We have studied retrospectively 37 hips in 36 children at an average of 91 months after simultaneous open reduction and Salter innominate osteotomy for developmental hip dysplasia. At the latest review 97.3% were clinically and 83.8% radiologically good or excellent. In three hips (8%) there were signs of avascular necrosis, but only one had been symptomatic. There were no cases of recurrent posterior displacement.

Received 19 October 1995; Accepted 19 December 1995

The management of developmental dysplasia of the hip aims at early diagnosis and treatment. It is claimed that adequate acetabular remodelling is possible only during the first 18 months of life. After this, satisfactory development cannot always be assured by non-operative treatment following closed reduction (Salter and Dubos 1974). Many methods of management have been described, but all have complications and result in a proportion of hips which develop imperfectly (Williamson and Benson 1988).

Innominate osteotomy was originally designed for children with delayed presentation of developmental hip dysplasia and those in whom earlier treatment had failed to produce remodelling (Salter 1961). Reorientation of the acetabulum makes the reduced hip more stable, increases the load-bearing area of the acetabulum in the weight-bearing position, and does not alter its shape or volume.

PATIENTS AND METHODS

From 1981 to 1991, 38 patients (39 hips) had simultaneous open reduction and Salter innominate osteotomy at the Robert Jones and Agnes Hunt Orthopaedic Hospital, representing the senior author’s first ten years’ experience of this procedure. Patients who also required femoral shortening and correction of excessive femoral anteversion, because they were older or had teratological dislocation, were excluded. Two patients were lost to follow-up, leaving 36 available for retrospective study.

There were 33 girls and three boys; the affected hips were left-sided in 27 and right-sided in ten. The mean age of independent walking was 15.4 months (10 to 20) and at diagnosis 20.7 months (birth to 65). The mean age at operation was 25.4 months (18 to 67), and the mean follow-up from operation to the latest review was 91 months (36 to 162).

Four patients had a positive family history of developmental dysplasia of the hip. Thirty-two had had a normal vaginal delivery, two were breech presentations, and two had been delivered by caesarean section. Four patients had had previous treatment at another hospital, three by closed reduction and splintage and one by a varus derotation osteotomy. All four had unsatisfactory results. One other patient had had previous traction and an attempted closed reduction in our hospital, but the result was unsatisfactory a week later.

We graded preoperative subluxation or dislocation according to the Tonnis (1982) classification, in which the centre of the ossific nucleus of the femoral head is related to
Perkins’ line and to a horizontal line at the level of the lateral margin of the acetabulum. Twenty-nine of the hips (78.4%) were classified as grade II (Table I).

Thirty-two patients had two weeks of preoperative skin traction; the other four did not require this, having had previous treatment.

**Surgical techniques.** We followed the recommendations of Salter and Dubos (1974) on preoperative indications and surgical technique, and the capsulorrhaphy was similar to that described by Wenger (1989).

Redundant capsule was excised and a capsulorrhaphy performed in all cases. The capsule was opened through a ‘T’-shaped incision, the medial limb of the ‘T’ passing across the hour-glass constriction and down to include the transverse ligament. When the femoral head had been reduced, the redundant lateral flap of capsule was trimmed by removal of a trapezoid segment wider posterolaterally than anteriorly. It was considered essential that the residual lateral capsule could be drawn down and medially to meet the whole of the anterior lip of the acetabulum. All adhesions between the capsule and the gluteal muscles were freed. Interrupted non-absorbable sutures were then inserted ready to repair the capsule, the lateral suture being passed through the apex of the everted limbus to ensure that the latter remained outside the head, thereby helping to provide a stable reduction.

To assist in the redirection of the acetabulum, a hook was placed around the inferior fragment at the sciatic notch, with its handle passing across the iliopectineal eminence. This helped the displacement of the acetabulum forwards and outwards, while preventing backward movement and posterior opening of the osteotomy. After fixation with two Kirchner wires, the acetabulum was palpated to ensure that there had been no penetration of the joint. The head was then reduced and the capsule closed.

After operation, the hips were immobilised in a bilateral hip spica for six weeks. This was changed to a bilateral ‘broomstick’ cast which allowed flexion and extension of the hip, but maintained moderate abduction and internal rotation for a further four weeks. The patients were then allowed to mobilise progressively without further splinting, at first under the guidance of a physiotherapist. The one patient with bilateral dysplasia had the procedures on both hips at an interval of one month.

**RESULTS**

The two patients who were lost to follow-up at 24 and 26 months after operation both had good or excellent clinical results with no radiological signs of avascular necrosis at their last review, but were not included in the analysis.

Clinical assessment on McKay’s criteria (1974) showed that 36 hips (97.3%) had good or excellent results (Table II). Radiological assessment on Severin’s criteria (1941) showed that 31 hips (83.8%) were grade I or grade II (Table II). Using Hilgenreiner’s line as a reference and the criteria of Gamble et al (1985), 14 hips (37.8%) had developed coxa magna, but in no case did this interfere with the concentricity of reduction or the radiological grading.

Three hips (8.1%) developed avascular necrosis after the combined procedure. On the Kalamchi and MacEwen classification (1980), two were grade III and one was grade IV. Despite radiological deformation of the head and neck (coxa plana and coxa brevis), the two grade-III hips were classified subjectively and clinically as good and excellent at the latest review. The patient with grade-IV avascular necrosis had previously been treated in a Craig splint, which may have been a contributory factor. This patient had a positive Trendelenburg test with moderate restriction of the range of motion, and was therefore classified as having only a fair result. We found no relationship between the development of avascular necrosis and the age at operation, the preoperative degree of dislocation, or the date of operation in relation to the learning curve for the procedure.

Four patients showed irregular, but progressive, ossification of the femoral head, suggesting fragmentation, on radiographs taken about one year after operation. These appearances later resolved completely, with no evidence of avascular necrosis, after ossification of the femoral head. Similar changes have been described by Salter, Kostuik and Dallas (1969) and by Gage and Winter (1972).

Two hips showed secondary subluxation and required reoperation. One had a second capsulorrhaphy after ten weeks, and the other had a varus derotation osteotomy at four months. Both achieved satisfactory concentric reduction of the hip. We found no evidence of secondary posterior displacement, as described by Fixsen (1987). The first patient in our series developed a flexion and abduction con-
reduction and innominate osteotomy is barely perceptible. The alternative operation is a femoral osteotomy. The removal of pelvic pins six weeks after the innominate osteotomy is a minor procedure compared with the removal of a femoral implant. This requires additional inpatient treatment, and may cause an added growth spurt and lead to 'long-leg dysplasia' of the acetabulum.

The most feared complication of treatment for developmental hip dysplasia is avascular necrosis. The diagnosis can be difficult, and a series of radiographs is required over a considerable time. Most of the classification systems for avascular necrosis are comprehensive, but have some interobserver error (Thomas et al 1989), especially when the radiological changes are minor. Three of the hips which we reviewed (8.1%) developed avascular necrosis (Fig. 1), but only one with a Kalamchi grade-IV lesion was symptomatic. In another patient the diagnosis of developmental hip dysplasia was made at the age of 45 months and operation was one month later. We have changed our policy for patients with developmental hip dysplasia who present over the age of three years; we now include femoral shortening in an attempt to reduce the risk of avascular necrosis.

Four other patients developed punctate epiphyses (MacKenzie, Seddon and Trevor 1960) or temporary irregular ossification (Salter et al 1969), but all four had good or excellent results both clinically and radiologically at the latest review. This transient appearance of irregular ossification of the femoral head, suggestive of early fragmentation, may represent accelerated ossification in response to the surgery or a temporary vascular disturbance (Salter et al 1969).

Reported rates of the incidence of avascular necrosis after surgical treatment vary considerably, ranging from 5.7% for primary simultaneous open reduction and innominate osteotomy (Salter and Dubos 1974) to 37% (8% partial and 29% total) after open reduction alone (Thomas et al 1989). In an earlier series of 161 hips seen late at our hospital and treated by open reduction alone, the incidence of Kalamchi grades II, III and IV of avascular necrosis was 8.7% (Ross, Ford and Evans 1987).

An alternative to the use of pelvic osteotomy with an open reduction is femoral osteotomy, but this also has a risk of avascular necrosis (10%: Chuinard and Logan 1963). Any patient having a secondary surgical procedure is more likely to have an increased incidence of complications; Salter and Dubos (1974) reported an incidence of 7.7% of avascular necrosis in this type of patient.

Mild coxa magna was seen in 37.8% of hips, and is frequent after treatment for developmental hip dysplasia (Gamble et al 1985; O'Brien and Salter 1985). In our patients, it was associated with a congruous joint and acceptable acetabular cover (Figs 2 and 3), and we found no relationship to the development of avascular necrosis or temporary irregular ossification.

The reoperation rate for secondary subluxation in our series (5.4%) compares favourably with other reports. Chui-
nard and Logan (1963) had a similar rate (5%) after open reduction and femoral osteotomy. Salter and Dubos (1974) reported a redislocation rate of 5.6% and a resubluxation rate of 14.3% after the combined procedure used as primary treatment, but these results were before they had developed a satisfactory capsulorrhaphy. Both Tachdjian (1982) and Fixsen (1987) suggest that the reasons for failure to maintain a reduced hip are a poorly executed osteotomy, a lax capsulorrhaphy and excessive femoral antversion. Our two patients who required reoperation both had the last two con-
A correct technique of capsulorrhaphy helps to prevent posterior displacement in the early postoperative period while the hip is remodelling.

The combined procedure of open reduction and pelvic osteotomy is technically demanding. Correct displacement of the osteotomy is more difficult during open reduction than in an isolated procedure when the anterior capsule is intact, which facilitates the appropriate displacement of the acetabulum. Control of the acetabulum is more difficult once the capsule has been opened. A staged Salter innominate osteotomy may therefore seem more attractive, but has the disadvantages of two inpatient periods, reoperation through previous surgical scar, two periods of immobilisation in a hip spica and two periods of rehabilitation. Provided that the innominate osteotomy can be performed effectively at the time of open reduction the combined treat-
A 16-month-old girl with a dislocated left hip (Tonnis grade II) (a). At 12 years of age there is a congruous joint (b) with slight coxa magna and a mild lateral deformity of the neck (Severin group II).

ment can be achieved over a 12-week period, after which the patient may be allowed to mobilise free from constraint. The clinical and radiological results of simultaneous and staged procedures have been compared by Barrett et al (1986) at an average follow-up of 8.3 years. They found no appreciable difference at 73% and 80% respectively and our results compare favourably.

We support the use of combined open reduction and Salter innominate osteotomy at 18 months to 3 years for the treatment of developmental dysplasia of the hip diagnosed late or after failure to respond to previous treatment. The surgeon must fully understand Salter’s prerequisites for the operation and the surgical technique of open reduction and its maintenance by an effective capsulorrhaphy. The procedure is technically demanding and the potential morbidity is considerable, but the combined procedure can provide a shorter treatment time, with no apparent increase in avascular necrosis or reoperation and satisfactory clinical and radiological results.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


