ORIGINAL ARTICLE

Which factor is more reliable considering prophylactic pinning of contralateral hip of unilateral SCFE patients?

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ABSTRACT

BACKGROUND: This study evaluates the radiological parameters of developing subsequent contralateral slips in unilateral slipped capital femoral epiphysis (SCFE) patients at the time of initial presentation.

METHODS: The study group included the review of unilateral SCFE patients treated between June 2007 and August 2018. Age, gender, side, stability, posterior slope angle, grade of slip, modified Oxford bone age score (mOBAS), the Risser classification, and the appearance of the triradiate cartilage were evaluated retrospectively. Data were analyzed between two groups: subsequent contralateral SCFE (SCFESC) patients that developed contralateral slip during follow-up and unilateral SCFE (SCFEU) patients that did not develop contralateral slip up to skeletal maturity. Descriptive statistics were used to compare risk factors between groups.

RESULTS: This study included 48 patients and 6 patients (12.5%) developed a SCFESC. Only mOBAS was significantly different between groups. The mOBAS scores in SCFESC were 18 in 2 patients (33.3%), 19 in 4 patients (66.7%). The mOBAS scores in SCFEU were 18 in 1 patient (2.4%), 19 in 24 patients (57.1%), and >20 in 17 patients (40.5%). In the SCFESC group, all patients had a Risser score of 0 and all had open triradiate cartilage.

CONCLUSION: Patients with unilateral SCFE are at risk for SCFESC, and the mOBAS is the best predictor of risk assessment. We agree that mOBAS score of 16,17 or 18 patients' contralateral hips can be prophylactically pinned. We also suggest pinning or close screening of mOBAS 19 patients that some carry relatively high risk of subsequent contralateral slip.

Keywords: In situ pinning; modified oxford bone age score; prophylactic pinning; SCFE; slipped capital femoral epiphysis.

INTRODUCTION

Slipped capital femoral epiphysis (SFCE) may cause pain and disability in the adolescent hip with an incidence of 1 in 10,000.[1] Patients may initially present with unilateral or bilateral SCFE. The third pattern is the development of subsequent contralateral slip during follow-up period in unilateral SCFE patients.[2] In the early stages of SCFE, patients have the potential to displace the femoral epiphysis severely and acutely. For this reason, SCFE is often referred to as an orthopedic emergency in the standard texts and has importance in emergency service practice.[3-5] Therefore, it is crucial to evaluate the risk of subsequent contralateral slip development in all unilateral SCFE patients and recommend prophylactic pinning

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to the asymptomatic contralateral hip if the risk is high. Since pinning of a normal hip is not free from complications, it is essential to identify the patients at the risk of subsequent contralateral slip development and recommend prophylactic pinning of the contralateral hips.[6] There is no consensus in risk evaluation, and it is commonly made according to patients' radiological parameters that evaluate growth potential.[7-9] In this study, we aimed to compare the radiological parameters of unilateral SCFE patients who reached skeletal maturity without developing subsequent contralateral slips and unilateral SCFE patients who developed subsequent contralateral slips. Therefore, we compared the radiological parameters of initially presented unilateral SCFE patients in two groups: (i) patients developed subsequent contralateral slip during follow-up (SCFESC) and (ii) patients stayed unilateral SCFE up to maturation (SCFEU). We reviewed the outcomes between two groups that may indicate prophylactic pinning of contralateral hips in unilateral SCFE patients.

MATERIALS AND METHODS

After approval from the Institutional Review Board, the study was carried out retrospectively. Between June 2007 and August 2018, a total of 122 SCFE patients treated with percutaneous cannulated screws were identified from surgical records. Data of age at surgery, gender, side, follow-up period, and stability of the slip according to Loder classification were provided from the records.[10] A total of 74 patients were excluded from the study, including unilateral patients treated with prophylactic simultaneous pinning of the contralateral hips (n=42), patients with endocrinopathy (n=12), patients initially presented as bilateral slips (n=13) and patients who did not reach up to skeletal maturity (n=7). The decision of prophylactically pinning of the contralateral side was made at the discretion of the treating surgeons. The study consisted of 48 unilateral SCFE patients that contralateral hip was not pinned prophylactically [Figure 1]. All patients reached up to skeletal maturity on the final follow-up. Patients were divided into two groups "subsequent contralateral SCFE" (SCFESC) and "unilateral SCFE" (SCFEU) according to the observation of subsequent contralateral slip during follow-up period (Fig. 1). A subsequent contralateral slip was diagnosed by the onset of pain during follow-up that was confirmed by radiographs (Fig. 2). All patients in the SCFESC group were treated by percutaneous pinning.

The initial and final follow-up anteroposterior and lateral pelvic radiographs of the patients were evaluated. Posterior slope angle (PSA) of the asymptomatic side was measured as the angle between the growth plate and the line perpendicular to the axis of the femur on the preoperative lateral view (Fig. 3).[9] The grade of slip was determined according to Southwick angle (SA) by calculating the differences of SA of both hips. A degree of difference of SA below 30° was defined as mild slip, between 30° and 50°defined as moderate slip and above 50° was defined as severe slip [Figure 3].[9] Skeletal maturity of patients was evaluated according to the modified Oxford Bone Age Score (mOBAS) and the Risser classification.[7,8] Radiographic feature of triradiate cartilage was evaluated for its appearance as open or closed. All parameters were evaluated by an author (MO) and confirmed by another author (EA). All evaluations were made using INFINITT Healthcare Picture Archiving Communication System (INFINITT Healthcare Co., Ltd., Seoul, South Korea).

Statistical analyses were performed using the SPSS software version 20. The variables were investigated using skewness and kurtosis to determine whether they are normally distributed. Gender, side, grade of slip, the Risser classification, and triradiate cartilage were compared with Fischer's exact test. Median scores of ages, PSA, and mOBAS were compared with nonparametric Mann–Whitney U test. A P-value of <0.05 was considered to show a statistically significant result.

RESULTS

The study group was 39 boys and 9 girls with a mean age at surgery was 13.5 years Standard deviation (SD 1.4). There were 27 patients who had the SCFE on the left side and 21 on the right side. The mean follow-up period was 37.0 months

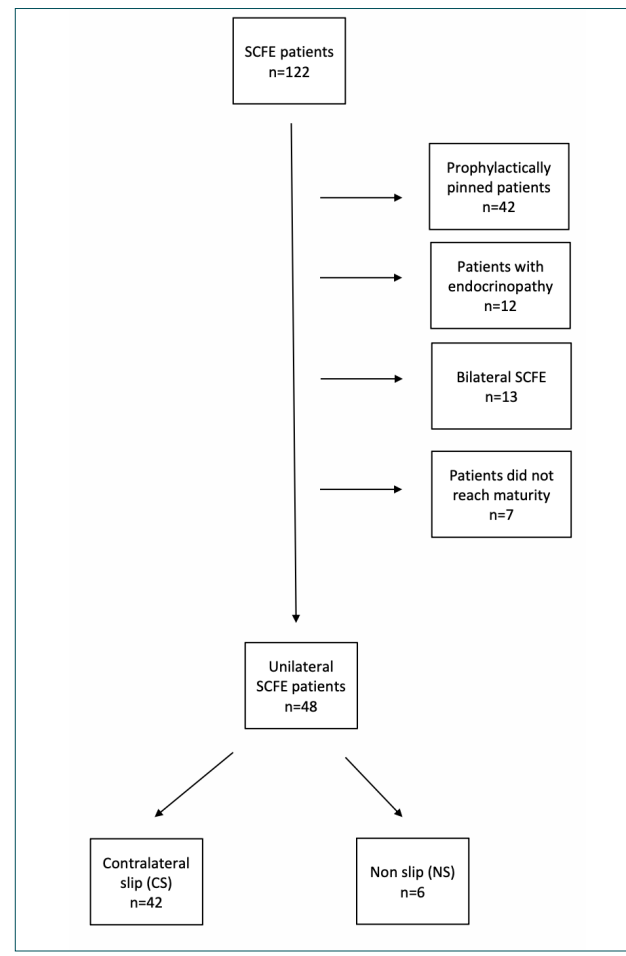

Figure 1. The flow chart of the study

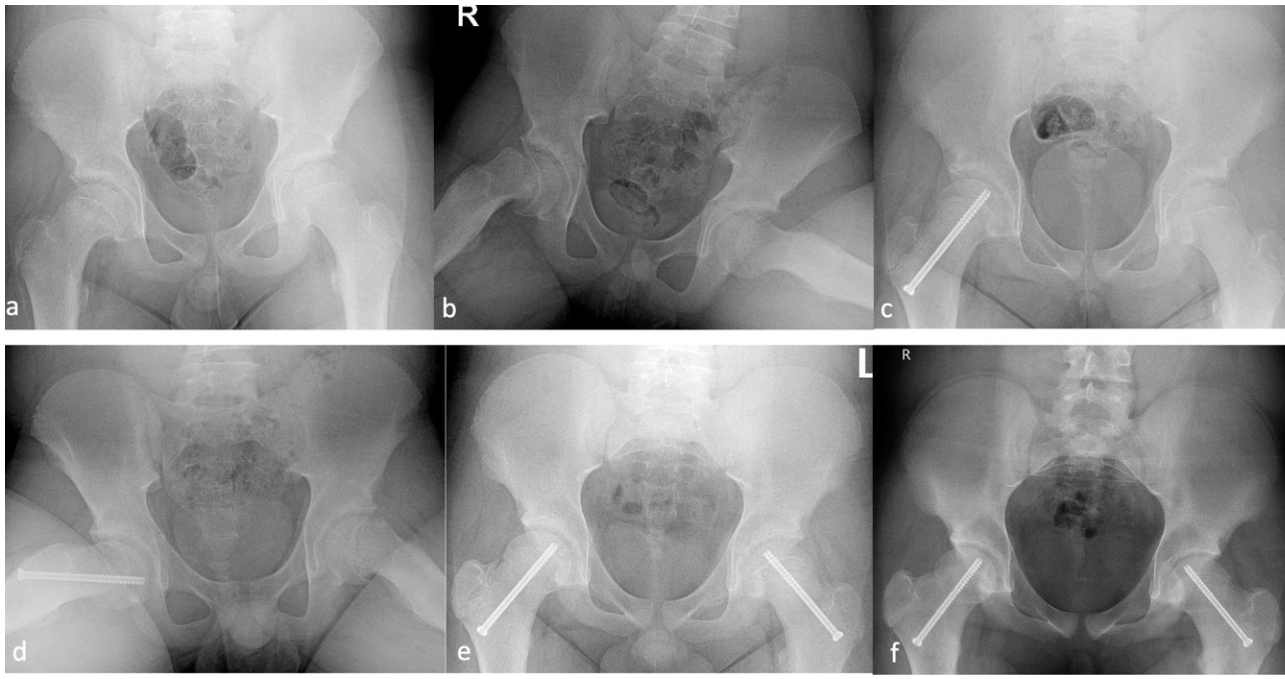

Figure 2. A 13-year-old-boy with SCFE on the right side **(a-c)** treated with in situ pinning **(c)**. 17 months after the initial surgery, the patient was diagnosed with subsequent SCFE of the contralateral hip, which was treated with in situ pinning of the left side **(d and e)**. Final radiograph at age 16 **(f)**.

(SD 19.6). There were 39 stable slips and 9 unstable slips. The mean PSA of the contralateral side was 18.1° (SD 6.9). 19 of slips were mild, 19 of slips were moderate and 10 of slips were severe. The mean mOBAS was 19.7 (SD 1.3). 42 patients were Risser 0, 1 patient was Risser 1, 4 patients were Risser 2, and 1 patient was Risser 3. The appearance of the triradiate cartilage was open in 35 patients and closed in 13 patients (Table 1).

There were 42 patients in SCFEU group, and 6 (12.5%) patients were in SCFESC group. There were 34 boys and 8 girls

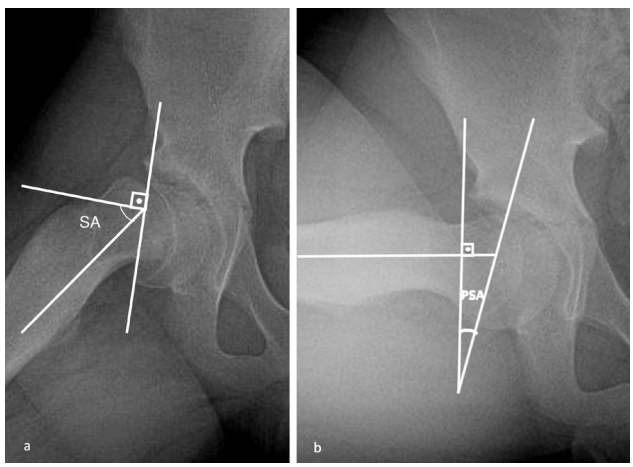

Figure 3. (a) Measurement of Southwick angle: The angle between the line along the axis of the femoral shaft and the line perpendicular to the line connects the margin of the epiphysis on the lateral view. **(b)** Measurement of the posterior slope angle: The angle between the line connects the margins of the epiphysis and a line perpendicular to the axis of the femoral shaft on the lateral view.

in SCFEU group and 5 boys and 1 girl in SCFESC group. The mean age was 13.6 (SD 1.3) years in SCFEU group and 13.1 (SD 2.0) in SCFESC group. There were no girls younger than 10 years and 2 boys (total=33%) younger than 12 years in SCFESC group, compared with 1 girl younger than 10 years and 5 boys (total=14.3) younger than 12 years in SCFEU group. The mean PSA was 18.1 degrees (SD 6.9) in SCFEU group and 17.5 degrees (SD 7.6) in SCFESC group. The mean mOBAS was 19.8 (SD 1.3) in SCFEU group and 18.7 (SD 0.5) in SCFESC group. 25 of the left and 17 of the right side were affected in SCFEU group and 4 of left and 2 of the right side were affected in SCFESC group. 29 patients had open triradiate cartilage and 13 patients had closed triradiate cartilage in SCFEU group. 6 patients had open triradiate cartilage in SCFESC group. 33 patients had stable slips and 9 patients had instable slips in SCFEU group. 6 patients had stable slips in SCFESC group. 16, 16 and 10 patients had mild, moderate, and severe slips in SCFEU group, respectively. 3 patients with both mild and moderate slips in SCFESC group. 36 patients were Risser 0, 1 patient was Risser 1, 4 patients were Risser 2, and 1 patient was Risser 3 in SCFEU group. All patients were Risser 0 in SCFESC group (Table 1).

The data of age, gender, side, stability, PSA, grade of slip, the Risser classification, and appearance of triradiate cartilage were similar in SCFEU and SCFESC groups (P>0.05) [Table 1]. Only the mOBAS was different between SCFEU and SCFESC groups (P<0.05).

2 patients (33.3%) with mOBAS of 18 and 4 patients (66.7%) with mOBAS 19 were in SCFESC group. There was no patient with mOBAS 20 or higher in SCFESC group. 1 patient

Table 1. Variables with potential value for predicting contralateral progression

Measured variable by outcome	Total (mean[SD])n=48	SCFEU (mean[SD])n=42	SCFESC (mean[SD])n=6	P-value
Age (years)	13.5 (1.4)	13.6 (1.3)	13.1 (2.0)	0.417*
Gender (n[%])				
Male	39 (81)	34 (81)	5 (83)	0.688†
Female	9 (19)	8 (19)	1 (17)	
Side (n[%])				
Left	27 (56)	25 (60)	4 (67)	0.383†
Right	21 (44)	17 (40)	2 (33)	
Stability (n [%])				
Stable	39 (81)	33 (79)	6 (100)	0.578†
Instable	9 (19)	9 (21)	0 (0.0)	
PSA (degree)	18.1 (6.9)	18.1 (6.9)	17.5 (7.6)	0.938*
Grade of slip (SA)				
Mild	19 (40)	16 (38)	3 (50)	0.406†
Moderate	19 (40)	16 (38)	3 (50)	
Severe	10 (20)	10 (24)	0 (0)	
mOBAS	19.7 (1.3)	19.8 (1.3)	18.7 (0.5)	0.011*
Risser				
0	42 (87.5)	36 (85.7)	6 (100)	0.806†
1	1 (2.1)	1 (2.4)	0 (0)	
2	4 (8.3)	4 (9.5)	0 (0)	
3	1 (2.1)	1 (2.4)	0 (0)	
Triradiate cartilage (n [%])				
Open	35 (72.9)	29 (691.)	6 (100)	0.171†
Closed	13 (27.1)	13 (30.9)	0 (0)	

PSA; Posterior slope angle; SA; Southwick angle; mOBAS; modified Oxford Bone Age Score; *Mann Whitney U test; †Fisher exact test.

(2.4%) with mOBAS of 18, 24 patients (57.1%) with mOBAS of 19 and 17 patients (40.5%) with mOBAS of 20 or higher in SCFEU group.

Subsequent contralateral slips were observed at mean 8.0 months (SD 5.0, range: 3.2–17.2 months) after the initial slip.

DISCUSSION

It is challenging to decide whether to perform prophylactically pinning of the contralateral hip in initially presented unilateral SCFE patients. Unilateral SCFE patients are at risk whether surgical treatment is performed or not. Non-surgically treated patients may develop slip or surgically treated patients suffer from iatrogenic injuries. Studies found relations between pubertal staging and PSA with the development of contralateral slip.[8,11] The risk for a contralateral slip is higher at an earlier stage of puberty.[12]

Popejoy et al. reviewed 260 unilateral SCFE patients and observed contralateral slip in 64 (24%) of them at an average of 10 months after initial presentation. Their study showed that patients with mOBAS of 16, 17, or 18 have 96% probability of developing a contralateral slip. They stated that their clinical practice is to prophylactically pin all unilateral SCFE patients with a mOBAS of 16, 17 or 18 due to the high risk of development of slip (5). In our study, 2 (67%) of 3 patients with mOBAS 18 developed contralateral slip. Therefore, it is reasonable to prophylactically pinning the contralateral hips with an mOBAS of 18 or below as stated in previous studies.[8]

SCFE is a common cause of degenerative joint disease of the hip that is treated by hip replacement surgery.[8] The degenerative process of SCFE is related to the grade of slip.[8] Early surgical intervention can prevent further slip progression. Therefore, it is important to know the risk of contralateral slip development in patients with unilaterally treated SCFE. Despite proper education, some families may overlook pain in the contralateral hip, resulting in delays in diagnosis.[8] In our study group, contralateral slip developed between 3.2 and 17.2 months. We think that the onset of pain in the con-

tralateral hip, especially in 18 months postoperatively, may be a sign of slip in the contralateral hip, which should be referred to orthopedic examination. In our study, 4 (14.3%) of 28 patients with mOBAS 19 developed contralateral slip. We think that mOBAS 19 patients carry the risk of contralateral slip, which is not as high as mOBAS 16, 17, or 18 patients. Therefore, according to our results, it is reasonable to inform and monitor closely mOBAS 19 patients for the relatively high risk of subsequent contralateral slip development.

The use of mOBAS in determining skeletal maturity may be difficult.[5] The triradiate closure is an easy way to determine the risk for a contralateral slip.[8,12] In a study by Puylaert et al., 6 of 68 unilateral SCFE patients developed contralateral slip. They stated that the risk of developing contralateral slip quickly diminishes to %4 after the closure of triradiate cartilage.[12] Popejoy et al., found that a wide-open triradiate cartilage was a good predictor, but may not screen all range of patients widely as mOBAS.[8] In our study, we did not encounter any contralateral slip in patients after closure of the triradiate cartilage. We agree that it would be more accurate to determine skeletal maturity with mOBAS, instead of using the previously described method of triradiate cartilage evaluation alone.[8]

The Risser classification also can be used in staging puberty.[12] The Risser classification has been shown to be less appropriate compared to triradiate cartilage closure due to its ability to monitor late development stages.[12] It was stated that when the Risser classification is stage I, the risk of developing contralateral slip drops almost to zero.[12] In our study, all patients in SCFESC group were in the Risser 0, that confirms the previous studies.

Biomechanical properties of the proximal femur as PSA have been studied as another risk factor. In an in vitro biomechanical study, it was shown that the threshold of 15° of PSA is a measure for prophylactic fixation of the contralateral hip in SCFE.[9] In our study, PSA was >15° in four (66.7%) patients in SCFESC group and 30 (61.2%) in SCFEU group. Although PSA>15° was reported as a risk factor for contralateral slip, there was no difference between in our study groups. We think that it may cause overtreatment to suggest pinning of the contralateral hips at the PSA>15° threshold.

At follow-up, 12.5% of the patients required contralateral pinning. If two patients with mOBAS 18 were prophylactically pinned in our study group, our rates of contralateral slip would drop to 8% as supported previously reported studies that analyse the risk with the mOBAS.

Park et al., reported that age is a reliable predictor of contralateral slip.[10] They stated that being at a young age (girls <10 years, boys <12 years) with unilateral SCFE may cause slip on the contralateral side.[13] In our study, 2 (33.3%) patients were in SCFESC group, and 6 (14.3%) patients were in SCFEU group. Accordingly, being at a young age can be considered as a risk factor. However, the risk of contralateral slip continues at older ages.

The major limitation of our study is the small sample size of SCFESC group. In our clinic, prophylactically pinning of the contralateral hip is routinely recommended for patients with a mOBAS 16, 17, or 18, as recommended in the current literature.[8] Therefore, we think that prophylactic pinning in patients with mOBAS 16,17, or 18 reduced the number of patients in SCFESC group.

Conclusion

Our study confirms previously stated that mOBAS is the best predictor of contralateral pinning of unilateral SCFE patients yet. We agree that mOBAS 16, 17, or 18 patients should be suggested to prophylactically pinned their contralateral hips. We suggest pinning or close follow-up of mOBAS 19 patients that some carries potentially high risk of subsequent contralateral slip.

Ethics Committee Approval: This study was approved by the Baltalimani Bone Diseases Education and Research Hospital Animal Experiment Ethics Committee (Date: 07.03.2019, Decision No: 308).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: E.A., A.S., O.N.O., M.O., M.B., Y.A., A.I.B.; Design: E.A., A.S., O.N.O., M.O., M.B., Y.A., A.I.B.; Supervision: E.A., A.S., O.N.O., M.O., M.B., Y.A., A.I.B.; Data: E.A., A.S., M.O., M.B.K., Y.A.; Analysis: E.A., A.S., O.N.O., A.I.B.; Literature search: E.A., A.S., O.N.O., A.I.B.; Writing: E.A., A.S.; Critical revision: E.A., A.S., O.N.O., A.I.B.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Tek taraflı FBEK hastalarının kontralateral kalçasının profilaktik olarak sabitlenmesi düşünüldüğünde hangi faktör daha güvenilirdir?

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AMAÇ: Bu çalışmada, tek taraflı femur başı epifiz kayması (FBEK) tanısı ile takip edilen hastalarda başlangıçta etkilenmemiş olan karşı taraf femur başı epifizinin kayma riski ile ilişkili radyolojik parametrelerin belirlenmesi amaçlanmıştır.

GEREÇ VE YÖNTEM: Çalışma grubu, Haziran 2007 ile Ağustos 2018 arasında tedavi edilen tek taraflı FBEK hastalarını içermektedir. Yaş, cinsiyet, taraf, stabilite, posterior eğim açısı, kayma derecesi, modifiye Oxford Kemik Yaşı Skoru (MOKYS), Risser sınıflandırması ve triradiat kıkırdak görünümü retrospektif olarak değerlendirildi. Hastalar takipleri sırasında kontralateral kayma gelişen hastalar (SCFESC) ile iskelet olgunluğuna kadar kontralateral kayma gelişmeyen hastalar (SCFEU) olarak iki grupta değerlendirildi. Gruplar arasında risk faktörlerini karşılaştırmak için tanımlayıcı istatistikler kullanıldı.

BULGULAR: Bu çalışmaya 48 hasta alındı ve SCFESC grubunda 6 hasta (%12.5) mevcut idi. Sadece MOKYS gruplar arasında anlamlı derecede farklıydı. SCFESC grubunda MOKYS 2 hastada (%33.3) 18, 4 hastada 19 (%66.7) idi. SCFEU grubunda ise MOKYS skorları 1 hastada 18 (%2.4), 24 hastada 19 (%57.1) ve 17 hastada >20 (%40.5) idi. SCFESC grubundaki tüm hastalarda Risser skoru 0 ve triradiat kıkırdak açık olarak izlendi.

TARTIŞMA: Tek taraflı FBEK hastaları, takiplerde kontralateral FBEK gelişmesi açısından risk altındadır ve MOKYS, risk değerlendirmesinin en iyi öngörücüsüdür. MOKYS 16,17 veya 18 olan hastaların kontralateral kalçalarının profilaktik olarak pinlenmesi konusunda literatürü destekleyen sonuçlar elde ettiğimizi söyleyebiliriz. Ayrıca, göreceli olarak yüksek kontralateral kayma riski taşıyan MOKYS 19 hastalarının pinlenmesini ya da kayma açısından yakın takibini öneriyoruz.

Anahtar sözcükler: Femur başı epifiz kayması; FBEK; in-situ pinleme; modifiye Oxford kemik yaşı skoru; profilaktik pinleme.

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