Anterior physeal separation

A SIGN INDICATING A HIGH RISK FOR AVASCULAR NECROSIS AFTER SLIPPED CAPITAL FEMORAL EPIPHYSIS

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A study of 78 children (110 hips) was undertaken in an attempt to assess the risk of avascular necrosis (AVN) after slipped capital femoral epiphysis based on the radiological appearances of the hip at the time of presentation.

Physeal separation, which was defined as the amount of separation of the anterior lip of the epiphysis from the metaphysis on the frog lateral view, was assessed. Of the eight hips which developed AVN, seven had anterior physeal separation. We conclude that anterior physeal separation is associated with a high incidence of subsequent AVN after slipped capital femoral epiphysis and that screw fixation may not be appropriate in these patients.

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Slipped capital femoral epiphysis (SCFE) affects adolescents. In most patients it may be treated successfully by percutaneous screw fixation without attempted reduction.¹⁻⁵ Recovery from this procedure is usually uneventful and patients can be discharged from orthopaedic review after physeal closure has occurred. A small group of patients, usually those with more severe slips, develop avascular necrosis (AVN). This serious complication accounts for much of the morbidity associated with this condition. It can lead to a poor outcome and subsequent major surgery.^{6,7}

SCFE has been classified into different groups in an attempt to identify those hips which are at greatest risk of developing AVN. For example, it has been demonstrated that the risk of AVN is higher in those patients classified as unstable who are unable to bear weight with or without crutches at the time of presentation.⁸⁻¹⁰ It has also been shown that the risk of AVN is higher in acute rather than

chronic cases.^{11,12} SCFE is defined as chronic if symptoms have been present for more than three weeks, or if there is evidence of formation of new bone on the radiograph at presentation.

We have noted that a number of our patients developed AVN within a short space of time. In these hips there was a separation of the physis anteriorly as well as translation of the epiphysis on the metaphysis. Anterior physeal separation is a radiological finding which is best seen in the frog lateral view of the affected hip (Fig. 1). In these patients there is reduced contact between the capital femoral epiphysis and the metaphysis. The epiphysis and metaphysis separate anteriorly through the physis, and contact is limited to a small area posteriorly. Our aim was to determine the relationship between physeal separation at presentation and the subsequent development of AVN. The prognostic significance of this finding was also compared with other factors which are known to influence the outcome of SCFE.

Patients and Methods

We identified 88 patients with 120 slipped capital femoral epiphyses who had been treated within the area of Greater Belfast between January 1997 and December 1999. The hospitals in this area serve a catchment area of 1.4 million people. Ten patients were excluded from the study because the notes or radiographs were incomplete leaving 78 patients with 110 affected hips for review.

In Northern Ireland there is a socialised medical service and a relatively static population. Since none of the ten patients with incomplete notes currently attends an orthopaedic clinic in Northern Ireland we believe that it is unlikely that these children developed AVN. Patients suffering from AVN are always referred to the Orthopaedic Department at Musgrave Park Hospital and we are confident that none of these patients was overlooked.

The notes and radiographs were reviewed. Data obtained included age, gender, side affected, type of implant, duration of symptoms, stability as defined above and complications. The radiographs were examined by both authors for the degree of SCFE, the presence and distance of separation of the epiphysis from the metaphysis, subsequent reduction of the slip or separation intraoperatively, penetration of the hip by the implant and the development of AVN.^{13,14}

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Fig. 1

Diagram representing anterior physeal separation.

The angle of the slip was also measured by the method described by Aronson and Carlson¹³ and Southwick.¹⁴ Displacement is measured by the angle subtended by the head and shaft of the femur. The angle of the slip is thus the angle in the normal hip subtracted from that in the affected hip, in a true frog lateral view. The SCFE could then be graded into mild (grade 1), moderate (grade 2) and severe (grade 3) as described by Boyer, Mickelson and Ponseti.¹⁵

Physeal separation was measured on the frog lateral view of the presenting radiographs as demonstrated by the arrow in Figure 1. It was defined as the distance between the anterior lip of the bony capital femoral epiphysis and the closest point of the adjacent bony metaphysis. In normal subjects and in most slips the width of the physis is uniform and the separation radiologically is less than 1 mm. In all subjects with a physeal separation it was noted that the epi-

physis always remained in contact with the metaphysis posteriorly. We recognise that there will be some error in the exact measurement because of projection, magnification and also difficulty in obtaining a true frog lateral view due to pain during positioning of the leg. In all hips in which a separation was noted the distance was at least 4 mm and in one it measured 12 mm.

Results

There were 50 boys and 28 girls (male:female ratio 1.8:1). The mean age at diagnosis was 13.2 years (8.9 to 17.6) for the boys and 11.7 years (7.5 to 13.8) for the girls. There was bilateral SCFE in 29 patients (37%) and the mean time between presentation of the first and second hips was four months (3 to 7). In 62 hips (56%) the left side was affected and in 48 (44%) the right. Eight hips (7%) developed AVN. The mean time from the onset of symptoms to the diagnosis of AVN was 4.3 months (3 to 7).

After diagnosis, all patients were kept on strict bed-rest until operation. All hips were treated by a single cannulated screw inserted percutaneously except in one in which three screws were used. Active reduction was not attempted in any hip at the time of operation.

After operation the patients were mobilised either partially weight-bearing or non-weight-bearing with crutches. They were followed up routinely until the physis had fused radiologically. Anteroposterior and frog lateral views of the hip were taken at most visits. The mean follow-up was 30 months (9 to 45).

We classified 46 (42%) as unstable and 49 (46%) as acute. There was associated trauma in 18 hips.^{16,17} A total of 80 hips had a grade-1 slip, 22 had grade-2 and eight grade-3. An unintentional reduction of the angle of the slip

Fig. 2a

Fig. 2b

Fig. 2c

Radiographs showing a) anterior physeal separation at presentation, b) after insertion of a cannulated screw (the physeal separation has closed) and c) progression to AVN.

Table I. Details of patients who developed AVN

Case	Trauma	Unstable	Acute	Duration of symptoms (days)	Grade	Southwick angle (degrees)		Anterior physeal separation (mm)	
						Preop	Postop	Preop	Postop
1	Fall downstairs	Yes	Yes	14	3	60	60	9	2
2	Fall outdoors	Yes	Yes	7	3	55	35	6	2
3	Fall outdoors	Yes	Yes	2	3	80	60	12	2
4	Fall from bicycle	No	Yes	14	1	30	30	0	0
5	Fall outdoors	No	No	30	3	75	30	4	2
6	Fall outdoors	Yes	Yes	5	2	45	25	8	8
7	No trauma	No	No	60	3	90	70	4	0
8	Fall outdoors	Yes	Yes	3	3	80	35	6	3

of 20° or greater was seen in 21 hips (19%) when the preoperative and postoperative radiographs were compared. The mean preoperative angle of slip for this group was 25°. ^{13,14} There was anterior physeal separation in seven hips of between 4 and 12 mm. There was complete agreement between observers regarding the presence or absence of anterior physeal separation. The physeal gap was closed postoperatively in six of the seven hips with separation (Fig. 2). All these hips developed AVN; six (86%) were classified as acute, five (71%) as unstable, one (14%) as grade 1 and six (86%) as grade 2.

We separated the hips into two groups, those affected by AVN and those which were not. In those with AVN, all except one had anterior physeal separation on the initial radiographs (87.5%) (Table I). There was associated trauma in seven hips (87.5%) and five were unstable (62.5%) and six acute (75%). One slip was grade 1 (12.5%), one grade 2 (12.5%), and six grade 3 (75%). The mean preoperative angle of slip in this group was 59° (30 to 90). Of these hips, six (75%) had a reduction in the angle of slip by 20° or more when pre- and postoperative radiographs were compared. The risk factors for AVN following SCFE are shown in Table II.

Of the 102 hips which did not develop AVN, none had anterior physeal separation, 11 (11%) had associated trauma, 41 (40%) were classified as unstable and 43 (42%) were acute. There were 79 (77%) grade-1, 21 (21%) grade-2 and two (2%) grade-3 slips. The mean preoperative angle of slip in this group was 23° (5 to 75); 18 hips (18%) had a reduction in the angle of slip by 20° or more when preoperative and postoperative radiographs were compared. It was also noted that large angles of slip could occur without associated separation. For example, one patient in this group had a slip measuring 75° with no demonstrable anterior physeal separation.

A review of all the postoperative radiographs showed no evidence of penetration of the screw into the hip and no chondrolysis.

Discussion

Our results suggest that those patients who present with demonstrable physeal separation have a high risk of developing AVN if managed by percutaneous screw fixation. The risk in this study group was 87.5%. The other risk factors for the subsequent development of AVN were a grade-3 slip (75%) and trauma (39%). Although five of the eight hips with AVN were classified as unstable (62.5%) only five of 46 unstable hips (11%) developed AVN (Table II).

One of the limitations of our study is that it is retrospective. We therefore had to rely on the information recorded in the patients' notes. The group of patients with acute slips is large. This may be due to the fact that some of those patients with an acute exacerbation of chronic hip pain were recorded as acute.

We recognise that errors in the measurement of physeal separation can occur because of the difficulty in obtaining a true lateral view of the proximal femur in this painful condition. As this separation suggests an element of mobility between the metaphysis and capital epiphysis it could vary with the position of the patient. We have, however, found it to be a sign that is reliably definable as present or absent. It is associated with severe slipping, trauma and unstable hips (Table I). Although, rarely, it can be present in hips categorised as stable or chronic, conversely, absence of physeal separation does not mean that the hip cannot be classified as acute or unstable.

In our study, anterior physeal separation was associated with the more severe slips. A larger degree of slip reduces the area of contact between the epiphysis and metaphysis and therefore reduces the stability. This may allow the epiphysis to tilt on the posterior cortex of the metaphysis and separate anteriorly. Physeal separation was also more common in acute slips and in those associated with trauma and those which were classified as unstable. These factors would not appear to be independent variables, but are all indicators which place these slips at the severe end of the spectrum. In our study, anterior physeal separation appeared

Table II. The risk factors for AVN after SCFE

Risk factor	Number affected	Percentage
Physeal separation	7/8	87.5
Grade 3	6/8	75
Trauma	7/18	39
Unstable	5/46	11
Acute	6/49	12

to be a more specific and sensitive predictor of the development of AVN (Table II).

We observed that in the patients who had anterior physeal separation, all but one of the physeal gaps closed during fixation (Fig. 2). It may be that the capsular blood vessels are disrupted at the time of physeal separation, and so the progression towards AVN has already started.¹⁸

It has been reported that patients with untreated SCFE do not develop AVN and therefore it is likely to be a result of treatment.⁸ It may be that closure of the physeal separation can tilt the head on an axis of the posterior cortex of the metaphysis and stretch the posterior capsular vessels, disrupting the blood supply to the femoral head and causing AVN.¹⁹ It would appear likely that closed reduction would exacerbate this risk in patients with anterior physeal separation, although Phillips, Griffiths and Clarke²⁰ have shown that reduction and stabilisation within 24 hours reduces the incidence of AVN in unstable hips. They speculate that impingement of the blood supply may be released by reducing an acute slip.

Because of the high risk of AVN, we suggest that alternative methods of treatment, such as open reduction with osteotomy through the metaphysis or even primary immobilisation in a spica, should be evaluated in this high-risk group.²¹ Further studies are required to establish the safety of such procedures in this group.

We conclude that the presence of anterior physeal separation in SCFE is associated with a high incidence of the subsequent development of AVN, and that screw fixation in situ may not be appropriate in these patients.

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