample was divided into two groups: those treated with PIS and those with the MD procedure. Univariate and multivariate logistic regression analyses were performed to determine the relationship between age, Loder classification (stable/unstable), as well as Southwick slip angle (severity of the slip) to return to previous PA. Furthermore, linear regression was used to investigate the association of the above predictor variables to Oxford and Harris hip scores (HHS).

Results: A total of 32 patients were identified (16 treated with PIS and 16 with the MD procedure). None of the examined predictor variables (age, Southwick slip angle, Loder classification) had statistically

Address for correspondence:

C Koutsierimpas, MD, PhD

Department of Orthopaedics and Traumatology, “251” Hellenic Air Force General Hospital of Athens, 11525 Athina, Greece

Postal address: Kanellopoulou Av 3, 11525, Athens, Greece

Tel: +306948712130; email: chrisku91@hotmail.com; ORCID: 0000-0002-1398-9626

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significant effect on the ability to return to previous PA in either the *in situ* or Dunn group. Univariate analysis showed that higher patients' age at the time of surgery was related to worse HHS and Oxford scores in both the PIS and MD groups. Unstable hips seem to affect unfavorably the HHS.

Conclusions: The present study did not reveal any relationship between the age, degree of the Southwick slip angle, the stability of the physis, and the return to PA. Exploration of additional confounding factors are warranted to better understand the physis-related impact on the functional outcomes in both groups.

Keywords: slipped capital femoral epiphysis, pinning, femoral head children, hip surgical anatomy, Dunn procedure, femoral epiphysis anatomical reduction, hip surgery.

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is a severe hip condition that commonly occurs in adolescents during growth, characterized by the displacement of the capital femoral epiphyses from the femoral neck along the growing physis plate, while it has been associated with obesity and hypothyroidism (1). Slipped capital femoral epiphysis may lead to avascular necrosis, cartilage loss, femoral-acetabular impingement (FAI) and premature osteoarthritis (OA). Delays in identifying and appropriately managing SCFE may worsen these complications (2). The incidence of childhood obesity has been rising; thus, the occurrence of SCFE is actually increasing and affecting younger age groups (3).

Percutaneous *in situ* screwing is the well-established method treatment for mild to moderate SCFE cases and has been shown to have satisfactory long-terms outcomes (4). Nevertheless, severe SCFE, even when treated, may result in reduced functionality of the hip (5). Poor outcomes have been reported for moderate to severe slips with close reduction and so open treatment surgeries have been advocated. The modified Dunn (MD) technique described by Zierbath *et al*, including surgical hip dislocation by performing a trochanteric osteotomy, has been used for these cases (6, 7). The Southwick slip angle (SSA) is the most common classification revealing the severity of the slip (2). Based on this, SCFE is considered mild when the Southwick angle is $<30^\circ$, moderate when the angle is 30° - 50° and severe when it is $>50^\circ$ (2).

The present study aims to investigate the influence of age, severity of slip and physeal stability on functional outcomes and the ability to return to previous physical activity (PA) in pa-

tients undergoing surgical treatment for SCFE at long-term follow-up. □

METHODS

We performed a six-year retrospective observational study using a prospectively maintained database. From January 2010 to December 2015, all patients with SCFE treated surgically at the Department of Pediatric Orthopaedic Surgery, Robert Debré University Hospital, Paris, France were enrolled and re-evaluated during a six-month period (January 2023- June 2023).

The decision to perform PIS or MD procedure was based on the severity of the slip according to the SSA. Pinning *in situ* was performed in cases of mild to moderate severity according to SSA, while the MD technique was used in severe cases. Postoperatively, patients followed a non-weight bearing protocol for six weeks, followed by protected weight bearing for another six weeks. Return to PA was allowed after three months.

The current study recorded patient's demographic characteristics, including gender, age and body mass index (BMI). Clinical and radiological data such as physeal stability (Loder classification: stable, unstable) and severity according to the Southwick classification (mild, moderate, serious) were investigated. Treatment and surgical details (PIS or MD procedure), days of hospitalization as well as postoperative clinical outcomes, including the development of complications, were recorded.

At the latest follow-up, the Oxford hip score (OHS) and the Harris hip score (HHS) were recorded. These scores represent patient-reported outcome measures evaluating the subjects' functional status and quality of life. They consist of several questions covering pain, physical func-

Hip scores	Scale
Oxford hip score (OHS)	
≥41	Excellent
34-40	Good
27-33	Fair
0-26	Poor
Harris hip score (HHS)	
≥91	Excellent
81-90	Good
71-80	Fair
≤70	Poor

TABLE 1. Summary of scores used in the study for the clinical assessment of the sample

tion and social activities (8, 9). A summary of the hip scores is presented in Table 1.

Moreover, at the final follow-up, the range of motion in supine position, the presence or absence of a Drehmann sign (the Drehmann sign is positive if an unavoidable passive external rotation of the hip occurs when performing a hip flexion) and the performance of an anterior impingement test (AIMT) were evaluated in each group (9). The return to previous PA was also evaluated, with PA being defined as non-professional recreational sports.

Univariate and multivariate logistic regression analyses were performed to determine the relationship between return to previous PA (binary response variable) and age, Loder classification and SSA. Furthermore, linear regression was performed to investigate the association of OHS and HHS (numerical outcomes) to the above predictor variables. We used $p=0.05$ significance level. Statistical analysis was performed using R software version 4.0.0 (R Development Core Team, Vienna, Austria).

The present study was conducted in accordance with the guidelines outlined in the Helsinki Declaration, while it has been approved by the institutional bioethics committee. Patients gave their informed consent for their data to be used in the study in an anonymous way (all patients were over 18 years old at the final follow-up). ■

RESULTS

At the mean final follow-up of 9.4 years [standard deviation (SD) 1.8], 32 patients, of which 18 females (56.3%) and 14 males (43.7%), were evaluated. Sixteen of them (50%) underwent the modified MD procedure and the remaining 16 the PIS one. The mean BMI was 26.5

TABLE 2. Patients' postoperative clinical characteristics

Characteristic	Dunn (N=16) ¹	In situ (N=16) ¹
Extension°	1.9 (2.5)	3.8 (2.9)
Flexion°	112.8 (14.8)	120.3 (15.0)
Abduction°	45.0 (7.5)	45.0 (7.5)
Adduction°	40.0 (15.0)	45.0 (7.5)
Internal rotation°	27.5 (26.3)	42.5 (16.3)
External rotation°	32.5 (12.5)	32.5 (15.0)
Anterior impingement test (AIMT)		
Negative	10.0/16.0 (62.5%)	16.0/16.0 (100%)
Positive	6.0/16.0 (37.5%)	0.0/16.0 (0%)
Drehman sign		
Negative	13.0/16.0 (81.3%)	15.0/16.0 (93.8%)
Positive	3.0/16.0 (18.8%)	1.0/16.0 (6.3%)
Patients returned to physical activities		
No return	3.0/16.0 (18.8%)	2.0/16.0 (12.5%)
Return	13.0/16.0 (81.3%)	14.0/16.0 (87.5%)

¹Mean (SD: standard deviation); median (IQR: interquartile range); n/N (%)

²Wilcoxon rank sum test; Fisher's exact test

(SD 4.3) in the MD group and 26.2 (SD 7.7) in the PIS group. The median duration of the hospitalization was 12.5 (interquartile range IQR 4.8, 14.8) days for the MD group and eight (IQR 5.8, 11.8) days in the PIS group. The median age at the time of the surgery was 12 years (IQR 10.0, 14.0) in the MD group and 11 (IQR 11.0, 12.3) in the PIS group, with a male:female sex ratio of 1.3:1.

Table 2 highlights the clinical characteristics of the two groups. The Drehmann sign was evident in 3 (18.75%) patients in the MD and 1 (6.25%) in the PIS group ($p=0.6$), the AIMT in 6 (37.5%) in the MD and none in PIS group ($p=0.018$). Furthermore, 13 patients (81.25%) returned to previous physical activity in the MD group and 14 (87.5%) subjects in the PIS group ($p>0.9$). Regarding complications, two patients, one (6.25%) in each group, had avascular necrosis.

The regressions analyses were performed separately for each group (PIS and MD).

PIS group

The univariate and multivariate regression analyses showed that there was no significant correla-

Univariate regression									
	Physical activity			Harris hip score			Oxford hip score		
Characteristic	OR ¹	95% CI ¹	p-value	Beta	95% CI	p-value	Beta	95% CI	p-value
Age	0.55	0.14, 1.62	0.3	-2.7	-5.8, 0.38	0.081	-1.7	-3.0, -0.35	0.017
Loder									
Stable	(Reference)								
Unstable	0.75	0.03, 21.6	0.8	-3.0	-12, 6.4	0.5	-1.3	-5.7, 3.2	0.5
Southwick ^o	0.92	0.71, 1.09	0.4	-0.19	-0.69, 0.90	0.4	-0.08	-0.31, 0.15	0.5

TABLE 3. Univariate analysis for the patients treated with pinning *in situ*

¹OR: odds ratio, CI: confidence interval

Multivariate regression									
	Physical activity			Harris hip score			Oxford hip score		
Characteristic	OR ¹	95% CI ¹	p-value	Beta	95% CI	p-value	Beta	95% CI	p-value
Age	0.43	0.08, 1.50	0.2	-3.2	-6.4, 0.03	0.052	-1.9	-3.2, -0.56	0.009
Loder									
Stable	(Reference)								
Unstable	1.00	0.03, 4.33	>0.9	-2.4	-11, 6.4	0.6	-1.0	-4.7, 2.6	0.6
Southwick ^o	0.91	0.68, 1.07	0.3	-0.27	-0.75, 0.20	0.2	-0.13	-0.33, 0.07	0.2

TABLE 4. Multivariate analysis for the patients treated with pinning *in situ*

¹OR: odds ratio, CI: confidence interval

Univariate regression									
	Physical activity			Harris hip score			Oxford hip score		
Characteristic	OR ¹	95% CI ¹	p-value	Beta	95% CI	p-value	Beta	95% CI	p-value
Age	0.68	0.26, 1.30	0.3	-3.6	-7.0, 0.17	0.041	-1.6	-3.1, -0.14	0.034
Loder									
Stable	(Reference)								
Unstable	1.71	0.13, 42.5	0.7	-15	-30, -0.42	0.045	-6.2	-13, 0.25	0.058
Southwick ^o	1.00	0.90, 1.11	>0.9	-0.38	-0.98, 0.22	0.2	-0.21	-0.46, 0.04	0.091

TABLE 5. Univariate analysis for patients treated with the modified Dunn procedure

¹OR: odds ratio, CI: confidence interval

Multivariate regression									
	Physical activity			Harris hip score			Oxford hip score		
Characteristic	OR ¹	95% CI ¹	p-value	Beta	95% CI	p-value	Beta	95% CI	p-value
Age	0.63	0.22, 1.29	0.3	-3.4	-7.0, 0.16	0.060	-1.3	-3.0, -0.30	0.10
Loder									
Stable	(Reference)								
Unstable	2.27	0.03, 180	0.7	-22	-45, 1.7	0.066	-5.6	-16, 5.2	0.3
Southwick ^o	1.00	0.84, 1.22	0.9	-0.52	-0.41, 1.5	0.2	-0.05	-0.38, 0.48	0.8

TABLE 6. Multivariate analysis for patients treated with the modified Dunn procedure

¹OR: odds ratio, CI: confidence interval

tion between age, SSA and Loder classification (stable as reference) to returning to PA (Table 3).

The univariate and multivariate analyses found that higher age had a significant negative impact on postoperative OHS ($p=0.017$ and $p=0.009$, respectively) (Table 4).

MD group

The univariate showed that age had significant clinical impact as measured by the HHS ($p=0.041$) and the OHS ($p=0.034$) (Table 5).

In addition, univariate analysis revealed that “unstable hip” had a significant negative impact on HHS ($p=0.045$) (Table 6).

Regarding both groups (PIS and MD), all these three predictor variables (age, SSA and Loder classification) revealed variance inflation factor (VIF) values less than 5 for all models, indicating that multicollinearity was not a major issue. $\square$

DISCUSSION

Slipped capital femoral epiphysis is a severe hip condition commonly affecting adolescents that may lead to devastating complications such as avascular necrosis, cartilage loss and FAI (1).

This study aimed to evaluate the correlation between age, SSA (the severity of the slip) and physeal stability (Loder classification) to functional postoperative outcomes by evaluating the OHS and HHS as well as the return to PA. Importantly, our study examined the impact of these variables in long-term follow-up (more than nine years).

The present study revealed that higher age at the time of surgery had a significant negative impact on postoperative OHS in both uni- and multi-variate analyses for the PIS group at long-term follow-up. This means that as patient's age increases, their functional outcomes, based on the OHS, tend to worsen. In the MD group, univariate analysis revealed that higher age had significant negative impact on the HHS and the OHS. However, when all parameters were considered simultaneously (multivariate analysis), the influence of age on both post operative scores seemed to be weakened as it did not reach statistical significance. Furthermore, none of the studied variables (age, Loder classification

and SSA) seemed to have significant impact on return to PA.

There have been a few studies that examined the impact of age in adolescents with SCFE, surgically treated with PIS, in predicting symptomatic FAI and therefore, worse functional outcomes (10–12). Most of them showed that age >12 years might be associated with an elevated risk, although this result exhibited only a tendency. Further multivariate studies are needed to better understand the potential negative impact of age onset on later hip function.

Furthermore, the present study evaluated the impact of physeal stability, according to Loder classification, on the functional outcome at long-term follow-up. Our study showed that unstable physis significantly negatively affected the HHS at the final follow-up. Many studies have evaluated the association between physeal stability and long-term clinical outcomes, showing a trend that unstable hip negatively affects functional outcomes (13, 14). Thus, the present study raises the possibility that unstable hip, as defined by Loder, could have significant association with the post operative clinical outcomes, as measured by HHS and OHS, but it is crucial to interpret the results within the broader context of other potential influencing factors.

The results of the regression analyses for returning to PA in both the PIS and MD groups showed that none of the predictor variables (age, SSA, Loder classification) had a statistically significant influence. There is scarce data regarding sports activity and SCFE. Sports activities that impose both vertical stress such as running and rotational stress, like basketball or soccer, might have a higher incidence of SCFE (15). There is a potential correlation between sports participation and occurrence of SCFE, but few studies have examined the return to previous PA in these patients. The present analysis showed that patients were able to take back their non-professional physical activities in most of the surgically treated cases. This is also supported by Trisolino et al, who found that 11 patients were able to return to a low to moderate impact sport activity (bicycling, swimming, aerobics, running), while eight subjects could return to high impact non-professional sport activity (soccer) after surgical treatment of SCFE (16).

The current study has some limitations, including its retrospective nature and a relatively

small sample size. Nevertheless, this study encompassed a long follow-up (more than nine years), showing that neither age, SSA or Loder classification have a significant impact on returning to previous PA in patients undergoing surgical treatment for SCFE, while age seems to be inversely correlated with the clinical outcomes in terms of patient-reported scores at long-term follow-up. $\square$

not significantly correlated with the probability of returning to previous PA. Age at the time of diagnosis and therefore, of surgery, as well as unstable hips could influence HHS at long-term follow-up. Nevertheless, the evaluation of more potential risk factors for adverse outcomes is needed in future studies. $\square$

CONCLUSIONS

This study suggests that age, the degree of the Southwick slip angle and unstable hips are

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