Hong Kong Journal of Orthopaedic Research
(An Open Access Journal for Orthopedics and Trauma Research)

Review Article

Hong Kong J Orthop Res
2021; 4(1): 18-24
ISSN (e): 2663-8231
ISSN (p): 2663-8223
Received: 15-03-2021
Accepted: 13-04-2021

www.hkorthopaedicjournal.com
DOI: 10.37515/ortho.8231.4105

Is prophylactic fixation preferable to active surveillance of the unaffected contralateral hip in unilateral slipped capital femoral epiphysis? - A Systematic Review

Vishvas Shetty [1, 2], ***Kash Akhtar*** [1, 2]

1 *Centre for Trauma Sciences, Blizard Institute, Queen Mary University of London, 4 Newark Street, London*

2 *Royal London Hospital, Barts Health NHS Trust, Whitechapel Rd, Whitechapel, London*

Abstract

Slipped capital femoral epiphysis is one of the commonest musculoskeletal disorders amongst children. Whilst its management is reasonable well established, the treatment of the unaffected contralateral hip is controversial. The incidence of subsequent contralateral slip has been reported to be between 19 and 63%. The two treatment modalities are prophylactic fixation at initial presentation or active surveillance and fixation on diagnoses of subsequent slip. Both approaches have their merits but there is no clear consensus. Known risk factors include age, sex, young age at initial presentation, endocrine disorders and obesity. Clinical, epidemiological and radiological predictors have been assessed retrospectively but have limited prospective accuracy. We performed a systematic review of the existing literature as per PRISMA guidelines to determine which treatment modality is more effective. Qualitative analysis of the literature also yielded interesting insights into different aspects of the management of the contralateral hip in unilateral SCFE.

Keywords: Slipped capital femoral epiphysis (SCFE), Musculoskeletal disorders, Active surveillance.

INTRODUCTION

Slipped capital femoral epiphysis [SCFE] is one the commonest musculoskeletal disorders amongst children [1]. It has been traditionally classified based on severity [mild, moderate, severe] or presentation [acute, chronic, acute on chronic] [1]. Known risk factors include age, sex, endocrine disorders, socioeconomic conditions [2]. Treatment is always surgical and can range from closed reduction and percutaneous pinning in mild acute cases to femoral osteotomies in severe and chronic cases [3]. Long-term morbidity of missed SCFE varies based on age at presentation, severity and bilateral involvement. Mild slips tend to present as femoro-acetabular impingement [FAI] and severe slips can lead to avascular necrosis [AVN], chondrolysis and osteoarthritis [OA] [4].

The treatment of the unaffected contralateral hip in unilateral SCFE is controversial due to the availability of two contrasting options: prophylactic fixation or active surveillance [5]. Both views have well established merits and demerits but a clear consensus is yet to emerge [6]. The prophylactic fixation approach is based on the increased likelihood of subsequent slip, up to 2335 times more in children diagnosed with unilateral SCFE, and the attempt to offset the complications of an untreated subsequent slip [2,7]. The active surveillance approach is based on the notion that prophylactic surgery on a "normal" hip is unnecessary and does not justify the risks associated with it [8, 9].

Surveys regarding the management of SCFE in professional bodies have also shown a lack of overwhelming consensus. An opinion survey of members of the British Society of Children's Orthopaedic Surgery [BSCOS] revealed 27% of members would prophylactically pin the contralateral hip whereas 32% of the members of the European Paediatric Orthopaedic Society [EPOS] voted the same way in a similar survey [10, 11]. A earlier survey among BSCOS in 2007 had only 6% of British surgeons recommending prophylactic fixation of the contralateral hip [12]. Whether this increase in favouring prophylactic fixation is based on evidence or personal preference, remains to be seen.

***Corresponding author:**
Dr. Vishvas Shetty
[1] Centre for Trauma Sciences, Blizard Institute, Queen Mary University of London, 4 Newark Street, London, E1 2AT
[2] Royal London Hospital, Barts Health NHS Trust, Whitechapel Rd, Whitechapel, London E1 1FR
Email: Vishvas.Shetty@nhs.net
Tel: +44 07814642423

The uncertainty in management of the contralateral hip lends itself well to a systematic review due to only two possible treatment modalities with discrete outcomes to measure. We carried out a systematic review to find an evidence-based answer.

MATERIALS AND METHODS

The review question for this systematic review was *In cases of unilateral slipped capital femoral epiphysis, what management plan is more suitable for the unaffected contralateral hip: prophylactic fixation or active surveillance?* Our hypothesis was that both management plans were equally effective. A PICO format was used to formulate the review question [Table A]. The review protocol was as per PRISMA guidelines [13]

Inclusion and exclusion criteria were determined prior to literature review [Table B]. All relevant studies from MEDLINE [1/1/1900 to 30/04/2020] and EMBASE [1/1/1900 to 30/04/2020] were included. The search strategy is as described in Table C. The PRISMA flowchart for the literature review is as described in Table D. All levels of evidence were included and the identity of the author or institution were not masked. Two reviewers [VS and MT] assessed the included studies separately. Any discrepancy was resolved by discussion, review of abstract or full text and referring to the eligibility criteria and review question. Data was extracted by both reviewers separately and tabulated as in Table E.

There was an obvious lack of high quality studies in the field. There were no randomized controlled trials and both the included studies are retrospective cohort comparisons with no randomization and heavy bias. We amended the eligibility criteria to include these studies. However there were certain studies identified that, despite not adhering to the eligibility criteria, contribute important insights to the review question. These papers will be discussed in a separate section.

RESULTS

195 studies were identified in total of which 61 were duplicates, leaving 134 studies. Of these 92 were eliminated based on title and 42 underwent a further review of abstract or full text leaving 2 studies for final review which fit the inclusion criteria. Both were retrospective non-randomized cohort comparisons. Table I lays out the characteristics of the included studies.

Clement et al

In 2015, Clement et al published a retrospective cohort comparison study comparing prophylactic fixation with active surveillance for the unaffected contralateral hip in SCFE [14]. From January 2000 to December 2010, they identified a total of 86 patients with a mean follow up 8 years [3-13]. These were divided into the prophylactic fixation group [PF] or the active surveillance group [AS] at the discretion of the admitting consultant. However, following data collection and analysis, there were no significant differences in the demographics of the two groups with regard to age, sex, gender, medical history and socioeconomic status. All procedures were performed or supervised by a consultant. A single fully or partially threaded screw was inserted percutaneously into the femoral head with atleast three threads across the physis on orthogonal views. The primary outcomes measured were functional outcomes [Short Form 12 and Oxford Hip Score], complication rate and radiographic evidence of cam lesion and osteoarthritis [OA] in both groups. Secondary outcome was a cost analysis of prophylactic fixation based on Quality adjusted Life Years [QALY]. One patient died during follow up, unrelated to the study.

The AS group had 50 patients of which 46% [23/50] underwent a subsequent slip in a median interval of 128 days [65-297] and only 2 presented late. Of these, 2 had femoro-acetabular impingement [FAI], 2 needed an osteotomy and 1 had a total hip replacement [THR]. The remaining 54% [27/50] had no further slip till end of follow up. The PF group had 36 patients, none of whom had a further slip, post operative infections or secondary fixation.

Functional outcomes via the SF 12 and OHS were collected retrospectively over the telephone at a mean of 7.8 years after index presentation. 72 patients responded [41 in PF and 31 in AS]. All scores were higher for the PF group with the SF 12 physical component being significantly so. The OHS in the patients of the AS group who did not have a subsequent slip was higher than those who did. Review of initial radiographs only included 78% [67/86] due to a conversion from physical to digital images in 2007. There was no significant difference in the PSA of the two groups. On sub group analysis, a significant difference was found between the PSA of those with subsequent slips and those without in the AS group [10.3* vs. 5.9*]. Follow up radiographs were reviewed at mean of 3.8 years for 69% [59/86] of the patients. Eight cam lesions were seen in AS group, three of who had a subsequent symptomatic slip and five did not. A cost analysis was performed based on the QALY calculated from SF-12-6D responses. The cost per patient in the AS group was £7241 and the PF group was £7882 [difference of £641]. The cost per QALY for the PF group is £1431. Of note is that the cost of QALY of a THR is £1372 and a TKR is £2101 [15].

Overall, the authors conclude that prophylactic fixation is the preferable choice based on the better functional, radiological and cost outcomes. The merits of the study are that it directly compares prophylactic fixation to active surveillance with well-defined primary and secondary outcomes. The limitations of the study are the retrospective design, lack of randomization and bias, retrospective collection of data, incomplete radiological follow up and variable follow up durations.

Bhattacharjee et al

In 2015, Bhattacharjee et al published a retrospective cohort comparison study comparing prophylactic fixation with active surveillance for the unaffected contralateral hip in SCFE [16]. 80 patients fit the eligibility criteria, 44 in the PF group and 36 in the AS group. Method of division into groups was not specified. Follow-up was for a minimum of 12 months with review and radiograph [antero posterior and frog-leg] at 3, 6 and 12 months. Follow-up beyond 12 months was done if clinically indicated though these indications are not mentioned. Mean follow up for 2.4 years [1-8.8] in PF group and 2.9 years [1-9] in AS group. All fixations were done by one of three consultants or their trainees under supervision. A single Richards cannulated hip screw was inserted percutaneously under image guidance with 2-3 threads within the physeal plate on orthogonal views and the screw head left proud. The primary outcome was the incidence of sequential slip in both groups. The secondary outcome was the incidence of AVN, chondrolysis and post-operative complications in both groups. Demographically there were no significant differences between the two groups for age at primary presentation, severity of index slip, sex or duration of follow-up. The chronological age of the AS group at final follow-up was significantly higher than the PF group.

The AS group had 10 sequential slips [28%], which was 12.2 times as likely as the PF group with 1 slip [2%]. Average age of those with subsequent slip was 13 years and those without were 12.9 years. The average duration between slips was 8.4 months [3-12] with an outlying 27 months for the slip in the PF group. Regarding complications, there were no cases of AVN or chondrolysis. 1 patient required metalwork revision due to increased growth of the neck, 1 complained of pain from the metalwork and 1 had a superficial infection.

The authors conclude that prophylactic fixation is preferable based on the relative risk of subsequent slip in the observation group and low rate of complications from prophylactic surgery. The merits of the study are that it directly compares prophylactic fixation to active surveillance with

well-defined primary and secondary outcomes. The limitations are the retrospective design, lack of randomization and bias, lack of patient reported outcomes and variable follow up duration.

DATA SYNTHESIS

On comparing the two studies, they are both retrospective studies without randomization. Both had similar number of patients [86 vs. 80] and but the rate of sequential slip in the AS group was disparate [46% vs. 28%]. This could be related to the different demographic [Edinburgh vs. Oswestry] but there is insufficient data to prove or refute this. The other comparable outcome was the incidence of AVN or chondrolysis; both studies reported no incidence of either. The method of fixation also differed [partially/fully threaded vs. fully threaded]. There is evidence that the spanning the physis with threads can cause early closure, reduced growth of the neck and leg length discrepancy in unilateral fixations [17]. It is interesting to note that the only case in both studies that required secondary fixation was fixed initially using a fully threaded screw.

Additional studies of note

Two of the most commonly referenced studies in relation to management of the contralateral hip are by Kocher et al and Schultz et al [18,19]. Both are expected value decision analyses to determine to optimal management for the unaffected contralateral hip in unilateral SCFE based on the literature. Surprisingly they come to opposite conclusions, with Schultz et al favouring prophylactic fixation and Kocher et al favouring active surveillance. This is due to some key differences between the studies. The decision tree for Schultz included only two complications – chondrolysis and AVN. Additionally at the time of publication there were no reported cases of AVN post prophylactic fixation. However in 2013, Sankar et al reported a 2% incidence of AVN following prophylactic fixation [9]. This could potentially alter the utility value in the prophylactic fixation arm. Additionally, the study states that the model swings in favour of active surveillance if the risk of AVN goes above 18% or risk of chondrolysis above 21%. The utility values in the Schultz paper are derived from Iowa hip scores as described in Carney et al [20, 21]. The Kocher study used a similar decision tree but with more terminal nodes and complications. Utility values were gained from questionnaires to twenty-five adolescent males with normal hips [i.e. patient preferences], which they argue is the correct method in traditional expected value decision analyses [18]. The model favours active surveillance by a small margin and swings towards prophylactic fixation when the risk of contralateral slip is more than 27%. This incidence of contralateral slip has been reported between 19%-80% [2, 4, 22]. These figures are based on a number of factors and will be discussed in the next section.

Castro et al published one the largest reviews in the field to determine if the literature supported prophylactic fixation [2]. They collected demographic data from two hundred and six studies to reveal important insights. Children with a unilateral SCFE were 2,335 times more likely to develop a contralateral SCFE as compared to the risk of a child from the general population developing an initial SCFE. 26% of all patients have bilateral SCFE, of which 34% are simultaneous and 66% are sequential. This means that for every 100 patients, 17 [19%] will be diagnosed with a subsequent contralateral slip. Of the sequential slips, 71% are diagnosed within the first year and 88% within eighteen months. The average interval between primary and secondary diagnosis was 11 months. Regarding the severity of slips, 48% of the primary slips were mild compared to 73% of the subsequent slips. This is likely due to better patient education. The authors have also made the assumption that 80% of contralateral hips will have satisfactory outcome on long term follow up based on a review of studies with long term follow up of SCFE hips. This estimate is consistent with the 19% incidence of subsequent slips.

DISCUSSION

Based on the above, there is an obvious need for high quality evidence on the subject. Though both studies included recommend prophylactic fixation, there is a high degree of bias in poor quality studies that cannot be translated into evidence-based medicine. When making a clinical decision regarding the contralateral hip, there are few matters to consider, as we will discuss below.

Surgical technique

Whether or not the contralateral hip is fixed, the method of fixation is of considerable importance. There is evidence that the use of multiple pins risk premature closure of the physis, especially when they cross the physis at non-perpendicular angles [23, 24]. Contrasting evidence proves that a single screw inserted perpendicular to the physis is sufficient and the biomechanical gain in stiffness from a second screw does not offset its risk [25, 26]. There is also evidence that the femoral neck grows about 4mm a year till skeletal maturity and can grow up to 15mm after primary fixation [4, 17]. Hence some authors recommend leaving the head of the screw proud atleast 1.5cm at the lateral cortex[17]. This may not be a problem in obese patients but may cause local irritation in thin patients.

Implant choice

Fixation of head with threads spanning the physis prevents further growth at the neck [27]. This can lead to a short neck, high riding trochanter and possibility of late secondary osteoarthritis[27]. To avoid this, some surgeons use non threaded pins or K-wires[23,24]. Though this is effective initially, if the femoral neck grows, the pin loses fixation and a subsequent slip could occur[8]. A better alternative is a partially threaded screw with screws only in the epiphysis or a Hansson hook pin, which allow good fixation and continued growth of the physis along the smooth barrel [28].

Radiation burden

An argument against active surveillance is the radiation exposure from repeated radiographs on follow-up. This claim is tenuous at best. The patients who undergo the prophylactic fixation also require regular follow up with radiographs to check position of metalwork and for early diagnosis of subsequent slip due to growth [17]. The frequency of this is suggested to be twice a year till skeletal maturity if the rate of growth of the femoral neck is 4mm/year[17]. Additionally, a lateral radiograph would suffice as most slips begin in the posterior direction[17]. The exposure of a single lateral hip view in an adolescent is 0.03mSv, which is 1% of the annual exposure to natural radiation[17]. Hence both groups will undergo serial radiographs and that must not be a factor in the decision making process.

Number needed to treat

Castro et al concluded that if all patients with unilateral SCFE had prophylactic fixation of the contralateral hip, then 81% would have been subjected to an unnecessary procedure[2]. Hansson et al estimates about 50% in the same scenario and Jerre et al puts the number at 56% [17,29]. If the posterior sloping angle [PSA] is taken as a predictive tool then the number needed to treat has been reported as 1.79 or 1.9 [30,31]. These numbers indicate the volume of unnecessary surgery performed if prophylactic fixation is the preferred option.

Length of follow up

Most subsequent slips are detected within 18 months of the index slip[2]. To prevent missed slips, multiple centres recommend follow up till physeal closure[22,32,33]. Some authors report that the fusion of the triradiate cartilage indicates the improbability of future slips[33,34]. When

planning a study or treatment protocol, the follow up period must be strictly defined.

Posterior sloping angle

Since its introduction by Barrios et al in 2005, the PSA has been used as a radiological predictor of bilaterality[35]. It has been shown to be an effective tool with good to excellent intraobserver and interobserver reliability[31]. Patients with subsequent slips have been retrospectively found to have a higher PSA than patients who did not have a subsequent slip[30,31,35,36]. However the exact cutoff point to accurately predict future slip varies and has been estimated from 12* - 19* [31,35–37]. This reduces the predictive value of PSA.

Radiological method

The standard radiographic views used in follow-up are the AP and frog leg or Lauenstein view[38–40]. There is evidence to show that the Billing true lateral view is more reproducible and detects a higher number of slips, as most early slips are posterior[22]. This is probably why Swedish studies, where the Billing view is standard, report a higher rate of subsequent slip[4,17,29]. Standardized radiography protocols are essential for accurate follow up.

Clinical presentation and education

It is important to note that early SCFE can present at knee or thigh pain[17]. All patients, especially those under active surveillance, must be duly educated. Additionally it must be recognized that these children will be followed up for years and may inadvertently alter their lifestyle to prevent a slip. They must be suitably reassured at every visit.

Age

Young age at initial unilateral presentation is known to be a risk factor for future contralateral slips[41,42]. Predicting which young child will have a subsequent slip is difficult and the exact age at which risk significantly rises varies amongst authors, reporting between 10-12.4 years[41,43–45]. Chronological age aside, bone age is also a reasonable predictor of future slips[41,44,46,47]. From this we can glean that the younger the age at first presentation, higher the risk of subsequent slip. Interestingly in Bhattacharjee et al, the average age of the cohort of patients from the AS group who had a subsequent slip was more than that of the patients who did not have a slip[16].

Clinical indicators

The relation between obesity and bilateral SCFE is well established[48,49]. When compounded with young age at index presentation, a strong case for prophylactic fixation can be made[48]. The presence of endocrine disorders such as adiposogenital dystrophy, juvenile hypothyroidism or growth hormone treatment are commonly seen in patients presenting with bilateral SCFE [17]. A good clinical history and examination at index presentation can identify these high-risk patients.

Cam lesions

The cam deformity of the femoral head has been variously considered a primary deformity, an undiagnosed minor slip or a secondary remodeling following idiopathic OA[50–53]. Long term follow up has shown no difference in outcome between patients with unilateral and bilateral slips[54]. But their reported mean Harris hip score is lower than the average population[55,56]. If considered to be an undiagnosed slip, robust imaging and follow up could lower its incidence. Interestingly, Lerch et all found that 11% of prophylactically fixed contralateral developed a cam deformity requiring further surgical intervention [57].

CONCLUSION

This systematic review has some limitations. There is inherent reviewer bias, which is partly eliminated by having two reviewers analyse the data independently. There is a possibility of incomplete retrieval of data as we have only included studies published on MEDLINE and EMBASE, forgoing any gray literature on the subject. The included studies themselves are not randomized controlled trials.

Due to a lack of quantity and quality of evidence, a clear answer to the review question could not be found. Despite the fact that both included studies prefer prophylactic fixation, their poor study design and bias preclude their conclusions being translated into practice. The existing evidence does offer valuable insights into predictive tools, surgical technique, implant choice, follow up and imaging techniques. However, currently, our diagnostic ability is far superior to our predictive ability[2]. Management plans should be made on a case-by-case basis taking into account patient demographics, surgical and outpatient resources and patient preferences. Further research in the field is required, preferably in the form of prospective randomized controlled trials.

Compliance with Ethics Standards

Funding: No funding was received in the study design or manuscript drafting.

Conflicts of Interest: On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Table A: PICO format for review question

PICO format	
Population	All cases of unilateral SCFE in humans were considered. Cases were not discriminated based on gender, age at presentation, severity or associated conditions
Intervention	Two interventions are being studied in this review: prophylactic pinning or active monitoring of the contralateral hip.
Control	There is no control group. Patients treated with prophylactic pinning will be compared against patients who were actively monitored.
Outcome	The suitability of either management plan is based on the outcomes of reduced incidence of avascular necrosis [AVN], osteoarthritis [OA] and femoro-acetabular impingement [FAI] in the contralateral hip.

Table B: Eligibility criteria

Inclusion criteria	Exclusion criteria
English language articles	Articles not in English
Human studies – no discrimination based on gender, age at presentation, severity or associated conditions	Animal studies
Studies comparing prophylactic pinning to active monitoring	Case series of prophylactic pinning or active monitoring alone
	Anecdotal evidence
	High degree of bias in patient selection
	Poor quality studies

Table C: Search terms

Search terms
• Search [[[contralateral] AND [[[[slipped capital femoral epiphysis] OR slipped upper femoral epiphysis] OR SUFE] OR SCFE]]] AND [[femoroacetabular impingement] OR FAI]
• Search [[[contralateral] AND [[[[slipped capital femoral epiphysis] OR slipped upper femoral epiphysis] OR SUFE] OR SCFE]]] AND [[Osteoarthritis] OR OA]
• Search [[[contralateral] AND [[[[slipped capital femoral epiphysis] OR slipped upper femoral epiphysis] OR SUFE] OR SCFE]]] AND [[avascular necrosis] OR AVN]
• Search [femoroacetabular impingement] OR FAI
• Search [Osteoarthritis] OR OA
• Search [avascular necrosis] OR AVN
• Search [contralateral] AND [[[[slipped capital femoral epiphysis] OR slipped upper femoral epiphysis] OR SUFE] OR SCFE]
• Search [[[slipped capital femoral epiphysis] OR slipped upper femoral epiphysis] OR SUFE] OR SCFE
• Search [[slipped upper femoral epiphysis] OR SUFE]
• Search slipped capital femoral epiphysis

Table D: PRISMA flow chart

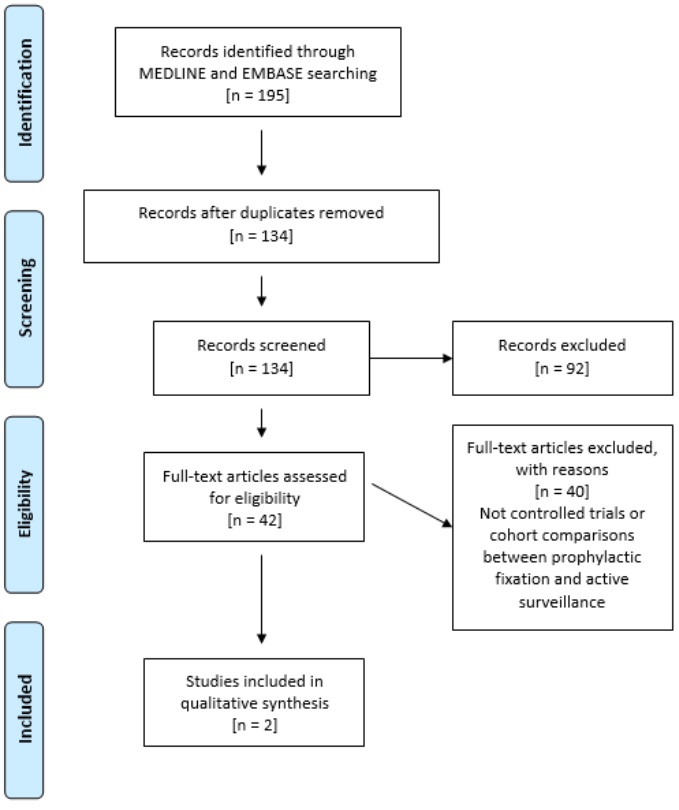

Table E: Extracted data from included studies

Study	Year	Population	Intervention	Primary outcome	Secondary outcome	Randomised	Prospective/ Retrospective	Follow up	Notes
Clement et al	2015	86 hips 54M 32F	36 PF 50 AS	Complication rate, functional status, radiographic evidence of cam lesions and OA	Cost analysis of prophylactic fixation	N	Retrospective	Minimum 3 years	One death unrelated to study
Bhattacharjee et al	2016	80 hips	44 PF 36 AS	Incidence of sequential slip, severity and interval	Incidence of AVN, chondrolysis and post op infections	N	Retrospective	Minimum 1 year	One secondary fixation required

ABBREVIATIONS

SCFE: Slipped capital femoral epiphysis
AVN: Avascular necrosis
OA: Osteoarthritis
SF 12: Short form health survey 12
OHS: Oxford hip score
THR: Total hip replacement
PF: Prophylactic fixation
AS: Active surveillance
PSA: Posterior sloping angle
QALY: Quality adjusted life year
AP: Antero-posterior

REFERENCES

1. Peck K, Herrera-Soto J. Slipped capital femoral epiphysis: what's new? Orthop Clin North Am. 2014; 45[1]:77-86.
2. Castro FP, Bennett JT, Doulens K. Epidemiological perspective on prophylactic pinning in patients with unilateral slipped capital femoral epiphysis. J Pediatr Orthop 2000; 20[6]:745-8.
3. Bittersohl B, Hosalkar HS, Zilkens C, Krauspe R. Current concepts in management of slipped capital femoral epiphysis. Hip Int J Clin Exp Res Hip Pathol Ther. 2015;25[2]:104–14.
4. Hägglund G. The contralateral hip in slipped capital femoral epiphysis. J Pediatr Orthop Part B. 1996; 5[3]:158-61.
5. Johari AN, Pandey RA. Controversies in management of slipped capital femoral epiphysis. World J Orthop. 2016;7[2]:78–81.
6. Loder RT. Controversies in slipped capital femoral epiphysis. Orthop Clin North Am. 2006; 37[2]:211–21, vii.
7. Falciglia F, Aulisa AG, Giordano M, Guzzanti V. Fixation in slipped capital femoral epiphysis avoiding femoral-acetabular impingement. J Orthop Surg. 2017;12[1]:163.
8. Woelfle JV, Fraitzl CR, Reichel H, Nelitz M. The asymptomatic contralateral hip in unilateral slipped capital femoral epiphysis: morbidity of prophylactic fixation. J Pediatr Orthop Part B. 2012;21[3]:226-9.
9. Sankar WN, Novais EN, Lee C, Al-Omari AA, Choi PD, Shore BJ. What are the risks of prophylactic pinning to prevent contralateral slipped capital femoral epiphysis? Clin Orthop. 2013;471[7]:2118–23.
10. Jamjoom BA, Butler D, Thomas S, Ramachandran M, Cooke S. Opinion survey of members of British Society of Children's Orthopaedic Surgery related to specific case scenarios in slipped capital femoral epiphysis. J Pediatr Orthop Part B. 2017;26[4]:340–3.
11. Sonnega RJA, van der Sluijs JA, Wainwright AM, Roposch A, Hefti F. Management of slipped capital femoral epiphysis: results of a survey of the members of the European Paediatric Orthopaedic Society. J Child Orthop. 2011;5[6]:433–8.
12. Witbreuk M, Besselaar P, Eastwood D. Current practice in the management of acute/unstable slipped capital femoral epiphyses in the United Kingdom and the Netherlands: results of a survey of the membership of the British Society of Children's Orthopaedic Surgery and the Werkgroep Kinder Orthopaedie. J Pediatr Orthop Part B. 2007;16[2]:79-83.
13. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ. 2009;339:b2535.
14. Clement ND, Vats A, Duckworth AD, Gaston MS, Murray AW. Slipped capital femoral epiphysis: is it worth the risk and cost not to offer prophylactic fixation of the contralateral hip? Bone Jt J. 2015;97-B[10]:1428–34.
15. Jenkins PJ, Clement ND, Hamilton DF, Gaston P, Patton JT, Howie CR. Predicting the cost-effectiveness of total hip and knee replacement: a health economic analysis. Bone Jt J. 2013;95-B[1]:115-21.
16. Bhattacharjee A, Freeman R, Roberts AP, Kiely NT. Outcome of the unaffected contralateral hip in unilateral slipped capital femoral epiphysis: a report comparing prophylactic fixation with observation. J Pediatr Orthop Part B. 2016;25[5]:454–8.
17. Hansson G, Nathorst-Westfelt J. Management of the contralateral hip in patients with unilateral slipped upper femoral epiphysis: to fix or not to fix--consequences of two strategies. J Bone Joint Surg Br. 2012;94[5]:596–602.
18. Kocher MS, Bishop JA, Hresko MT, Millis MB, Kim Y-J, Kasser JR. Prophylactic pinning of the contralateral hip after unilateral slipped capital femoral epiphysis. J Bone Joint Surg Am. 2004;86-A[12]:2658-65.
19. Schultz WR, Weinstein JN, Weinstein SL, Smith BG. Prophylactic pinning of the contralateral hip in slipped capital femoral epiphysis : evaluation of long-term outcome for the contralateral hip with use of decision analysis. J Bone Joint Surg Am. 2002;84-A[8]:1305–14.
20. Carney BT, Weinstein SL. Natural history of untreated chronic slipped capital femoral epiphysis. Clin Orthop 1996;[322]:43–7.
21. Carney BT, Weinstein SL, Noble J. Long-term follow-up of slipped capital femoral epiphysis. J Bone Joint Surg Am. 1991;73[5]:667–74.
22. Jerre R, Billing L, Hansson G, Karlsson J, Wallin J. Bilaterality in slipped capital femoral epiphysis: importance of a reliable radiographic method. J Pediatr Orthop Part B. 1996;5[2]:80-4.
23. Seller K, Raab P, Wild A, Krauspe R. Risk-benefit analysis of prophylactic pinning in slipped capital femoral epiphysis. J Pediatr Orthop Part B. 2001;10[3]:192-6.
24. Emery RJ, Todd RC, Dunn DM. Prophylactic pinning in slipped upper femoral epiphysis. Prevention of complications. J Bone Joint Surg Br. 1990;72[2]:217-9.

25. Blanco JS, Taylor B, Johnston CE. Comparison of single pin versus multiple pin fixation in treatment of slipped capital femoral epiphysis. J Pediatr Orthop. 1992;12[3]:384–9.
26. Karol LA, Doane RM, Cornicelli SF, Zak PA, Haut RC, Manoli A. Single versus double screw fixation for treatment of slipped capital femoral epiphysis: a biomechanical analysis. J Pediatr Orthop. 1992;12[6]:741–5.
27. Wölfle-Roos JV, Urlaub S, Reichel H, Taurman R. Significantly lower femoral neck growth in screw fixation of the asymptomatic contralateral hip in unilateral slipped capital femoral epiphysis. J Pediatr Orthop Part B. 2016;25[3]:197–201.
28. Hansson LI. Osteosynthesis with the hook-pin in slipped capital femoral epiphysis. Acta Orthop Scand. 1982;53[1]:87–96.
29. Jerre R, Billing L, Hansson G, Wallin J. The contralateral hip in patients primarily treated for unilateral slipped upper femoral epiphysis. Long-term follow-up of 61 hips. J Bone Joint Surg Br. (1994;76[4]:563–7.
30. Phillips PM, Phadnis J, Willoughby R, Hunt L. Posterior sloping angle as a predictor of contralateral slip in slipped capital femoral epiphysis. J Bone Joint Surg Am. 2013;95[2]:146–50.
31. Zenios M, Ramachandran M, Axt M, Gibbons PJ, Peat J, Little D. Posterior sloping angle of the capital femoral physis: interobserver and intraobserver reliability testing and predictor of bilaterality. J Pediatr Orthop. 2007;27[7]:801–4.
32. Wensaas A, Gunderson RB, Svenningsen S, Terjesen T. Good long-term outcome of the untreated contralateral hip in unilateral slipped capital femoral epiphysis : Forty hips with a mean follow-up of 41 years. J Child Orthop. 2014;8[5]:367–73.
33. Puylaert D, Dimeglio A, Bentahar T. Staging puberty in slipped capital femoral epiphysis: importance of the triradiate cartilage. J Pediatr Orthop 2004;24[2]:144–7.
34. Billing L, Severin E. Slipping epiphysis of the hip; a roentgenological and clinical study based on a new roentgen technique. Acta Radiol Suppl. 1959;174:1–76.
35. Barrios C, Blasco MA, Blasco MC, Gascó J. Posterior sloping angle of the capital femoral physis: a predictor of bilaterality in slipped capital femoral epiphysis. J Pediatr Orthop. 2005;25[4]:445-9.
36. Park S, Hsu JE, Rendon N, Wolfgruber H, Wells L. The utility of posterior sloping angle in predicting contralateral slipped capital femoral epiphysis. J Pediatr Orthop. 2010;30[7]:683–9.
37. Kohno Y, Nakashima Y, Kitano T, Nakamura T, Takamura K, Akiyama M, et al. Subclinical bilateral involvement of the hip in patients with slipped capital femoral epiphysis: a multicentre study. Int Orthop. 2014;38[3]:477–82.
38. Lino W, Akkari M, Waisberg G, Braga SR, Santili C. Chronic slipped capital femoral epiphysis: a radiographic evaluation of the Southwick osteotomy. J Pediatr Orthop Part B. 2013;22[6]:536–41.
39. Mestriner MB, Verquietini CMA, Waisberg G, Akkari M, Fukunaga ET, Santili C. Radiographic evaluation in epiphysiolysis: possible predictors of bilaterality? Acta Ortop Bras. 2012;20[4]:203–6.
40. Santili C, de Assis MC, Kusabara FI, Romero IL, Sartini CM, Longui CA. Southwick's head-shaft angles: normal standards and abnormal values observed in obesity and in patients with epiphysiolysis. J Pediatr Orthop Part B. 2004;13[4]:244–7.
41. Riad J, Bajelidze G, Gabos PG. Bilateral slipped capital femoral epiphysis: predictive factors for contralateral slip. J Pediatr Orthop. 2007;27[4]:411–4.
42. Koczewski P. [An epidemiological analysis of bilateral slipped capital femoral epiphysis in children]. Chir Narzadow Ruchu Ortop Pol. 2001;66[4]:357–64.
43. Bidwell TA, Susan Stott N. Sequential slipped capital femoral epiphyses: who is at risk for a second slip? ANZ J Surg. 2006;76[11]:973+6.
44. Stasikelis PJ, Sullivan CM, Phillips WA, Polard JA. Slipped capital femoral epiphysis. Prediction of contralateral involvement. J Bone Joint Surg Am. 1996;78[8]:1149-55.
45. Krahn TH, Canale ST, Beaty JH, Warner WC, Lourenço P. Long-term follow-up of patients with avascular necrosis after treatment of slipped capital femoral epiphysis. J Pediatr Orthop 1993;13[2]:154–8.
46. Popejoy D, Emara K, Birch J. Prediction of contralateral slipped capital femoral epiphysis using the modified Oxford bone age score. J Pediatr Orthop. 2012;32[3]:290-4.
47. Zide JR, Popejoy D, Birch JG. Revised modified Oxford bone score: a simpler system for prediction of contralateral involvement in slipped capital femoral epiphysis. J Pediatr Orthop. 2011;31[2]:159–64.
48. Aversano MW, Moazzaz P, Scaduto AA, Otsuka NY. Association between body mass index-for-age and slipped capital femoral epiphysis: the long-term risk for subsequent slip in patients followed until physeal closure. J Child Orthop. 2016;10[3]:209-13.
49. Nasreddine AY, Heyworth BE, Zurakowski D, Kocher MS. A reduction in body mass index lowers risk for bilateral slipped capital femoral epiphysis. Clin Orthop. 2013;471[7]:2137–44.
50. Harris WH. Etiology of osteoarthritis of the hip. Clin Orthop. 1986;[213]:20–33.
51. Hoaglund FT, Steinbach LS. Primary osteoarthritis of the hip: etiology and epidemiology. J Am Acad Orthop Surg 2001;9[5]:320–7.
52. Murray RO. The aetiology of primary osteoarthritis of the hip. Br J Radiol. 1965;38[455]:810–24.
53. Solomon L. Patterns of osteoarthritis of the hip. J Bone Joint Surg Br. 1976;58[2]:176-83.
54. Baghdadi YMK, Larson AN, Sierra RJ, Peterson HA, Stans AA. The fate of hips that are not prophylactically pinned after unilateral slipped capital femoral epiphysis. Clin Orthop. 2013;471[7]:2124–31.
55. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am. 1969;51[4]:737–55.
56. Lieberman JR, Hawker G, Wright JG. Hip function in patients >55 years old: population reference values. J Arthroplasty 2001;16[7]:901–4.
57. 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. Clin Orthop Relat Res 2019;477[5]:1111-1122.