Special Issue: Surgical Treatment of Hip Pathology: from Childhood to Adulthood

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2018, Vol. 46(6) 2120–2127

DOI: 10.1177/0300060517731683
journals.sagepub.com/home/imr
SAGE

Outcome of pinning in patients with slipped capital femoral epiphysis: risk factors associated with avascular necrosis, chondrolysis, and femoral impingement

Alexandru Ulici[1], Madalina Carp[1], Iulia Tevanov[1], Catalin Alexandru Nahoi[1], Alin Gabriel Sterian[1] and Dan Cosma[2]

Abstract

Objective: This study aimed to assess the principal risk factors that could lead to the most common long-term complications of slipped capital femoral epiphysis, such as avascular necrosis, chondrolysis, and hip impingement.

Methods: We conducted a single-centre, retrospective study and evaluated patients (70 patients, 81 hips) who were treated for slipped capital femoral epiphysis from 2010 to 2015 and who underwent pinning. We measured the severity of displacement radiologically using the Southwick angle. Postoperative radiographs were evaluated for the most frequent long-term complications of avascular necrosis (AVN), chondrolysis, and femoral acetabular impingement (FAI).

Results: We found seven cases of AVN, 14 cases of chondrolysis, and 31 hips had an α angle of 60°. Sex, ambulation, and symptoms did not affect development of these complications. Patients with a normal weight were almost two times more likely to develop FAI. Patients with moderate and severe slips had a similar percentage of AVN. In severe slips, 85.7% of patients had an α angle higher than 60°.

Conclusions: This study shows that severe slips have a higher risk of developing AVN and hip impingement. Every patient who suffers from SCFE (even the mildest forms) should be regularly checked for FAI.

[1]Department of Paediatric Orthopaedic Surgery, Emergency Hospital for Children "Grigore Alexandrescu", Bucharest, Romania
[2]Department of Orthopaedics and Trauma, Rehabilitation Clinical Hospital Cluj Napoca, University of Medicine and Pharmacy Cluj Napoca

Corresponding author:
Madalina Carp, Department of Paediatric Orthopaedic Surgery, Emergency Hospital for Children "Grigore Alexandrescu", 30–32, Iancu de Hunedoara Blvd 011733, Bucharest, Romania.
Email: madalina.carp@gmail.com

Keywords
Femoral acetabular impingement, slipped capital femoral epiphysis, avascular necrosis, chondrolysis, adolescent hip, radiograph

Date received: 9 May 2017; accepted: 24 August 2017

Introduction

Slipped capital femoral epiphysis (SCFE) is one of the most common disorders affecting adolescent hips, and usually appears during the early adolescent growth spurt. In SCFE, the epiphysis stays in the acetabulum while the neck is displaced anteriorly and rotates externally. This creates a varus-extension and external rotational deformity of the femoral neck. Clinically, SCFE often presents with knee or thigh pain and limping because of anatomical innervation of the hip. This causes delayed treatment.[1,2]

The surgical treatments of SCFE have different methods of stabilization, including closed reduction and pinning, *in situ* pinning, and open osteotomies and fixation.[3] The most frequent complication is avascular necrosis (AVN), and different rates have been reported for this complication with different treatments. AVN usually has better results with *in situ* pinning for chronic SCFE and closed reduction and pinning for acute SCFE. Open reduction with different osteotomies is used in severe acute slips because decompression of the joint is needed.[4]

Besides AVN, another long-term complication is persistent deformities of the proximal femur, which can cause femoral acetabular impingement (FAI). A multicentre French study concluded that prevention of AVN, osteoarthritis (OA) and FAI should be considered as the goal of treatment by using the anterior Dunn procedure for severe slips.[5] In the SCFE-affected hip, the presence of FAI causes mechanical abnormalities that can lead to osteoarthritis due to repetitive injury to the articular cartilage. Considering this situation, preventing impingement is preferable, rather than treating it later.[6]

Determining long-term functional and radiological outcomes of different treatments for SCFE related to hip impingement is important. A previous study examined 11 hips with SCFE that were treated with *in situ* fixation, with a follow-up of 26 years.[7] The authors determined that *in situ* fixation for moderate and severe SCFE had poor functional results because of FAI and osteoarthritis (OA). In typical SCFE, the metaphysis is in a pathological anterolateral position. Because of the healing process, an anterolateral protuberance, called a bump or cam deformity, usually appears on the proximal femur eroding the acetabulum. In the long term, this can lead to hip pain and decreased range of motion due to osteoarthritis. This is common in severe slips, but even a mild slip can cause FAI.[8,9]

This study aimed to assess the main risk factors that could lead to the most common long-term complications of SCFE, namely AVN, chondrolysis, and hip impingement.

Material and methods

A single-centre, retrospective study, which evaluated the medical records of patients who were treated for SCFE from 2010 to 2015, was conducted. Data from all of the patients' records were analysed, such as age, sex, body mass index, medical history at the time of diagnosis, date of surgery, and outcome of surgery. Patients who underwent pinning with or without closed reduction were selected. We excluded patients who

underwent femoral osteotomies. The series consisted of 70 patients and 81 displaced hips. Ethics committee approval was not required for this retrospective study. The patients provided written and verbal informed consent.

The patients were classified as acute if they had pain or limping less than 3 weeks, chronic if the pain or limping lasted for longer than 3 weeks, or acute on chronic. Based on this classification of SCFE, the patients were surgically treated by closed reduction and internal fixations with pins (1, 2, 3), or *in situ* fixation with pins. Based on Loder's criteria, the patients were categorized as stable or unstable. The patients were considered to have a stable hip when they could bear weight with or without crutches and unstable if they were unable to bear weight.[10]

We measured the severity of the displacement radiologically using the Southwick angle, which was measured on the primary frog-leg view at the time of presentation. The Southwick angle is the difference between the angle measured on the affected side and the normal side. This angle was measured between the line at the base of the capital femoral epiphysis and a line perpendicular to the longitudinal axis of the femoral shaft. The degree of slip was classified as mild if the angle was less than 30°, moderate if the angle was between 30° and 60°, and severe if the angle was greater than 60°.[11,12]

Postoperative radiographs were evaluated to determine the presence of the most frequent long-term complications, which are AVN, chondrolysis and FAI. The minimum follow-up period was 18 months (Figure 1).

We reviewed the radiographic signs of AVN, such as collapse of the femoral head, sclerosis, and cyst formation. Narrowing of the femoroacetabular space was measured and we classified it as chondrolysis when it was less than 3 mm.[13]

To determine the cam deformity responsible for hip impingement, we performed measurements of the α angle. The measurements were performed on radiographs at follow-up after pinning. The α angle was measured on lateral radiographs according to Notzli's method as follows: the angle between a line from the centre of the femoral head and the centre of the neck and a second line from the centre of the femoral head point on the antero-lateral neck–head junctions.[14,15] Diagnosis of impingement was determined by an angle greater than 60° and the presence of a radiological bump.[7]

To examine the data, we used Microsoft Excel and calculated the risk ratio with www.medcalc.org. We examined the potential risk and predisposing factors for patients with and those without complications, such as AVN, chondrolysis, and FAI, using odds ratios and relative risks. We used a data warehouse to optimize access to our data and for better operation of our data.[16,17]

Results

The average follow-up was 30 months. Among 70 patients and 81 hips, 11 patients had bilateral involvement (13%). There were 22 females and 48 males who presented with limping, groin pain, and loss of internal rotation. The age of the patients ranged from 9 to 16 years and the mean age of patients who underwent surgery was 12.5 years. We calculated the body mass index and 58 patients (82.8%) were overweight.

With regard to symptoms, there were 20 patients with acute SCFE (25%), 47 patients with chronic SCFE (58%), and 14 with acute episodes in the chronic phase (17%). With regard to ambulation, 15 patients had unstable SCFE (18.5%) and 66 had stable SCFE (81.5%). To investigate the severity of displacement, we measured 32 hips with mild displacement, 41 hips with

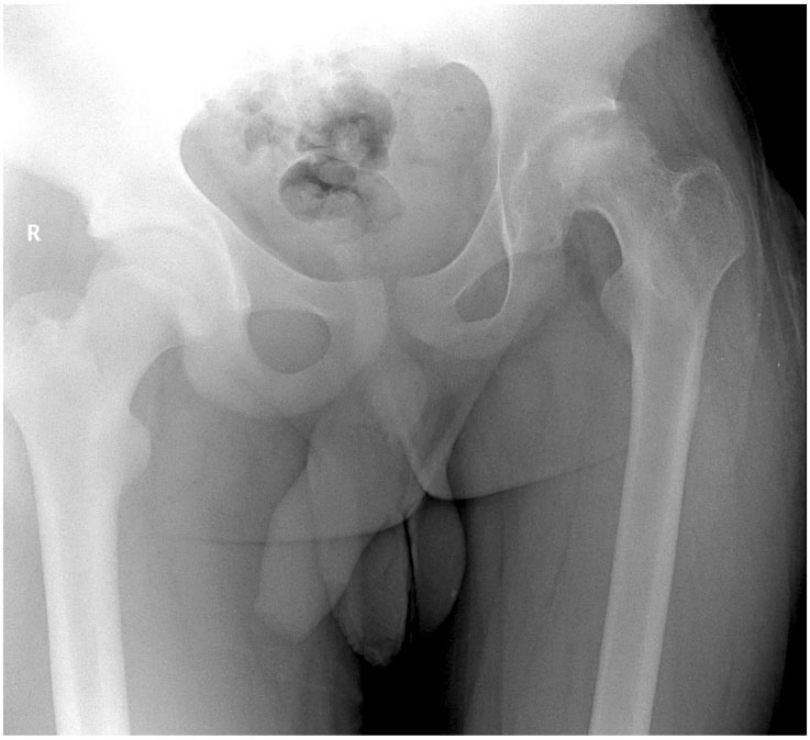

Figure 1. Avascular necrosis, chondrolysis, and femoral acetabular impingement after moderate displacement treated with pinning
After removal of the pins, the presence of sclerosis and cyst formation were observed, as well as cam deformity and narrowing of the joint space.

Table 1. Characteristics and risk and predisposing factors associated with AVN in patients with slipped capital femoral epiphysis who underwent pinning

Variable	With AVN	Without AVN	Risk ratio	95% CI	P
Sex					
Male	4	44	0.6	0.1493–2.5202	0.49
Female	3	19	1.6	0.3998–6.6982	0.49
Ambulation					
Stable	4	62	0.3	0.0756–1.2142	0.09
Unstable	3	12	3.3	0.8236–13.2229	0.09
Symptoms					
Acute	3	17	2.11	0.5126–8.7640	0.29
Chronic/acute on chronic	4	61	0.4	0.1141–1.9508	0.29

AVN, avascular necrosis.

moderate displacement, and seven hips with severe displacement. Seven cases of AVN were observed and six of these cases appeared in overweight patients.

Table 1 shows a univariate model of risk factors for AVN that were treated individually. There were no significant correlations between sex, ambulation, or symptoms and

Table 2. Characteristics of risks and predisposing factors associated with chondrolysis in patients with slipped capital femoral epiphysis who underwent pinning

	With chondrolysis	Without chondrolysis	Risk ratio	95% CI	P
Sex					
Male	10	48	1.8	0.4508–7.9784	0.38
Female	2	20	0.5	0.1253–2.2181	0.38
Evaluated side					
Right	8	30	1.5	0.5752–3.9578	0.4
Left	6	37	0.6	0.2527–1.7386	0.4
Ambulation					
Stable	10	56	0.56	0.2059–1.5678	0.27
Unstable	4	11	1.76	0.6378–4.8565	0.27

CI, confidence interval.

Table 3. Study characteristics of risks and predisposing factors associated with FAI, reflected by the α angle in patients with slipped capital femoral epiphysis who underwent pinning

	Patients with FAI, α angle > 60	Patients without FAI, α angle ≤ 60	Risk ratio	95% CI	P
Ambulation					
Stable	24	35	0.75	0.4187–1.3630	0.35
Unstable	7	6	1.32	0.7337–2.3883	0.35
Weight					
Normal weight	9	4	1.8	1.1366–3.0329	0.01
Overweight	22	37	0.53	0.3297–0.8798	0.01

CI, confidence interval; FAI, femoral acetabular impingement.

development of AVN (all $P > 0.05$). Among the 14 patients with chondrolysis, nine were overweight. Table 2 shows the risk factors predisposing to chondrolysis. These risk factors were treated individually. There were no correlations between sex, the evaluated side, or ambulation and development of chondrolysis. There was no effect of sex of the patients, ambulation, or symptoms in developing FAI (Table 3). Patients with a normal weight were almost two times more likely to develop FAI (risk ratio: 1.8). Table 4 shows the percentage of AVN, chondrolysis, and FAI in every category of slip. In moderate and severe slips, we observed a similar percentage of AVN. There were no differences in the category of slip for chondrolysis. With regard to FAI, for severe slips, 85.7% of patients developed an α angle higher than 60°.

Discussion

This study showed no significant correlations between risk factors such as sex, the evaluated side, ambulation, weight, and symptoms and long-term complications (AVN, chondrolysis and FAI). The exact aetiology of chondrolysis has not yet been determined, but chondrolysis occurs in treated and untreated hips, and an immune mechanism is thought to be involved.[13]

Table 4. Complications based on slip grade in patients with slipped capital femoral epiphysis who underwent pinning

	Mild (N = 33)	Moderate (N = 32)	Severe (N = 7)
AVN			
With AVN	1 (3%)	5 (15.5%)	1 (14.2%)
Without AVN	32	27	6
Chondrolysis			
With chondrolysis	3 (9%)	7 (21%)	2 (28%)
Without chondrolysis	30	25	5
FAI			
With FAI	4 (12%)	21 (65.6%)	6 (85.7%)
Without FAI	29	11	1

AVN, avascular necrosis; FAI, femoral acetabular impingement. Data are presented as n (%)

Hip impingement is considered an important factor for developing OA. A multicentre study reviewed 69 stable hips for signs of remodelling of femoral head-neck junction.[14] This study showed that in patients with SCFE, almost 30% of the hips had residual deformities that could cause FAI.

Patients with moderate SCFE and with FAI may suffer from micro-trauma of a cam deformity and this can occur during workouts or daily activities. This micro-trauma produces irreversible chondral damage, which results in degenerative diseases of the hip. Recurrent trauma can lead to avulsion of the cartilage from the subchondral bone. The grade of asphericity of the femoral head that is responsible for FAI can be determined by calculating the α angle, the femoral offset, or the offset ratio.[18]

Evolution of hip impingement without treatment leads to recurrent synovitis due to mechanical stress on the articular cartilage. This situation results in OA pain and progressive loss of motion.[19] This is the reason why long-term follow-up of patients with mild and severe slips is required. Other factors that are a risk for the appearance of FAI need to be determined.[20,21]

We found that normal weight patients had a higher risk of developing FAI compared with overweight patients. In moderate and severe slips, we observed a similar percentage of AVN. This finding is in contrast to previous reports, which showed that a severe slip has a higher percentage of AVN.[4,5]

There are some limitations to our study. One limitation is that radiological evaluation was performed by the same examiner. Additionally, diagnosis of FAI should be established in association with a clinical exam, but this was limited because of restricted access to clinical follow-up of some of the patients. The normal α angle is controversial. The α angle was initially used for magnetic resonance imaging data, but it is starting to be applied to radiographs. Pollard et al.[22] considered that a positive diagnosis of FAI can be considered for an angle of greater than 63° and another study suggested angles of greater than 50°.[18] A further study considered 60° to be the upper limit for the α angle.[14]

Every patient that suffers from SCFE (even the mildest forms) should be regularly checked for FAI. This is because, in time, even a mild slip can evolve or degenerate into hip impingement causing premature osteoarthritis. If this impingement is diagnosed early, before any signs of osteoarthritis are observed, it can be treated arthroscopically with a favourable long-term outcome.

Declaration of conflicting interest

The authors declare that there is no conflict of interest

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Loder RT. Slipped capital femoral epiphysis. *Am Fam Physician* 1998; 57: 2135–2142, 2148–2150. Review. Erratum in: Am Fam Physician 1998 Jul; 58(1): 52. PubMed PMID: 9606305.
2. Lehmann CL, Arons RR, Loder RT, et al. The epidemiology of slipped capital femoral epiphysis: an update. *J Pediatr Orthop* 2006; 26: 286–290. Review. PubMed PMID: 16670536
3. Cosma D, Vasilescu DE, Corbu A, et al. The modified Dunn procedure for slipped capital femoral epiphysis does not reduce the length of the femoral neck. *Pak J Med Sci* 2016; 32: 379–384
4. Palocaren T, Holmes L, Rogers K, et al. Outcome of in situ pinning in patients with unstable slipped capital femoral epiphysis: assessment of risk factors associated with avascular necrosis. *J Pediatr Orthop* 2010; 30: 31–36. doi: 10.1097/BPO.0b013e3181c537b0. PubMed PMID: 20032739.
5. Abu Amara S, Cunin V, Ilharreborde B, et al. Severe slipped capital femoral epiphysis: A French multicenter study of 186 cases performed by the SoFOP. *Orthop Traumatol Surg Res* 2015; 101(6 Suppl): S275–S279. doi: 10.1016/j.otsr.2015.04.005. Epub 2015 Jul 26. PubMed PMID: 26215089.
6. Millis MB and Novais EN. In situ fixation for slipped capital femoral epiphysis: perspectives in 2011. *J Bone Joint Surg Am* 2011; 93(Suppl 2): 46–51. doi: 10.2106/JBJS.K.00040. Review. PubMed PMID: 21543688.
7. Murgier J, de Gauzy JS, Jabbour FC, et al. Long-term Evolution of Slipped Capital Femoral Epiphysis Treated by in Situ Fixation: A 26 Years Follow-up of 11 Hips. *Orthop Rev (Pavia)* 2014; 6: 5335. doi: 10.4081/or.2014.5335. eCollection 2014 Apr 22. PubMed PMID: 25002939; PubMed Central PMCID: PMC4083312
8. Hosalkar HS, Pandya NK, Bomar JD, et al. Hip impingement in slipped capital femoral epiphysis: a changing perspective. *J Child Orthop* 2012; 6: 161–172. doi: 10.1007/s11832-012-0397-z. Epub 2012 Mar 31. PubMed PMID: 23814615; PubMed Central PMCID: PMC3399996.
9. Klit J, Gosvig K, Magnussen E, et al. Cam deformity and hip degeneration are common after fixation of a slipped capital femoral epiphysis. *Acta Orthop* 2014; 85: 585–591. doi:10.3109/17453674.2014.957078. Epub 2014 Sep 1. PubMed PMID: 25175666; PubMed Central PMCID: PMC4259021
10. Loder RT, Richards BS, Shapiro PS, et al. Acute slipped capital femoral epiphysis: the importance of physeal stability. *J Bone Joint Surg Am* 1993; 75: 1134–1140. PubMed PMID: 8354671.
11. Southwick WO. Osteotomy through the lesser trochanter for slipped capital femoral epiphysis. *J Bone Joint Surg Am* 1967; 49: 807–835. PubMed PMID: 6029256.
12. de Poorter JJ, Beunder TJ, Gareb B, et al. Long-term outcomes of slipped capital femoral epiphysis treated with in situ pinning. *J Child Orthop* 2016; 10: 371–379. doi: 10.1007/s11832-016-0759-z. Epub 2016 Jul 20. PubMed PMID: 27438268; PubMed Central PMCID: PMC5033778
13. Lubicky JP. Chondrolysis and avascular necrosis: complications of slipped capital femoral epiphysis. *J Pediatr Orthop B* 1996 Summer; 5: 162–167. Review. PubMed PMID: 8866280
14. Akiyama M, Nakashima Y, Kitano T, et al. Remodelling of femoral head-neck junction in slipped capital femoral epiphysis: a multicentre study. *Int Orthop* 2013; 37: 2331–2336. PubMed PMID: 24022736; PubMed Central PMCID: PMC3843194.
15. Nötzli HP, Wyss TF, Stoecklin CH, et al. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. *J Bone Joint Surg Br* 2002; 84: 556–560. PubMed PMID: 12043778.

16. Cosma S, Valeanu M, Cosma D, et al. Efficient data organisation in distributed computer systems using data warehouse. *Int. J. of Computers, Communications & Control* 2013; 8
17. Văleanu M, Cosma S, Cosma D, et al. Optimization for date redistributed system with applications. *Int. J. of Computers, Communications & Control* 2009; 4: 178–184.
18. Tannast M, Siebenrock KA and Anderson SE. Femoroacetabular impingement: radiographic diagnosis—what the radiologist should know. *AJR Am J Roentgenol* 2007; 188: 1540–1552
19. Ingram AJ, Clarke MS, Clarke CS Jr, et al. Chondrolysis complicating slipped capital femoral epiphysis. *Clin Orthop Relat Res* 1982; : 99–109. PubMed PMID: 7075078
20. Wylie JD, Beckmann JT, Maak TG, et al. Arthroscopic treatment of mild to moderate deformity after slipped capital femoral epiphysis: intra-operative findings and functional outcomes. *Arthroscopy* 2015; 31: 247–253. doi: 10.1016/j.arthro.2014.08.019. Epub 2014 Oct 16. PubMed PMID: 25442644
21. Basheer SZ, Cooper AP, Maheshwari R, et al. Arthroscopic treatment of femoroacetabular impingement following slipped capital femoral epiphysis. *Bone Joint J* 2016; 98–B: 21–27. doi: 10.1302/0301-620X.98B1.35831. PubMed PMID: 26733511.
22. Pollard TC, Villar RN, Norton MR, et al. Femoroacetabular impingement and classification of the cam deformity: the reference interval in normal hips. *Acta Orthop* 2010; 1: 134–141. doi: 10.3109/1745367100361901