We have examined the effect of arthrodiastasis on the preservation of the femoral head in older children with Perthes’ disease. We carried out a prospective trial in boys over the age of eight years and girls over seven years at the time of the onset of symptoms. The patients had minimal epiphyseal collapse and were compared with a conventionally treated, consecutive, historical control group. Arthrodiastasis was applied for approximately four months. The primary outcome measure was the extent of epiphyseal collapse at the end of the fragmentation phase. One of the 15 treated hips and nine of the 30 control hips showed a loss of height of 50% or more of the lateral epiphyseal column on the anteroposterior radiographs (Herring grade-C classification). On a Lauenstein view, one of the treated hips and 19 of the control hips showed at least a loss of height of 50% of the anterior epiphyseal column. The complications of arthrodiastasis included pin-site infection in most hips, transient joint stiffness in two, and breakage of a pin in two. The final outcome will be known when all the patients and the control group reach skeletal maturity.

The course and prognosis of Perthes’ disease are variable and difficult to predict. At worst this condition can lead to debilitating degenerative arthritis during early adulthood. It is widely accepted that those most at risk of a poor outcome are patients who develop the disease in later childhood, after eight years of age. Possible reasons include an increased likelihood of severe collapse for mechanical reasons in the older child who has less time remaining for growth and remodelling and who has decreased elasticity of the acetabulum.

The best treatment for Perthes’ disease is still unknown. The main principles of treatment have traditionally been relief of loading and containment. Bedrest, traction and bracing have been used to relieve symptoms of the disease with a better outcome to be expected in the younger patient. For older children in whom the head is more ‘at risk’, surgical interventions such as pelvic osteotomies, augmentation of the acetabular shelf and muscle releases have been advocated. No treatment has been shown convincingly to be significantly effective in improving the outcome of Perthes’ disease or of influencing its course. This is partly due to the difficulty in evaluating the effect of treatment on a disease that has a variable course, duration and outcome, but also because of methodological difficulties such as lack of a control group and patient selection.

Arthrodiastasis is a relatively new treatment for Perthes’ disease. The term describes a regime of articulated distraction and open surgery of the hip, which has been used in Verona since 1979, in order to treat a variety of conditions such as osteoarthritis, chondrolysis and avascular necrosis. It is thought that by creating a space between the bony surfaces, minimizing mechanical stress and maintaining movement, the synovial circulation will be restored. This encourages fibrous repair of defects of articular cartilage and the preservation of an intact and congruent femoral head.

The use of MRI or arthrography (Fig. 1) can indicate the extent of femoral epiphyseal necrosis before it is seen on radiography. Our aim was to assess the effect of arthrodiastasis in a select group of patients who would normally expect to have a poor outcome by conventional methods of treatment. We hoped that by applying distraction early in the disease, before any significant collapse of the femoral head had occurred, further fragmentation would be halted. We present our preliminary results of this prospective trial, the primary outcome measure of which is the epiphyseal height at the end of the fragmentation phase of the disease as seen on anteroposterior and Lauenstein views.
Patients and Methods
Ethical permission for this study was obtained from the Queen’s University of Belfast Research Ethical Committee and informed consent was obtained from all patients and their guardians before participation in the study.

All children presenting with Perthes’ disease after November 1998 to the Northern Ireland orthopaedic service, over the age of eight years for boys and seven for girls, were invited to participate in this trial. One child who fitted the inclusion criteria was not recruited because of lack of parental consent.

The exclusion criteria included hips which demonstrated collapse of the lateral one-third of the femoral head of over 50% (i.e. Herring grade C), patients with lateral ossification, those with other possible causes of avascular necrosis such as sickle-cell anaemia or multi-epiphyseal dysplasia and children who were immunosuppressed. To date no patient has been excluded because of these restrictions. Overall, 15 children (11 boys and four girls) have so far met all the inclusion criteria and have been treated by arthrodiastasis (Table I). Three had previously experienced Perthes’ disease in the contralateral hip at an earlier age and had been treated conservatively.

Using identical age-inclusion criteria, a consecutive historical control group was selected from the comprehensive database of children with Perthes’ disease17 who had presented to our orthopaedic service between January 1990 and July 1998. Most of these children had been managed conservatively by symptomatic treatment alone. This group, which comprises 38 children (33 boys and five girls) with 41 affected hips, will be used for the final comparison at skeletal maturity by using the classification of Stulberg et al.1 Of these 41 hips, 30 were diagnosed and x-rayed in the initial or fragmentation stages of the disease. This group was used to compare the extent of radiographic epiphyseal collapse at the end of the fragmentation phase and was therefore used as the control group in our study. Although all the hips in this group were at similar risk because of their late age at onset, only five underwent operations, three with femoral osteotomies and two shelf procedures, during the active stages of the disease. The results for these hips are

Table I. Details of the patients who were treated by arthrodiastasis

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Mean age at the onset of symptoms (yrs)</th>
<th>Herring grade before arthrodiastasis</th>
<th>Mean age at the time of application of the fixator (yrs)</th>
<th>Mean weight at the time of application of the fixator (kg)</th>
<th>Mean duration of application of the fixator (wks)</th>
<th>Final Herring grade</th>
<th>Mean length of follow-up from the onset of symptoms (mths)</th>
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<td>B</td>
<td>15.8</td>
</tr>
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</table>

*Lost to follow-up six weeks after removal of the external fixator
Operative procedure. Under general anaesthesia and using radiographic control, a percutaneous guide-wire was passed into the hip approximately 5 mm distal to the perceived centre of the femoral head with the hip in 15° of abduction. The guide-wire was used to locate the fixator hinge. Two tapered, hydroxyapatite-coated bone screws were introduced into the subchondral bone of the ilium in the transverse plane. An Orthofix hinged external fixator (Orthofix srl; Bussolengo, Italy) (Fig. 2) was positioned in 15° of abduction and two further bone screws were placed distally in the femur in the axial plane. Using a compression-distraction unit, the hip was distracted until widening of the joint space was seen on the image intensifier. The range of movement of the hip was checked to ensure that flexion from 20° to 70° was maintained. After operation, the patients were mobilised partially weight-bearing on crutches and hip flexion-extension exercises were encouraged. The distractor was hand-tightened at intervals of two weeks and the pin sites were monitored for signs of infection. The frame was left in place for approximately four months.

Results
In the study group the mean age at the onset of symptoms was 9.9 years (7.1 to 12.5) and the mean age at the time of surgery was 10.4 years (8.0 to 12.7). All patients were in the fragmentation stage when operated on. Details of the patients and treatment are listed in Tables I and II. In the control group the mean age at the onset of symptoms was 9.1 years (7.0 to 12.1) All hips were in the stages of reossification or healing at the time of follow-up and had therefore been assigned a final Herring classification. One patient (one hip) was lost to follow-up six weeks after removal of the fixator. This hip had already entered the reossification stage and was therefore given a final Herring grade. However, this hip will not be included in any further
analysis of the results. The mean length of follow-up for the remaining treated hips was 38.4 months (15.8 to 56.6), but that of the control group was 58.5 months (10.5 to 143).

Of the 15 hips which had been recruited into the study, only one has progressed to a Herring grade-C classification. It also showed collapse of more than 50% of the anterior epiphyseal column. One further hip has deteriorated from a Herring grade-A to a grade-B classification. All the other hips maintained epiphyseal height and largely retained their sphericity (Figs 3 and 4). Of the 30 control hips, nine (30%) have progressed to a Herring grade-C classification. This number increased to 19 of 30 hips (63.6%) when collapse of the anterior column was measured on a Lauenstein view.

Of the five control hips which had been treated surgically, one had already sustained collapse of over 50% of both the anterior and lateral epiphyseal columns before surgery. Operation would not have influenced this result. Two other hips sustained collapse of over 50% of the anterior column but preserved at least 50% of the lateral column before surgery. After operation one of these hips showed further collapse of the lateral column. The remaining two hips both retained over 50% of the height of the anterior and lateral epiphyseal columns before and after surgery. It is not possible to establish whether any further epiphyseal collapse would have occurred if the surgical procedures had been avoided.
During treatment two patients fractured a pin, one after a fall which occurred 2.5 months after the fixator had been applied. The other patient had no history of trauma but fractured a pin 3.5 months after application of the fixator. Subsequently, the technique of screw placement was altered. After the initial placement, the screw was removed and its tip cut to ensure that all the threads were in the bone once the screw was reinserted. Most of the patients developed a pin-site infection and required at least one course of antibiotics. One frame had to be removed three weeks prematurely because of this.

After removal of the frame, two patients required manipulation under anaesthesia and physiotherapy because of stiffness of the joint. A satisfactory range of movement was re-established in both cases. Assessment of the range of movement was performed at a mean of 38.5 months (16 to 57) from the onset of the disease. The mean hip flexion of the 14 patients who were reviewed was 109° (85 to 132), abduction was 22° (10 to 35), internal rotation 25° (5 to 44), and external rotation 32° (12 to 46).

An altered pattern of reossification was seen after arthrodiastasis but not in the control hips (Fig. 5). The appearance of osteolysis around the dead bone was reduced and there was a relatively rapid peripheral reversion of the dense bone to a normal texture.

As yet it is too early for all the patients to be given a grading according to Stulberg et al1 as a measure of their final outcome, since this can only be given at skeletal maturity. However, at this later stage, radiographs will also be evaluated using the criteria of Mose18 and function will be measured by using the modified Harris hip score.

**Discussion**

Our study indicates that arthrodiastasis, when performed in the early stages of Perthes’ disease in patients with symptomatic onset over the age of seven years in girls and eight years in boys, is effective in preventing further femoral collapse. This is particularly true of the anterior epiphyseal column. Only those hips with minimal femoral collapse (Herring grade A or grade B) were recruited into the treat-
ment group so that early distraction would preserve epiphyseal height. Overall this rationale has succeeded with the exception of two hips, one of which progressed to show collapse of more than 50% of both the anterior and lateral epiphyseal columns and the other from a Herring grade-A to a grade-B classification. It compares favourably with the results of the historical control group. Both of the hips which displayed further epiphyseal collapse in our study were treated by arthrodiastasis within 2.5 months of the onset of their symptoms. It is known that most of the collapse occurs within seven months of the onset of symptoms. Since distraction of the joint is maintained for approximately four months, it may be detrimental to the outcome of the hip to apply the fixator too early. The child whose hip showed further collapse (>50%) of both the anterior and lateral columns also fractured a pin near the end of treatment, and was the oldest at the onset of symptoms and one of the heaviest at the time of application of the fixator (Table I). The possible influences of the time of application of the fixator and the weight of the child during external fixation requires further investigation and follow-up.

Several studies have been performed to assess the role of arthrodiastasis in Perthes’ disease. Kocaglu et al²⁰ applied joint distraction with an Ilizarov fixator in 11 patients whose mean age was 7.5 years at the time of surgery. Seven of the 11 hips were classified as Herring grade-C. All the hips were in groups 3 or 4 of the Catterall classification before treatment. During the period of treatment, which ranged from 40 to 150 days, no movement at the hip was possible in any plane. Eight of these patients were assigned to Stulberg classes 3 or 4 at follow-up. It was noted that the disease process progressed more rapidly to the healing phase. Because of the relatively high rate of complications, the most common being pin-site infection, the authors did not advocate routine use of this technique. A group from Brazil have prospectively studied 36 children with Perthes’ disease. Eighteen were treated by femoral varus osteotomy with a lateral shelf acetabuloplasty at skeletal maturity in 26 patients (27 hips) who had undergone early operation. Most of the hips in their study had extensive involvement of the femoral head (Catterall groups 3 or 4). These patients were compared with 30 historical control subjects. The results showed that a larger proportion (30 of 48) of the children who had undergone surgery had spherical heads at the time of healing, as assessed by the classification of Mose, than in the control group (six of 30). Little attention was paid to the complications of surgery in this study. Limb shortening ranged from 1 to 2 cm, while no reference was made to complications such as fracture of the plate which can be clearly seen in one of the radiographs which accompany the study.

Daly et al¹² reviewed the results of lateral shelf acetabuloplasty at skeletal maturity in 26 patients (27 hips) who had onset of the disease over the age of eight years and who had undergone early operation. Most had been classified as Catterall groups 3 or 4 before surgery. The authors concluded that a better long-term outcome was obtained with this procedure than with either femoral or innominate osteotomy. At the final follow-up, however, 13 of the 27 hips were classified as Stulberg 3 or higher and no control group was available for comparison. Previously, Willett et al¹¹ had compared the results of 20 children over eight years of age at the onset of symptoms, who had undergone a lateral shelf acetabular procedure early in the course of the disease. There were 14 untreated control subjects and the length of follow-up was similar to that of our study. Early
results showed this technique to yield a higher percentage of congruent hips (90%) when compared with a control group (43%). The authors stressed the importance of early surgical intervention in order to improve the likely outcome.

The variable nature of Perthes’ disease makes the condition difficult to study. The use of different classification systems and outcome measures leads to confusion. The analysis of surgical procedures is hampered by the use of small subject groups, infrequent use of a control group, unmatched selection of patients of varying ages and a varying severity of the disease process. Complications of traditional surgical techniques are common and include limb shortening, scarring and stiffness.1,2,5 These may outweigh the benefits of intervention.

While the search for an effective treatment for patients with a poor outcome in Perthes’ disease continues, every effort should be made to standardise the testing of the various operations in use. Our study presents our early experience with arthrodiatasis. Complications have occurred, although infrequently, and these must be balanced against benefits which may eventually be achieved. With follow-up to skeletal maturity, we hope that it will become apparent whether arthrodiatasis gives a better long-term result in older children with Perthes’ disease. Our preliminary results show considerable potential. The early radiographic findings are promising since further epiphyseal collapse has largely been arrested and the overall shape of the femoral head has been maintained.

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References