



■ ASPECTS OF CURRENT MANAGEMENT

The management of slipped capital femoral epiphysis

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The treatment for most patients with slipped capital femoral epiphysis (SCFE) is well established but controversy remains as to how to manage the more difficult cases. The advent of fixation by a single cannulated screw has made this the operation of choice. The morbidity is considerably less than that with any of its predecessors, but the optimum timing for treatment remains uncertain, particularly in the management of unstable and severe slipped epiphyses. Delay in diagnosis continues to be the single most important factor associated with a poor outcome.

Delay in diagnosis

It is well known to orthopaedic surgeons that pain in the knee or thigh in children originates from the hip until proven otherwise.¹ The absence of symptoms in the hip may lead to a missed or delayed diagnosis.² There has been an increase in the involvement of professions allied to medicine, including physiotherapists, sports therapists, podiatrists and massage therapists in the management of children with musculoskeletal symptoms. The incidence of SCFE is reported to vary between one and seven per 100 thousand. It is therefore a rare condition and general practitioners and therapists may see only one or two cases in their professional lifetime. However, the prognosis for patients with severe displacement is such that those with musculoskeletal symptoms should be confident that whoever takes on the responsibility to treat them will have an awareness of the condition and be able to refer on without delay.

A review of patients admitted to our hospital has shown that of the last 20 admissions only one did not have any delay between first seeking advice for their symptoms and referral.

Aetiology

The physis is clearly abnormal with the hypertrophic zone being wider than the resting zone and the columnar organisation of the cells appearing to be less organised.^{3,4} The entity

‘pre-slip’ has been confirmed recently by MRI.⁵ The true aetiology remains elusive although there is a clear association with endocrine abnormalities especially hypothyroidism and treatment with growth hormone. A relationship between patients with juvenile chronic arthritis and SCFE has been linked to the presence of HLA-DR4 antigen.⁶ However, a study from Bahrain did not show this and neither was there an association with HLA-B12.⁷ Treatment with GnRH-agonist has also been associated with a higher incidence of SCFE.⁸

Multiple studies have shown an association between retroversion of the neck of the femur and a reduced neck-shaft angle with slipped upper femoral epiphysis. Advances in imaging software have allowed a more elaborate evaluation to be made.⁹ Such knowledge is unlikely to affect the initial presentation although it could be used as a factor in deciding whether prophylactic fixation of the opposite side is needed.

Classification

Functionally, SCFE may be classified according to weight-bearing, chronologically relating to the time of the onset of symptoms and graphically depending on the degree of displacement as measured on radiographs. Loder et al¹⁰ have provided the most useful classification for clinical practice describing the slip as either ‘stable’ or ‘unstable’.

The distinction between a stable and an unstable slip is the ability to bear weight. The significance is that avascular necrosis (AVN) develops in an unstable slip but very rarely in a stable slip. The traditional method of temporal classification uses a period of three weeks from the onset of symptoms as referring to the acute state whereas a period longer than this is termed chronic. An acute exacerbation with a longer background of symptoms is referred to as acute-on-chronic. This again relates to the complication of AVN which develops with a higher incidence in patients who have been defined as acute compared with the chronic

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Fig. 1a



Fig. 1b



Fig. 1c

Radiographs of remodelling after screw fixation in situ showing a) the initial film of a grade-3 unstable (acute-on-chronic) SCFE in a 14-year-old boy, b) after screw fixation and c) after 18 months.

group. The consideration of a temporal classification has relevance when considering the timing of surgery.

The degree of displacement of the epiphysis on the femoral neck can be measured on plain radiographs, although there is a potential for error with non-standardised films. Differentiation of mild, moderate and severe slips has been described by Southwick¹¹ as the difference between the head-shaft angle on the normal and abnormal side. The degree of displacement can be conveniently classified as grade 1 (0° to 30°), grade 2 (30° to 60°) and grade 3 (60° to 90°).

In clinical practice a true lateral radiograph of the hip is preferred to a frog-leg lateral radiograph because of the risk of further displacement of the epiphysis. Measurements using CT of the hip are the most accurate but are not required routinely for clinical use.

Treatment

The first premise is to prevent further slipping of the epiphysis. Patients presenting with a chronic or stable acute slip should be treated with screw fixation in situ using a single cannulated screw. The basis for the acceptance of fixation in situ is the capacity for remodelling of the proximal femur¹² (Fig. 1), although the degree may not be as complete as was originally thought.¹³ Longer-term studies confirm that the outcome of a slipped capital epiphysis is correlated with the severity of the initial slip and degenerative arthritis is the predictable outcome in moderate and severe slips.¹⁴ The assumption that restoration of the anatomy at the outset of treatment will reduce the incidence of degenerative arthritis has stimulated surgeons to seek a reliable solution. Manipulation of the acute unstable slip^{15,16} and the use of corrective osteotomies^{17,18} in severe and sometimes moderate degrees of slip in both stable and unstable situations have their proponents.

Treatment must be aimed at minimising AVN and chondrolysis, which are the two main complications which occur. When considering the options for treatment the long-

term outcome of the condition should be considered and it must be clearly understood that AVN does not occur without therapeutic intervention.¹⁹

The primary aim is to prevent further slipping of the epiphysis. In grades 1 and 2 fixation *in situ* using a single screw is considered to be the optimal treatment. If the slip is stable no improvement in the position of the caput can be achieved, but if unstable there is an opportunity to realign the anatomy of the proximal femur. Phillips et al¹⁶ reviewed 100 cases and noted 14 acute slips, all of which were reduced on the operating table. No cases of AVN were seen and the technique of 'gentle' repositioning was advocated. There is agreement among those who support reduction of the acute slip that the patient should be positioned on the operating table with care, ensuring that gentle traction is employed.²⁰ No forceful manoeuvre should be used. The ideal position for the limb is in internal rotation of 15° to 20° and abduction of 20° to 30° .

The timing of intervention is relevant to the outcome. The acute reductions described in the series of Phillips et al¹⁸ were performed within 24 hours of the onset of symptoms. Peterson et al¹⁵ found that in 91 acute slips the rate of AVN was 7% for reductions performed within less than 24 hours of presentation and 20% if treatment was delayed for more than this. Loder et al¹⁰ noted that 87.5% of patients treated within 48 hours of the onset of symptoms developed AVN but only 32% did so if treated after 48 hours. However, Loder et al²¹ has acknowledged that the true cause-and-effect relationship between the timing of intervention and the development of AVN cannot be determined.

It has been postulated that the epiphyseal blood supply is interrupted by kinking of the posterior vasculature in the acute slipped epiphysis. It is suggested that the reduction of the unstable, acute or acute-on-chronic slip relieves the pressure on the blood vessels and restores blood flow. Pre-operative bone scanning has been shown to be a good predictor of ischaemia. In a group of ten unstable patients, five



Fig. 2a



Fig. 2b



Fig. 2c



Fig. 2d

Radiographs of a Fish cuneiform osteotomy showing a) the initial AP film of a grade-3 unstable (acute-on-chronic) SCFE in a 13.5-year-old boy, b) the initial lateral film, c) after the cuneiform osteotomy and screw fixation and d) an AP film after 18 months showing complete union with no AVN but the presence of coxa breva.

of the six whose bone scan showed ischaemia developed AVN whereas the remaining four with no ischaemia, did not.²²

In chronic cases the gradual process of slipping allows adaptation of the vasculature and maintenance of the blood supply to the caput.²³ The rate of displacement in a chronic slip is uncertain. It is likely that it occurs in a step-wise progression rather than as a continual smooth process as indicated by the intermittent symptoms reported by patients. This also helps to explain the longevity of the history and the delay in presentation in many of the cases.

Each small progressive slip may or may not be sufficient to compromise the blood flow to the epiphysis. A small reduction or temporary occlusion of the blood supply may resolve, with no permanent damage to the bone and avoidance of AVN. It may therefore be safer to defer treating an

acute slip for three weeks to minimise vascular embarrassment (Jones, personal communication).

Severe morphological displacement

Correction of the deformity of the femoral neck can be achieved by osteotomies at various levels of the proximal femur. An osteotomy close to the physis allows greater anatomical realignment of the capital epiphysis to be made, and, in theory, reduces the risk of later degenerative changes and improves the function of the hip. However, the risk of AVN and chondrolysis is significantly greater. The more distant the osteotomy, the less beneficial it is in terms of correction, but the risk of complications is reduced.

Fish¹⁷ and Dunn¹⁸ have described similar osteotomies at the level of the physis. Dunn¹⁸ stated that “if accidental trauma can detach the head and tear the synovium from the

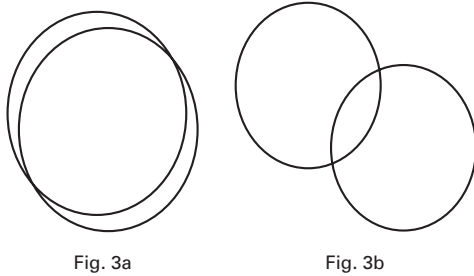


Diagram of the diminishing area of contact between the epiphysis and metaphysis with advancing degrees of slip showing a) mild slip with a wide cross-sectional area to allow safe passage of a screw and b) a severe slip with considerably less area of contact making encroachment of the screw more likely.

back of the neck without pulling the vessels out of the head the surgeon should be able to do so as well.” The significant difference between the two procedures is that Fish’s operation¹⁷ results in complete removal of the physis from both the metaphysis and epiphysis (Fig. 2). This allows bone-on-bone apposition which enhances union and revascularisation. Vascular buds can advance into the caput to restore blood flow if the posterior vessels are compromised. An osteotomy is contraindicated if the physis has closed.

The rate of occurrence of AVN was 4.5% in Fish’s series¹⁷ similar to the 5.5% experienced by Nishiyama, Sakamaki and Ishii²⁴ but other reports suggest a rate of up to 35%.²⁵ Chondrolysis has an incidence of 10% to 30%

but tends to occur with AVN. These higher rates of complications make the procedure much less favourable. However, the long-term outcome is correlated with the degree of the initial severity of the slip and the worst cases have a high incidence of degenerative joint disease. Loder²¹ noted that “The natural history of chronic (stable) slipped capital femoral epiphysis is favourable provided that displacement is mild and remains so”. If the displacement is not mild the outcome is considerably less favourable. Does a corrective osteotomy pose an acceptable level of risk for a hip which is likely to be condemned to an early arthroplasty? A risk of 5% for the development of AVN is acceptable but that of 10% or more is not. The longer-term outcome as regards to the influence of this procedure on the onset of degenerative changes is not yet certain and may be no better than with other techniques. If these procedures were more predictable and performed more often then their use may have greater acceptance.

The alternative to performing an osteotomy at the level of the physis is to realign the femur more distally either at the base of the neck or in the trochanteric region. The risk of AVN is less, but the correction is less sound biomechanically. The procedure can be performed around the time of presentation or later if the slip is initially pinned *in situ*. The latter approach allows observation of how much remodelling occurs with time with performance of the osteotomy only if indicated. The insertion of a pin *in situ* becomes technically more challenging with the greater degree of displacement of the epiphysis and requires knowledge of

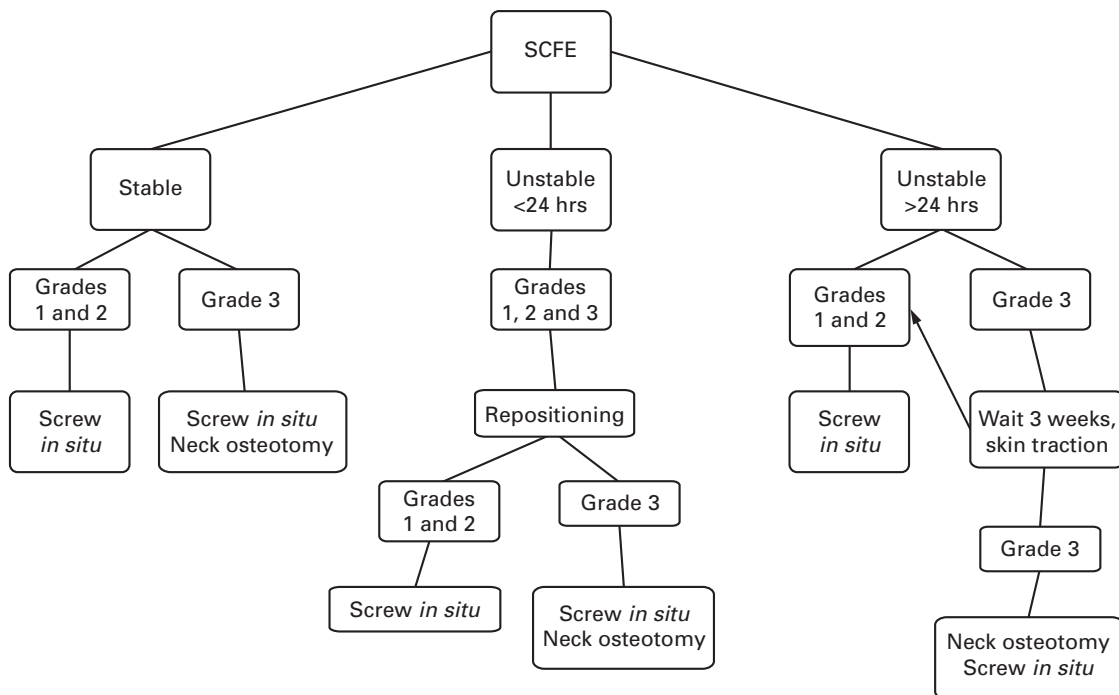


Fig. 4

An algorithm for the treatment of SCFE.

pathoanatomy for the secure anterior placement of the screw. The area of contact between the epiphysis and neck of the femur diminishes significantly with greater degrees of slip and the risk of penetration of the pin with vascular injury increases (Fig. 3).

Therefore, with a severe slip, it may well be reasonable to undertake a cuneiform osteotomy as described by Fish.¹⁷

Treatment algorithm

A suggested treatment algorithm for the management of SCFE is given in Figure 4. Most cases will be straightforward requiring a single cannulated screw *in situ*. This will apply to all cases of grade-1 and grade-2 slips, but if an unstable slip presents less than 24 hours from the onset of symptoms then a gentle repositioning manoeuvre should be performed to improve the alignment of the caput. If the presentation is delayed no reduction should be attempted.

For severe unstable slips of $>60^\circ$ presenting within 24 hours of the onset of symptoms a gentle repositioning manoeuvre should be attempted to improve the alignment of the caput and if the displacement improves to grade 2 or grade 1 fixation *in situ* should be undertaken. If no improvement is achieved the surgeon must decide whether the degree of slip allows fixation *in situ* or whether a cuneiform osteotomy should be considered.

If there is a delay in presentation of more than 24 hours, the definitive treatment should be delayed for a period of three weeks to minimise the risk of AVN. During this time skin traction should be used to ensure strict rest and there may be some improvement in the position of the caput²⁶ such that fixation *in situ* can be used. If severe displacement remains a cuneiform osteotomy should be considered.

Conclusion

The management of SCFE remains an area of controversy among orthopaedic surgeons. The true aetiology is not yet confirmed and treatment still produces considerable complications for some patients. Screw fixation *in situ* is the accepted procedure for most cases, but the less common unstable and severe slips pose most problems. The surgeon must decide whether to fix all cases with a single screw and to osteotomise secondarily those which fail to remodel, or correct the deformity from the outset accepting a higher risk of potentially devastating complications for the patient. An awareness of the time from the onset of symptoms is vital in helping to reduce the risks of treatment. Concentrating the treatment of these difficult patients in a few centres will allow the development of appropriate skills and the follow-up of sufficient numbers to permit meaningful long-term analysis.

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