Prognostic factors and outcome of treatment in Perthes' disease

A PROSPECTIVE STUDY OF 368 PATIENTS WITH FIVE-YEAR FOLLOW-UP

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This nationwide prospective study was designed to determine prognostic factors and evaluate the outcome of different treatments of Perthes' disease.

A total of 28 hospitals in Norway were instructed to report all new cases of Perthes' disease over a period of five years and 425 patients were reported and followed for five years. Of these, 368 with unilateral disease were included in the present study. The hips were classified radiologically according to a modified two-group Catterall classification and the lateral pillar classification. A total of 358 patients (97%) attended the five-year follow-up, when a modified three-group Stulberg classification was used as a radiological outcome measure. For patients over six years of age at diagnosis and with more than 50% necrosis of the femoral head (152 patients), the surgeons at the different hospitals had chosen one of three methods of treatment: physiotherapy (55 patients), the Scottish Rite abduction orthosis (26), and proximal femoral varus osteotomy (71). Of these hips, 146 (96%) were available for the five-year follow-up.

The strongest predictor of outcome was femoral head involvement of more or less than 50% (odds ratio (OR) = 7.76, 95% confidence interval (CI) 2.82 to 21.37), followed by age at diagnosis (OR = 0.98, 95% CI 0.92 to 0.99) and the lateral pillar classification (OR = 0.62, 95% CI 0.40 to 0.98). In children over six years at diagnosis with more than 50% of femoral head necrosis, proximal femoral varus osteotomy gave a significantly better outcome than orthosis (p = 0.001) or physiotherapy (p = 0.001). There was no significant difference between the physiotherapy and orthosis groups (p = 0.36), and we found no difference in outcome after any of the treatments in children under six years (p = 0.73).

We recommend proximal femoral varus osteotomy in children aged six years and over at the time of diagnosis with hips having more than 50% femoral head necrosis. The abduction orthosis should be abandoned in Perthes' disease.

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The treatment of Perthes' disease has been controversial since its description almost simultaneously by Legg,[1] Waldenström,[2] Calvé[3] and Perthes.[4] It includes casts, braces, bed rest, weight-bearing, non-weight-bearing, physiotherapy, soft-tissue releases, femoral osteotomy, pelvic osteotomy and combinations of the above. The results of containment of the femoral head were first reported by Petrie and Bitenc.[5] Containment of the vulnerable and biologically plastic femoral head in the acetabulum early in the disease was believed to result in a more spherical head during the repair process, thereby resulting in a more congruent joint.[6]

Non-operative containment treatment has involved different braces,[7-11] whereas surgical containment includes varus osteotomy of the proximal femur,[12-14] or various types of innominate osteotomy[15-17] to redirect the acetabulum and thereby improve femoral head cover. Most studies on treatment are retrospective, with a relatively small number of patients and without a control group. There is a lack of uniformity concerning the selection of patients, indications for treatment, criteria for evaluation and age groups. To our knowledge, there has hitherto been only one multicentre, prospective study comparing methods of treatment.[18]

In 1996, the Norwegian Paediatric Orthopaedic Society started a nationwide prospective study on Perthes' disease in order to gain more knowledge of its epidemiology, aetiology[19] and treatment. A total of 425 children were followed clinically and radiologically for five years. They underwent one of three treatments involving either physiotherapy, the Scottish Rite abduction orthosis,[10] or femoral varus osteotomy. The aims of our study were to determine prognostic factors and evaluate the outcome of the three forms of treatments.

Patients and Methods

This was a prospective multicentre study whereby all 28 hospitals with paediatric orthopaedic services (six university hospitals, 16 county and six local) throughout Norway were instructed to report all new cases of Perthes' disease presenting between 1996 and 2000. The diagnosis was made by the local orthopaedic surgeon on the clinical and radiological findings. Recruitment was through informed consent, and the study was approved by the Norwegian Data Inspectorate and the Norwegian Directorate of Health and Social Affairs.

Demographic and clinical data were recorded by the treating surgeon at diagnosis and submitted to the study group for registration. In order to minimise loss to follow-up, repeated requests were made by mail and telephone to the treating surgeons. Bilateral cases were excluded.

At five-year follow-up, the patients and their parents were asked about the level of function. Walking distance was considered normal if the child could walk 5 km; otherwise it was classed as reduced. Sporting activity was classified into four categories: normal, participation in all activities but with reduced function, activities such as swimming only and no participation. Patients who missed the five-year follow-up were contacted by telephone and radiographs obtained by direct request to the different hospitals.

After initial assessment the radiographs at diagnosis and at one and five years were submitted to the study group, where one of the authors (SS) recorded the classification, the relevant measurements and any other changes on all radiographs. The inter-observer reliability of the classification and measurements was assessed both within the study group and between members of the group and the treating surgeons. We obtained adequate reliability using our two-group version of the Catterall classification[20] (weighted κ 0.62), the lateral pillar classification[21] (κ 0.70), femoral head cover (intraclass correlation coefficient 0.95), and the three-group Stulberg classification (κ 0.70), when assessed by experienced examiners.[22,23]

The radiological phases were determined at diagnosis and characterised by differences in epiphyseal height, width and structure compared with the normal hip. The fragmentation phase included hips where the necrotic bone was partly or totally resorbed. Hips with obvious signs of re-ossification were classified as such.

Based on anteroposterior and Lauenstein projections,[24] the diseased hips were classified according to the original four groups of Catterall.[20] Based on this, we combined groups 1 and 2 (less than 50% necrosis of the femoral head), and 3 and 4 (more than 50% necrosis), thereby creating a simpler two-group classification. We also used the lateral pillar classification of Herring et al,[21] whereby hips were divided into group A, hips with no height reduction of the lateral pillar of the femoral head; B, with more than 50% height of the lateral pillar maintained; and C, less than 50% height maintained.

The femoral head cover was calculated as the percentage of that of the femoral head medial to Perkins' line compared to the width of the femoral head, both measured parallel to Hilgenreiner's line.[22]

The articulotrochanteric distance was measured as the distance between two lines perpendicular to Perkins' line, one through the proximal aspect of the greater trochanter and the other through the most proximal aspect of the femoral head.

At the five-year follow-up the hips were classified according to Stulberg et al,[13] as modified by Neyt et al,[25] whereby class I hips are spherical with a normal femoral head, neck and acetabulum. Class II heads are spherical, with either coxa magna, a short neck or a steep acetabulum. Class III hips have ovoid femoral heads and do not fit within 2 mm of the Mose[26] concentric circles in either anteroposterior or Lauenstein projections. Class IV hips have flat outlines of the femoral head (at least one-third of the contour of the femoral head resembles a straight line on at least one projection), but there is congruency between the femoral head and the acetabulum. Class V hips have flat femoral heads and a normal acetabulum (aspherical incongruency).

The hips were also classified according to a three-group classification[23] where group A hips (Stulberg I and II) have a spherical femoral head, group B (Stulberg III) have an ovoid femoral head, and group C (Stulberg IV and V) have a flat femoral head.

All children with less than 50% femoral head necrosis (Catterall groups 1 or 2) received physiotherapy alone. In those hips with more than 50% involvement (Catterall groups 3 or 4), the treatment was dependent on age at diagnosis and femoral head coverage. Children six years or older at diagnosis, received either physiotherapy, Scottish Rite orthosis, or proximal femoral varus osteotomy, according to the choice of the local orthopaedic surgeons. These decisions were based on surgeons' preferences, treatment philosophy and local tradition. All patients from the same hospital were treated by the same method. The number of hospitals choosing physiotherapy, orthosis and osteotomy were 10, 9 and 9, respectively. Children with hips in the radiological re-ossification (new-bone formation in the epiphysis) or healing (fully rebuilt hips where the epiphysis was completely ossified) phase of the disease received physiotherapy only.

In children under six years at diagnosis, treatment was dependent on femoral head cover and radiological phase of the disease. Children whose femoral head cover was good (> 80%) were treated by physiotherapy alone. Those with reduced cover (< 80%) in the early or fragmentation phase were allocated to the treatment groups above, depending on the hospital where they were treated. The flow of patients through the different phases of the study is shown in Figure 1.

Physiotherapy consisted of range of movement exercises with special emphasis on abduction, internal rotation and extension, in addition to muscle strengthening exercises.

The Scottish Rite abduction orthosis comprised a pelvic band, single-axis hinge joints, thigh-lacers, and an

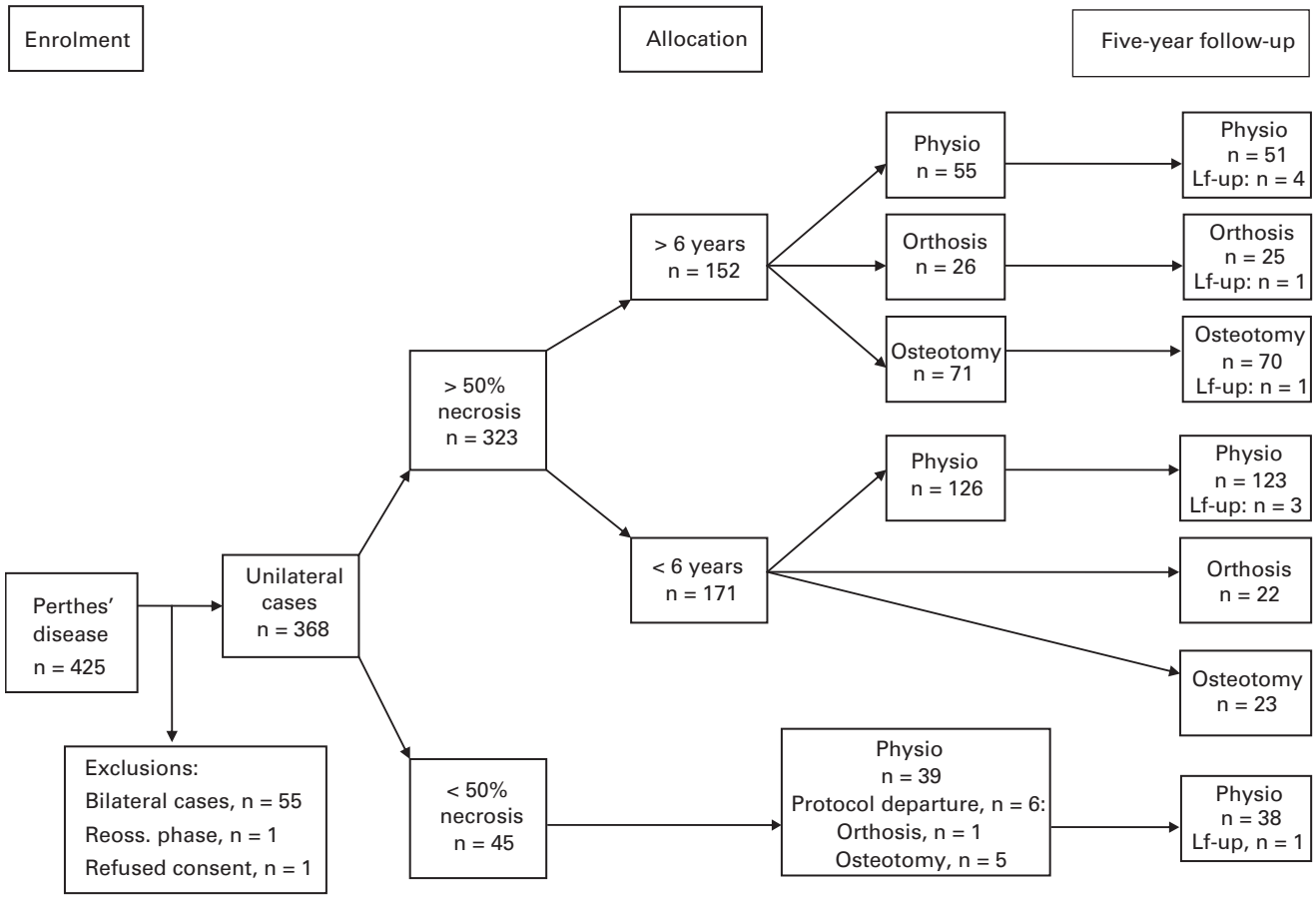

Fig. 1

Flowchart of 425 patients with Perthes' disease (n, number of patients; Reoss. phase, hip in reossification phase; Physio, treatment with physiotherapy; Orthosis, treatment with the Scottish Rite abduction orthosis; Osteotomy, treatment with proximal femoral varus osteotomy; Lf-up, lost to follow-up).

abduction bar that could piston on itself and was connected to the medial part of the thigh cuff by an eccentric ball-and-socket joint. Hip abduction had to exceed 35° on the affected side in order to use the orthosis, in which both hips were abducted approximately 40° with slight flexion. The orthosis was worn all day and night, except for bathing or swimming (maximum one hour daily), and the treatment was terminated when there were signs of new bone formation on both anteroposterior and Lauenstein projections.

Proximal femoral varus osteotomy was either subtrochanteric with a pre-bent plate or intertrochanteric with a paediatric blade plate, aiming for a neck-shaft angle of approximately 110° to 115°. Slight external rotation of the femoral shaft was performed in cases of increased femoral anteversion. Post-operative immobilisation in spica cast was at the surgeon's discretion.

The patients had clinical and radiological follow-up at one, three and five years after diagnosis. Those undergoing femoral varus osteotomy were also reviewed two months' post-operatively.

Statistical analysis. This was performed using SPSS version 13.0 (SPSS Inc., Chicago, Illinois) and SAS (Statistical Analysis System, version 9.1.3, Cary, North Carolina). For the evaluation of risk factors regarding outcome, all variables were run in simple models, only estimating the effect of single variables one at a time. Outcome was assessed using the modified three-group Stulberg classification.[23] The categorical data were analysed by Pearson's chi-squared test and continuous variables using a one-way analysis of variance (ANOVA). A multinomial proportional odds logistic regression analysis was performed with the three-group Stulberg classification as outcome. The assumption of proportionality was assessed with a score test. Variables significant at the 0.25 level were included in the multivariate analysis. Variables were excluded from the multivariate model one at a time using a backwards stepwise procedure. All variables removed were tested for confounding factors.[27] The odds ratio (OR) in this setting is defined as the ratio for being in the same or a lower Stulberg category, given that the value of the covariate is reduced by one unit. A mixed-model repeated-measures ANOVA was performed to assess the

Table I. Prognostic factors other than treatment associated with radiographic outcome

		Stulberg three-group classification		
		A	B	C
Variables	**Number**	**Number (%)**	**Number (%)**	**Number (%)**
Two-group Catterall classification				
1	44	37 (*84*)	7 (*16*)	-
2	314	139 (*44*)	115 (*37*)	60 (*19*)
Age at diagnosis (yrs)				
< 6	197	113 (*57*)	63 (*32*)	21 (*11*)
≥ 6	161	63 (*39*)	59 (*37*)	39 (*24*)
Lateral pillar classification				
A	33	23 (*70*)	8 (*24*)	2 (*6*)
B	262	134 (*51*)	82 (*31*)	46 (*18*)
C	63	19 (*30*)	32 (*51*)	12 (*19*)

In the Stulberg 3-group classification, group A has a spherical, group B an ovoid, and group C a flat femoral head. In the two-group Catterall classification, 1 is < 50% femoral head necrosis and 2 is > 50%. In the lateral pillar classification, group A has no height reduction of the lateral pillar, group B has > 50% of the lateral pillar maintained, and group C has < 50% maintained

change in femoral head cover over time. The underlying assumptions were checked using Studentised residuals, Cook's *d* and the Covratio statistics. No indications of any abnormalities were found. All p-values below 0.05 were considered significant.

Results

There were 324 boys (76%) and 101 girls enrolled in the study. The mean age at diagnosis was 5.8 years (1.3 to 15.2) and there was no significant difference in mean ages between boys (5.8) and girls (5.9). There were 370 unilateral and 55 (13%) bilateral cases. The latter were excluded along with one patient in the re-ossification phase and another who refused consent. Of the 368 children remaining, the left side was affected in 201 (55%) and the right in 167. A total of 220 (60%) children had been treated with physiotherapy, 99 (27%) by osteotomy and 49 (13%) with orthosis.

There were 358 patients (97%) who attended the five-year clinical follow-up examination. Of these, 83 (23%) had pain or discomfort, mostly in the groin or thigh, and 83 (23%) had a limp. There was no limitation in walking distance in 304 (85%), whereas 54 (15%) were unable to walk 5 km before they had pain. A total of 269 (75%) patients said that they could participate in all sports, 79 (22%) had reduced function, ten (3%) could participate in swimming only, and one was unable to do any sport. We found a strong association between sporting and walking ability, as 263 (87%) of the patients with a normal walking distance could participate in all sports, compared to five (9%) of those with reduced walking ability ($p < 0.0001$). There were no significant differences in walking ability and level of sporting activity between the treatment groups.

Radiographs of 358 patients were available at the five-year follow-up. These showed that 176 patients (49%) were classified as Stulberg groups I or II, 122 (34%) were in group III, and 60 (17%) in groups IV or V. We found a strong association between sporting and walking ability in relation to Stulberg outcome, as hips classified in groups IV and V had a more limited walking distance ($p < 0.001$) and reduced sporting ability ($p = 0.002$).

There was a highly significant association ($p < 0.001$) between the modified two-group Catterall classification and radiographic outcome at the five-year follow-up (Table I). Of 44 hips, 37 (84%) with femoral head involvement less than 50% resulted in Stulberg groups I to II, whereas none were in group IV or V. The outcome was worse in hips with more than 50% femoral head necrosis, where 60 of 314 (19%) were IV or V. Because of this markedly better prognosis in hips with femoral head involvement less than 50% they were omitted from the comparison of treatment methods.

Age at diagnosis was strongly associated with outcome: the younger the patient at diagnosis, the better the outcome, as shown in Table I, where the outcome in children under six years of age was markedly better than in those aged six and older ($p < 0.0001$).

We found a significant association ($p = 0.001$) between the lateral pillar classification and Stulberg outcome, as 70% of hips classified as A had spherical femoral heads at five-year follow-up, compared to 51% of B hips and 30% of C hips (Table I). There was a similar association when the lateral pillar classification was applied one year after diagnosis.

The multinomial proportional odds logistic regression analysis showed that the modified two-group Catterall classification was the strongest prognostic factor (OR = 7.76, 95% CI 2.82 to 21.37), followed by age at diagnosis (OR = 0.98, 95% CI 0.92 to 0.99) and the lateral pillar classification at the time of diagnosis (OR = 0.62, 95% CI 0.40 to 0.98, Table II).

Table II. Multinomial proportional odds logistic regression analysis (odds ratio estimates) of prognostic factors in Perthes' disease

Prognostic factor	OR*	95% CI†
Two-group Catterall classification	7.76	2.82 to 21.37
Age at diagnosis	0.98	0.92 to 0.99
Lateral pillar classification	0.62	0.40 to 0.98

* OR, odds ratio

† 95% CI, 95% confidence interval

Table III. Radiographic outcome in relation to treatment groups in children with more than 50% femoral head necrosis

		Stulberg three-group classification			
		A	B	C	
Age at diagnosis	Treatment	Number (%)	Number (%)	Number (%)	Total
≥ 6 years	Physiotherapy	17 (*33*)	14 (*27*)	20 (*40*)	51
	Orthosis	5 (*20*)	9 (*36*)	11 (*44*)	25
	Osteotomy	30 (*43*)	32 (*46*)	8 (*11*)	70
	Total	52 (*35*)	55 (*38*)	39 (*27*)	146
< 6 years	Physiotherapy	65 (*53*)	41.0 (*33*)	17 (*14*)	123
	Orthosis	10 (*45.5*)	10 (*45.5*)	2 (*9*)	22
	Osteotomy	12 (*52*)	9 (*39*)	2 (*9*)	23
	Total	87 (*52*)	60 (*36*)	21 (*12*)	168

There was no significant association between radiological outcome and the following factors: articulotrochanteric distance, gender, county where the patient lived and duration of symptoms at diagnosis ($p > 0.05$). The femoral head coverage at diagnosis was not significantly associated with radiographic outcome ($p = 0.14$). After one year the cover was significantly lower ($p = 0.001$) in Stulberg classes IV and V compared to Stulberg classes 1 and 2 (mean cover 79% and 87%, respectively). The femoral head cover in patients treated with physiotherapy decreased during the first years of the disease. The mean at diagnosis was 92% (95% CI 90.8 to 93.2) and decreased by 9% (95% CI 6.7 to 11.6) to 83% (95% CI 81.7 to 84.8) after one year ($p < 0.0001$). Three years after diagnosis the femoral head cover decreased by 4% (95% CI 2.0 to 5.8) to a mean of 79% (95% CI 77.8 to 80.9), which was significantly less than at one year ($p < 0.0001$). From three to five years there was a slight increase in mean cover to 80%, but the difference was not significant ($p = 0.38$).

Of the children over six years of age with more than 50% femoral head necrosis, 146 of 152 (96%) were available for the five-year follow-up. The number of patients according to treatment modality was 51 (34%) for physiotherapy, 25 (17%) for orthosis and 70 (48%) for osteotomy (Fig. 1).

The three treatment groups were similar as regards demographic and clinical data such as age at diagnosis, gender, duration of symptoms, side affected, presence of a limp, and pain at diagnosis (all p-values > 0.26). There was a significantly lower femoral head cover ($p = 0.03$) at diagnosis in the osteotomy group (cover 85%, 95% CI 79.6 to 90.1) than in the orthosis group (92%, 95% CI 86.8 to 96.0), but no significant differences between osteotomy and physiotherapy (cover 87%, 95% CI 84.6 to 90.3, $p = 0.56$) or orthosis and physiotherapy ($p = 0.23$).

The distribution of hips according to treatment groups and the modified three-group Stulberg classification is shown in Table III. Proximal femoral osteotomy obtained the best radiological results compared to both orthosis ($p = 0.001$) and physiotherapy ($p = 0.001$). There was no significant difference in outcome between the physiotherapy group and the orthosis group ($p = 0.36$).

Of those children under six years with more than 50% femoral head necrosis, 168 of 171 were available for the five-year follow-up; 123 (73%) had been treated with physiotherapy, 22 (13%) with an orthosis and 23 (14%) with osteotomy (Fig. 1). Radiological outcome is shown in Table III, and there was no significant difference between the groups ($p = 0.73$).

Of those children with less than 50% femoral head necrosis regardless of age, 38 of 45 (84%) were treated with physiotherapy, five (11%) by osteotomy and one (2%) with an orthosis as a result of a departure from the protocol,

probably because the treating surgeons considered these hips to be in Catterall group 3 rather than group 2. One child was lost to follow-up. Statistical analysis comparing treatments could not be performed reliably in this group.

Discussion

Our study was similar to the randomised surgeon design described by Rudical and Esdaile[28] and Herring et al,[18] in which surgeons and hospitals were assigned to the treatment of their choice. Before the study, orthopaedic surgeons at each hospital were allowed to choose one of the three methods according to their preference and local tradition. We believe this contributed to the elimination of the patient selection bias and enhanced surgeon compliance. The study design also eliminated performance bias, as the surgeons at each hospital chose the treatment with which they were most familiar, usually their established treatment for Perthes' disease. When the study began in 1996, there was no prospective randomised study evaluating outcome. The studies available were mostly retrospective case series, and no firm conclusion could be drawn regarding the efficacy of any treatment. Consequently, we did not think that offering one of the three treatment methods to patients with a less favourable prognosis posed an ethical dilemma.

Children with bilateral disease were excluded because there is evidence to suggest that they have a more benign disease,[29] and that inclusion might positively skew our results.

At the five-year follow-up, 15% of the patients had closure of one or both of the triradiate cartilages, and 14% had closure of one or both femoral head physes. Therefore, a significant proportion were skeletally immature. However, all hips were completely healed at the last follow-up. A spherical femoral head (Stulberg class I or II) at the time of healing may theoretically become slightly oval by skeletal maturity if there were a partial physeal arrest, thereby moving the hip to class III. However, we believe that such a physeal arrest would occur during the disease, deforming the femoral head before healing. In agreement with others,[11,30,31] we think each patient can be reliably assigned to a Stulberg class even if the hips are not skeletally mature.

As did Herring et al,[18] we found no significant differences in walking distance and level of sporting activity between the treatment groups. However, there was a significant association between Stulberg outcome after five years and level of activity, as the radiologically worst hips had the lowest functional level. Longer term follow-up using walking tests, validated activity questionnaires and pain scales is required to better understand the level of association between radiological and clinical outcomes.

Catterall[20] found a correlation between his four-group classification system and the radiological outcome. We and others[32] support this. However, insufficient inter-observer reliability with the Catterall classification has been reported,[33,34] and Herring et al[18] abandoned the classification for this reason. We do not entirely agree, because in a previous study we found that the inter-observer reliability of the Catterall classification was adequate (κ value 0.62) when performed by experienced observers.[22] With less experienced examiners, the modified two-group classification, with 50% involvement of the femoral head as the dividing line, was more reliable. In this study the two-group classification was the strongest prognostic predictor according to the multinomial proportional odds logistic regression analysis. Therefore, we recommend the classification in clinical practice.

Most long-term studies conclude that patient age at diagnosis is an important prognostic factor, as younger patients have a better outcome,[13,20,26,35,36] and this was confirmed by our results. It is believed that the younger the child at the onset of disease, the more time is available for remodelling after healing. The ability of the acetabulum to remodel and conform to the shape of the femoral head seems to diminish after the age of eight years.[37] Herring et al[18] found that children older than this had worse results than those younger than eight years. In our study, age at diagnosis was the second strongest predictor of outcome.

Although a young age is a predictor of good outcome, studies with a different experience have been published. Snyder[38] found that 32% of patients aged five years or younger at onset and Catterall hips 3 or 4 had radiologically poor results. Likewise, Fabry, Fabry and Moens[39] reported 48% poor results according to a modified Stulberg classification, and Schoenecker, Stone and Capelli[40] reported that 24% of children under six years of age with hips in Catterall groups 3 or 4 had poor results. Our study did not support these findings, as the poor results in this group were only 12%, the same as those reported by Rosenfeld et al.[30]

As with some previous studies,[36-41] we found a significant association between the lateral pillar classification and radiological outcome. Herring et al[18] reported that this classification was the strongest predictor of outcome. Our results did not confirm this, as the multinomial odds logistic regression analysis showed that this was the third strongest predictor, after the modified two-group Catterall classification and age at diagnosis.

Increasing degree of femoral head uncovering at diagnosis has been linked to a poor prognosis.[32,42,43] This was not supported by our results, as the femoral head cover at diagnosis was not associated with the radiological outcome. However, there was a strongly significant association between cover one year after diagnosis and the five-year outcome, indicating that good femoral head cover during the disease predisposes to favourable long-term results, thereby supporting the containment concept of Salter.[6]

Catterall[20] found that girls had a worse prognosis than boys, which is confirmed by others.[21,32,42] It has been assumed that this is due to earlier skeletal maturity in girls, hence a shorter time for remodelling. However, we could not confirm any relationship with gender.

There was no significant association between articulotrochanteric distance at diagnosis and Stulberg outcome.

Although we obtained good inter-observer reliability using this measurement,[22] it does not seem to be of prognostic significance.

Herring et al[18] reported 51% of the hips in Stulberg classes I and II, 34% in class III, and 15% in classes IV and V in children between six and 12 years at diagnosis, treated with or without operation. We found fewer hips in classes I and II (35%), a similar number in class III (38%), and more in classes IV and V (27%) in this age group. Thus, our overall results in patients aged over six years were inferior to those of Herring et al.[18]

Along with the present study, the only prospective multicentre study on the effect of treatment is that of Herring et al.[18] These authors found that children over eight years of age at diagnosis with hips classified as lateral pillar B or 'B/C border' benefited from surgery rather than bracing or physiotherapy. Our results are similar, because proximal femoral varus osteotomy gave significantly better outcomes than treatment with an orthosis or physiotherapy in children older than six at diagnosis whose hips had more than 50% femoral head necrosis. There was no significant difference in outcome between the orthosis and physiotherapy groups, which also supports the findings of Herring et al.[18]

As in our study, several case series have shown favourable outcomes after femoral osteotomy.[44-46] Some studies comparing treatment methods show better results from surgery than from other methods,[47-49] whereas others have reported equal results.[50-52] However, it is difficult to draw firm conclusions, as these studies were not prospective, patient numbers were small and the inclusion criteria, severity of disease, age groups treated and indications for surgery varied considerably.

Our results showed that physiotherapy was inferior to femoral osteotomy. As physiotherapy has to our knowledge never been proved to have any effect on outcome in Perthes' disease, we consider this group as representing the natural history of the disease.

Varying results are reported with the Scottish Rite orthosis. In patients over 5.5 years at diagnosis and with total epiphyseal involvement, Curtis et al[8] reported 84% good or fair, and 16% poor results according to the Mose[25] criteria. Herring et al[18] also had good outcomes with 52% of the hips in Stulberg classes I and II, and only 17% poor results in Stulberg class IV and V for patients of all ages. However, we found that patients over six years at diagnosis with more than 50% femoral head necrosis obtained inferior results, with 44% in Stulberg class IV and V. Our results in this group were worse than those of Martinez et al[11] and Meehan, Angel and Nelson,[53] who had 33% and 21% poor Stulberg outcomes, respectively.

Price, Day and Flynn[54] evaluated the psychological effects of treatment and concluded that patients treated with bracing had a more significant deficit with regard to social and sexual behaviour, and academic ability than children who had been treated operatively. Also, bracing created a sense of being different and handicapped. We think there is sufficient evidence to abandon the orthosis in the treatment of Perthes' disease.

Although Catterall[20] stated that there was no change from one group to another during the disease, Dickens and Menelaus[32] and Van Dam et al[55] experienced changes in Catterall groups during the disease when classification had been applied before the fragmentation stage. Similarly, the lateral pillar classification was not reliable if applied before the early fragmentation phase.[18] Therefore, it is inadvisable to decide on treatment at the time of diagnosis. Herring et al[21] stated that it was usually possible to determine the lateral pillar group within six months of onset of the disease. Joseph et al[56] showed that in order for a femoral osteotomy to succeed, it had to be performed within one year of diagnosis. In children treated with physiotherapy we found that the greatest reduction in femoral head cover was between the time of diagnosis and the one-year follow-up. This is probably close to the expected disease progress in untreated hips. Therefore, we think it reasonable to recommend that decisions on treatment should be made at the six-month follow-up, or perhaps earlier if the disorder has already reached the fragmentation stage at diagnosis.

In conclusion, this study shows that the strongest predictor of outcomes is the modified two-group Catterall classification, followed by age at diagnosis and the lateral pillar classification.

We recommend proximal femoral varus osteotomy in children above six years of age at diagnosis with hips having more than 50% femoral head necrosis. The abduction orthosis should be abandoned in the treatment of Perthes' disease.

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