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Slipped Capital Femoral Epiphysis: Surgical Techniques, Complications, Special Topics

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ABSTRACT

Several types of implants have been used for the treatment of SCFE. Apart from the non specific implants, such as pins or cannulated screws, other specific implants for SCFE have been manufactured. Most of these specific implants (telescopic screw, pinscrew, Hansson screw etc) efficiently prevent slip progression while preserving bone growth. Thus head and neck growth and remodeling is maintained, resulting in a lower slip angle and increased head neck offset. Femoroacetabular impingement is the most frequent complication of SCFE, that is seen even in mild slips. Its impact on the acetabulum depends on the severity but also on the chronicity of the slip. Avascular necrosis of the femoral head is the most devastating complication of SCFE leading to early total hip replacement. A rare but catastrophic complication is chondrolysis, causing a substantial articular cartilage loss. Other complications are implant related, including implant failure such as bending, migration and loosening. Prophylactic stabilization of the asymptomatic contralateral hip remains controversial. SCFE still remains a disease characterized by a high incidence of delayed diagnosis and many studies have dealt with the incidence of silent, asymptomatic and subclinical SCFE. There is still no consensus about the removal of the implants in the absence of implant-related symptoms. Lately, there is increasing interest on the role of arthroscopically assisted osteochondroplasty for the prevention and early treatment of FAI.

KEY WORDS: SCFE, surgical techniques, complications

1. Implants used for slip stabilization

Several types of implants are available for the treatment of SCFE: cannulated screws, pins and implants especially designed for SCFE treatment, such as the telescopic screw, the pinscrew or the Hansson screw. Common aim of these implants is to stabilize the slip, yet they do not have the same effect on the remaining growth of the proximal femoral physis.

In situ stabilization of the proximal femoral physis with one partially threaded cannulated screw (**Fig. 1**) is deemed the most efficient stabilization method for stable or unstable SCFE [1]. The cannulated screw is accompanied by a lower risk of implant related complications such as avascular necrosis and

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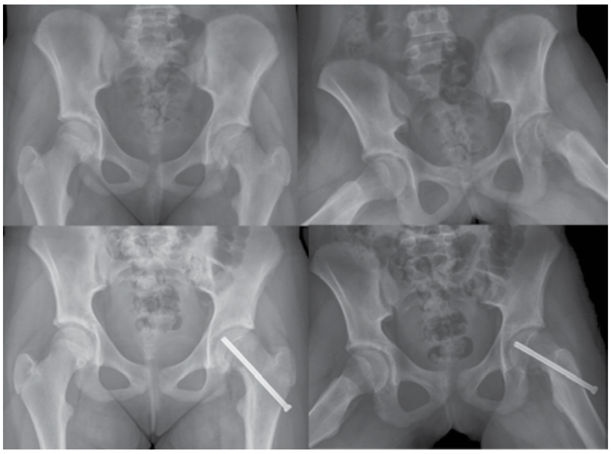

Fig. 1: *In situ stabilization of the proximal femoral physis with one 6.5mm partially threaded cannulated screw is the most accepted treatment for all types of SCFE, irrelevant of slip stability, chronicity or severity. It combines effective physis stabilization with low morbidity and a low complication rate*

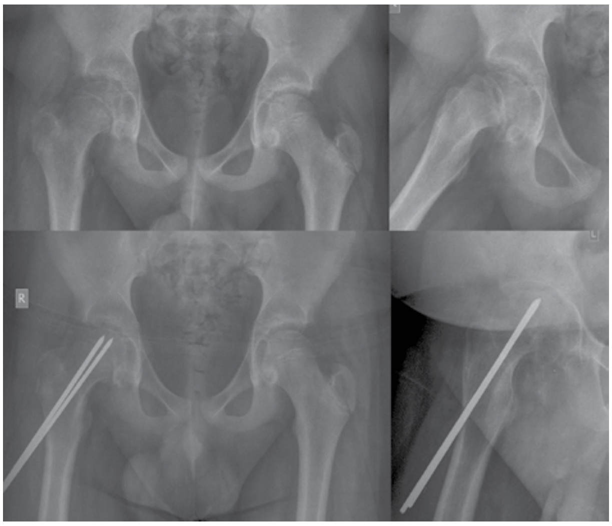

Fig. 2: *In situ stabilization with two 5-6mm nonthreaded pins is a safe and cheap method to treat both stable or unstable SCFE. The second pin provides rotational stability and additional stability to shear forces*

chondrolysis, compared to the stabilization by multiple pins. Furthermore, if this is the surgeons intention, the screw may simultaneously compress the epiphysis on the metaphysis and thus accelerate proximal femoral physis closure [1,2,3] .The cannulated screw is inserted under intraoperative fluoroscopy, and preferably passes vertically to the center of the proximal femoral epiphysis as seen in both AP and lateral hip view ("center-center") [4], while the tip of the screw is advanced up to 2.5 mm [5] or 5 mm [6] from the subchondral bone of the femoral head. However, other studies have shown that the stability of the fixation and the incidence of complications do not differ whether the screw enters the epiphysis centrally or not [7]. The head of the screw may be in contact with the lateral cortex of the femur or protrude 2-3cm out of the lateral cortex (gliding screw technique). Stabilization is most effective when at least five steps of the screw enter the femoral head.

The insertion of a second screw [8] increases the stability of the proximal femoral physis by 66%, however other studies discourage a second screw because it does not increase the structural stability of the construct proportionally [9]. Furthermore, additional implants may be associated with higher risk of complications, such as AVN, chondrolysis [9] or a subtrochanteric fracture of the femur due to weakening of the lateral femoral cortex by multiple drilling during screw placement. The strength of the stabilization increases with increasing diameter of the implant [6,10].

Safe advancement of the screw into the femoral head may be assessed by intraoperative arthrography [6]. Computer navigation may also help to reduce the distance of the screw from the subchondral bone of the epiphysis, but with increased cost and duration of the surgery [6,11].

Multiple (2-3) nonthreaded pins across the physis seem also to be a safe biomechanical alternative to the one cannulated screw (**Fig. 2**). Furthermore, multiple pins may be advantageous compared to the cannulated screw in terms of preserving the residual growth of the femoral neck [3,12,13,14].

2. Growth preserving surgical techniques

In the past, the premature closure of the proximal femoral physis was the main target of any treatment of SCFE in order to prevent slip progression [1,2,3].

However, this concept is currently being challenged. SCFE is a disease of the developing skeleton. The growth plate of the femoral head contributes significantly to the longitudinal growth of the lower limb: it provides 15% of the overall increase in length of the lower limb, at a rate estimated at about 6mm/year [15] and normally fuses at age 16-18 years. Studies of femoral neck growth and remodeling emphasize that any therapeutic intervention in SCFE should take advantage of the remaining growth of the skeleton, especially in younger patients, since a small yet significant correction of the slip angle and the head-neck offset is anticipated [16].

The surgical techniques that are used for slip stabilization, depending on their effect on the remaining growth of the physis, can be classified to those which promote premature physis closure and those which preserve residual growth.

The classic stabilization of the slip with one cannulated screw eventually compresses the physis and promotes premature fusion, which is anticipated within 6-12 months after surgery [17,18,19,20]. This technique restricts the remaining longitudinal growth of the femoral neck and eliminates the growth related decrease of the slip angle and increase of the head-neck offset. Additionally, a short femoral neck may weaken the lever arm of the hip abductors [13,18]. This is exacerbated by the continuing growth of the greater trochanter [21,22].

There are several ways to stabilize a SCFE without affecting the remaining growth, such as multiple (2-3) nonthreaded pins and the classic cannulated screw inserted with a technique that allows physeal growth (gliding screw, Gleitschraube). Especially designed screws, like the telescopic screw, the pinscrew and the Hansson pin (hook pin) are also available in order to stabilize the physis without accelerating its fusion.

Two nonthreaded pins (3-3,5mm) that traverse the physis are sufficient to stabilize the slip without promoting early closure of the proximal growth cartilage compared to the traditional cannulated screw technique [3,12,13]. The pins are inserted percutaneously under image intensification. The patient is placed either on a traction or on a regular surgical table.

The gliding screw (Gleitschraube): The classic cannulated screw may be placed in a way that stabilizes the slip without compressing the femoral neck physis. The thread of the screw is fully contained in the capital epiphysis but a screw with a relative longer shaft is selected, so that (depending on the child's age, for a presumed residual growth of 2-3 years) 1.5-3 cm of the screw protrude out of the lateral femoral cortex [5,19,24,25]. With ongoing femoral neck growth, the femoral head pulls the screw along the femoral neck until the screw head reaches the lateral femoral cortex, thus preventing further longitudinal growth of the femoral neck. If further growth is anticipated, the screw may be replaced by a longer one that protrudes out of the lateral femoral cortex too.

After stabilization with a gliding screw or with stainless steel non-threaded pins, the growth cartilage closes at about 31-37 months [5,18,23], both for the slipped and for the contralateral healthy hip [23]. Furthermore, there is no significant difference in the acetabulotrochanteric distance between the painful and the prophylactically stabilized hips [18]. Some authors showed that non-compressive stabilization (Knowless pins, Hansson pin) of the primary affected and the healthy contralateral hip leads also to simultaneous closure of the neck physis of both hips (about 17 months), while in hips that were not pinned (obviously healthy contralaterals, not clearly stated) the growth cartilage fused at about 2.5 years [25], implying some interference of implant placement with residual growth of the hip. Growth is more pronounced on the contralateral hip [18,23,26], implying that some damage on the slipped physis may be irreversible. A similar gliding mechanism, that allows further longitudinal neck growth, is provided by the Hansson pin [26].

Stabilization of the epiphysis by means of the Pinscrew [13]: the thread of the screw is located at the base of the screw and is anchored at the lateral cortex of the proximal femur, while the body of the screw is smooth and enters the femoral head, to approximately 2 mm from the subchondral bone. During femoral neck growth the capital femoral epiphysis slides along the screw. Femoral neck growth after Pinscrew fixation may eventually lead to: a) a

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higher head-neck offset of the SCFE hip compared to the preoperative head-neck offset (but usually lower than the head-neck offset of the contralateral hip that has been prophylactically stabilized by the same technique), b) increased neck length (reduced compared to the length of the contralateral hip) and c) increased neck thickness (greater than the contralateral hip). The changes of the affected hip in relation to the healthy contralateral hip indicate that the growth cartilage of the SCFE hips is either primarily deficient or is irreparably damaged by the slip or by the surgical technique. Therefore, the implant that is used to stabilize the slip should have as little deleterious effect as possible on the residual growth of the physis. The Pinscrew is also effective for the treatment of unstable slips [13], indicating that growth preserving stabilization techniques are suitable for both stable and unstable slips.

The telescopic screw (Dynamische Epiphysaere Telescopschraube) is another method to stabilize the capital femoral epiphysis without promoting early physeal closure. This screw consists of two tubular parts. The one part (epiphyseal part, of smaller diameter) has a distal thread, which is anchored completely into the epiphysis. The other part of the screw (metaphyseal, of greater diameter) is proximally threaded and is anchored to the lateral cortex and the base of the femoral neck. The epiphyseal part is contained in the metaphyseal part. As the femoral neck grows, the epiphyseal part of the screw is pulled by the epiphysis and slides out of the metaphyseal part of the screw, which is firmly located at the femoral neck metaphysis. The whole construct resembles to a telescope, hence the name of this screw. The use of the telescopic screw in mild and moderate slips has led to a reduction of the slip angle by about 11^o and of the α-angle by 30^o. Sixty per cent of the correction was achieved within the first year of stabilization, emphasizing the importance of early diagnosis in order to maximize the benefits of bone growth and remodeling [27]. In unstable slips, the insertion of an additional nonthreaded pin across the physis is recommended in order to ensure rotational stability [27]. A biomechanical study showed that in terms of stability there was no difference between the telescopic screw and the classic single cannulated screw, although maximal stability was observed by placing three 2mm Kirschner wires across the physis [3].

It seems that the slipped physis takes some time to resume the normal growth rate, which is probably faster in younger patients. After Hannson pin insertion (gliding pin, growth preserving), the affected hip grows initially in a caudal direction, probably due to inherent disturbance of the growth cartilage but also due to inadequate stabilization. After this initial period, growth continues in the normal direction, medially and cranially, resembling to the growth of the prophylactically stabilized hip. This explains the slightly shorter limb on the SCFE side in these patients [26].

3. Complications of SCFE

3.a. Avascular necrosis of femoral head:

Avascular necrosis of the femoral head (AVN) is the most devastating complication of SCFE [2,28,29]. AVN is mostly anticipated after unstable slips [28,30], complicating 24%-47% [28,31] of the cases. AVN onset is rapid, within the first year after the slip [29] and is usually located at the anterosuperior part of the femoral head, while the posteroinferior part of the epiphysis is usually spared, even in advanced stages of the disease [32].

AVN leads SCFE patients to total hip replacement within 10 years, as opposed to patients with postslip degenerative arthritis, who will undergo total hip replacement approximately 23 years after the slip [33]. A study of SCFE patients, who eventually underwent total hip replacement, showed that AVN is a more frequent cause of total hip replacement, compared to postslip femoroacetabular impingement [33].

Risk factors for AVN are: unstable SCFE, extreme displacement of unstable SCFE, a young patient with unstable SCFE [30,20], overreduction or anatomic reduction of unstable SCFE, placement of a screw or pin at the posterosuperior quadrant of the capital femoral epiphysis, injury of the femoral neck vessels due to extreme posterior placement of the implant in an attempt to aim the center of the femoral

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head [34], an attempt to reduce an acute on chronic SCFE [17,21,25,35] and intra-articular osteotomies of the femoral neck [2,36].

The pathology of the impaired vascular supply of the femoral head after unstable SCFE varies. The nutrient vessels of the capital femoral epiphysis may be ruptured, twisted or obstructed either mechanically or functionally, due to a high intraarticular pressure caused by the intraarticular hematoma [37]. Closed reduction manoeuvres may dramatically increase the intra-articular pressure of the hip up to levels that exceed the pressure of a compartment syndrome and are therefore also suggested to predispose to AVN [29,37]. Since all unstable slips present pathology of chronic disease (new bone deposition at the posteroinferior neck metaphysis), any attempt to reduce the femoral head, whether open or closed, should stop at this point of chronicity and should not pass beyond it, towards anatomic reduction, otherwise the vessels of the femoral head will be compressed against this newly formed bone (callus) or may be tensed [38] and subsequently obstructed. Anatomic reduction of the capital femoral epiphysis without jeopardizing blood flow is reasonable only after removal of the posteroinferior neck callus and after femoral neck shortening by means of a modified Dunn procedure [20,39,40].

Bone scintigraphy before unstable SCFE treatment is prognostic for subsequent AVN development: cold bone scans are almost exclusively observed in unstable slips and are associated with AVN in 80-100% of the cases [36,41].

3.b. Chondrolysis

Hip pain due to a SCFE resolves almost immediately after slip stabilization. Persisting pain and stiffness of the hip after surgery may be due to ongoing articular cartilage damage of the hip joint, known as chondrolysis. Pain may be located at the hip joint or it may be reflected on the ipsilateral anterior thigh or knee. Internal rotation is further restricted and the limp of the patient is getting worse [2,20]. The diagnosis is confirmed radiologically by the loss of more than 50% of the intraarticular height compared to the healthy contralateral hip, or in case of bilateral disease, if the joint space is less than 3mm [20]. The incidence of chondrolysis is 5-7%. Its cause has not been clearly identified. Autoimmune and trophic factors, permanent intraarticular protrusion of the stabilizing implant, prolonged hip spica immobilization, severe SCFE, obesity, delayed treatment, and subtrochanteric osteotomy before physeal closure [2,20] are factors suspected to underlie chondrolysis. Transient intraoperative implant penetration into the hip joint during SCFE stabilization does not seem to be associated with chondrolysis [20,42]. The treatment of chondrolysis involves revision of the protruding implant, physiotherapy and analgesics. The overall prognosis of chondrolysis is better than that of AVN. Restoration of the joint space within 10 months is anticipated, however residual hip stiffness may persist [20].

3.c. Femoroacetabular Impingement and early onset Hip Osteoarthritis

Femoroacetabular impingement (FAI) is the most frequent complication of SCFE. Practically, all stable SCFE hips which were pinned *in situ*, even those with mild slips, are candidates for FAI development that almost always will result in osteoarthritic lesions, which may be severe or only subtle and subclinical [43,44,45,46,47,48,49]. FAI could actually deemed not a complication, but the end point of the natural history of SCFE whether untreated or after *in situ* stabilization. After this point secondary disease and reconstruction surgery of the hip is highly anticipated.

FAI occurs during flexion and internal rotation of the SCFE hip, when the deformed femoral neck (pistol-grip deformity) impacts against the acetabular labrum and the acetabular articular cartilage. Patients with SCFE typically describe pain relief after in-situ hip stabilization for over a period of months (6-48 months) [45] or years (6.1-20 years) [50,51]. After this time symptoms of FAI emerge, indicating permanent labral and/or articular cartilage damage [45].

In mild and moderate slips, the deformed femoral neck enters the joint resulting in abrasion of the anterosuperior labrum and the articular cartilage of the acetabulum (cam type or inclusion type femo-

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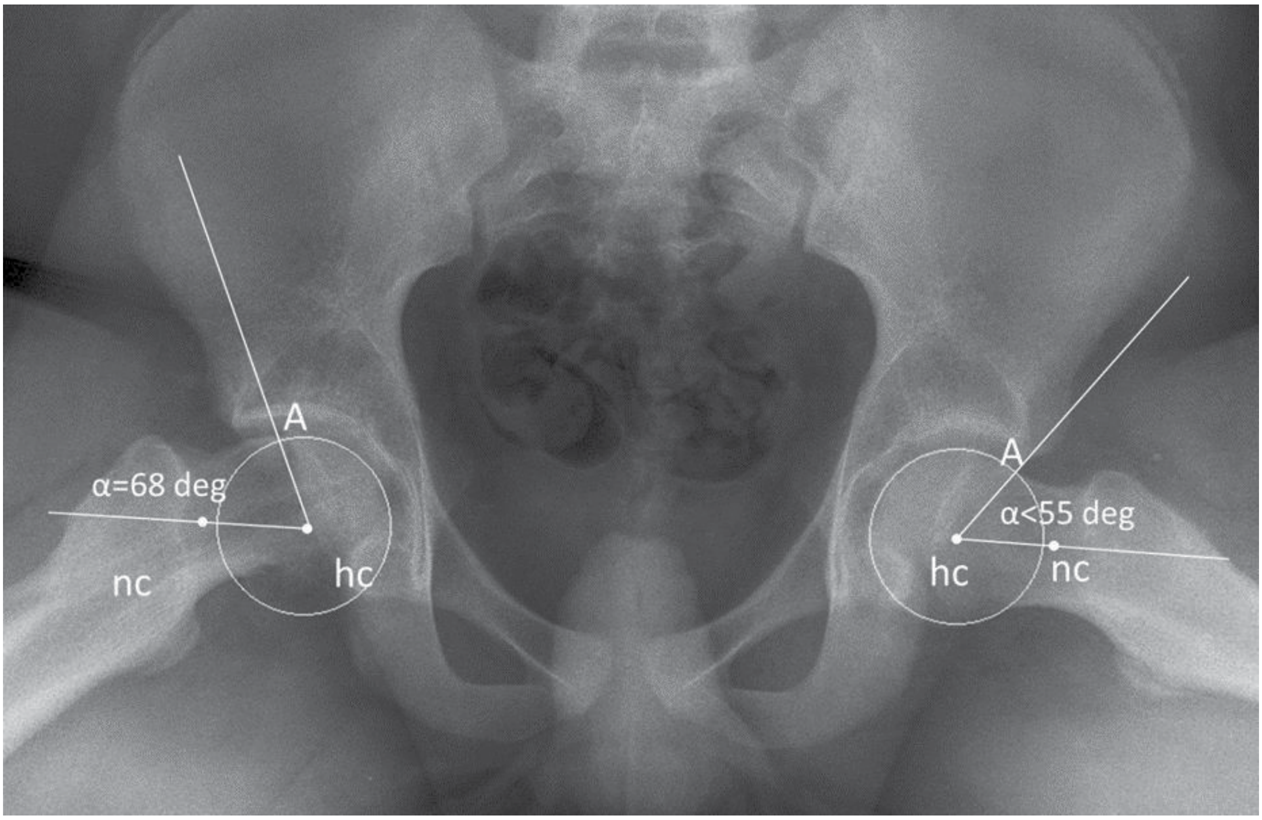

Fig. 3: *The alpha angle [54] is measured on the frog lateral pelvis view. It is formed between the line hc-nc (connects the center of the femoral head –hc- with the center of the narrowest point of the femoral neck -nc) and the line hc-A (A is the point where the continuation of the femoral neck intersects with the contour of the femoral head). An alpha angle ≥55° is the lower limit above which femoroacetabular impingement occurs. Left hip: a= 52°, asymptomatic, Right hip: a=68°, symptomatic FAI*

roacetabular impingement) [52]. In severe slips, the deformed femoral neck can no longer enter the acetabulum, but it strikes the rim of the acetabulum (pincer type, impaction type impingement) [52]. Intra-articular lesions that are observed in severe slips, are considered the result of impaction type impingement that occurred at the early stages of the slip [53].

Depending on its severity, FAI is heralded by pain and restriction of flexion, abduction and internal rotation of the hip. The FADIR sign is positive [51] (exacerbation of pain with flexion, adduction and internal rotation of the affected hip). Any SCFE hip with limited internal rotation (<10°) in 90° of flexion or inability of flexion >90° is suspected for FAI [46,47,54]. Characteristic of FAI is the Drehman sign, that is, the progressive mandatory external rotation of the thigh when the patient tries to flex the hip. This is due to an attempt of the hip to overcome the impact of the deformed anterosuperior femoral neck on the anterosuperior acetabulum. Sitting on a chair may be problematic in severe cases.

The risk of FAI in SCFE increases with slip severity: FAI will present 100% of the patients with a severe slip, 50% of the patient with a moderate slip and 33% of the patients with a mild slip [55]. Mild slips are not free of risk for FAI [20,39,45,53,55,56]. However, many authors report that symptoms of FAI appear at a slip angle >30° [55,57] and exacerbate further depending on the concomitant decrease of the head-neck offset [57]. Eventually, regardless of slip severity, 80-90% of the treated slips will present labral and acetabular cartilage lesions [1,45]. The

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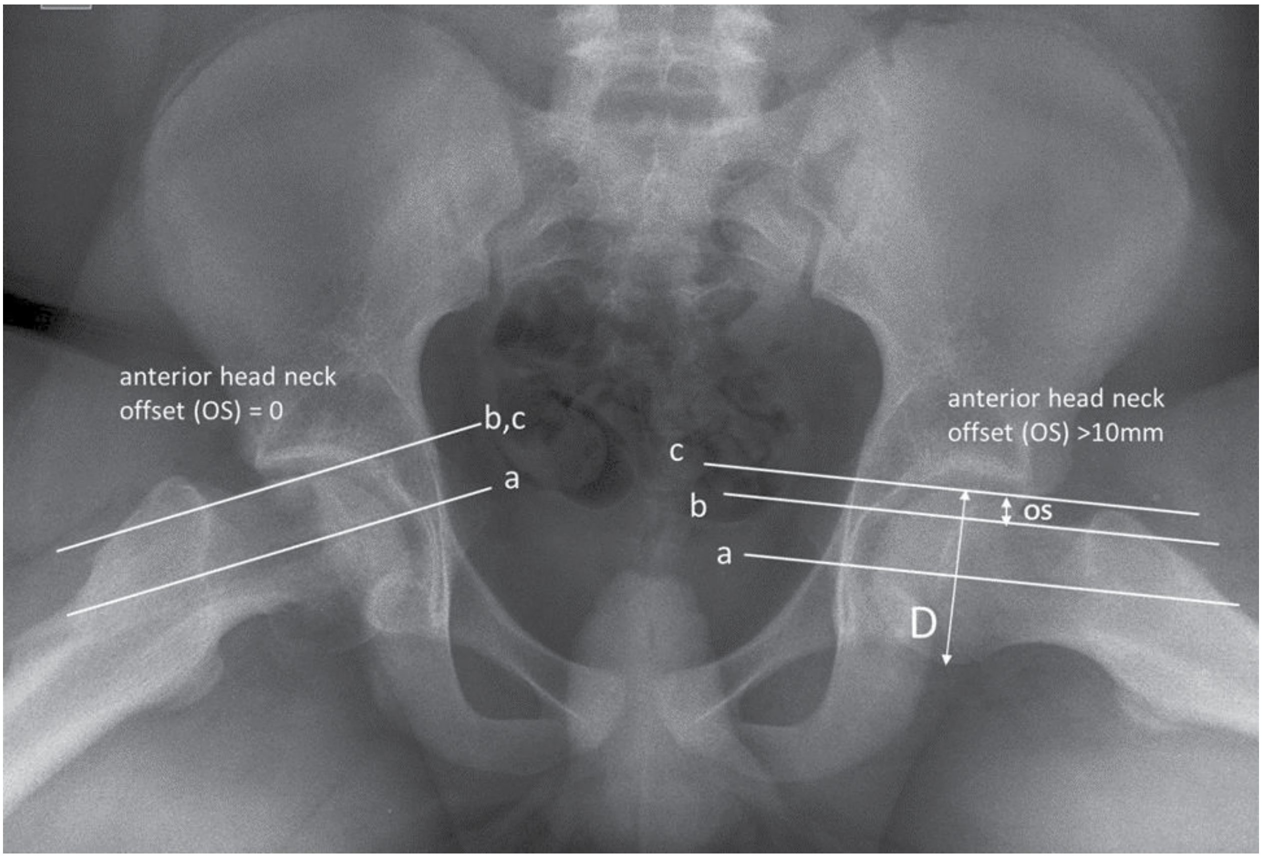

Fig. 4: *the Anterior Head Neck Offset (OS) and the anterior Head Neck Offset Ratio (HNOR) are calculated on the frog lateral pelvis view. A line (a) is drawn across the axis of the femoral neck. A second line (b) is drawn parallel to (a) at the level of the anterior contour of the femoral neck. A third line (c) parallel to (a) is drawn across the upper border of the femoral head. The widest diameter of the femoral head is measured as D. The distance between the lines b and c is defined as the Anterior Head Neck Offset (OS) and is normally ≥10mm. The ratio OS/D is deemed the anterior Head Neck Offset Ratio (HNOR), that in normal hips exceeds 0.15. Left hip: normal OS and HNOR, asymptomatic. Right hip: zero (!) OS - HNOR, symptomatic FAI*

labral lesions appear soon (within 6-12 months) after slip onset, are located between the 10th and the 3rd hour of the acetabulum and are observed even in mild slips [39,45,49,58,59]. Later on (within about 3 years) acetabular cartilage defects (Outerbridge 3 and 4) appear [45,58]. The labral and joint cartilage damage may be subclinical for a long period of time, but once symptomatic it may eventually lead to early reconstructive hip surgery [59].

The radiologic diagnosis of FAI is made on the frog lateral pelvis view [60]: an alpha angle >55° [54] (**Fig. 3**), an anterior head-neck offset ratio (HNOR: neck-head offset divided by the femoral head width) <0.15 [60] and an anterior femoral head - neck offset <10mm (OS) are signs indicating FAI [61] (**Fig. 4**). Some authors suggest a high risk of FAI when the alpha angle on the cross table lateral hip projection is >70° [62].However, the original description of the alpha angle was based on MRI scans [54]. Other projections that are useful for the radiologic assessment of FAI associated femoral neck deformity are the 45° Dunn view (45° hip flexion, neutral rotation, 20° abduction) because this view portrays the maximal femoral head asphericity [51], and the

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TABLE 1. *SCFE is a cause of early onset hip osteoarthritis and total hip replacement (THR)*

1. Patients treated for SCFE in adolescence	
Abraham 2007 [67]	SCFE patients undergo THR 11 years earlier compared to patients with primary hip osteoarthritis
Wensaas 2011 [43]	• Mean age at THR - of SCFE patients: 48 years - of primary hip osteoarthritis patients: 69 years. • Patients with a history of SCFE in adolescence will receive a THR: - 9% in 30 years - 23% in 40 years
Larson 2012 [56]	5% of SCFE patients will have a THR within 20 years from SCFE diagnosis
2. Radiologic studies in patients with hip osteoarthritis	
Murray 1965 [68]	• SCFE is the underlying cause in 4.1-6.5% of cases of hip osteoarthritis • 39.5% of patients with hip osteoarthritis without a history of hip symptoms in adolescence present a pistol grip deformity of the femoral neck (described by the author as "tilt deformity of femoral head"). These cases may be attributed to a silent, hence undiagnosed, SCFE
Clohisy 2011 [69]	• SCFE is the cause of hip osteoarthritis in 2.9% of patients that undergo a THR before the age of 50 years. According to the authors, SCFE represents a distinct severe cause of FAI. • Cam type FAI is the cause of hip osteoarthritis in 9.3% of patients that had a THR before the age of 50 years
Murgier 2013 [48]	• Age at THR: 56.2 years (SCFE patients) vs 66 years (primary hip osteoarthritis patients) • radiologic signs that suggest a SCFE history are present in 24.7% of all THR patients and in 35.7% of THR patients younger than 60 years.

false profile hip view (patient standing, pelvis angled 65° to the cassette, foot parallel to the cassette) [62]. Therefore, the comparison of the alpha angle of the SCFE hip with that of the opposite asymptomatic hip seems reasonable in order to diagnose a symptomatic FAI causing neck deformity. The head-neck offset affects hip mobility independently from the slip angle. A decreased head-neck offset may restrict hip mobility of a moderate slip to that observed in case of a severe slip [57].

The incidence and severity of FAI induced labral and articular cartilage damage of the acetabulum increase with slip chronicity [39] and slip severity [47]. Interestingly, slips that were deemed unstable during surgical hip dislocation presented less labral and acetabular cartilage damage compared to chronic stable hips, probably because the dramatic clinical presentation of instability forces the patient to seek early medical care [39]. This explains why *in situ* stabilization yields better long term results in patients with acute on chronic slips compared with patients who suffer chronic slips of the same severity [63].

According to some authors, the correlation of radiologic signs of SCFE (slip angle, alpha angle) with the clinical presentation of FAI is not statistically significant [51]. This is because the clinical (symptomatic) FAI is multifactorial and depends on the patient's occupation and level of physical activity, and on other anatomic factors of the hip as well, such as the acetabular depth (coxa profunda), the femoral neck version [51], the acetabular version (retroversion results in mixed type cam and pincer FAI) [20,51,64] and an anterior and lateral Center-Edge Angle of the acetabulum >35° [46,64]. These factors multiply the damaging effect of the abnormal postslip femoral neck on the acetabulum.

The end result of FAI is secondary hip osteoarthritis and a total hip replacement at a younger age, compared to the general population. Osteoarthritic lesions of the hip are extremely common in patients with SCFE (Haegglund 1987: 24% of SCFE hips were osteoarthritic after 28 years follow up) [21] and are observed in all types of slip severity [56]. Furthermore, SCFE is the most frequent (35.7%) cause of hip osteoarthritis in patients younger than 60 years of age [48].

The incidence of total hip replacement in SCFE patients has not been clearly elucidated, because all published studies are retrospective. It appears, however, that SCFE patients will undergo a total hip replacement at least 10 years earlier than patients with idiopathic hip osteoarthritis (**table 1**).

3.d. Implant related Complications

In addition to complications inherent to SCFE (AVN, chondrolysis, FAI), there are complications related to the surgical technique, the type of the implant that is used to stabilize the slip and the impact of the implant on the residual growth of the femoral neck physis.

Thin pins may migrate, loosen or bend under the patient's weight and may lead to slip progress. In the treatment of severe slips, aiming the center of the capital femoral epiphysis may result in extreme posterior placement of the implant (pin, screw) into the femoral neck. At this position the implant may injure the nutrient vessels of the epiphysis, either at their course in the posterosuperior (lateral) retinaculum [65], if the implant exits the posterosuperior neck cortex [34], or at the posterosuperior quadrant of the epiphysis, where the nutrient vessels enter the capital femoral epiphysis [2,42,66].

Implants that protrude into the hip joint will inevitably result in hip chondrolysis, while temporary intraoperative joint penetration by the implant does not seem to increase the risk of chondrolysis [20,42].

Occasionally, the remaining femoral neck growth may cause the epiphysis to "grow out" of a non-threaded pin. In this case, the epiphysis disengages from the implant and slips further on the femoral neck (lost epiphyseal grip due to growth) [21]. Cyclic loading on the free end of a pin that protrudes out of the lateral femoral cortex may cause this pin to loosen and migrate (windshield wiper loosening, lost epiphyseal grip due to sliding) [21,23].

Multiple drilling of the femur in order to obtain a perfect pin/screw insertion into the femoral neck and head may significantly weaken the lateral femoral cortex and result in a fracture of the femur at the point of screw insertion [23,34]. The same can be observed after physeal fusion, if excess bone is removed from the femur in an attempt to expose and remove deep buried implants.

An entry point of the implant at or below the lesser trochanter should be avoided, since it may predispose to a subtrochanteric fracture [42]. The risk of complications rises with the number of pins or screws that are used.

Considering the above, one screw fixation seems to be the optimal method to treat SCFE, because it combines stability with a low risk for implant related complications [1,66,70]. The surgeon should insert the implant above the level of the lesser trochanter and avoid multiple drilling of the lateral cortex [1,66].

In addition to the Cam-type FAI, hip flexion may occasionally cause the screw head to impinge against the acetabulum. This is observed when the entry point of the screw is placed on the anterior metaphysis, medial to the intertrochanteric line, in an attempt to insert the screw vertically through the center of the epiphysis [17]. This risk can be avoided if the screw entry is lateral to the intertrochanteric line. The oblique course of the screw does not seem to harm the stability of the fixation [71,72].

4. Special topics about SCFE

4.a. Bilateral disease - Prophylactic fixation of the Contralateral Hip?

Klein estimated the frequency of bilateral hip involvement in SCFE up to 40% of the patients [73]. However, the incidence of contralateral disease seems to be much higher [42,74,75,76]. One may consider that a frequency of bilateral hip involvement of about 50% within 2 years of the first hip disease is a reliable estimate that complies with most reports. The risk of bilateral disease is much higher in obese patients or in patients with endocrine disorders [22], where the contralateral hip may be involved in up to 100% of patients [77]. It has been calculated that

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the risk of contralateral disease of a patient with one SCFE hip is 2,335 times higher than the risk of the general population to suffer the first SCFE [78]. The most extreme view was recently stated by Billing, who suggested that theoretically all slips are bilateral, just in some patients the fusion of the contralateral hip physis prevents the slip angle from exceeding 13º, that is deemed the upper normal limit [79].

The contralateral hip may present SCFE either simultaneously with the first hip (8-27%) [75], or later, usually within 3-5 months after the first hip disease (19-40%) [23,75]. However, not infrequently, the contralateral slip is first diagnosed in adulthood, either incidentally (e.g. pelvis x-ray after an accident) or because the patient complains of a nontraumatic painful hip. This is due to either a missed diagnosis during adolescence or to a subclinical contralateral disease during adolescence (aymptomatic or silent slip). Indeed, most contralateral slips (41-92%) [74,75,80] are asymptomatic, and when diagnosed in adulthood they often (29%) present secondary osteoarthritic lesions [21].

It is obvious that the contralateral hip should always be stabilized if symptomatic. It should also receive prophylactic stabilization if it is asymptomatic but with radiologic evidence of an established slip or a preslip. However, the question is whether the asymptomatic and radiologically normal contralateral hip should undergo prophylactic fixation in order to prevent future SCFE. Obesity and underlying hormonal disorder are certainly indicative of prophylactic stabilization of an asymptomatic contralateral hip. However, there is no consensus among the authors.

The opponents of prophylactic stabilization of an asymptomatic contralateral hip argue that prophylactic stabilization of the contralateral hip bears complications too, although not as frequent as in case of therapeutic slip stabilization [81]. Such complications are inflammation [82], AVN [20,33,42,83] and implant-related fracture [42]. Other authors question the increased risk of secondary osteoarthritis of the contralateral hip [43,84], despite the increased alpha angle observed on the contralateral hip of patients with SCFE [84]. Others advocate that the preventive contralateral physis stabilization represents unnecessary surgery in 59% [80] to 81% [78] of cases, because the contralateral slip is usually a mild (73-78%) [78,85] acute SCFE (the first hip is usually a chronic slip [85]), that is prompt diagnosed (alert patient and physician) and treated. On the other hand, it is questionable if prophylactic fixation of the asymptomatic contralateral hip may spare this hip from the development of a pistol grip deformity or a retroverted femoral head, which are considered as the mildest forms of a silent SCFE. Furthermore, these mild deformities are frequently found in asymptomatic adults and it is not evident that they predispose to hip osteoarthritis [78].

The advocates of prophylactic stabilization of the healthy contralateral hip state that the morbidity and the complications of prophylactic fixation are minor compared to those observed with therapeutic intervention for the established slip [27,40,75,86,87,88]. Furthermore, prophylactic fixation spares the contralateral hip from a silent slip and the prophylactically fixed hip rarely presents radiographic evidence of Cam type FAI [51,76]. Hansson suggests that the contralateral hip should receive growth preserving prophylactic treatment only in case of endocrine disorder, obesity, a delay in the diagnosis of the first hip or if geographical or social factors will omit prompt medical care to the patient [22].

Preventive stabilization of the contralateral hip bears some controversy in regard to the remaining growth of the hip. Prophylactic stabilization of the contralateral hip does not seem to accelerate physeal closure relative to the primary SCFE hip, provided that a growth preserving technique is applied [18,23,25,26]. Growth arrest promoting techniques, such as the classic (compressive) insertion of a cannulated screw is no longer favored compared with multiple K-wire stabilization [14]. Other surgeons abandon K-wires for prophylactic pinning in order to avoid disengagement of the capital femoral epiphysis out of the stabilizing implant by the growing femoral neck [22]. However, it is reasonable to fix the contralateral hip with the same implant and technique as the primary hip in order to affect the residual growth of both hips symmetrically. This implant

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should not promote early physeal closure, especially in younger children, that are prone to present bilateral disease.

Between those extremes is the attempt to identify signs that may predict increased risk for future contralateral hip disease, in order to select patients with unilateral SCFE for targeted preventive stabilization of the contralateral hip.

The posterior sloping angle of the femoral neck physis, i.e. the angle formed by the physis (not the epiphysis! – slip angle) and a line vertical on the femoral neck-shaft axis as seen on the frog lateral pelvic projection has been suggested to predict increased risk for future SCFE of the contralateral hip [89]. This angle depicts the orientation of the physis and seems to be a significant anatomic difference between SCFE and normal hips [89]. A posterior sloping angle greater than 12°-15° [20,90] entails increased risk of slippage and is indicative for preventive stabilization [20], while a slope angle of>19° is observed in symptomatic slippage and the corresponding hips should be stabilized [91].

The modified Oxford score estimates the slip risk of the contralateral hip by assessing five radiologic parameters that are visible in the pelvis view: The iliac crest, the triradiate cartilage, the capital femoral epiphysis, the trochanter major and the trochanter minor are each scored in one of three stages of maturation. Younger patients have lower scores and have a greater risk for contralateral hip disease. A total score of 16.17 or 18 has a 96% positive predictive value and 92% negative predictive value and is probably the most reliable predictor of a future contralateral slip [92].

The maturation of the triradiate cartilage appears to be a reliable prognostic factor *per se* for an increased slip risk, yet not as effective as the modified Oxford score. An open triradiate cartilage (Grade 1 in the scoring system) implies a 89% probability for a contralateral slip [92].

The alpha angle is also a useful predictor of a contralateral SCFE: an alpha angle >50.5° is associated with increased risk of contralateral hip involvement and could be used as a threshold for prophylactic stabilization of the contralateral asymptomatic hip [93].

Other factors that favor prophylactic stabilization of the contralateral hip are: obesity (BMI >95th,>35kg/m2), young age (girls <10 years, boys <12 years), female gender, endocrine disorders [20,90,94,95,96,97].

4.b. Subclinical –Silent – Asymptomatic SCFE?

Hip morphology suggesting an underlying SCFE is a frequent finding in the adult population, ranging from 6.6% in a healthy cohort of young adults [100] to 24.7% in patients who had a total hip replacement [48]. Similar morphology was found in 8% of bone samples [98]. Moreover, most contralateral slips are first diagnosed in adulthood without a positive history for hip disease [74,75,80].

Compared with the rarity of SCFE in adolescence, this increased SCFE morphology in end-stage osteoarthritis of the hip strongly suggests the existence of a subclinical (silent, asymptomatic) slip of the capital femoral epiphysis, that stops with physis fusion. Some of these silent slips will become symptomatic in the adult life. A Southwick angle >13° at physeal closure of a hip without a SCFE history during adolescence sets the diagnosis of a silent SCFE [79]. Nevertheless, the ratio between the symptomatic (pain, limp) diagnosed SCFE, the symptomatic missed (nondiagnosed) SCFE and the asymptomatic (silent, subclinical) SCFE is unknown.

4.c. Post-slip and Slip-like Femoral Neck Deformity

More than 50 years ago, it has been suggested that a mild deformity of the proximal femur, that resembles to the pistol grip deformity observed in SCFE might be the cause of 39.5% of cases of hip osteoarthritis, which were originally classified as idiopathic (primary or of unknown etiology, in patients without history of hip symptoms in the adolescence [68]). This deformity was originally described by Murray (1965) as the “tilt deformity of the femoral head”. It is observed mostly in men and becomes symptomatic before the onset of radiological signs of hip osteoarthritis [68].

The question is to what extent the femoral head-neck deformity that leads to a Cam-type FAI is the result of a pre-existing SCFE. It is estimated that slip-like (of unknown etiology, no SCFE history in adolescence) or post-slip (after *in situ* pinning for SCFE in adolescence) morphology (positive fovea sign: the neck axis does not pass through the fovea capitis; tilt angle: the angle between the perpendicular to the line joining the edges of the capital femoral epiphysis and the axis of the femoral neck >4°) account for 12% and for 3% of all cam type FAIs respectively [99].

It seems that post-slip hip deformity that leads to hip osteoarthritis and total hip replacement is less frequent compared to the slip-like deformity of the femoral neck (**table 1**). This is due to the fact that the suggestion of an underlying SCFE in the adult hip is based on a different methodology (pistol grip deformity, fovea sign, tilt angle etc), which is not applied to the adolescent hip (Klein line etc). Therefore, the prevalence of post-slip and slip-like deformity in the adult population are not comparable and there is an obvious risk to overdiagnose an underlying SCFE in the adult hip. However, the increased SCFE morphology in end-stage osteoarthritis of the hip may to some extent reflect the high incidence of subclinical or undiagnosed SCFEs that were never treated in the past and that will become symptomatic in the adult life [98,100].

4.d. Delayed diagnosis or missed diagnosis?

An average delay of 14.6 months to diagnose and hence to treat SCFE has been reported since almost a century ago [35]. To date, progress towards a prompt diagnosis has not been spectacular, as recent studies report an average delay in the diagnosis of SCFE of about 5-7 months [43,73,101,102,103] with 1,186 days being the most extreme reported delay [104].

There are various explanations for this delay. Some factors are related to the patient, such as the subjective perception of hip pain and limp by the patient or the educational and social status of the family. Other causes of a delayed diagnosis are the availability and accessibility of any kind of Health Service. However, in about the half cases, the cause of late diagnosis is the physician himself [105,106], usually a non-orthopedic. In this case, the delayed diagnosis is a diagnosis missed by the health professional [103,106].

A stable, slowly progressing slip, which is accompanied by relatively mild symptoms, may be underestimated by the patient and the doctor as well. History of pain may obscure the diagnosis: only half of cases complain of hip pain [2,17,101]. In the remaining cases, patients report knee pain (26%), thigh pain (16%), or a painless limp (8%) [101]. It is not uncommon for the doctor to be misled by the referred pain on the thigh or the knee and to seek radiological control of the respective anatomic regions. Even if the clinical examination indicates hip pathology, the classic anteroposterior pelvis view has low sensitivity for a SCFE diagnosis. The frog lateral (Launstein) pelvis view is the most appropriate examination for this purpose [107,108], yet this projection is ignored and not even requested by many physicians, or it is usually requested at a subsequent visit of the complaining patient [106,109]. Patients examined by specialized orthopedic surgeons have the shortest delay in diagnosis compared with other doctors involved in primary health care [103]. This should raise attention to all non-orthopedic health professionals (primary care, trainees), who will most likely be the first to examine the adolescent with a non-traumatic limp [104].

The duration of the symptoms until hip stabilization, in other words the length of the delay in diagnosis and treatment, is directly related to the severity of the slip [43]. A greater delay of the diagnosis is associated with higher slip severity [17,21,43,100,110,111] and worse long term results after treatment [101]. For each month of delay of diagnosis the severity of the slip increases by one level [43,102].

Considering that mild SCFEs have excellent prognosis in 94-96% of cases [112], that femoral neck residual growth and remodeling will correct the slip angle about 10°-15° and the alpha angle about 10°-30°and that FAI is observed with a slip angle >30° [55,57] and an alpha angle >55° [54], it is concluded that a delayed diagnosis and treatment of SCFE deprives the hip of the potential to regress to a less severe deformity and thus to avoid FAI and early onset secondary osteoarthritis. Given that in-situ stabilization is the universally accepted treatment for all SCFEs, it appears that early diagnosis is the most important factor in order to obtain satisfactory long-term results with this treatment [73,109]. Therefore, SCFE should be a key component of the differential diagnosis of every non-traumatic limp of the adolescent.

A delayed diagnosis refers almost always to stable slips. It is extremely uncommon for an unstable slip to skip immediate diagnosis and treatment, because the dramatic clinical presentation urges the patient to seek medical help. However, if an unstable slip is left untreated, it seems that after 2-3 weeks the hip pain moderates but always persists. Within months the hip is stiff in flexion, adduction and external rotation [2]. Osteoarthritis is evident on x-ray [2].

4.e. Growth and Remodeling in SCFE

4.e.1. Limb Length Discrepancy in SCFE

Postslip Limb Length Discrepancy (LLD) is always due to a -ipsilateral to the SCFE hip- shorter lower limb [51]. In a retrospective study of patients with SCFE, who did not receive surgical treatment, the ipsilateral limb was 2-5cm shorter and the ipsilateral thigh circumference was 2-7cm thinner compared to the contralateral [113]. A retrospective study of patients operated for SCFE showed that the operated lower limb was only 0.5-0.8 cm shorter than the contralateral in almost all cases [21].

There are two types of LLD in SCFE: apparent LLD and true LLD. The true LLD is attributed to the posterior and medial epiphyseal slip and the subsequent proximal migration of the femoral neck. It is also secondary the potentially disturbed remaining growth of the slipped physis due to mechanical trauma or added surgical morbidity. True LLD is evident in moderate to severe slips and is on average 14-15 mm at the time of physeal closure [114,115]. The apparent shortening is slightly greater than the true shortening (~17mm). It is also observed in moderate to severe slips and is the result of the restricted abduction of the affected hip in an attempt to avoid impingement of the deformed femoral neck on the acetabulum (cam type FAI). The patient compensates the restricted abduction by ipsilateral pelvis elevation during walking [114]. Older children may present a greater LLD, probably secondary to a delayed diagnosis and hence a slip of higher severity and less remaining growth [115].

4.e.2. Bone Remodeling of the SCFE hip

Femoral neck remodeling of the SCFE hip has been described since almost a century ago [35]. This process consists of bone absorption at the anterosuperior surface of the femoral neck metaphysis and bone deposition at the posteroinferior aspect of the metaphysis. Femoral neck remodeling starts shortly after slip initiation. Callus formation at the posteroinferior neck is evident on ultrasound three weeks after slip onset and signals the transition of the acute slip to a chronic one [116].

Bone absorption at the anterosuperior metaphysis results in the formation of a hump (or bump), known as the "Herndon's hump". Bone deposition at the posteroinferior metaphysis is described on the frog lateral pelvis view as the "crow's beak"sign [73]. There is shortening and overall thickening of the femoral neck. The proximal femur assumes the "pistol grip deformity".

Femoral neck remodeling may be beneficial for the postslip anatomy of the proximal hip (**table 2**) and may prevent FAI or gait disturbance, but this potential is not unlimited. Some correction of the slip angle, the alpha angle and the head-neck offset is anticipated in relatively younger patients with mild or moderate slips, but not in severe slips [19,11] . Unfortunately, this correction will probably not compensate a slip angle of >30^{o} [55,57] -35^{o} [118] and thus will not be able to prevent FAI and early hip osteoarthritis. Therefore, a slip angle of 30^{o}-35^{o} could theoretically be the upper limit for *in situ* stabilization, while in more severe slips additional surgery (arthroscopic osteochondroplasty, open osteochondroplasty, modified Dunn procedure) should be considered in order to prevent FAI [55,118]. However, according to the same authors, the generally reported good long-term results after *in situ* stabilization of moderate slips, do not justify prophylactic surgery for FAI in moderate slips, unless the hip becomes symptomatic [118].

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TABLE 2. *The effect of femoral neck remodeling on factors associated with FAI after in situ fixation of SCFE*

Jones 1990 [19]	• 70 hips, 7.1 years after in situ pinning, probably classic cannulated screw • remodeling occurred in 90% of patients with mild slips and 50 % with moderate slips. • 75% satisfactory remodeling if slip angle ≤40º • Hip kinematics: remodeling leads to an increase of internal rotation of the hip.
Wong-Chung 1991 [125]	• 55 hips, in situ fixation, classic cannulated screw • Mean slip angle correction: 11.7º (6º-25º) • Compensatory (non anatomic) osteotomy should be considered 2 years after slip fixation, if remodeling is insufficient.
Bellemans 1996 [25]	• 59 hips, Knowless pins, Hansson pins • Slip angle reduction: 13.5º on the frog lateral view, 7º on the anteroposterior pelvis view • Increased width of the neck (+2.95mm compared to contralateral) • head – neck angle: correction towards 0º (normal, optimal support of the epiphysis on the metaphysis) • excellent results in 90% of patients, except of a slight (!?) reduction of internal rotation of the hip
Kumm 2001 [23]	• gliding cannulated screw • 29 slips in 25 patients, • Mild slips (<30°) • longitudinal neck growth 15-30 mm, • slip angle reduction 15%
Dawes 2011 [117]	• 59 hips, mild-moderate SCFE • in situ stabilization with one cannulated screw • alpha angle correction: 17.7° • Klein's line offset increase 4.8 mm
Akiyama 2013 [119]	• 69 hips, 56 patients, stable SCFE, in situ pinning • Mean alpha angle correction: 24.9º • Mean Head-Neck Offset Ratio (HNOR) correction:0.086 => 0.135 • Residual cam type deformity in 29.4 % of patients
Schumann 2016 [27]	• 19 cases, retrospective study, stable and unstable SCFEs • telescopic screw • Slip angle correction from 30.3º to 19.3º • Alpha angle correction from 91.3º to 62º • in 9 of 11 patients: correction of the neck shaft angle (varus neck due to slip) • the maximal correction was observed 6-12 months after slip stabilization
Megalooikonomos 2017 [126]	• mean correction of alpha angle: 13.45º • mean correction of the HNOR: - 0.030 => + 0.039

Growth and remodeling of the femoral neck progress as long as the physis is open and end with physis fusion [19,23]. It appears that FAI is less common in children younger than 11 years [119]. A sign indicative of the remaining growth and remodeling potential of the SCFE hip is the triradiate cartilage of the acetabulum. Fusion of the triradiate cartilage precedes femoral neck physis closure by 12 months [5]. There are three stages of maturation of the triradiate cartilage: open, intermediate open and closed triangular cartilage [120]. A wide to intermediate open triangular cartilage implies a significant residual growth and remodeling potential of the affected hip [111] that might be effective to improve the postslip femoral neck deformity even in moderate slips [13,120]. Such patients may benefit from growth preserving slip stabilization surgery (technique, implant) [27,120].

However, the correction of the femoral neck-head relationship through bone remodeling after *in situ* slip stabilization is significantly less compared to the immense correction achieved after a modified Dunn

TABLE 3. ***Current concepts for the treatment of SCFE***

1. Stable SCFE

- ***a. mild (<30º):***
  - 1. in situ stabilization
  - 2. ± growth preserving technique in case of open triradiate cartilage
  - 3. ± osteochondroplasty (open, arthroscopic)
- ***b. severe (>50o):***
  - *i. open physis:*
    - 1. in situ stabilization
    - 2. anatomic reduction (modified Dunn procedure)
    - 3. ± osteochondroplasty (open, arthroscopic)
  - *ii. closed physis (in case of FAI following primary in situ fixation)*
    - 1. subtrochanteric osteotomy Southwick, Imhauser
    - 2. osteochondroplasty (open, arthroscopic)
- ***c. moderate (30o-50º): treat as mild or severe SCFE!***

2. Unstable SCFE:

- ***a. Incidental reduction ± decompression of hip haematoma + in situ stabilization (AVN 0-50%)***
- ***b. Partial reduction with arthrotomy (Parsch) + pinning (AVN 5%)***
- ***c. Modified Dunn procedure (AVN 0-26%)***

procedure of the hip (alpha angle correction: 53°, slip correction: 43°) [114].

4.f. Should the implants be removed?

Implant removal after fusion of the proximal femoral physis bears some risks (34%-50%) [121,122]. A partially threaded screw may not "unscrew" or it may break. Titanium screws may bind strongly to the bone and their removal may be particularly problematic. Excess bone removal at the lateral femoral cortex in order to access an implant that is buried deep into the bone may increase the risk for a pertrochanteric fracture. Despite the general perception that the implants should be always removed because they may cause late inflammation, malignancy or make a future total hip replacement difficult, it seems that such complications lack literature support [121]. For this reason, SCFE stabilization implants should be removed only if they are deemed responsible for secondary symptoms such as tendinitis of the iliotibial band, bursitis of the greater trochanter or if the implants are loose and migrate. However, there are no clear indications to remove or not an asymptomatic implant and the surgeon should assess the risks and benefits of this additional surgery [121].

4.g. The role of hip arthroscopy in the treatment of SCFE

Arthroscopic osteochondroplasty of the femoral neck is a useful procedure in the treatment of SCFE and may be performed either simultaneously with *in situ* pinning [123] or later [59], in order to prevent or treat FAI [124].

Arthroscopic osteoplasty reduces the alpha angle by 20º-40º and increases the head-neck offset [58,59], not only in mild and moderate but also in severe slips (slip angle up to 65º) and leads to a remission of FAI related pain as well as to increased hip motion [58].

Hip function both before and after arthroscopic osteochondroplasty is inversely related to the time elapsed from slip onset (duration of slip). For this reason, neck osteochondroplasty should be performed as early as possible in order to avoid irreversible damage of the labrum and the acetabular cartilage [58]. Consequently, the question is whether mild and moderate slips should undergo early arthroscopic osteochondroplasty, or should the post-slip femoral neck deformity be addressed later, after femoral neck remodeling is complete [59]?

A shortcoming of arthroscopic osteochondroplasty is that it does not restore the normal relation between the femoral head and the load bearing surface

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of the acetabular roof. The articular cartilage of the femoral head has a maximum thickness around the area of the fovea capitis, while the cartilage at the periphery of the femoral head is thinner. Femoral head retroversion seen in SCFE leads to a change of the normal load bearing surface of the femoral head. Acetabular load is transmitted through regions of the femoral head with a thinner articular cartilage. Thus, even in the absence of FAI, the femoral head cartilage may present a higher risk for early damage [67]. Therefore, anatomical femoral epiphysis reduction by means of a modified Dunn procedure (and not arthroscopic osteochondroplasty) is expected to be more effective in preventing early osteoarthritis of the SCFE hip, especially in the treatment of moderate and severe slips.

There are only a few published cases of arthroscopic subcapital osteotomy in moderate and severe stable SCFE. The technique is extremely demanding but reportedly quite effective, with a mean restoration of the slip angle of about 40º and a significant improvement of hip function. There is no need for a trochanteric osteotomy and the ligamentum teres is spared. Main disadvantage of this method is the relative short follow-up, so that safe conclusions cannot be drawn [127].

Hip arthroscopy may also be useful in the treatment of unstable slips. Reduction of the capital femoral epiphysis to the pre-slip position without tensioning the nutrient vessels has been attempted. The results are promising, yet a longer follow up of more cases are needed before this technique is adopted for the treatment of unstable slips [95].

5. Conclusion

The effectiveness of any treatment for SCFE depends on two factors: (a) early diagnosis, that results in less proximal femoral deformity and less damage to the acetabulum due to FAI, and (b) the restoration of the femoral head – neck relationship, either through growth and remodeling or by means of surgery. A SCFE of higher severity and duration is associated with more severe lesions of the labrum and the articular cartilage of the acetabulum and with more severe osteoarthritic lesions of the hip. On the other hand, *in situ* stabilization of a slipped physis is not enough to reverse the continuing damage of the acetabulum that is caused by a permanently deformed femoral neck. Table 3 summarizes current concepts on how to deal with SCFE. There is a trend towards more aggressive methods, such as hip arthroscopy and modified Dunn procedure. Prospective randomized studies will highlight the most appropriate technique. Until then, *in situ* stabilization is the safe choice for the patient and the surgeon. The prevention of child obesity is a key factor in order to reduce the incidence of SCFE. Delay in diagnosis and treatment leads to worse long term outcomes. Therefore, SCFE should be always kept in mind of the primary care provider when dealing with a limping adolescent. The frog lateral projection of the pelvis should always be requested when examining a non traumatic limping adolescent.

Conflict of interest:

The authors declared no conflicts of interest.

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ΠΕΡΙΛΗΨΗ

Διάφοροι τύποι υλικών έχουν χρησιμοποιηθεί για την αντιμετώπιση της Επιφυσιολίσθησης της Μηριαίας Κεφαλής (ΕΜΚ). Εκτός από τα μη ειδικά υλικά, όπως οι βελόνες και οι αυλοφόρες βίδες, έχουν κατασκευαστεί επίσης ειδικά για την ΕΜΚ υλικά, όπως είναι η τηλεσκοπική βίδα, η βίδα-βελόνα, ο ήλος Hansson κα. Χαρακτηριστική ιδιότητα των τελευταίων είναι ότι σταθεροποιούν την ολίσθηση χωρίς να καταστέλουν το υπολειπόμενο δυναμικό ανάπτυξης της εγγύς μηριαίας επίφυσης. Η διατήρηση της ανάπτυξης, σε συνδυασμό με την ανακατασκευή του μηριαίου αυχένα, έχει ως συνέπεια τη μείωση της γωνίας ολίσθησης και την αύξηση του offset μηριαίας κεφαλής – μηριαίου αυχένα, γεγονός που αποδεικνύεται ευεργετικό ως προς την αποφυγή μηροκοτυλιαίας πρόσκρουσης, ιδιαίτερα σε μικρής και μέτριας βαρύτητας ολισθήσεις. Η μηροκοτυλιαία πρόσκρουση αποτελεί την πιο συχνή επιπλοκή της ΕΜΚ, η οποία παρατηρείται ακόμα και σε μικρής βαρύτητας ολισθήσεις. Η άσηπτη νέκρωση της μηριαίας κεφαλής αποτελεί την πιο καταστροφική επιπλοκή της ΕΜΚ και αναπόφευκτα οδηγεί σε πρώιμη ολική αντικατάσταση του πάσχοντος ισχίου. Σπάνια, αλλά επίσης σοβαρή επιπλοκή της ΕΜΚ, είναι η χονδρόλυση, η οποία χαρακτηρίζεται από σημαντική απώλεια αρθρικού χόνδρου του ισχίου. Άλλες επιπλοκές σχετίζονται με τα υλικά σταθεροποίησης, όπως είναι η κύρτωση, η χαλάρωση και η μετανάστευση του υλικού. Η προληπτική ήλωση του ασυμπτωματικού ετερόπλευρου ισχίου αποτελεί αντικείμενο επιστημονικής διαμάχης. Ανθεκτικό σε χρόνο και χώρο χαρακτηριστικό της ΕΜΚ αποτελεί η καθυστέρηση στη διάγνωση και - επομένως - στην αντιμετώπισή της. Η ύπαρξη υποκλινικής, αλλά εν δυνάμει επιδεινούμενης, ΕΜΚ, στοιχειοθετεί το αντικείμενο πολλών ερευνών. Δεν υπάρχει ομοφωνία σχετικά με την αφαίρεση ή μη των υλικών σταθεροποίησης, ιδιαίτερα εφόσον αυτά δεν προκαλούν συμπτώματα. Αυξανόμενο ενδιαφέρον παρουσιάζει ο ρόλος της αρθροσκοπικής οστεοχονδροπλαστικής για την πρόληψη και την πρώιμη αντιμετώπιση της μηροκοτυλιαίας πρόσκρουσης.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: επιφυσιολίσθηση μηριαίας κεφαλής, χειρουργικές τεχνικές, επιπλοκές