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Clinical outcome after transfixation of the epiphysis with Kirschner wires in unstable slipped capital femoral epiphysis

Received: 12 December 2005 / Revised: 23 January 2006 / Accepted: 23 January 2006 / Published online: 19 April 2006
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Abstract Treatment of slipped capital femoral epiphysis (SCFE) is still controversial. Agreement has not yet been reached on the appropriate time to perform surgery, the necessity of repositioning manoeuvres, the type of implants for stabilisation, or the need for prophylactic treatment of the contralateral side. In this retrospective study, we present 29 patients with unstable (acute and acute-on-chronic) SCFE treated by internal fixation of the epiphysis with three or four Kirschner wires both therapeutically on the affected side and prophylactically on the not (yet) affected side. After hardware removal and mean follow-up of 3.5 years, radiological and clinical examination of hip function was carried out. X-ray in two planes showed no incidence of any slip progression. Applying the score used by Heyman and Herndon, 18 results (62.1%) were classified as excellent, nine (31.1%) as good, one (3.4%) as fair, and one (3.4%) as poor. The rate of severe complications such as chondrolysis and avascular necrosis of the femoral head was low in our series (0% and 6.8%,

respectively). This form of therapeutic management shows good clinical results with low complication rates. The slip can be efficiently stabilised, progression is reliably prevented, and remodelling of the joint gives the patient good overall hip function. We see no indication for emergency surgery.

Résumé Le traitement de l'épiphysiolyse fémorale (SCFE) est toujours controversé. Il n'y a pas de consensus en ce qui concerne le moment de la chirurgie, l'utilité des manœuvres de réduction, le type d'implant permettant de stabiliser l'épiphysiolyse de même que le traitement prophylactique du côté controlatéral. Au cours d'une étude rétrospective nous présentons 29 patients avec une épiphysiolyse instable aigue ou chronique, traitée par fixation interne de l'épiphyse par trois ou quatre broches de Kirschner avec intervention également sur le côté opposé avec fixation controlatérale. Après ablation du matériel et un suivi de 3,5 ans, clinique et radiologique, nous avons évalué la fonction de la hanche. Nous avons également pratiqué une radiographie face profil qui montre qu'il n'y a pas d'aggravation du glissement. En utilisant le score de Heyman et Herndon, 18 résultats (62,1%) ont été classés excellents, 9 (31,1%) bons, un (3,4%) moyen et un (3,4%) mauvais. Le taux de complications sévères nécroses vasculaires et coxite laminaire est très bas dans notre série (respectivement de 6,8 à 0%). Cette forme de traitement donne de bons résultats avec un taux très minime de complications. Le glissement peut être stabilisé de façon efficace, le remodelage de la hanche donne aux patients un bon résultat, une bonne fonction. Nous n'avons jamais eu d'indications de chirurgie en urgence.

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Introduction

Slipped capital femoral epiphysis (SCFE) is a typical hip disorder in adolescents. It is characterised by a displacement of the upper femoral epiphysis in a dorsomedio-caudal direction (Fig. 1). Because the epiphysis cannot leave the acetabulum, the femur externally rotates to compensate.

Fig. 1 X-rays (anteroposterior and frog-leg lateral views) of a 12-year-old boy with unstable slipped capital femoral epiphysis on the left side with a slip angle of 20° ($26^\circ - 6^\circ = 20^\circ$)

Stanitski et al. [22] showed in their study that during puberty, the epiphyseal plane becomes oblique, which leads to higher shear forces. These are enhanced by a reduced anteversion of the femoral neck in patients with SCFE, while acetabular anteversion remains normal [23]. The aetiology of SCFE is still unknown, but most authors agree that predisposing factors include male gender, black racial origin, obesity, and unknown genetic factors. Obesity increases the shear stress across the pathologically oriented physeal plate in patients with SCFE. Endocrine disorders, such as hypothyroidism, growth hormone deficiency or excess, hyperparathyroidism, and hypogonadism [15, 25], may predispose to SCFE.

SCFE has been classified according to the duration of symptoms into chronic, acute, and acute-on-chronic SCFE. Other authors prefer to classify SCFE as either stable or

unstable according to the stability of the femoral epiphysis and the ability to bear weight [14].

Treatment of SCFE is always surgical. Screws [4] and Kirschner wires [21] are currently the implants of choice for stabilising the femoral epiphysis. The goals of treatment in epiphyseal slips are to stop further slippage by stable fixation with a low complication rate and to restore good hip function with painless motion by remodelling the joint. In addition to the complications generally associated with surgery, the main short-term complications are avascular necrosis of the femoral head (AVN) and chondrolysis.

Aspects that are still controversial are the implants used for stabilisation, the appropriate time to perform surgery, traction or reposition manoeuvres for the acute slip, and the need for prophylactic treatment of the contralateral, not (yet) affected side in patients with SCFE. In this report we present our results and experiences in the treatment of unstable (acute and acute-on-chronic) SCFE.

Patients and methods

All patients presenting to the Orthopaedic Department of the University of Wuerzburg with unstable (acute and acute-on-chronic) SCFE between January 1990 and January 1999 were included in this retrospective study.

All patients with unstable (acute and acute-on-chronic) SCFE were unable to bear weight. The duration of first symptoms or acute exacerbation of mild pre-existing pain was less than three weeks in all patients. The X-rays showed specific radiographic signs indicating instability, such as a clear separation of the epiphysis from the femoral neck with angulated slip.

The degree of the slip was determined either by measuring the slip in the true lateral X-ray or by subtracting the value of the unaffected side from that of the affected side on the frog-leg lateral radiographs [3] (Fig. 1). Because true lateral X-rays often cannot be obtained in patients with severe acute symptoms, we used 15 frog-leg and 14 true lateral X-rays. The degree of slip was classified according to Rao et al. [18] as mild ($0-29^\circ$), moderate ($30-50^\circ$), or severe ($>50^\circ$).

The mean slip angles and the basic statistical data are shown in Table 1.

Operations were performed by experienced surgeons in an early elective procedure after admission and initial treatment with bed rest under mild traction (10% of body weight) for about two days and medication with non-

Table 1 Patient statistical data, mean slip angle (SA), classification of severity of slipped capital femoral epiphysis

Total patients <i>n</i> =29	Age (mean) 12 years, 6 months	Female 10	Male 19	Right 8	Left 18	Bilateral 3	Follow-up 3 years, 6 months
Mean SA		30.7°					
Mild (SA<30°)		<i>n</i> =19					
Moderate (30°<SA<50°)		<i>n</i> =7					
Severe (SA>50°)		<i>n</i> =6					

steroidal antiinflammatory drugs (NSAIDs). All patients were surgically treated by gentle, careful closed reduction of the unstable slip and bilateral fixation of the epiphysis with three or four Kirschner wires (Fig. 2).

After hardware removal (Fig. 3) and at follow-up (mean 3.5 years after initial surgery), the patients were clinically examined with regard to gait, pain, and range of motion (ROM) according to the classification of Heyman and Herndon [9]. Results were classified as (1) excellent, with normal ROM, no limp, and no pain; (2) good, with no limp, no pain, and slight limitation of internal rotation; (3) fair, with no limp, no pain, and slight limitation of internal rotation and abduction; (4) poor, with mild limp, slight pain after strenuous activities, and slight limitation of internal rotation/abduction; or (5) failure, with limp, pain with

activity, and marked limitation of motion requiring a reconstructive procedure.

Hardware was removed in all patients after radiologically determined closure of the growth plates on both sides. Radiological follow-up examinations were carried out every six months and immediately before and after hardware removal to detect complications such as AVN or chondrolysis as well as pins becoming too short due to normal growth of the femoral neck. Apart from one case, all patients had one final follow-up examination (clinical and radiographic) six months after hardware removal. The mean time between the index operation and removal of the implants was three years and two months (range one year and six months to four years and ten months).

Fig. 2 X-rays (anteroposterior and true lateral views) of a 10-year-old girl with unstable slipped capital femoral epiphysis on the left side with a slip angle of 22° after transfixation of the epiphysis and metaphysis with Kirschner wires (four wires on each side)

Results

Out of 29 patients with an average follow-up of 3.5 years, 18 results were classified as excellent (62.1%), nine as good (31.1%), one as fair (3.4%), and one as poor (3.4%) according to the classification system described by Heyman and Herndon [9] (see Table 2). X-rays at follow-up showed no incidence of any slip progression.

No patient developed chondrolysis, but AVN occurred in one patient with complete and one patient with partial involvement of the femoral head. AVN occurred only in the affected hip and not in the prophylactically pinned hip. In eight patients, a repeat transfixation became necessary. Because of further growth of the femoral neck, the Kirschner wires had become too short so that the pins no longer reached the epiphysis. The mean interval between initial treatment and repeated surgery was one year and eight months (range one year and four months to two years and 11 months). In four patients, secondary intertrochanteric osteotomies with valgus angulation, flexion, and rotation were carried out to improve hip function (flexion/rotation), two of these after development of AVN. All of these had moderate or severe slips with a mean SA $>30^\circ$ ($30\text{--}57^\circ$). Interestingly, there was no correlation between the devel-

Fig. 3 Anteroposterior X-ray of the same girl as in Fig. 2, showing closed growth plates after hardware removal (4.5 years after initial surgery)

Table 2 Data for 29 patients with unstable (acute and acute-on-chronic) slipped capital femoral epiphysis (AVN avascular necrosis of the femoral head, IO intertrochanteric osteotomy)

Patient number	Age at surgery (years, months)	Side	Degree of slip	Follow-up (years, months)	AVN	IO	Heyman and Herndon classification ^a
1	13, 1	Left	25°	2, 7			Fair
2	9, 10	Left	30°	3, 6			Good
3	10, 2	Left	22°	4, 5			Excellent
4	11, 7	Bilateral	Left 40°, right 15°	3, 8			Excellent
5	14, 6	Left	25°	3, 11			Excellent
6	11, 11	Left	28°	0, 6			Excellent
7	16, 7	Left	27°	2, 2			Excellent
8	13, 10	Left	23°	5, 8			Excellent
9	11, 9	Right	52°	3, 0			Good
10	11, 4	Left	10°	4, 8			Excellent
11	12, 9	Left	29°	4, 10			Excellent
12	12, 9	Right	57°	3, 7			Good
13	11, 11	Right	58°	6, 6			Excellent
14	12, 0	Left	20°	3, 7			Excellent
15	11, 9	Right	10°	2, 11			Good
16	14, 7	Right	20°	1, 7			Good
17	11, 0	Left	26°	2, 11			Excellent
18	13, 4	Left	13°	3, 9			Excellent
19	12, 6	Left	20°	4, 5			Excellent
20	13, 10	Right	28°	2, 10			Excellent
21	12, 1	Left	57°	1, 5	Partial	X	Good
22	11, 10	Left	35°	3, 0		X	Good
23	15, 3	Left	42°	3, 10			Good
24	12, 3	Right	60°	3, 7		X	Good
25	12, 6	Right	18°	4, 10			Excellent
26	13, 11	Left	45°	2, 7			Excellent
27	12, 4	Left	30°	6, 11	Complete	X	Poor
28	13, 6	Bilateral	Left 65°, right 10°	5, 10			Excellent
29	15, 1	Bilateral	Left 30°, right 12°	1, 10			Excellent

^aClassification of Heyman and Herndon:

Excellent: (normal ROM, no limp and no pain),

Good: (no limp, no pain and slight limitation of internal rotation),

Fair: (no limp, no pain and slight limitation of internal rotation and abduction),

Poor: (mild limp, slight pain after strenuous exercise and slight limitation of internal rotation/abduction),

Failure: (limp, pain with activity and marked limitation of motion)

opment of AVN and the clinical result at follow-up. Patient 1 with spherical femoral head and no AVN had only a fair result according to the classification of Heyman and Herndon [9], whereas patient 21 with partial AVN showed a good clinical outcome at follow-up. Patient 27 with complete AVN and aspherical femoral head had a poor result (Table 2). There were no complications either during initial surgery (infections, implant failure) or during removal of the Kirschner wires.

Discussion

The overall incidence of AVN in unstable (acute and acute-on-chronic) SCFE is reported in the literature as being around 15% (range 10–47%) [11, 14, 19]. AVN is related to severity, acuteness, instability, and type of treatment [11,

13, 14] and to impaired blood supply to the femoral head [16]. Raised intracapsular pressure from effusion or haemarthrosis, which might tamponade the blood vessels, is one suggested mechanism for developing AVN and might be regarded as an argument for emergency operation. However, Loder et al. [14] reported a higher incidence of AVN in a group of patients with unstable SCFE with early operative treatment than in a comparison group with delayed operation. AVN developed in 7/8 patients (87.5%) with unstable SCFE treated surgically within 48 hours, whereas the rate of AVN was 7/22 (31.8%) for unstable slips treated surgically after 48 h. This difference was statistically significant ($p=0.012$).

Although Aronsson et al. [3] recommend no preoperative traction or reduction manoeuvres because of decreased oxygen tension in the femoral head, other authors state that reduction should start within 24 hours of onset of acute

symptoms and that the time from acute slippage to reduction is important for preventing AVN. Aadelen et al. [1] found no AVN in patients with unstable SCFE when manipulative reduction was performed within 24 hours of the onset of symptoms, but 10% (3/30) when reduction treatment started later than 72 hours after the onset of symptoms. Interestingly, they report about 50% AVN (6/12) when repositioning began between 24 and 72 hours after the onset of symptoms.

In our study, surgery was done as an early elective procedure after admission and initial treatment with bed rest under mild traction (10% of body weight) for about two days and medication using NSAIDs. Intra-operatively we applied gentle, careful closed reduction of the unstable slip. With this regimen only two patients developed AVN (6.8%), and there were no cases of chondrolysis. It is probable that pain reduction and gentle traction with repositioning diminished the intraarticular synovitis, effusion, and pressure, thus enhancing the blood supply in the femoral head.

The position of the pins or screws and the surgical technique itself have a great impact on the risk of developing AVN. Brodetti et al. [5] showed that the lateral epiphyseal vessels enter the femoral head in the posterosuperior area. They found that placing a nail or a screw in the valgus position—in other words, in the posterosuperior quadrant of the femoral head—gives a high risk of impairment of the lateral epiphyseal vessels and thus of AVN. The blood supply to the femoral head comes partially from the central artery in the ligamentum, partially from the inferior metaphyseal vessels entering from the anteroinferior aspect, and mainly from the lateral epiphyseal vessels that enter the femoral head in the posterosuperior area and that supply the outer two-thirds of the femoral head. For this reason it is important to avoid placing pins mainly in the posterosuperior quadrant and also, if possible, in the anteroinferior quadrant [3].

Chondrolysis, an acute necrosis of the articular cartilage of the femoral epiphysis, can occur in all forms of SCFE and in both treated and untreated hips. Its overall incidence is reported to be 7% (range 1.1–28%) [6, 16], but the aetiology is still unknown. Risk factors for development of chondrolysis are pin penetration [2, 16], cast immobilisation, male gender, black racial origin, severe SCFE, and instability [4, 24]. It is thought that chondrolysis may be due to an immune response (autoimmune disease) [16].

In our study of 29 patients with unstable (acute and acute-on-chronic) SCFE, there were no cases of chondrolysis either in the prophylactically treated or the affected hips. The most important factor for avoiding pin penetration is considering the “approach-withdraw phenomenon” [13, 17]. It is essential to control and document the correct positioning of all pins and screws with hip flexion and rotation manoeuvres under image intensification during and at the end of the procedure to detect any concealed pin penetrations.

Remodelling of the hip was judged by comparing the initial X-rays of the unstable slip with the X-rays in two

planes at the time of closure of the growth plates. The head-neck-shaft (CCD) angle, functionally reduced in patients with acute SCFE due to the mediocaudally displaced epiphysis, was obvious on the initial X-rays and increased remarkably up to the end of growth. As only mild preoperative traction and gentle, careful intraoperative closed reduction were applied, only a partial repositioning of the unstable slip was achieved. Therefore, the bony remodelling process of the hip during the remaining growth period led to further “normalisation” of the CCD angle.

Swedish studies have shown a high percentage (up to 60%) of bilateral involvement in SCFE [10]. In children suffering from SCFE at a very young age, the likelihood of a bilateral slip rises to as much as 80%, and in SCFE secondary to endocrine disorders, bilateral slips occur in up to 100% of cases [8, 10]. Recently Schultz et al. [20] applied an interesting decision analysis model with calculation of the probability of a contralateral slip. This showed that patients who are first seen with unilateral SCFE have a 2335 times greater risk of developing a contralateral slip. They concluded that prophylactic pinning is beneficial, as documented in other studies.

In a long-term study, Hägglund [8] showed that 25% of patients who did not undergo prophylactic pinning developed osteoarthritis of the hip before age 50 on that side showing secondary slip, whereas no osteoarthritis developed in any hip that was stabilised prophylactically. Our previously reported series on prophylactic pinning [21] and those from other authors [7] showed no complications (AVN, chondrolysis, infection, hardware-related problems) or functional impairment at all [21].

Re-operations became necessary in eight patients (27.6%). These were required on both sides in three patients (10.3%) and on the unaffected side alone in five patients (17.3%). However, in only two patients was dislocation of the Kirschner wires on the affected side the reason for re-operation (6.9%). In the other cases, secondary surgery was necessary because the pins had become too short because of femoral neck growth. Therefore, the need for five re-interventions due to normal growth of the femoral neck away from the pins after prophylactic pinning of the unaffected side may be seen as a complication. On the other hand, it indicates that transfixation of the epiphysis and metaphysis with Kirschner wires does not stop further growth.

Screws and Kirschner wires are currently the implants of choice for stabilising the femoral epiphysis in patients with SCFE, and each method has specific advantages and disadvantages. König et al. [12] examined different methods of internal fixation of the epiphysis in patients with SCFE. This study showed that transfixation of epiphysis and metaphysis using Kirschner wires (pins) was the safest method with the lowest complication rate when compared with stabilisation using screws or Smith-Peterson nails. After fixation with Kirschner wires, there were significantly better long-term results regarding subjective (pain) and objective parameters (Harris score, osteoarthritis, sphericity of the femoral head, differences

in limb length, neck/shaft ratio of the proximal femur). Stimulating early closure of the physis brings with it a risk of deforming the femoral head because of the potentially asymmetric growth arrest by one or two screws. This could explain the poorer results of screw fixation or nailing with one Smith-Peterson nail by comparison with pin fixation with three or four Kirschner wires [12]. The results of König et al. [12] and our own results indicate that stabilising the epiphysis with Kirschner wires may impair the further growth of the femoral neck less than transfixation of the epiphysis with screws. In our opinion, the advantage of further growth of the femoral neck outweighs the “complication” of probable re-operation due to the pins becoming too short during the growth period.

In patients with unstable (acute and acute-on-chronic) SCFE, transfixation of the epiphysis and metaphysis with three or four Kirschner wires both on the affected side and prophylactically for the (as yet) nondisplaced femoral epiphysis is, in our experience, the method of choice. This surgical treatment, performed by experienced surgeons as an early elective procedure after initial traction, NSAIDs and bed rest for about two days, showed very low complication rates. We see no indication for emergency surgery. Additional corrective osteotomies (intertrochanteric osteotomy) may be indicated secondarily in more severe slips ($>30^\circ$) to improve hip function, especially after development of AVN.

Acknowledgments This study was conducted at the Orthopaedic Hospital of the University of Würzburg, König-Ludwig-Haus, Germany (Director: Prof. Dr. med. Jochen Eulert) and the Orthopaedic Hospital of the University of Duesseldorf, Germany (Director: Prof. Dr. med. Rüdiger Krauspe).

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