OPEN REDUCTION OF THE SEVERELY SLIPPED UPPER FEMORAL EPIPHYSIS

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The results of open reduction of the severely slipped upper femoral epiphysis are reported for 115 hips with an average follow-up of 12 years 11 months (range 2 to 33 years). In 70 hips with a chronic slip and an open growth plate the incidence of complications was low: two developed avascular necrosis, five chondrolysis, and one had both. There were more complications in the 38 hips with an acute-on-chronic slip: six developed avascular necrosis, one chondrolysis, and three had both. Of the seven hips operated upon with a partially fused plate, only one did well. All these complications were obvious within the first year but there were also three hips in the series in which osteoarthritis developed between 10 and 20 years after operation.

Management of the severely slipped upper femoral epiphysis with an angulation of over 50° between the epiphysis and the femoral neck on the lateral radiograph is difficult. Many methods have been advocated including pinning in situ to allow remodelling (Boyer, Mickelson and Ponseti 1981), manipulation (Fairbank 1969), osteoplasty and epiphysiodesis (Herndon, Heyman and Bell 1963) and subtrochanteric osteotomy (Southwick 1967).

Although it is important to prevent avascular necrosis and chondrolysis, which are the main short-term complications, it is equally important that these hips do not develop degenerative changes in middle age. We feel that a safe anatomical reconstruction by open reduction of the epiphysis is the best way to avoid hip deformity in adolescence and prevent the development of osteoarthritis in the hip in later life.

The results of open reduction reported in 1964 showed an acceptably low incidence of early complications (Dunn 1964). We now present a larger series with longer follow-up to assess the development of late complications.

MATERIAL

Between 1950 and 1984 115 open reductions were performed in 110 patients, 77 boys and 33 girls, and all have been followed for more than two years. The average angulation of the epiphysis to the femoral neck on the lateral radiograph was 61° (range 33° to 90°), with only 15 hips less than 50°. The average age of the boys was 14 years 6 months (range 8 to 19 years) and of the girls 12 years 3 months (range 8 to 18 years). The average follow-up was 12 years 11 months (range 2 to 33 years).

Patients were classified according to the categories previously defined (Dunn 1964; Dunn and Angel 1978). Of the 115 hips reviewed 70 had a chronic slip with an open growth plate, 38 an acute-on-chronic slip and 7 a chronic slip with a partially fused growth plate.

RESULTS

The criteria for postoperative assessment are shown in Table I.

Chronic slip with open growth plate. The results in these 70 patients are presented in Table II. The eight asymptomatic patients with only "fair" radiographs were satisfactory, apart from minor radiographic imperfections such as a small notch in the femoral head or a flat top to the femoral head; none had deteriorated and one had been followed for 28 years. One patient initially did well but developed osteoarthritis 20 years after operation and had a total hip replacement at 25 years. Two patients had pain in the hip but no clinical or radiographic abnormality. One patient developed slowly progressive subluxation of the hip after trivial trauma; he was treated by acetabuloplasty but later developed osteoarthritis. We

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were unable to identify any pre-operative factors which predisposed patients to develop complications. Accuracy of reduction at operation did not appear to influence the results.

Acute-on-chronic slips. The results in these 38 patients are presented in Table III. Overall they are worse than in the chronic group, presumably because of damage to the vessels at the time of the acute episode. Figures 1 to 6 show a typical good result. Patients in this group with a shorter duration of symptoms were more likely to develop avascular necrosis or chondrolysis but neither the angle of the slip nor the accuracy of reduction influenced the result.

Chronic slip with a partially fused growth plate. The results in these patients are presented in Table IV.

Avascular necrosis (Figs 7 to 9). Nine hips developed avascular necrosis without chondrolysis. This was most common in the acute-on-chronic group. Although all nine were degenerate hips by our radiological criteria, four were still asymptomatic at 2, 5, 9 and 26 years and three were fair symptomatically at 6, 10 and 14 years. These hips are unlikely to remain symptomatically satisfactory although some have already defied our expectations.

Chondrolysis (Figs 10 to 13). Nine hips developed chondrolysis alone. This was more common after operation for a chronic slip than for an acute-on-chronic slip. Some showed a temporary symptomatic and radiographic improvement over the first five years but eight of them developed degenerative changes later, seven giving rise to significant symptoms. Only one maintained symptomatic and radiographic improvement eight years after operation.

Avascular necrosis and chondrolysis. Within the first six months five hips developed joint space narrowing characteristic of chondrolysis, and changes in bone density with eventual collapse characteristic of avascular necrosis. These hips all did badly: two were arthrodesed three years after the operation; the other three became symptomatic degenerate hips, one of which had a total hip replacement at 21 years after the original operation.

Late onset osteoarthritis. Three hips had none of the above early complications but developed osteoarthritis at 12, 15 and 20 years after the operation. No factors could be identified to account for this degeneration. There was also one patient who developed osteoarthritis after acetabuloplasty.

Longer term follow-up

Within this series a group of 23 hips has been followed for more than 20 years (average 25 years 6 months). The type of slip was chronic with an open plate in 11, acute-on-chronic in nine and chronic with a partially fused growth plate in three. The results showed 11 to be normal, three to be clinically normal but with a non-progressive minor radiographic imperfection, three had developed avascular necrosis and chondrolysis, one of which had undergone total hip replacement at 21 years, three had

developed chondrolysis alone and one had avascular necrosis alone but was still asymptomatic at 28 years. Of the 16 that escaped early complications only two have so far developed osteoarthritis at 12 and 20 years.

DISCUSSION

Of the 115 cases of slipped epiphysis treated by open reduction, approximately 30% occurred in girls; this applied to both acute-on-chronic and chronic slips. The major complications were avascular necrosis and chondrolysis, both of which were always obvious within the

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Good result. Figures 1 and 2 – Anteroposterior and lateral radiographs of an acute-on-chronic slipped epiphysis. Figures 3 and 4 – Two years after operation, with the growth plate fused. Figures 5 and 6 – At 20-year follow-up, the joint is normal with a good joint space and no irregularity. There is the characteristic short neck appearance seen after this procedure.

first year. After the first year it was unusual to develop complications but three hips developed early onset osteoarthritis. As previously reported (Boyer et al. 1981) avascular necrosis always gave poor radiographic appearances, but the clinical results were often surprisingly good. Although it has previously been stated that chondrolysis commonly recovered to give good results (Lowe 1970) we found that, despite some variable and temporary symptomatic and radiological recovery within the first five years, most hips affected by chondrolysis subsequently developed degenerative changes on the radiograph and then significant symptoms.

Various techniques have been recommended for the management of the severely slipped upper femoral epiphysis. In order to compare different methods it is important to define the severity of the slip and the type of slip (acute-on-chronic or chronic). The chronic group should be subdivided according to whether the growth plate is still open or not. Though avascular necrosis and chondrolysis will be evident within the first year, abnormal anatomy may well predispose to osteoarthritis in early middle age. It is therefore important that these patients should be followed for over 10 years. Assessment should use strict criteria: a hip giving any pain should not be classified as excellent.

Pinning in situ to allow remodelling has been advocated (Boyer et al. 1981). This is a difficult procedure and in a severe slip the pins are liable to protrude through the posterior cortex of the neck, endangering the retinacular vessels. O'Brien and Fahey (1977), in their study of the remodelling potential of 56 cases, felt that full remodelling could not be expected to take place with more than 60° of angulation.

Manipulation has been recommended even for chronic slips. In Fairbank's report in 1969, 16 slips of varying severity (four acute) were manipulated under anaesthesia and pinned but no objective measurement was possible of the amount of correction obtained; none developed avascular necrosis, and at average follow-up of seven years 11 were considered good and three unsatisfactory. Manipulation of the acutely slipped epiphysis was reported by Aadalen et al. in 1974: of 50 hips treated by manipulation under anaesthesia and then by pinning or epiphysiodesis, nine developed avascular necrosis and chondrolysis. Griffith (1976) described manipulation under anaesthesia in 29 acute slips: the position was improved in 11 but avascular necrosis developed in eight of these.

Osteoplasty of the femoral neck with epiphysiodesis was originally described as suitable for the severe slip

Fig. 7

Fig. 8

Fig. 9

Avascular necrosis. Figure 7 - Ten months after operation, the superior part of the head has collapsed indicating avascular necrosis. Smith-Petersen nails were used in the first 10 patients in the series. Figure 8 - One year later the head has started to reform. Figure 9 - At 28 years after operation the hip is reasonable, although this was categorised as poor because of degenerative features. The patient is on her feet 18 hours a day, but takes analgesics; the hip flexes to 100° and abducts to 15°.

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Chondrolysis. Figure 10 - Six months after operation chondrolysis has developed with a narrowed joint space. Figure 11 - The appearance is worse one year after operation. Figure 12 - The joint space has improved four years after the operation. Figure 13 - At 22 years there is extensive osteoarthritis. The patient is limited in all his activities and has been offered a total hip replacement.

(Herndon et al. 1963) but in a later study Melby, Hoyt and Weiner (1980) reported on 289 hips and used it in only one hip with more than 50° angulation. The recently reported experience from Nottingham (Szypryt, Clement and Colton 1987), suggests that this is a useful technique for the moderate slip but that open reduction is superior in the severe slip.

Pearson and Ridell (1964) reported on the use of subtrochanteric osteotomy in the management of slipped upper femoral epiphysis: of 25 hips followed for an average of 8 years 6 months, four developed avascular necrosis, and osteoarthritis developed after 8 to 15 years. Southwick (1967) reported on the use of a biplanar or

triplanar osteotomy through the lesser trochanter: in 28 hips two developed chondrolysis, and at follow-up (average 7.8 years) 21 were excellent, five were good and two were fair. Rao, Francis and Siwek (1984) described 27 hips treated similarly with an average follow-up of 7 years 6 months, and although none had chondrolysis or avascular necrosis, three were said to have a reduced joint space; 23 were excellent, three were fair and one was poor. However, it would appear that few patients in these two series had more than 60° angulation. We are concerned that their assessments allow patients with some hip pain to be classified as excellent. It would be interesting to see how many of these patients with gross

Table I. Criteria for assessment of outcome of operation

	Good	Fair	Poor
Subjective	No complaint, normal function	Occasional hip consciousness, full function	More than hip consciousness, some limitation of function, any secondary operation
Clinical	Normal range of movement	Flexion range at least 90°, no fixed deformity	Flexion less than 90°, any fixed deformity
Radiological	Good reduction; head contour, joint space and bone texture all normal	Notch or flattened head but no narrowing of joint space or progression of above changes	Narrow joint space, cysts, density changes, osteophytes or other changes

Table II. Results of 70 operations for chronic slip with an open growth plate (50 boys, 20 girls)

	Good	Fair	Poor
Subjective	62	1	7
Clinical	59	3	8
Radiographic	50	10	10
50 Normal	8 Asymptomatic, full range, fair radiographically		
Early complications (13%)	Late significant complications (14%)		
2 Avascular necrosis alone	} (on going)		
1 Avascular necrosis and chondrolysis			
5 Chondrolysis alone			
1 Subluxation after trivial injury	1 Osteoarthritis (after 20 years)		
95% confidence interval 3.4–14.6 (5% to 21%)	1 Developed osteoarthritis after acetabuloplasty		
	4.1–15.9 (6% to 23%)		

Two patients had pain of unknown cause

Table III. Results of 38 operations for acute-on-chronic slip (26 boys, 12 girls)

	Good	Fair	Poor
Subjective	28	5	5
Clinical	27	5	6
Radiographic	21	7	10
20 Normal	5 Asymptomatic, full range, fair radiographically		
Early complications (26%)	Late significant complications (29%)		
6 Avascular necrosis alone	} (on going)		
3 Avascular necrosis and chondrolysis			
1 Chondrolysis alone			
92% confidence interval 4.4–15.4 (12% to 41%)	1 Osteoarthritis		
	5.4–16.6 (14% to 44%)		

Two patients had pain of unknown cause

distortion of the upper femoral anatomy developed osteoarthritis in early middle age, 20 years or more after the operation, and how they were then treated.

Open reduction of the severely slipped upper femoral epiphysis can be performed even with slips of 90°. Although in the past the operation acquired a reputation for an unacceptable incidence of avascular necrosis and chondrolysis (Pearl, Woodward and Kelly

We feel that an open reduction of the chronic severely slipped upper femoral epiphysis with an open growth plate is an acceptable procedure. With the acute-on-chronic cases it gives results comparable to other techniques reported in the literature and the incidence of complications may represent the inherent risks associated with this injury. Open reduction should not be used in hips with a partially fused growth plate, and a recent

Table IV. Results of seven operations for chronic slips with partially fused growth plates (4 boys, 3 girls)

	Good	Fair	Poor
Subjective	2	1	4
Clinical	1	1	5
Radiographic	1	—	6
1 Normal			
Early complications	Late significant complications		
1 Avascular necrosis alone	} (on going)		
1 Avascular necrosis and chondrolysis			
3 Chondrolysis alone			
	1 Osteoarthritis		

1961; Wiberg 1966), in more recent studies, with careful technique, surgeons have been reporting much lower levels of complications (Sijbrandij 1982; Szypryt et al. 1987). In 1984 Fish reported on 36 hips with a chronic slip and open growth plate treated by open reduction: all had an excellent result and no hip developed avascular necrosis or chondrolysis. Of seven hips with an acute-on-chronic slip treated by open reduction, one developed avascular necrosis and one developed osteoarthritis at eight years.

radiograph should be examined carefully if fusion is suspected. For this condition an osteotomy of the Griffith type (Griffith 1976) is preferable.

One of the major difficulties in conducting a review of this type is to keep in touch with the patients, as they grow up and move away. Mrs Sheila Upson, medical secretary at Black Notley Hospital since 1950, has been meticulous in keeping records of patients and indefatigable in tracing those who have strayed. This review would have been impossible without her assistance. We are also grateful to Mr Alan Finch, medical photographer, for the illustrations.

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