Subcapital reorientation for moderate and severe slipped capital femoral epiphysis: early results of Ain Shams University Hospitals

Mahmoud A. Mahran, Mohamed A.M. Eid

Department of Orthopedic surgery, Ain Shams University Hospital, Cairo, Egypt

Correspondence to Mahmoud A. Mahran, MD, Ain Shams University, Medical School, Department of Orthopedic Surgery, Ahmed Lotfy Al-Sayed Street, Abbassia, Cairo 11341, Egypt; Tel: +21000689100; e-mail: mmahran@med.asu.edu.eg

Received 10 December 2016
Accepted 15 February 2017

The Egyptian Orthopaedic Journal
2017, 52:122–128

Background
Subcapital reorientation for severe slipped capital femoral epiphysis offers the double benefit of immediate restoration of range of motion (ROM), limb length discrepancy (LLD), and long-term hip preservation from premature osteoarthrosis.
Patients and methods
Modified Dunn's technique through safe surgical hip dislocation was performed in 12 adolescents who presented with moderate-to-severe slipped capital femoral epiphysis. There were 10 males and only two females, with a mean age of 15 years. The mean Southwick's slip angle was 47°. Only two slips were clinically unstable.
Results
After a mean follow-up of 23 months, the mean α angle measured 37°, and the mean slip angle decreased to 4.7°. The mean hip flexion range was 104°; the mean internal rotation in flexion was 33°; and the mean external rotation in flexion was 34°. The mean Harris hip score at the latest follow-up was 99.6. None of the cases developed chondrolysis or osteonecrosis.
Conclusion
It has been a long-standing orthopedic myth, believed by many surgeons, that the capital epiphysis cannot be realigned for fear of avascular necrosis. On the basis of the present study, we believe that subcapital reorientation through safe surgical hip dislocation approach restores close to normal the proximal femoral anatomy, and thus, presumably, would offer good long-term outcomes for a condition that can have serious lifelong consequences on young adults.

Keywords:
modified Dunn's osteotomy, slipped capital femoral epiphysis, surgical hip dislocation

Egypt Orthop J 52:122–128

1110-1148

Introduction

The rate of radiographic changes in osteoarthritis (OA) of hips with moderate or severe slip that remain untreated ranges from 60 to 100% at long-term follow-up; this has been explained by the resultant femoroacetabular impingement (FAI) that leads to acetabular cartilage and labral damage [1,2].

Realignment procedures have been described at the subcapital [3,4], intertrochanteric, and subtrochanteric levels with increased incidence of osteonecrosis avascular necrosis (AVN) as correction approaches the physis [4–6]. Subcapital realignment corrects the deformity at its apex, restoring near-normal hip anatomy and mechanics. Historical series of open reduction for unstable slips report rates of AVN ranging from 5 to 16% [7]. In the young patient, this is unacceptably high, because the treatment options after AVN are hip fusion or hip arthroplasty [8].

Originally, Dunn subcapitally aligned the epiphysis with AVN rates ranging between 10 and 100% and the combination of chondrolysis with AVN up to 40% [3,4,6,9,10].

Until recently, the results of pinning *in situ* for stable slips were considered to be generally good, with many hips remaining asymptomatic for decades [11]. Enough evidence emerged to convict even subclinical slips with resultant FAI as being a major cause for what was previously designated as idiopathic OA [12–15]. This led to renewed interest in Dunn's approach with a modification that decreases the incidence of AVN [12]. Ganz *et al.*'s [16] modification increased the safety of the original Dunn's approach by creating a larger retinacular flap after dislocation; this gives more working space and permits subcapital reorientation without tension on the capital blood supply [17]. At present, the treatment for slipped capital femoral epiphysis (SCFE) comprises

two goals – a short-term goal preventing further progression of the slip and a longer-term goal of preventing FAI, the cause of labral and cartilage damage [18].

Since 2008, we have used the technique of safe hip surgical dislocation for subcapital realignment in our institution with considerable success, and this manuscript presents our early results.

Patients and methods

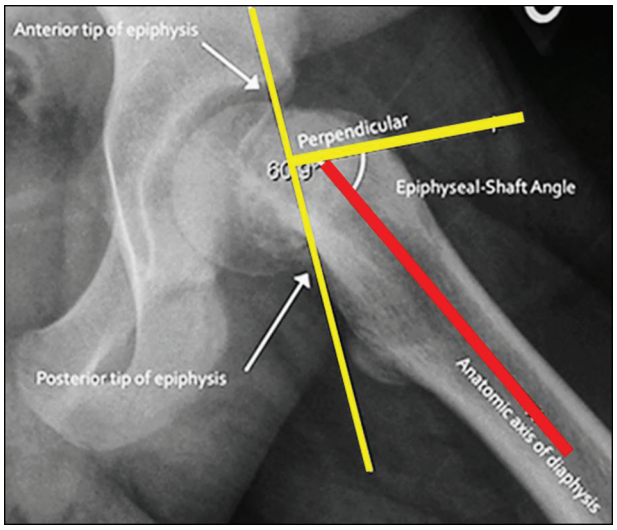
Since 2008, 12 cases presented with SCFE to Ain Shams University hospitals and were operated upon by a modified Dunn's approach aiming for epiphyseal stabilization and restoration of the proximal femoral anatomy at the apex of the deformity in a single operative session. There were only two females in this sample. The mean age was 15 years with predilection to the left side (only two with the right side affected). The duration of symptoms varied from 8 weeks to 24 months. The average Southwick's slip angle [19] was 47 (range: 30–70°) (Fig. 1). The epiphyseal slip percentage was less than 25% in three cases, from 25 to 50% in four cases, and more than 50% in five cases. The approximate values are due to disturbance of the neck breadth caused by remodeling in chronic SCFE, which was demonstrated in all cases. The mean α angle (Fig. 2) was 37° (range: 12–36°). In only two cases, the slip was unstable according to Loder's definition [12,19,21].

All patients presented with hip pain and groin pain sometimes radiating to the knee. Four of them were concerned about external rotational deformity of their lower limbs and inability to squat while praying. Two patients with unstable slips could not bear weights and were reviewed first in the emergency department. Their radiographs showed a chronic slip with evidence of remodeling, and history taking revealed a long history of out-toeing. They presented with an acute on top of chronic slip after sustaining a minor trauma. Hip range of motion (ROM) was not recorded as it was painful in many cases. All cases with stable slips showed positive impingement test and obligatory external rotation on passive flexion. Cases with severe stable chronic slip demonstrated marked limitation of internal rotation range, lost external rotation range, and limb length discrepancy in the range of 1–2 cm. Cases with evident endocrinal etiology (renal osteodystrophy) were excluded from the study.

Preoperative evaluation

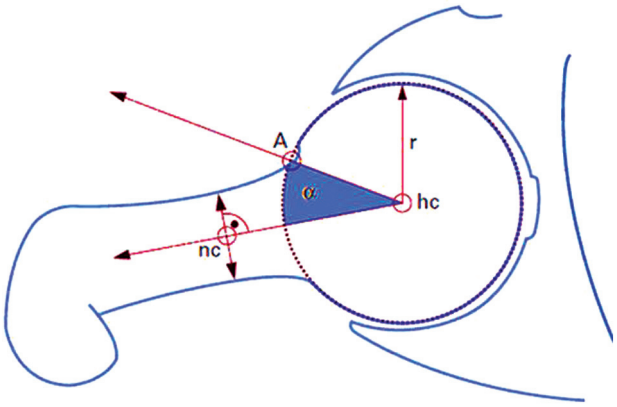
All cases underwent radiological evaluation in the form of plain radiograph of both hips, anteroposterior and

Figure 1



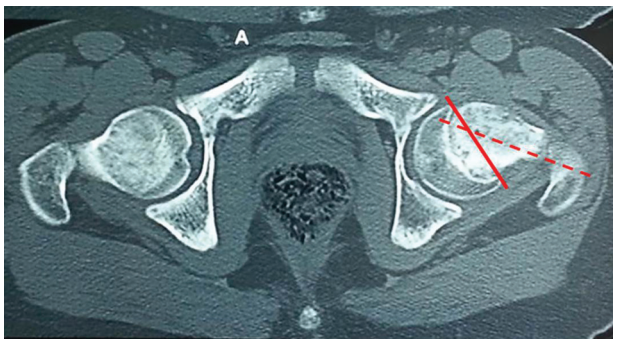
Plain radiograph showing the measurement of Southwick's slip angle

Figure 2



Schematic drawing showing the measurement of the α angle [20]

Figure 3



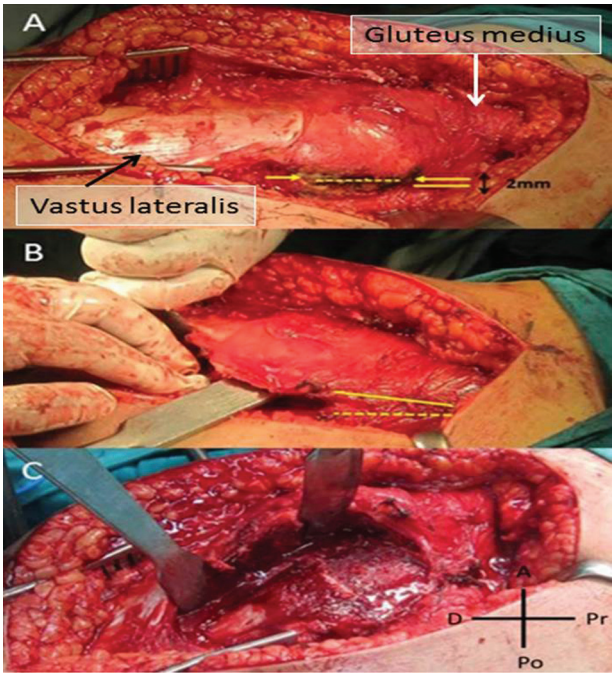
Computerized tomography scan showing chronic, moderate slipped capital femoral epiphysis. The bold line represents the epiphyseal width, whereas the dashed line represents the neck axis

frog lateral views, to measure the slip angle and slip percentage. Computerized tomography scan with sagittal, coronal, and three-dimensional reformat was ordered for all cases to better characterize the deformity (Fig. 3). Hip ROM was not recorded preoperatively.

Operative technique

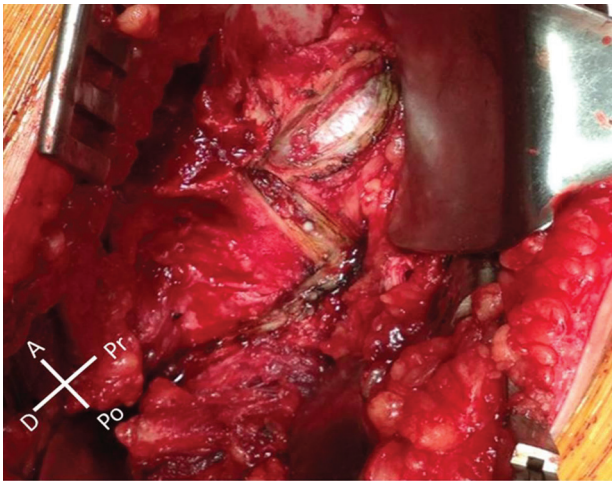
The modified Dunn's technique using the safe surgical hip dislocation approach of Ganz *et al.* [6,16,17,22] was performed in all cases. Patients were positioned laterally after general anesthesia was administered (Figs 4–10).

Figure 4



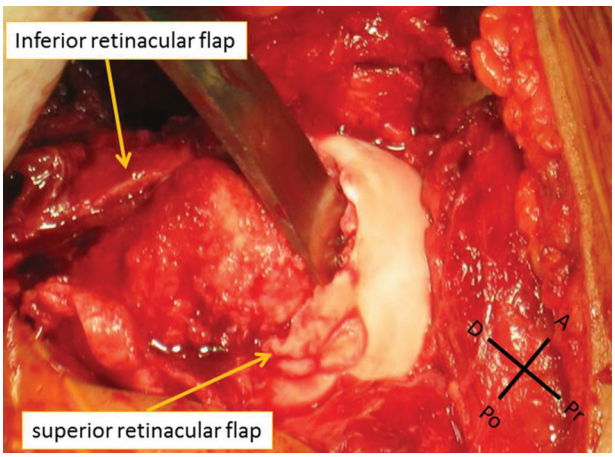
Fashioning of the trigastric osteotomy (three muscle bellies; vastus lateralis, gluteus medius, and gluteus minimus). (a) Osteotomy is marked by electrocautery sparing the posterior most 2 mm of the gluteus medius fibers. Osteotomy is executed by an oscillating saw and completed by an osteotome (b and c). A, anterior; D, distal; Po, posterior; Pr, proximal

Figure 5



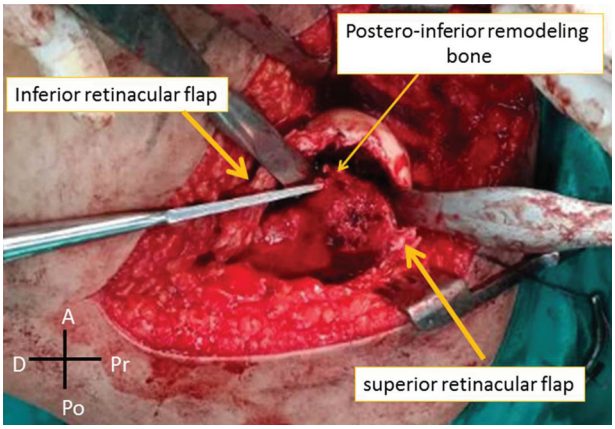
Fashioning of capsular flaps. A, anterior; D, distal; Po, posterior; Pr, proximal

Figure 6



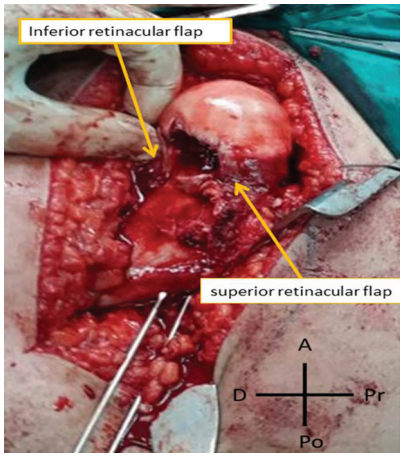
Epiphyseal separation by a curved osteotome. A, anterior; D, distal; Po, posterior; Pr, proximal

Figure 7



Neck preparation. A, anterior; D, distal; Po, posterior; Pr, proximal

Figure 8



Initial tension-free realignment. A, anterior; D, distal; Po, posterior; Pr, proximal

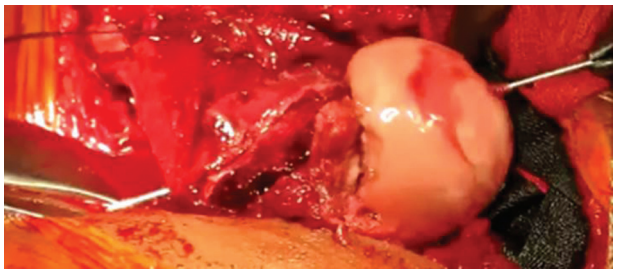
Postoperative protocol

Hip ROM apart from active abduction is encouraged on the second postoperative day after drain removal. Only touchdown weight bearing with two axillary crutches is permitted for 6 weeks. Partial to full weight bearing is permitted after radiological evidence of epiphysiodesis.

Postoperative evaluation was carried out clinically using the Harris hip score and radiologically using slip angle (the slip angle is measured by subtracting the head-shaft angle of the unaffected side from the corresponding angle on the affected side) [19], slip percentage, and Notzeli's α angle [20]. We noted chondrolysis and AVN. The minimum joint space is measured in the weight-bearing portion of the femoral head [23].

Implants were not routinely removed unless they became prominent and problematic.

Figure 9

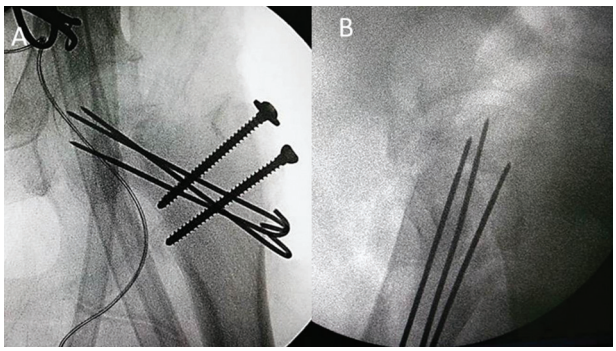


Retrograde fovial wire exiting the femur distal to the trochanteric flip bed

Results

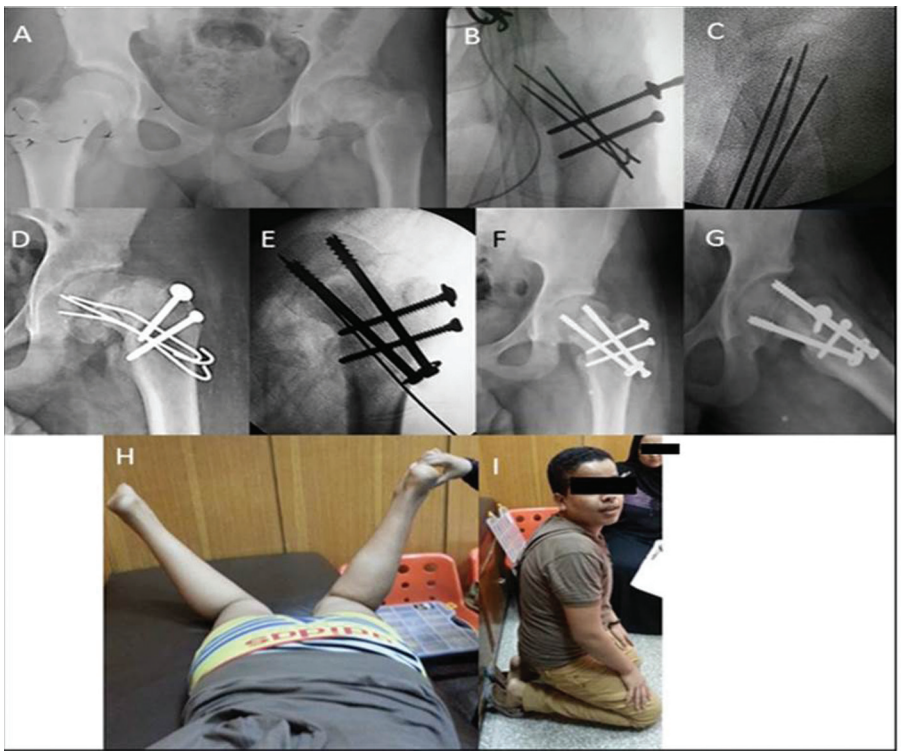
After a mean follow up of 22 months (range: 12–36), the mean hip flexion range was 104 (range: 90–120°), whereas the mean internal and external rotation values

Figure 10



Anteroposterior (a) and lateral (b) intraoperative image intensifier views showing final epiphyseal fixation with three threaded wires and trochanteric fixation with two fully threaded 4.5-mm screws

Figure 11



(a) Moderate left-sided slipped capital femoral epiphysis that was surgically realigned and fixed with three threaded wires (b, c). The patient slipped and fell on the second postoperative day, and the wires bent with loss of reduction (d). The patient was taken to the OR for wire removal. Gentle manipulation on a traction table successfully realigned the physis that was fixed with two 6.5 cannulated screws (f, g). The clinical course was uneventful with successful uncomplicated epiphysiodesis and excellent function at the latest follow-up (h, i)

in flexion were 32 (range: 20–45°) and 39° (range: 20–50), respectively. The mean Harris hip score at the final follow-up was 99.6 (range: 98.5–100). The mean α angle was 37° (range: 14–55). The mean slip angle decreased from 47 (range: 30–70°) to 4.7 (range: 0–10°). limb length discrepancy (LLD) was corrected in all cases. At the latest follow-up, none of the cases developed nerve palsy, deep venous thrombosis, heterotopic ossification, AVN, or chondrolysis.

One patient fell down on the second postoperative day, and an radiograph showed bending of the wires and epiphyseal displacement. the wires were withdrawn with successful closed reduction of the epiphysis. The epiphysis was refixed with two 6.5 mm AO cannulated screws. Accordingly, the patient's BMI was then reconsidered before deciding to fix the epiphysis with threaded wires versus screws (Fig. 11). None of the cases required second surgery for hardware removal. The oldest case with the longest follow-up is shown in Fig. 12.

Discussion

As the long-term natural history of mild slips is quite good, pinning *in situ* for mild SCFE remains the gold standard [1]. It is a minimally invasive and relatively safe surgical procedure. For moderate-to-severe SCFE, it remains a valid treatment option but one has to consider a concomitant or consequent surgical step to deal with the disturbed proximal femoral anatomy with its resultant FAI, limitation in the hip ROM, and proven prognosis of future OA [12]. Supplementary surgical steps include a miniopen or arthroscopic management of the cam impingement and extracapsular osteotomies.

Extracapsular osteotomies, although much safer in comparison with intracapsular procedures, tackle the deformity away from its apex, and thus create a secondary deformity, namely an extension deformity that seriously limits the hip flexion range [17].

Dunn's original technique for open reduction of the femoral head is appealing as it tackles the deformity at its apex and restores anatomy close to normal without flexion limitation and at the time of slip diagnosis. It comprises a lateral approach to the hip and a trapezoidal osteotomy at the subcapital level, with careful elevation of the vessels in the periosteal fold to avoid undue stretch of blood vessels [10]. The rate of AVN and chondrolysis approached 100%, making the approach nearly abandoned in favor of in-situ fixation and extracapsular osteotomies [12].

Gautier *et al*. [5], after a thorough study of the vascular supply of the femoral head, modified the original Dunn's approach by creating a larger posterior retinacular flap; a retinacular incision starts at the head–neck junction anterosuperiorly and extends laterally toward the base of the stable trochanter. The trochanteric apophasis is split for easy dissection of the posterior retinacular flap together with insertion of piriformis as one mass. Retinacular reflection is performed sharply with a scalpel and a small periosteal elevator. The neck is completely delivered out of the

Figure 12

Three-years follow-up of a 13-year-old boy who presented with bilateral slipped capital femoral epiphysis (SCFE). The left severe SCFE was managed by subcapital realignment through safe surgical dislocation, whereas the right side with mild SCFE with open osteochondroplasty and trochanteric advancement. Plain radiograph of the pelvis and both hips in anteroposterior and in frog lateral positions (a, b) and clinical pictures (b, c) show excellent results

retinacular sleeve where the posteroinferior remodeling bone is completely excised, and the neck end is trimmed to a slightly curved surface. Capital realignment was accomplished by hand while the posterior retinacular flap was checked for undue tension. Otherwise, neck shortening should be attempted. Thus, they could safely dislocate the hip with much less reported ANV rates in all published series [6,17,22–24].

This recent approach toward preserving hips of adolescents and young adults to decrease the need for future hip arthroplasty in their early adulthood has motivated us to start the technique in Ain Shams University hospitals since 2008. The manuscript presents the short-term results of our experience that are surprisingly excellent, with no single case of AVN. This cohort study has serious limitations such as lesser number of cases, lack of a control group and randomization, and the short-term follow-up. Thus, it was not possible to compare our results with those of the current literature.

In agreement with Ziebarth *et al*. [6], we found some clinically stable physes turn out to be unstable intraoperatively and demonstrated easy physeal separation. When mild-to-moderate unstable SCFE has a reported AVN rate as high as 40% [21], then realigning these physis with a safe approach that can assure direct visualization and protection of the capital blood supply may theoretically decrease the incidence of AVN. Our series had two patients with unstable slips who did not develop AVN at the latest follow-up.

Neck shortening theoretically decreases abductor function with possible occurrence of Trendelenburg gait; therefore, we routinely distalize the trochanter for any case that needed neck shortening for tension-free capital realignment. Another compromise is to accept a few degrees of retroversion with tension-free retinacular flap, so as to avoid an unwanted neck shortening procedure that might jeopardize hip–joint stability.

It has been a long-standing orthopedic myth, believed by many surgeons, that the capital epiphysis cannot be realigned for fear of avascular necrosis. On the basis of the present study, we believe that it restores near-perfectly the proximal femoral anatomy, and thus, presumably, would offer good long-term outcomes for a condition that can have serious lifelong consequences on young adults. We believe that this technically demanding procedure is most appropriate for moderate-to-severe SCFE. Safely performing this procedure requires deep and full understanding of the vascular anatomy of the capital epiphysis.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Carney BT, Weinstein SL, Noble J. Long-term follow-up of slipped capital femoral epiphysis. J Bone Joint Surg Am 1991; 73:667–674.

2 Lykissas MG, McCarthy JJ. Should all unstable slipped capital femoral epiphysis be treated open? J Pediatr Orthop 2013; 33(Suppl 1):S92–S98.

3 Fish JB. Cuneiform osteotomy of the femoral neck in the treatment of slipped capital femoral epiphysis. J Bone Joint Surg Am 1984; 66:1153–1168.

4 Fron D, Forgues D, Mayrargue E, Halimi P, Herbaux B. Follow-up study of severe slipped capital femoral epiphysis treated with Dunn's osteotomy. J Pediatr Orthop 2000; 20:320–325.

5 Gautier E, Ganz K, Krugel N, Gill T, Ganz R. Anatomy of the medial femoral circumflex artery and its surgical implications. J Bone Joint Surg Br 2000; 82:679–683.

6 Ziebarth K, Zilkens C, Spencer S, Leunig M, Ganz R, Kim YJ. Capital realignment for moderate and severe SCFE using a modified Dunn procedure. Clin Orthop Relat Res 2009; 467:704–716.

7 Parsch K, Weller S, Parsch D. Open reduction and smooth Kirschner wire fixation for unstable slipped capital femoral epiphysis. J Pediatr Orthop 2009; 29:1–8.

8 Larson AN, McIntosh AL, Trousdale RT, Lewallen DG. Avascular necrosis most common indication for hip arthroplasty in patients with slipped capital femoral epiphysis. J Pediatr Orthop 2010; 30:767–773.

9 Gage JR, Sundberg AB, Nolan DR, Sletten RG, Winter RB. Complications after cuneiform osteotomy for moderately or severely slipped capital femoral epiphysis. J Bone Joint Surg Am 1978; 60:157–165.

10 Dunn DM. The treatment of adolescent slipping of the upper femoral epiphysis. J Bone Joint Surg Br 1964; 46:621–629.

11 Tokmakova KP, Stanton RP, Mason DE. Factors influencing the development of osteonecrosis in patients treated for slipped capital femoral epiphysis. J Bone Joint Surg Am 2003; 85-A:798–801.

12 Schoenecker PL, Gordon JE, Luhmann SJ, Dobbs MB, Keeler KA, Clohisy JC. A treatment algorithm for stable slipped capital femoral epiphysis deformity. J Pediatr Orthop 2013; 33(Suppl 1):S103–S111.

13 Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. Clin Orthop Relat Res 2003; 417:112–120.

14 Sink EL, Kim YJ. Femoroacetabular impingement: current clinical evidence. J Pediatr Orthop 2012; 32(Suppl 2):S166–S171.

15 Sink EL, Zaltz I, Heare T, Dayton M. Acetabular cartilage and labral damage observed during surgical hip dislocation for stable slipped capital femoral epiphysis. J Pediatr Orthop 2010; 30:26–30.

16 Ganz R, Gill TJ, Gautier E, Ganz K, Krugel N, Berlemann U. Surgical dislocation of the adult hip a technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. J Bone Joint Surg Br 2001; 83:1119–1124.

17 Sankar WN, Vanderhave KL, Matheney T, Herrera-Soto JA, Karlen JW. The modified Dunn procedure for unstable slipped capital femoral epiphysis: a multicenter perspective. J Bone Joint Surg Am 2013; 95:585–591.

18 Peck K, Herrera-Soto J. Slipped capital femoral epiphysis: what's new? Orthop Clin North Am 2014; 45:77–86.

19 Southwick WO. Osteotomy through the lesser trochanter for slipped capital femoral epiphysis. J Bone Joint Surg Am 1967; 49: 807–835.

20 Notzli 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 2002; 84: 556–560.

21 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 1993; 75:1134–1140.

22 Masse A, Aprato A, Grappiolo G, Turchetto L, Campacci A, Ganz R. Surgical hip dislocation for anatomic reorientation of slipped capital femoral epiphysis: preliminary results. Hip Int 2012; 22:137–144.

23 Alves C, Steele M, Narayanan U, Howard A, Alman B, Wright JG. Open reduction and internal fixation of unstable slipped capital femoral epiphysis by means of surgical dislocation does not decrease the rate of avascular necrosis: a preliminary study. J Child Orthop 2012; 6:277–283.

24 Leunig M, Slongo T, Ganz R. Subcapital realignment in slipped capital femoral epiphysis: surgical hip dislocation and trimming of the stable trochanter to protect the perfusion of the epiphysis. Instr Course Lect 2008; 57:499–507.