The timing of reduction and stabilisation of the acute, unstable, slipped upper femoral epiphysis
S. A. Phillips, W. E. G. Griffiths, N. M. P. Clarke
From Southampton General Hospital and Queen Alexandra Hospital, Portsmouth, England

We reviewed the management of 100 cases of slipped upper femoral epiphysis treated over a period of 26 years. A total of 14 slips was identified as unstable on admission. These underwent reduction and stabilisation within 24 hours of the onset of severe symptoms. Of the 86 stable slips four progressed to avascular necrosis (AVN), which was not seen in the unstable slips. The literature on slipped upper femoral epiphysis suggests that the acute unstable slip is at higher risk of developing AVN. We recommend reduction and stabilisation of unstable slips within 24 hours of the onset of symptoms in order to reduce the risk of AVN.

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The ‘acute’, unstable, slipped upper femoral epiphysis represents an acute fracture. In the past, closed reduction even by ‘gentle manipulation’ has been the subject of concern because of the potentially devastating complication of avascular necrosis (AVN). However methods of management which do not achieve anatomical reduction and result in residual deformity of the proximal femur may be associated with the development of premature degenerative changes.1-3 We now address the specific question of whether it is safe to reduce acute, unstable slips.

Historically, slips have been classified as acute, chronic or acute-on-chronic. More recently, Loder et al4 have introduced the concept of stability in relation to slips, and have published results for different timings of reduction and stabilisation. They described a slip as unstable if there was sudden onset of severe pain such that walking was not possible even with crutches, regardless of the duration of preceding symptoms. With a stable slip weight-bearing was possible.

This subgroup of unstable slips has been described in the literature for many years,5,6 but there are no clear guidelines on their management, and there are wide variations in the reported outcome. In 1967, Schein7 identified a small group of patients with hips which would now be classified as unstable. In those reduced in less than 24 hours, the rate of AVN was 50%; in those reduced after 24 hours, the rate was 55%. These results contrast with those of Casey, Hamilton and Bobechko8 and of Loder et al9 who showed rates of AVN of 66% and 80%, respectively, in hips reduced in less than 24 hours, and 15% and 40% in those reduced after 24 hours. The high rate of AVN in the group of Casey et al8 was associated with over-reduction. Also reported are the results of Aadalen et al9 and Peterson et al10 with rates of AVN of 0% and 7%, respectively, in hips reduced early, and of 23% and 20% in those reduced after 24 hours.

A retrospective review of all slips treated at one hospital in our region showed 11 which would now be classified as unstable; they had a rate of AVN of 36%.11 The management of this group of patients included a wide variety of treatments, and it was not clear whether it was the surgical intervention or the unstable slip which led to the development of AVN. With no clear guidance from the literature regarding the treatment of unstable slips, and in the light of the high rate of AVN at this centre, we reviewed the practice at an adjacent hospital which used a different protocol. Here, any slip with a sudden onset of severe pain and marked displacement was identified on admission as unstable and operated on within 24 hours of the onset of symptoms.

This small subgroup of patients who were identified at presentation is the basis for our study of reduction and stabilisation of the acute, unstable, slipped upper femoral epiphysis.

Patients and Methods
The clinical notes and operative and radiographic records were used to identify patients who had undergone treatment for slipped upper femoral epiphysis at the study hospital.
which prospectively identified unstable slips; 117 slips of all categories had been treated in the period from 1972 to 1998. Adequate notes and records were available for 100 patients of whom 14 had unstable slips which fulfilled the criteria of Loder et al.\textsuperscript{4}

There were nine boys and five girls, with a mean age of 13 years. The left hip was involved in nine cases and the right in five. Table I gives the clinical details of each patient and of the presentation and history. When reviewing the notes of patients with a very short history of severe pain, the precise duration of symptoms before diagnosis of the slip was noted as was the time taken from the onset of symptoms to operation. Some of these patients had mild, prodromal, symptoms before a sudden, severe onset of pain, and others had a hip which was free from discomfort before a specific event precipitated their symptoms. The surgical management and any complications were recorded from the notes and the final outcome determined from the last follow-up letter in the clinical notes. Avascular collapse was considered to be present if there was radiological loss of the normal contour of the head within two years of the initial treatment. The radiographs were also reviewed when possible to establish the severity of the slip which was measured in degrees of posterior displacement on the frog-lateral view.\textsuperscript{12} Some of the earlier films had been destroyed and the grade of slip was taken from the notes.

Patients with a history of sudden onset of severe pain and inability to bear weight, an unstable slip, were treated by gentle manipulative or open reduction and stabilisation within 24 hours of the onset of symptoms. All hips were reduced completely and none over-reduced. There were no failures of reduction. Multiple Crawford-Adams pins were used for stabilisation in most cases (Table II). Hips which were considered to be stable underwent stabilisation in situ, or osteotomy and stabilisation, depending on the severity of the slip. We reviewed the outcome of all patients who were available for study, with particular regard to those who had slips which would now be classified as unstable.

### Results

Of the 100 patients studied, 14 had a history of severe pain with inability to bear weight of less than 24 hours’ duration. The management of these unstable slips is shown in Table II. The mean duration of prodromal symptoms was 55 days (5 to 180) and the mean duration of acute symptoms before presentation was four hours (2 to 6) (Table I). In none of these unstable hips was there radiological evidence of chronicity of slip (Fig. 1). A variety of techniques was used to stabilise the slips, which reflects the duration of the study period (Table II).

There were no complications in the patients with acute,
unstable slips treated by early reduction and stabilisation.

Of the 100 patients reviewed there were four with AVN (4%), two with chondrolysis and three who required early reoperation for repositioning of pins or loss of reduction. All the complications occurred in ‘stable’ hips with severe displacement at presentation.

Discussion

Slipped capital femoral epiphysis is the most common disorder of the hip in adolescence, with an incidence of approximately two per 100 000 people. Minor degrees of slip do not usually result in significant long-term disability, but patients with severe slips in whom the anatomy cannot be restored to normal are at risk of developing severe degenerative changes at an early age. It would seem logical therefore to try to achieve an anatomical result in these hips by open reduction and stabilisation, or in some cases simply by allowing remodelling to occur. It has become apparent that any surgical intervention carries the risk of precipitating avascular necrosis or chondrolysis. Both of these conditions carry a poor prognosis and any intervention has always been tempered by these potentially devastating complications. In an effort to identify which slips are most at risk of complications after intervention, a variety of classification systems has been suggested. The traditional classification of slipped upper femoral epiphysis has been based on a rather arbitrary division depending on the duration of symptoms; patients with a short history of up to three weeks have been classified as ‘acute’, those with a longer history and radiological evidence of remodelling as ‘chronic’ and those with a short history and radiological remodelling as ‘acute-on-chronic’. The inference from this classification is that chronic slips have had time for bony and soft-tissue remodelling, and therefore manipulation should not be performed. Acute slips may be improved by manipulation since there has not been time for adaptive shortening of vessels, and acute-on-chronic slips fall into a ‘grey area’. The hypothesis that some slips remain mobile because the soft tissues have not become scarred or shortened has led to the concept of physeal stability, in which authors have tried to establish which slips can be safely reduced. This idea has been further expanded by Loder et al who have classified slips as ‘unstable’ or ‘stable’ in an effort to predict which hips are at risk of developing complications. Their classification concentrates on the ability of the child to bear weight without aids; a child with sudden severe pain who is unable to bear weight without aids is deemed to have an unstable slip. If a slip is unstable, i.e., the capital femoral epiphysis is mobile, the question of the timing of fixation becomes more important in terms of stabilisation of the blood supply to the epiphysis.

There are few papers in the literature which classify slips as stable or unstable, or which allow reclassification from the data presented. The limited number of studies, and the fact that most, like ours, are retrospective, make it difficult to draw an accurate comparison between results, particularly with regard to the timing of the intervention. Carney et al in their long-term review of slipped upper femoral epiphysis, describe a group of 13 patients in whom the slip had been termed acute. Of these, 11 had had a traumatic event which precipitated the onset of symptoms and it is likely that they could be considered to have had unstable hips. Of these 11, seven underwent reduction at an unspecified time, three developed AVN and three developed chondrolysis. Davidson et al considered a slip to be unstable if there was an improvement in the position after operation or if there was an acute injury, with inability to bear weight and no evidence of remodelling on radiographs. Of 45 hips fulfilling these criteria, 12 (27%) developed AVN. Those pinned in situ had a rate of AVN of 13%, whereas those which had been reduced had a rate of 38%. Unfortunately, no details were provided with regard to the timing of the interventions.

Schmidt, Cimino and Seidel classified their hips on the basis of the duration of symptoms and the degree of reducibility during operation to determine whether the slips were stable and could not be reduced on the table during gentle manipulation) or unstable. Using this system, six of 40 hips were classified as unstable and only one hip developed AVN after allograft epiphysiodesis; this hip was in the unstable group. These results further discouraged reduction of slipped upper femoral epiphyses but, again, no clear time scales were given for the duration of symptoms and time to reduction.

Aronsson and Loder state that "a stable slipped capital femoral epiphysis has a good prognosis, but an unstable slip has a guarded prognosis". This statement is based on the outcome of their 1993 series in which they found a rate of AVN of 80% in unstable hips treated within 24 hours and an incidence of 32% in those treated more than 48 hours after the onset of symptoms. This is the first study to address the issue of the timing of reduction, a concept which we feel is pivotal to the management of these difficult cases. Later, Peterson et al studied this specifically, but the work was retrospective over a period of 40 years during which a variety of methods of treatment was used. Their time to reduction was taken from the time of presentation rather than from the onset of symptoms. They found a rate of AVN of 7% in slips undergoing manip-

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<th>Table II. Method of stabilisation in the stable and unstable hips</th>
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<td><strong>Method of stabilisation</strong></td>
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<tr>
<td>Crawford-Adams pins</td>
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<tr>
<td>AO camuclated screw</td>
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<tr>
<td>Femoral neck osteotomy</td>
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<td>Smith-Petersen nail</td>
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* Dunn osteotomy
ulte reduction within 24 hours, compared with 20% in hips reduced after 24 hours.

In our study many methods of treatment have been used, reflecting the change in practice during the study period. The timing of intervention was consistent. Although one of the earliest slips was treated by a Smith-Petersen nail, which has been shown to have a higher incidence of AVN than other treatments, most were treated by multiple pins, again associated with an increased risk of complications. We did not see any collapse of the epiphysis in these patients. When compared with published results, our finding of no AVN in unstable hips reduced within 24 hours of the onset of symptoms is encouraging.

In conclusion, although slips which are unstable form a small percentage of the whole number, they are an important group, since their prognosis is, in general, worse than that of those which are stable.

We believe that the outcome for slips which are clearly acute and unstable can be influenced by early recognition and intervention, i.e., within 24 hours of the onset of symptoms.

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References