Adolescent slipped capital femoral epiphysis treated by a modified Dunn osteotomy with surgical hip dislocation

Between June 2001 and November 2008 a modified Dunn osteotomy with a surgical hip dislocation was performed in 30 hips in 28 patients with slipped capital femoral epiphysis. Complications and clinical and radiological outcomes after a mean follow-up of 3.8 years (1.0 to 8.5) were documented. Subjective outcome was assessed using the Harris hip score and the Western Ontario and McMaster Universities osteoarthritis index questionnaire.

Anatomical or near-anatomical reduction was achieved in all cases. The epiphysis in one hip showed no perfusion intra-operatively and developed avascular necrosis. There was an excellent outcome in 28 hips. Failure of the implants with a need for revision surgery occurred in four hips.

Anatomical reduction can be achieved by this technique, with a low risk of avascular necrosis. Cautious follow-up is necessary in order to avoid implant failure.

The average age of adolescents who present with slipped capital femoral epiphysis (SCFE) is 13.5 years for boys and 12.0 years for girls. The most common form of treatment in the United States for a stable SCFE is fixation in situ with a single cannulated screw. The advantages of this method include the easy technique, a low rate of further slip and lack of complications. However, some long- and mid-term studies of heterogeneously treated patients or of those treated by in situ fixation show poorer results and faster deterioration with increasing severity of the slip. Therefore, various corrective osteotomies have been proposed to improve hips with a moderate to severe slip. Osteotomies at the base of the neck or at the inter-subtrochanteric level introduce a distal reverse deformity to restore loss of movement at the hip joint. Only those osteotomies at the level of the physis can correct the anatomy and the alignment at the head/neck junction. Long-term follow-up studies show that these corrections lead to improved outcome, and the risk of avascular necrosis (AVN) is acceptable in the hands of experienced surgeons.

The possibility of performing a surgical dislocation of the hip without compromising the perfusion of the femoral head has led to a better understanding of the pathogenesis of degenerative arthritis following SCFE. Also, this approach led to a modification of the traditional Dunn osteotomy. In 2009, the mid-term results of 40 patients treated with this modified osteotomy were published by the same group and showed no instances of AVN or chondrolysis. Since 2001, we have treated patients by the same method and in this study we report our short- and mid-term experience of displaced SCFE treated by a modified Dunn osteotomy using a surgical hip dislocation approach.

Patients and Methods

Between June 2001 and November 2008 a modified Dunn osteotomy was performed using a surgical dislocation of the hip in 28 patients (30 hips) in two institutions in the same city. We retrospectively reviewed their records and radiographs. If existing data or the time of follow-up appeared to be insufficient, we asked patients to attend for examination. Also, a questionnaire comprising 24 questions with a five-point Likert scale was sent to all patients in order to obtain a Western Ontario and McMaster Universities osteoarthritis index (WOMAC) score, which has, at least in a slightly modified version, been shown to be a valid assessment tool for patients with femoroacetabular impingement. Approval of this study was given by the local ethical committee.

All 28 patients (30 hips) were included. Surprisingly, there was a preponderance of female patients (17 female vs 11 male). The mean age of adolescents who present with slipped capital femoral epiphysis (SCFE) is 13.5 years for boys and 12.0 years for girls.
therefore classified as unstable. The pre-operative range of walking even with crutches was impossible, and they were movement was reported inconsistently because of pain, and head-shaft angle on the lateral radiograph; 14 and graded posterior (AP) view.

Lateral radiographs were taken for all but one were analysed for all patients in order to classify the severity of slip. Lateral radiographs were taken for all but one patient with unstable slipped capital femoral epiphysis, with the perios- teum torn at the femoral head-neck junction (white arrow). The perios- teum was incised anteriorly in the direction of the femoral head (dotted arrow) and mobilised superolaterally while protecting the retinacular vessels (black arrow).

at diagnosis was 12.2 years (9.4 to 16.6). As expected, girls were younger (mean 11.2 years, 9.4 to 13.1) than boys (mean 13.9, 9.8 to 16.6). According to the classification of Loder et al,27 only three patients had such severe pain that walking even with crutches was impossible, and they were therefore classified as unstable. The pre-operative range of movement was reported inconsistently because of pain, and was therefore not evaluated. Pre-operative radiographs were analysed for all patients in order to classify the severity of slip. Lateral radiographs were taken for all but one patient, who showed a slip of almost 50% in the antero-posterior (AP) view.

In order to determine the slip angle, we measured the head-shaft angle on the lateral radiograph;14 and graded the SCFE as mild (< 30°), moderate (30° to 50°) or severe (> 50°). Of these 30 hips, three were rated as mild, 17 as moderate and ten as severe. The hip without a pre-operative lateral radiograph was rated severe, as it showed a dislocation of 50% relative to the metaphysis. The mean pre-operative epiphyseal-shaft angle of the 29 hips with a lateral radiograph was 44.9° (19° to 77°). The 30 operations were performed by five different surgeons (including SD, CD and LR). None of the patients had undergone fixation in situ beforehand.

Surgical technique. All operations were performed according to the technique described by Leunig et al.20-22 Under general anaesthesia, the patients were placed in a lateral decubitus position with the leg draped so it was fully move-able. Antibiotic prophylaxis with a second-generation cephalosporin was administered pre-operatively and for the first 24 hours post-operatively. The approach was through the Gibson interval between tensor fascia lata and gluteus maximus.28 A digastric trochanteric osteotomy was cut with an oscillating saw, leaving the trochanteric crest untouched. The 1 cm to 1.5 cm thick bony slice including the insertions of gluteus medius and minimus with the insertion of vastus lateralis was flipped anteriorly and the anterior hip capsule was exposed through the interval between the piriformis tendon and gluteus minimus. After capsulotomy in a Z- (right hips) or reverse-Z-shaped (left hips) manner, the head-neck junction was inspected. If physeal stability was in doubt, as in most cases, provisional fixation with a threaded Kirschner (K)-wire was made with no attempt at repositioning. Epiphyseal perfusion was checked with a Doppler ultrasound probe or by inspecting the blood flow out of a simple drill hole from the periphery of the head directed towards the centre. Following division of the ligamentum teres, the femoral head was dislocated. The area where the retinacular vessels enter the epiphysis could be identified (Fig. 1). The acetabulum was inspected for cartilage or labral damage and the femoral head was then reduced. The posterosuperior portion of the stable greater trochanter proximal and dorsal to the visible growth plate was trimmed down to the level of the femoral neck with a chisel, and the cortex on the medial side near the base of the femoral neck was broken by bending the chisel. The bone fragments were turned and carefully unhinged from the adherent posterior periosteum and the inserting external rotators with a spatula starting medially in the depths, taking great care to prevent damage to the posterior soft-tissue flap (the inside-out technique). The hip was then re-dislocated. The periosteum of the anterior neck, which was occasionally torn parallel to the level of the physis in unstable cases, was incised along the anterior neck and gradually elevated from the femoral neck, avoiding damage to the retinacular vessels (Fig. 1).

After these two steps, the extended retinacular flap consisting of the retinacular vessels, the external rotators and the periosteum, lay above and behind the femoral neck. Any provisional K-wires were removed and the epiphysis was mobilised from the underlying metaphysis by inserting a periosteal elevator or a bent chisel into the physis and carefully levering the instrument until the head and extended soft tissue-flap were completely freed from the femoral neck. Further external rotation of the leg allowed thorough inspection of the posteromedial part of the femoral neck (Fig. 2). Resection of buttress bone at this location was necessary in all cases, as none of our patients was truly acute without previous symptoms. The femoral neck was shaped to allow tension-free repositioning of the femoral head centred above the neck. Minor shortening of the neck had to be carried out only in exceptional cases. The remaining physis in the femoral head was curetted out in order to accelerate bony healing.

After the femoral head was centred on the neck without tension on the retinaculum (Fig. 3), it was provisionally fixed with a K-wire and an intra-operative fluoroscopy was taken to ensure correct positioning had been obtained, in particular the varus-valgus relationship. The aim was to
achieve an anatomical position especially in relation to the fovea capitis and to avoid any varus malalignment as this would make the fixation less stable. The blood perfusion of the femoral head was checked again, followed by definitive fixation with two cortical screws (3.5 mm, rarely 4.5 mm) or, in more recent cases, three fully threaded 3.0 mm K-wires (Hausmann Spitalbedarf, Wil, Switzerland). The periosteal sleeve and capsule were approximated with loose sutures and the greater trochanter was reattached with two 3.5 mm cortical screws in a slightly distal position to correct for the shortened femoral neck and to optimise abductor function. The fascia was accurately closed with a continuous suture followed by standard wound closure. A bandage with slight tension was applied from the foot to above the pelvis to provide pressure on the surgical field and reduce haematoma formation for the first 24 to 48 hours. In more recent cases, we regularly started physiotherapy with a continuous passive movement on day one or two. The patients were mobilised according to their physical and cognitive abilities with crutches and touch weight-bearing. Prophylactic fixation of the contralateral hip was done in most cases after a few days. A first post-operative control radiograph was arranged six to eight weeks after the initial operation. The degree of weight-bearing was prescribed according to the radiological appearance. Full weight-bearing without crutches was allowed after a mean of 12 weeks (8 to 16).

The operation notes were studied for descriptions of epiphyseal perfusion, established cartilage lesions at operation and intra-operative complications. The post-operative radiographs were studied for progression of slip, implant failure, osteonecrosis or chondrolysis. Major complications and the time until full weight-bearing without crutches was allowed were recorded. The implant was removed only if there were associated symptoms, or at the explicit request of the patient.

The latest clinical examination was made after a mean of 3.8 years (1.0 to 8.5), when a Harris hip score (HHS)\textsuperscript{30} was obtained. In some cases no radiograph (or only an AP view of the pelvis) was taken at this consultation and the radiological follow-up was slightly shorter (mean 3.6 years, 1.0 to 8.5). The anterior head-neck offset was measured by means of an $\alpha$ angle according to Nötzli et al\textsuperscript{31} on the latest lateral radiograph. All radiological parameters were measured by the first author (HH) and an independent radiologist (FB). There were no significant differences between these measurements.

In the autumn of 2009, WOMAC questionnaires were sent to those patients for whom no additional consultation was planned. The others completed the questionnaire before or after the latest consultation. We received completed questionnaires from all 28 patients after a mean follow-up of 4.3 years (1.2 to 8.5).

Results
In one hip, intra-operative evaluation of epiphyseal perfusion showed no blood flow either before or after repositioning. In another there was initially no detectable perfusion before repositioning, but afterwards we could detect pulsatile bleeding from a drill hole. The degree of acetabular cartilage lesion was described only in 18, two of which were unharmed. The other 16 showed cartilage lesions, from slight roughening at the periphery to complete loss of 1 cm from 9 o’clock to 1 o’clock.

The post-operative lateral radiographs showed a mean slip angle of 5.2° (-18° to +25°) and a well-centred epiphysis in relation to the femoral neck in all cases.

There were no major peri- or early post-operative complications such as nerve injuries, deep wound infection or haematoma formation requiring drainage. There was one case of AVN of the hip that showed no perfusion at operation. The radiograph taken six weeks post-operatively already showed partial collapse of the femoral head and
penetration of the K-wires (Fig. 4), which were therefore withdrawn and shortened. The patient and his parents decided to seek treatment elsewhere and we are aware that he developed AVN.

In four cases revision surgery was necessary owing to implant failure between six weeks and six months post-operatively (Fig. 5). All the failures occurred in the 20 hips that were fixed with cortical screws. There were no implant failures in the ten fixed with 3.0 mm full-threaded K-wires, but owing to the small sample size, this difference was not significant (Fisher’s exact test, p = 0.27). No other further operations were performed.

The patient with the AVN refused to attend a follow-up examination but agreed to complete a WOMAC questionnaire. Therefore, sufficient clinical follow-up data were obtained from 27 patients (29 hips). All showed flexion of 90° or more at latest follow-up. The mean internal rotation in the 90° flexed hip was 33.3° (10° to 50°) and the mean external rotation was 49.8° (20° to 70°). The mean HHS was 97.8 (56 to 100) with 28 hips showing an excellent outcome ≥ 95 points. One patient (no. 4) had a poor outcome, with a HHS of 56 points mainly due to severe pain. She also had a mild contralateral slip which was pinned in situ. On this side, she reported even more pain which did not improve after a surgical hip dislocation and osteochondroplasty. The results of the WOMAC score were evaluated separately for the three categories of pain, stiffness and function, with 0 signifying no restriction and 100 maximal restriction. The mean values in all 28 patients were 5.9 (0 to 50) for pain, 10.4 (0 to 62) for stiffness and 5.7 (0 to 53) for function (Fig. 6). The mean α angle at the time of the latest
lateral radiograph in 29 hips was 41.4° (27° to 77°). Only five had an α angle > 50° and we found no correlation between α angles, internal rotation and clinical outcome.

Discussion

We present the outcome of 28 patients (30 hips) with SCFE treated using a modified Dunn osteotomy with a surgical hip dislocation. This approach can restore the anatomy of the proximal femur and presumably prevent further cartilage deterioration due to impingement. Ziebarth et al.²³ reported on 40 patients with no case of AVN. However, this is the only published outcome study of patients treated by this method, and we were interested to compare the safety of the technique in the hands of five experienced hip surgeons. This seemed of particular interest, as the series reporting low rates of AVN after subcapital osteotomies,¹⁵,³⁸ were often interpreted as due to the success of surgeon rather than the technique.⁴

Our results show that repositioning the epiphysis and restoration of normal or almost normal proximal femoral anatomy in SCFE is possible with a low risk of AVN. Our single case of AVN showed no perfusion either before or after repositioning of the epiphysis. Although we graded this case as stable according to Loder et al.,²⁷ because he could walk partially with crutches weight-bearing, after a relatively acute trauma during a gymnastics lesson the intra-operative findings revealed an unstable epiphysis. Therefore, we assumed that the AVN was not caused by the operation itself. Another hip showed perfusion of the femoral head only after it was repositioned. The implant failures in four cases led us to change the implants to 3.0 mm full-threaded K-wires, and none of these has broken so far.

The cases of implant failure, with one occurring six months post-operatively, emphasise the need for both meticulous healing and cautious post-operative mobilisation.

Our study has several limitations, mainly the lack of a control group. Pre-, peri- and post-operative findings were collected from the medical records. Although it was not a problem to collect most of the data, the extent of any lesions of the acetabular cartilage was reported inconsistently. Also, radiographs were not taken in a standardised manner, and, as the angular measurement of the slip is dependent on the position of the femur,³² other techniques such as CT are reported to be more accurate.³³ Finally, we cannot draw any conclusions on the likelihood of the development of degenerative arthritis after this short follow-up, as such changes may not be seen for many years.⁷

Although the short- and mid-term outcome after in situ fixation of SCFE is generally reported to be good,⁶,⁹ more recent reports show that many patients have symptoms of femoroacetabular impingement within the first years after the operation.³⁴,³⁵ Therefore, precise evaluation, even on a short- and mid-term basis, should reveal differences between treatment regimes. Our results show that an almost normal range of movement can be achieved, and most had an excellent outcome.

The measurement of the α angle on the lateral view is a way to quantify the disturbance of the head-neck offset. We are aware that this measurement is of limited relevance clinically, as even the original publication could not show a statistically significant correlation between internal rotation and the α angle.³¹ The mean α angle in our group (41°) was almost the same as in an asymptomatic control group reported elsewhere.³¹ In patients with mild SCFE treated with fixation in situ, the mean α angle was 55° (40° to 94°).³⁶ This angle has been shown to correlate strongly with symptoms of femoroacetabular impingement in a group treated for SCFE,³⁴ but we could not find such a correlation in our patients.

In conclusion, the modified Dunn osteotomy using surgical dislocation of the hip is our treatment of choice for the surgeon properly experienced with this method. The technique is very versatile, epiphyseal perfusion as well as stability can be inspected directly, and intra-articular pathology can be evaluated and potentially treated at the time. Because of the direct evaluation of epiphyseal perfusion, this technique seems to be of special significance in the treatment of unstable SCFE, where even accidental closed repositioning might lead to further disturbance of epiphyseal blood flow and consequent AVN. In most cases the epiphysis can be repositioned without shortening the femoral neck with restoration of proximal femoral anatomy and range of movement. Also, the surgical dislocation allows inspection of the exact meta-epiphyseal displacement. An intra-operative decision to perform only an in situ fixation can be made, along with trimming of the anterolateral metaphysis if the amount of displacement is smaller than expected making mobilisation of the physis inappropriate, as was encountered with other patients during the study period. Conversely, we included three cases with a radiological slip angle < 30° because an intra-operative decision to perform a modified Dunn osteotomy was made as the displacement was more than expected. In cases of mild slip, in situ fixation with arthroscopic trimming of the metaphysis might be another option to treat the impingement.³⁷

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Supplementary material

A table detailing the demographics and outcome for all 28 patients is available with the electronic version of this article on our website at www.jbjs.org.uk

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References