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Radiological and clinical femoroacetabular impingement after slipped capital femoral epiphysis treated by in situ fixation

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Background: **The treatment of slipped capital femoral epiphysis (SCFE) is always surgical. In situ fixation (ISF) is widely accepted to stop the epiphysis slipping. Femoroacetabular impingement (FAI) is recognized as a complication after ISF and is one of the major causes of early hip osteoarthritis.**

Study aim: **The aim of this study was to characterize the relation between clinical and radiological signs of FAI.**

Methods: **A monocentric study that included all consecutive children treated for SCFE by ISF between 2006 and 2017 was performed. Clinical examination consisted in range of motion (ROM) measurement for both hips, impingements tests and functional scores (Harris Hip Score (HHS) and Womac score). Radiological analysis was based on signs of impingement (alpha angle, anterior head neck offset (OS), anterior head neck offset ratio (HNOR).**

Results: **36 hips were included. At follow-up, the difference between the mean hip ROM on the SCFE side and the healthy side were statistically significant in abduction and in internal rotation. Ten (28%) hips presented at least one clinical test positive for FAI (FADDIR and/or FABER). All the patients presented a good or excellent functional score. Eight patients (22%) presented all radiological signs of impingement; among these, 3 had a clinical sign of FAI. Twenty-eight hips (78%) presented at least one radiological sign of FAI; among these, 10 had clinical signs of FAI.**

Conclusion: **Despite a high rate of radiological FAI, less than one-third of patients have clinical signs of FAI after ISF for SCEFE.**

Level of evidence: **III: retrospective study**

Keywords: Femoroacetabular impingement, slipped capital femoral epiphysis, in situ fixation, functional outcomes.

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is the most common hip disorder in adolescence with an incidence varying from 0.2 to 10 per 100 000. depending on the country[1,2]. SCFE always requires surgical treatment. The type of surgery used depends on the importance of the displacement of the femoral epiphysis. In situ fixation (ISF) is the gold standard when the displacement is less than 35° [3,4]. If the displacement is greater there is no recommendation; surgical procedures vary from ISF to compensatory osteotomies and direct correction of the deformity at the head-neck junction[5]. Ideal management is still under debate mostly because of the risk of avascular necrosis (AVN) associated with open reduction on one hand, and the subsequent evolution toward femoroacetabular impingement (FAI) on the other. ISF presents less AVN[6] but it does not restore normal hip anatomy thus theoretically leading to a higher risk of FAI[7]. FAI after SCFE has been well described since 2000. It results from excessive bone at the femoral head-neck junction causing a cam-effect impingement against the acetabular rim[7]. This condition has been reported more and more in the literature[8-11] because there is claim that FAI is one of the major causes of early hip osteoarthritis (OA)[12,13]. Clinical and radiological signs of FAI are well described in the general population but not after SCFE. Furthermore, the relationship between clinical and radiological signs of FAI is not well-known, especially for mild to severe SCFE (initial displacement around 30-35°)[12,14-16]. Thus, the aim of this study is to report radiological and clinical signs of FAI after mild to severe SCFE treated by ISF and to characterize the relationship between them.

PATIENTS AND METHODS

We reviewed the records of children treated by ISF for SCFE between January 2006 and January 2017 in our pediatric surgery department. Inclusion criteria were

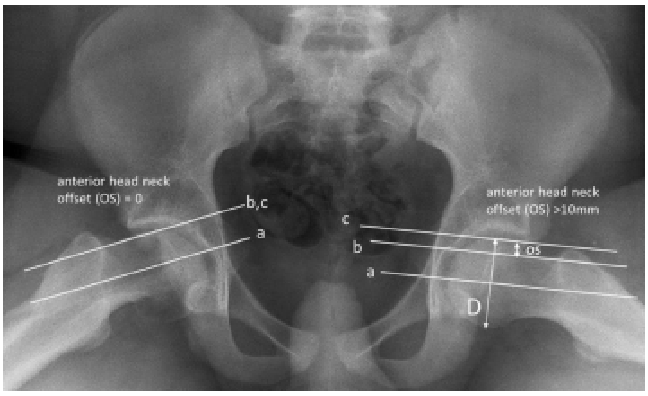

Figure 1. — Dunn view of 2 hip with SCFE on the right side. Measurement of OS and HNOR. A line (a) is drawn across the axis of the femoral neck. A second line (b) is drawn parallel to (a) at the level of the anterior contour of the femoral neck. A third line (c) parallel to (a) is drawn across the upper border of the femoral head. The distance between the lines b and c is defined as OS and is normally ≥10 mm. The widest diameter of the femoral head is measured as D. The ratio OS/D is the HNOR, in normal hips is > 0,15. On the left hip OS >10mm, HNOR >0,15 there is no FAI; whereas on the right hip OS = 0, HNOR <0,15.

children surgically treated for uni or bilateral SCFEs with a minimum 2 years of follow-up. Exclusion criteria were patients with incomplete data, previous hip surgery or dysplasia and femoral head AVN. The following surgical data were recorded: age at surgery, side involved, complications, measurement of the femoral epiphysis displacement (Southwick method[17], as well as stability as defined by Loder's criteria[18]. Clinical data included: height, weight, body mass index (BMI) and the practice of sport. The follow-up was calculated as the interval between date of surgery and clinical re-assessment. All eligible patients were contacted by phone, and were prospectively reassessed by an independent pediatric orthopedic surgeon.

The clinical evaluation consisted in the measurement with a goniometer of passive range of motion (ROM) of the 2 hips of each patient. Impingement FADDIR and FABER maneuvers were performed. The positive diagnosis of FAI was defined as the presence of pain during at least one of these maneuvers[15]. Functional scores assessed were Harris Hip Score (HHS) and WOMAC score.

At follow-up, radiological evaluation was performed including: anteroposterior radiographs and lateral Dunn incidence[17], alpha angle[14], anterior head neck offset (OS) and the anterior head neck offset ratio (HNOR)[16] measured on lateral view (Figure 1). Diagnosis of radiological impingement was defined as an α-angle ^{3}60° [12], and/or an OS <5mm and/or an HNOR <0.15[19].

STATISTICAL ANALYSIS

Quantitative data were presented as mean, and standard deviation. Patients were divided into 2 groups according to the presence or absence of clinical signs of FAI and both groups were compared using the paired Student's t-test. Spearman's correlation was used to search for a correlation between radiological and clinical data. Statistical analysis was done with Excel (Microsoft, Redmond, USA). A p value <0,05 was considered significant.

RESULTS

Patients

Thirty-eight patients underwent ISF for SCFE in our department between January 2006 and January 2017. Seven patients were excluded from analysis: 5 because of lack of data and 2 because of AVN. There were therefore 36 hips in 31 patients, characteristics are summarized in Table I. According to Loder's criteria 25/36 SFCE were stable.

Clinical results

At follow-up, mean BMI was 28.9 (±6) with 26/31 (84%) patients presented a BMI > 25. Hip ROM of the SCFE side compared to the healthy side are reported in **Table** II. The difference between the hip ROM on the SCFE side and the healthy side were statistically significant (p<0,05) in abduction and internal rotation. Clinically, there was 4° less in abduction and 10° less in internal rotation on the SCFE side. Ten (28%) hips presented at least one clinical positive sign for FAI (FADDIR and/or FABER). Mean HHS was 89 (±3.1); all the patient had good or excellent score. The mean WOMAC score was 1.4 (±2.1) and, 15/31 (48%) practiced sport.

Radiological results

Mean alpha-angle was 59° (±17), mean OS was 1.9° (±1.1) and mean HNOR was 0.15° (±0.08). Eight

Table I. — Description of patients included.

Sex	22 boys, 9 girls
SCEFE side	21 left, 15 right, 5 bilateral
Age at surgery (mean ±SD)	12.9 ±2 years old
Follow-up (mean ±SD)	64 months ±34
Initial displacement of femoral epiphysis (mean ±SD)	32° ±12
SD: Standard Deviation.	

Table II. — Mean ROM of the hip with SCFE compared to the ROM of the healthy side

	ROM of the SCFE Side (± SD) (n=36)	ROM of the healthy side (± SD) (n=31)	p
Flexion	106° (±13)	108° (±13)	0,26
Extension	18° (±11)	16° (±12)	0,3
Abduction	46° (±8)	42° (±7)	0,02
Adduction	27° (±9)	28° (±10)	0,08
External rotation	54° (±14)	53° (±10)	0,6

Table III. — Mean values of radiological measurement and functional score according to presence or not of clinical sign of FAI Comparison between the 2 groups

	FAI + (n=10)	FAI - (n=26)	p
Alpha (°)	65.4	54.7	0.04
OS (mm)	1.2	3.8	0.002
HNOR	0.09	0.16	0.08
WOMAC score	8	1	0.04
HARRIS	95	98	0.09

(22%) presented all radiological signs of impingement (α-angle ≥60°, OS<5mm, HNOR<0.15). Among these, 3 had clinical signs of FAI. Twenty-eight hips (78%) presented at least one of these signs: 14 (39%) had an α-angle ≥60°, 19 (53%) an OS <5 and 15 (42%) an HNOR<0.15. Among these, 10 (36%) had a clinical FAI.

Radio-clinical comparison and correlation

Alpha-angle was significantly ($p<0.05$) higher and OS was significantly ($p<0.05$) lower when there was a clinical FAI (Table III). HNOR seemed to be higher when there was no clinical FAI but this result was not statistically significant. When there was a clinical FAI, there was a correlation between external rotation and α-angle ($p=0.02$, $rs=-0.7$). No other statistical correlation was found between radiological and clinical sign of FAI. In the group with clinical FAI, the WOMAC is significantly lower than in the group without clinical FAI (Table III).

DISCUSSION

The current study reports good functional outcomes at nearly 5 years of follow-up after ISF for mild to severe SCFE. Four out of 6 hip ROM are similar between the SCFE and the healthy hip, functional scores are good or excellent and nearly 50% of patients do sport at follow-up. Results of HHS and WOMAC reported in literature for mild-severe SCFE are consistent with our results[20,21]. Clinical signs of FAI have been identified in the literature between 7% to 100% of cases making comparison with our study difficult. Thus, it seems that mild to severe SCFE treated by ISF have satisfying functional outcomes at mid-term follow-up whether or not there are radiological signs of FAI[20,21].

The alpha-angle is the most used radiological sign for FAI in the literature[22-26]. The mean values of the alpha-angle after ISF for mild to severe SCFE are around 60° in the literature as in the current study[21,27]. It seems that the higher the initial displacement is, the higher the alpha-angle is at follow-up[27]. Others radiological sign of FAI are more rarely reported; Akiyama et al[19] report values of HNOR comparable with those of the current study after SCFE.

The relationship between radiological and clinical signs is intuitive; it makes sense to believe that the greater the radiological deformity is, the greater the clinical signs should be. Several papers have described this trend[21,27] but only one reported a statistical correlation. Kamegaya et al[25], in a cohort of 92 hips, reported that the greater the alpha-angle is, the greater the rate of positive Drehmann sign is. However, the relationship between radiological and clinical signs of FAI is not so clear. In the current study, patients with clinical FAI are those with the more severe radiological FAI sign and the poorer functional score compared to patient without clinical FAI. This results is also reported by Castaneda et al[21] and by Murgier et al[27]. However, only 36% of patients with radiological FAI present clinical signs of FAI. These results probably mean that others parameters have to be taken in account to predict the appearance of clinical FAI. Some parameters are mentioned in literature, Akiyama et al[19] reported that age is a prognostic factor. They identify an age at onset above 11.1 years as a risk of less remodeling of the femoral neck deformity. Remodeling is a phenomenon well-known after SCFE, significant decreases of alpha-angle and increases of HNOR are described during the 5 first years following SCFE treatment[10,19]. The second prognostic factor of FAI after SCFE is the follow-up. Indeed, whereas radiological signs of FAI are present it probably takes times for labral lesion to appear and clinical signs to express. Some papers with follow-up longer than our, reported high rate of labral lesion[28] and early OA[8] even for SCFE with a small slip angle[24]. However, clinical and functional outcomes were usually reported as preserved at more than 10 years follow-up[24,28]. Thus, all these results suggest that after ISF for SCFE a part of patient is at risk to develop clinical FAI and early OA. This population is composed by patients older than 11 years-old with radiological sign of FAI after a SCFE treated over 10 years ago. These patients should be carefully clinically and radiologically followed in adulthood in order to propose early solutions such as local debridement of osteophytes, metaphyseal bump or torn labrum in case of appearance of clinical sign of FAI in order to avoid total hip replacement if possible. However, results of the current study do not question FAI for SCEFE with an initial displacement around 30°.

The current study presents limits, the main limit is the retrospective design responsible for loss of data and patients. A second limit is the mid-term follow-up. Indeed, to confirm the current results it could be interesting to follow these patients longer; specially to see if more clinical FAI are reported with time. However, there are only few studies dealing with FAI after SCFE with a functional evaluation by scores and range of motion compared to the contralateral side.

CONCLUSION

Despite a high rate of radiological FAI, less than one-third of patient have clinical sign of FAI after ISF of mild-severe SCEFE. Patient with clinical FAI present the more severe radiological measurement. Functional outcomes remain good or excellent in the whole cohort.

Conflict of Interest: Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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JF: study conception and design, manuscript preparation, data analysis.

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REFERENCES

1. Castañeda P, Macías C, Rocha A, Harfush A, Cassis N. Functional outcome of stable grade III slipped capital femoral epiphysis treated with in situ pinning. J Pediatr Orthop. août 2009;29(5):454-8.
2. Slongo T, Kakaty D, Krause F, Ziebarth K. Treatment of Slipped Capital Femoral Epiphysis with a Modified Dunn Procedure: The Journal of Bone and Joint Surgery-American Volume. déc 2010;92(18):2898-908.
3. Accadbled F, Murgier J, Delannes B, Cahuzac JP, de Gauzy JS. In situ pinning in slipped capital femoral epiphysis: long-term follow-up studies. J Child Orthop. avr 2017;11(2):107-9.
4. Nectoux E, Décaudain J, Accadbled F, Hamel A, Bonin N, Gicquel P. Evolution of slipped capital femoral epiphysis after in situ screw fixation at a mean 11years' follow-up: A 222 case series. Orthopaedics & Traumatology: Surgery & Research. févr 2015;101(1):51-4.
5. Aprato A, Conti A, Bertolo F, Massè A. Slipped capital femoral epiphysis: current management strategies. Orthop Res Rev. 2019;11:47-54.
6. Abu Amara S, Cunin V, Ilharreborde B. Severe slipped capital femoral epiphysis: A French multicenter study of 186 cases performed by the SoFOP. Orthopaedics & Traumatology: Surgery & Research. oct 2015;101(6):S275-9.
7. Leunig M, Casillas MM, Hamlet M, Hersche O, Nötzli H, Slongo T, et al. Slipped capital femoral epiphysis: Early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. Acta Orthopaedica Scandinavica. janv 2000;71(4):370-5.
8. Abraham E, Gonzalez MH, Pratap S, Amirouche F, Atluri P, Simon P. Clinical implications of anatomical wear characteristics in slipped capital femoral epiphysis and primary osteoarthritis. J Pediatr Orthop. nov 2007;27(7):788-95.
9. Dodds MK, McCormack D, Mulhall KJ. Femoroacetabular impingement after slipped capital femoral epiphysis: does slip severity predict clinical symptoms? J Pediatr Orthop. sept 2009;29(6):535-9.
10. Falciglia F, Aulisa AG, Giordano M, Guzzanti V. Fixation in slipped capital femoral epiphysis avoiding femoral-acetabular impingement. J Orthop Surg Res. déc 2017;12(1):163.
11. Lerch TD, Novais EN, Schmaranzer F, Ziebarth K, Steppacher SD, Tannast M, et al. What Is the Prevalence of Cam Deformity After Prophylactic Pinning of the Contralateral Asymptomatic Hip in Unilateral Slipped Capital Femoral Epiphysis? A 10-year Minimum Followup Study: Clinical Orthopaedics and Related Research. mai 2019;477(5):1111-22.
12. Agricola R, Heijboer MP, Bierma-Zeinstra SMA, Verhaar JAN, Weinans H, Waarsing JH. Cam impingement causes osteoarthritis of the hip: a nationwide prospective cohort study (CHECK). Ann Rheum Dis. juin 2013;72(6):918-23.
13. Johnston TL, Schenker ML, Briggs KK, Philippon MJ. Relationship between offset angle alpha and hip chondral injury in femoroacetabular impingement. Arthroscopy. juin 2008;24(6):669-75.
14. Nötzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as

a predictor for the risk of anterior impingement. J Bone Joint Surg Br. mai 2002;84(4):556-60.
15. Yen Y-M, Kocher MS. Clinical and radiographic diagnosis of femoroacetabular impingement. J Pediatr Orthop. août 2013;33 Suppl 1:S112-120.
16. Eijer H, Podeszwa DA, Ganz R, Leunig M. Evaluation and treatment of young adults with femoro-acetabular impingement secondary to Perthes' disease. Hip Int. déc 2006;16(4):273-80.
17. Southwick WO. Osteotomy through the lesser trochanter for slipped capital femoral epiphysis. J Bone Joint Surg Am. juill 1967;49(5):807-35.
18. Loder RT, Richards BS, Shapiro PS, Reznick LR, Aronson DD. Acute slipped capital femoral epiphysis: the importance of physeal stability. J Bone Joint Surg Am. août 1993;75(8):1134-40.
19. Akiyama M, Nakashima Y, Kitano T, Nakamura T, Takamura K, Kohno Y, et al. Remodelling of femoral head-neck junction in slipped capital femoral epiphysis: a multicentre study. Int Orthop. déc 2013;37(12):2331-6.
20. Wensaas A, Gunderson RB, Svenningsen S, Terjesen T. Femoroacetabular impingement after slipped upper femoral epiphysis: the radiological diagnosis and clinical outcome at long-term follow-up. J Bone Joint Surg Br. nov 2012;94(11):1487-93.
21. Castañeda P, Ponce C, Villareal G, Vidal C. The natural history of osteoarthritis after a slipped capital femoral epiphysis/the pistol grip deformity. J Pediatr Orthop. août 2013;33 Suppl 1:S76-82.
22. Accadbled F, Murgier J, Delannes B, Cahuzac JP, de Gauzy JS. In situ pinning in slipped capital femoral epiphysis: long-term follow-up studies. J Child Orthop. avr 2017;11(2):107-9.
23. Fujii Y, Endo H, Mitani S, Akazawa H, Tetsunaga T, Miyake T, et al. Residual Femoral Deformity and Femoroacetabular Impingement after Intertrochanteric Osteotomy for Slipped Capital Femoral Epiphysis. Acta Med Okayama. août 2017;71(4):315-23.
24. Fraitzl CR, Käfer W, Nelitz M, Reichel H. Radiological evidence of femoroacetabular impingement in mild slipped capital femoral epiphysis: a mean follow-up of 14.4 years after pinning in situ. J Bone Joint Surg Br. déc 2007;89(12):1592-6.
25. Kamegaya M, Saisu T, Nakamura J, Murakami R, Segawa Y, Wakou M. Drehmann sign and femoro-acetabular impingement in SCFE. J Pediatr Orthop. déc 2011;31(8):853-7.
26. Tannast M, Siebenrock KA, Anderson SE. [Femoroacetabular impingement: radiographic diagnosis – what the radiologist should know]. Radiologia. août 2008;50(4):271-84.
27. Murgier J, de Gauzy JS, Jabbour FC, Iniguez XB, Cavaignac E, Pailhé R, 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). 22 avr 2014;6(2):5335.
28. Klit J, Gosvig K, Magnussen E, Gelineck J, Kallemose T, Søballe K, et al. Cam deformity and hip degeneration are common after fixation of a slipped capital femoral epiphysis. Acta Orthop. déc 2014;85(6):585-91.