



## Elongation of the femoral neck in Perthes disease

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We present the long term clinical and radiological results of a series of 168 young patients with unilateral Perthes disease who were treated in our department between 1989 and 1997, using a combined osteotomy in the longitudinal and horizontal axis of the proximal femur and elongation of the femoral neck. Surgical treatment was undertaken for any group II (Catterall's classification) patient, with the presence of two or more radiographic signs of the "head at risk" and the clinical sign of flexion with abduction, as well as for all cases classified by Catterall as groups III and IV. The surgical procedure we describe provided 147 radiologically and clinically normal hips in the short and long-term. However, in the long term, 21 out of 168 patients presented with residual deformities such as shallow acetabulum, thickening of the acetabular floor, coxa magna, thicker and slightly shorter femoral neck. Thus for the vast majority of patients, the operation we describe here provided leg length equalisation and restored the working length of the abductors by maintaining the tip of the greater trochanter at the same level as on the unaffected side.

**Keywords** : Perthes disease ; osteotomy ; femoral neck ; elongation.

### INTRODUCTION

Treatment of Perthes' disease has always been controversial. In order to give balanced advice for the management of these children, we must understand the pathology of the condition, its natural history and carefully interpret the clinical and radiological findings during its evolution. It now appears

that there are four aspects to the aetiology of the condition: the susceptible child, usually a boy between 4 and 9 years of age (24), recurrent infarction associated with trabecular fracture and a process of repair resulting in a growth disturbance that, if uncontrolled, leads to femoral head deformity (3, 6, 10, 27).

Radiographic findings vary with the stages of the disease (early stage, fragmentation stage, healing stage, deformity) (22, 23). Clinical recognition of the early stages of progressive deformity of the femoral head is important. If treatment is going to be effective, it should be started as early as possible in these cases.

The prognosis for each individual case is proportional to the degree of the radiological involvement of the epiphysis and on this basis four groups (I-IV) have been defined by Catterall (6) in 1971.

The concept of "head at risk" was also introduced by Catterall (6) to allow the clinical recognition,

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in the early stages, of the progressive deformity of the femoral head. The radiographic signs reflect the pathology occurring in the epiphysis and metaphysis. The clinical signs reflect the progressive loss of movement, especially abduction, and the change in axis of flexion as the femoral head begins to flatten. In a review of the value of the "head at risk" signs, it has been shown that two or more adversely affect the prognosis (6, 8, 9, 25).

The lateral pillar classification (13) can also be used to indicate prognosis. A stable lateral pillar is a sign of good long-term prognosis and is observed in group I and II disease at any stage.

In a disease in which 57% of cases do well without treatment, it is important to identify the 40% that will require treatment (6). The prognosis is better for the younger than the older child, with boys having more favourable outcome than girls (10). Children with poor long-term results have disease starting around the age of 8 years (7). The principles of treatment are the restoration of movement of the hip, better distribution of forces through the hip, correction of subluxation, and containment and revascularisation of the necrotic bone with union of the subchondral fracture (1, 2, 4, 15, 17).

In Perthes' disease innominate osteotomy and subtrochanteric varus or varus rotational osteotomy of the femur have been used in order to achieve containment of the capital femoral epiphysis and sphericity of the joint. However, although reasonable function may be obtained, both the shortening of the femoral neck and the overgrowth of the greater trochanter reduce the power of the hip abductors (19). Also, leg length discrepancy can occur.

Between 1972 and 1988, patients with Perthes' disease referred to our hospital were usually managed with a femoral varus rotational osteotomy. We designed the operation presented here in order to improve the biomechanics of the hip by restoring anteversion, reorienting the femoral head into the acetabulum, repositioning the greater trochanter and lengthening the femoral neck so that limb equality can result. This operation provided containment and congruity of the hip joint in the great majority of cases.

## PATIENTS AND METHODS

### Clinical Material

This procedure was undertaken in 168 young patients with unilateral Perthes disease between 1989 and 1997. Even though the lateral pillar classification (12) that was first introduced in 1992 is currently favoured, Catterall's classification (6) is used in this paper, since it was this classification that was utilised in this series. Indication for surgical treatment was any group II case with the presence of two or more radiographic signs of "head at risk" and the clinical sign of flexion with abduction, as well as all cases classified as groups III and IV, with one or more clinical signs of "head at risk" (progressive loss of movement, adduction contracture, flexion with abduction, heavy child). In all cases, the treatment was at the early stages of the disease, when no serious deformity was present.

Thirty-five of our patients belonged to group II, 85 to group III and 48 to group IV (table I). There were 102 males and 66 females. The left hip was affected in 73 males and in 31 females; the average age at the time of operation was 7.5 years. All the patients were seen by the authors in 2002. The average duration of follow-up was 9 years, and, when reviewed, all patients were adolescents or adults.

### Surgical Technique

The patient was placed supine. The hip was exposed through an 8-cm lateral incision extending distally from the tip of the greater trochanter. The fascia lata was divided to expose the greater trochanter and vastus lateralis. The vastus lateralis was split and after periosteal elevation a specially designed four-hole plate was placed on the exposed lateral surface of the femur and fixed distally with two screws (20). The implant used was a static plate with the distance between the two central holes varying from 2.5 to 5 cm in 0.5 cm increments. The plate was bent to adapt it to the shape of the lateral surface of the proximal femur.

The trochanteric fossa was identified and a sagittal osteotomy was performed along the line of the longitudinal femoral axis to a point 3 mm above the proximal screw. A horizontal osteotomy of the medial cortex was then carried out to join the longitudinal cut (fig 1 a). A distractor was then inserted in the horizontal osteotomy. Significant force was not required for the first 1 to 1.5 cm distraction of the osteotomy (fig 1 b). With further distraction, the entire upper fragment moved gradu-

Table I. — Data on 168 cases operated on with this technique

Year of operation	Number of cases	Sex		Affected hip side		Average age at operation	Caterall's classification			Average age at last follow-up (in years)	Follow-up period of time (in years)
		M	F	Left	Right		II	III	IV		
1989	4	2	2	2	2	8	2		2	21	13
1990	9	5	4	6	3	8.3	8		1	20.5	12
1991	16	7	9	9	7	7.5	6	6	4	18	11
1992	19	10	9	12	7	7	2	12	5	17.25	10
1993	22	14	8	16	6	8.5	2	16	4	17	9
1994	27	18	9	16	11	6.25	4	18	5	16.5	8
1995	25	16	9	16	9	6.5	3	17	5	14.6	7
1996	25	17	8	16	9	7.25	4	8	13	14.5	6
1997	21	13	8	11	10	8	4	8	9	14	5

ally into varus as a result of the increased resistance of the soft tissues and the mobile femoral head rotated deeper into the acetabulum. Concurrently, the greater trochanter moved laterally and distally (fig 1 c). Because of this automatic rotation of the femoral head into the acetabulum during distraction, the two surfaces of the osteotomy advanced into an X shape anteriorly and posteriorly, depending on the rotation of the head into the acetabulum (fig 1 d). When engagement of the cortices of the proximal femur and the shaft was achieved, distraction was completed. Rotation restored the anteversion of the femoral neck to a proper degree and placed the femoral head deeper into the acetabulum. The final position was secured by the insertion of the two proximal screws. The preoperative and postoperative radiographs show the degree of reconstruction (fig 1 e, f) and correction of the rotational deformity. The wound was closed in layers and a hip spica cast applied for six weeks. Free mobilisation was then allowed and partial weight-bearing was permitted two weeks after removal of the plaster cast.

### Postoperative care

The operation results in immediate lengthening of the limb from 1.5 to 2 cm. Since some shortening was usually present pre-operatively, the actual lengthening was less than 1.5 cm. Initially, this produced some limping, which was not a major problem since limping pre-existed the operation, due to the disease. However, both the limp and the leg length discrepancy disappeared within a few months. The elongation of the neck achieved at the time of the operation and the repositioning of the greater

trochanter were maintained until skeletal maturity. Restoration of the length of gluteus medius followed. The implant was routinely removed one year after the initial operation. We did not observe any complications such as fracture, delayed union, nonunion or severe infection at the operated site.

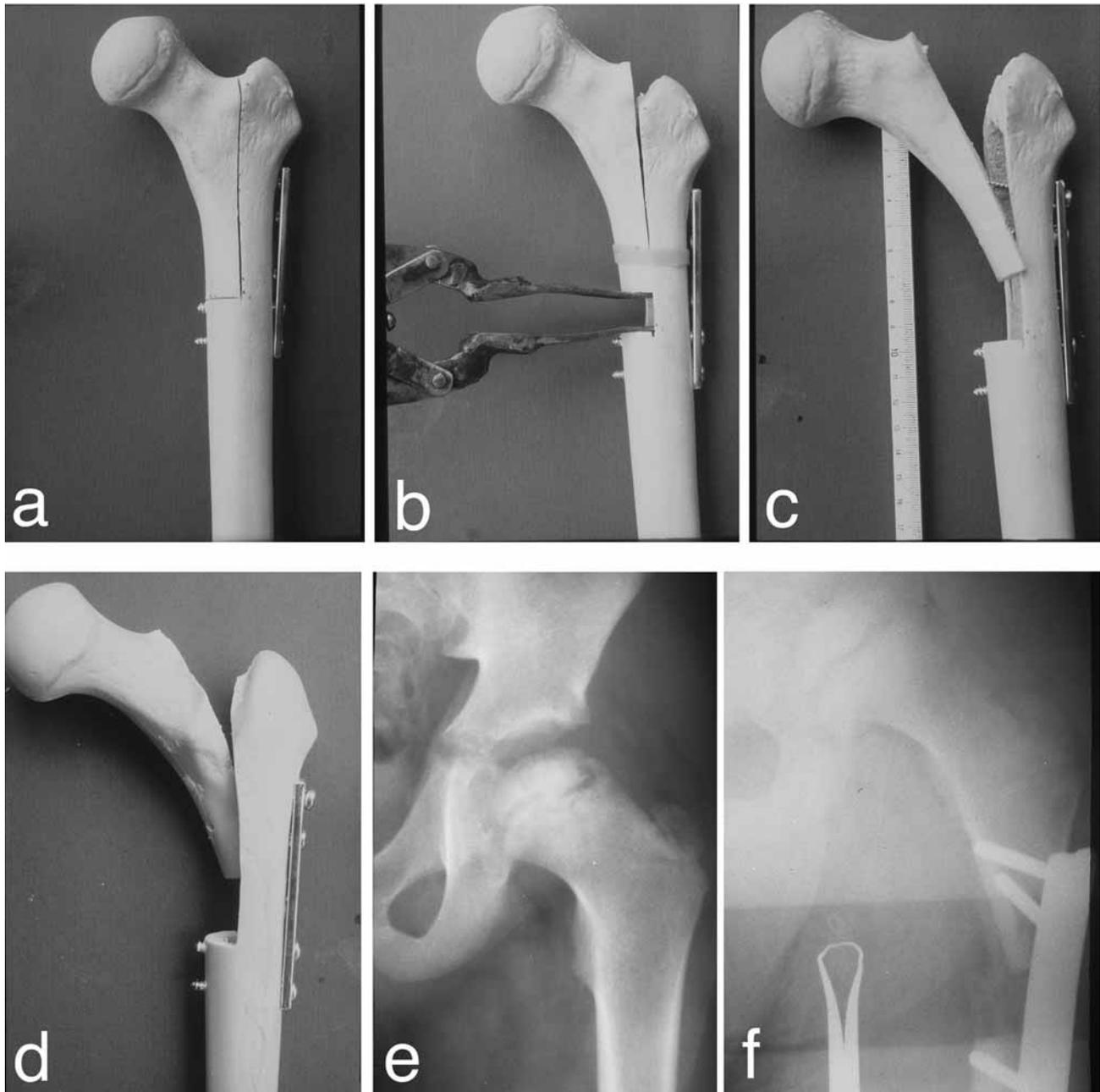
## RESULTS

The results are presented radiographically in the short and long-term and clinically in the long term. The appearance immediately after operation is shown in figure 1 f. Evidence of bone healing at the site of the osteotomy was seen rapidly after operation, and the subsequent progression of the disease is shown in figures 2 c, d and 3 b, c while figures 2 a, b and 3 a show the preoperative radiological appearances. The major distraction achieved at the upper end of the femur did not seem to retard new bone formation, which appears on radiographs at the end of the third or fourth week.

We reviewed all 168 patients clinically and radiologically in 2002.

### Functional Assessment

At the time of examination, all patients had a normal gait. No patient had leg length discrepancy and none had any fixed deformity of the operated limb. Full range of movement in comparison to the unaffected site was present in 147 hips. In 21 hips

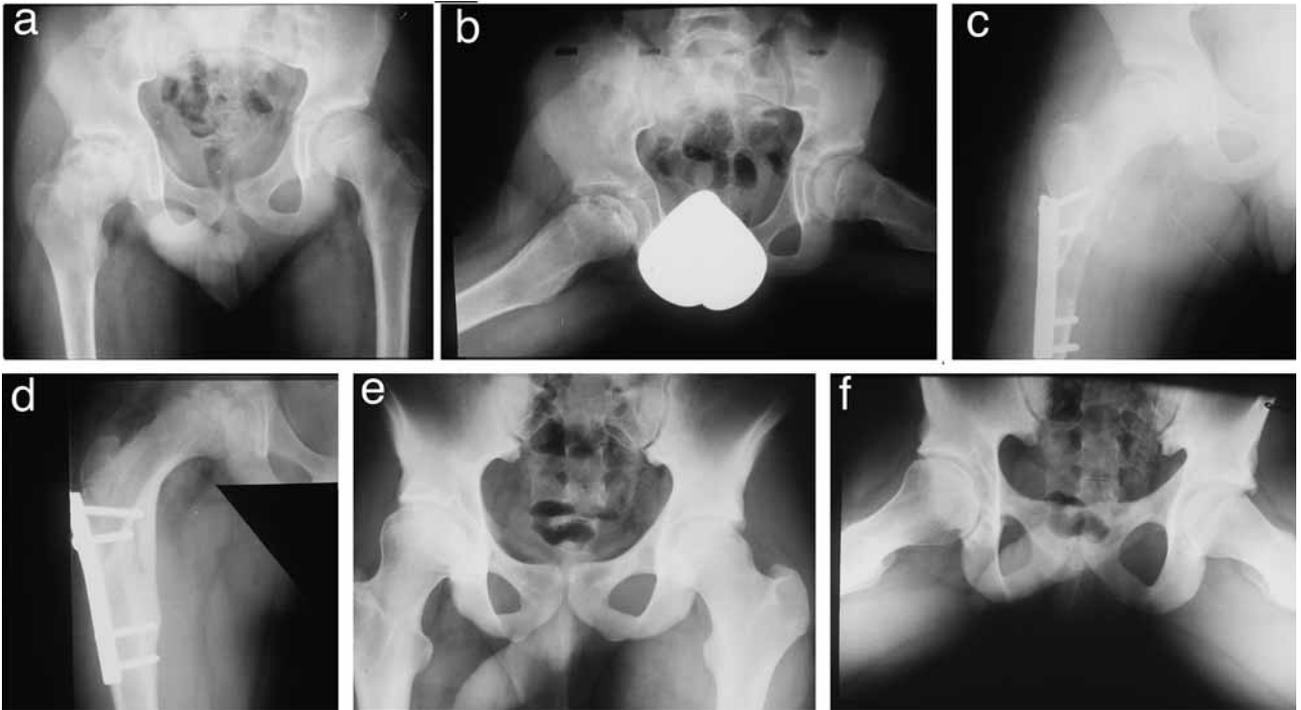


*Fig. 1.* — **a, b, c, d.** The main stages of the described osteotomy ; **e, f.** Pre-operative and post-operative radiographs

abduction with the limb in extension was limited to a maximum of one-third of the normal side. No patient complained of pain or limitation during activities. A delayed Tredelenburg sign was present only in 9 of these 21 cases.

#### **Radiological assessment**

Antero-posterior pelvis radiographs with the patella in neutral position and lateral hip radiographs were obtained in every case. The congruity



**Fig. 2.** — **a, b.** Pre-operative radiographs in a 13-year old boy ; **c, d.** Radiographs showing the progression at one and six months ; **e, f.** Antero-posterior pelvis radiographs taken in neutral and in full abduction and external rotation 12 years later.

of the hip joint and the length of the femoral neck were assessed.

The congruity of the hip joint was assessed by measuring the thickness of the true acetabulum (21) and the circumference of the femoral head in comparison with the normal side. The length of the femoral neck was easily measured from the A-P pelvis radiographs.

In 147 cases (tables II-III-IV) the operated side revealed a congruent hip joint. In 145 of these cases, the length of the femoral neck was equal to the unaffected side while it was longer in two cases, as shown in figures 2 e, f, 3 d, e, f. Both of these cases belonged to group II (table II).

In 4 “group II” cases (11% of total), incongruity of the hip joint was present. In three cases a shorter femoral neck was noted (figs 4 a 4, 4 b 4, 4 c 4 and 4 a 5, 4 b 5, 4 c 5) and in one case the femoral neck was longer (fig 4 a 3, 4 b 3, 4 c 3) (table II).

In group III, incongruity of the hip joint was present in 10 cases (11.7% of total) and was asso-

ciated in five of these cases with shortening of the femoral neck (fig 4 a 4, 4 b 4, 4 c 4), (table III).

In group IV, incongruity of the hip joint was present in 7 cases (14.5% of total). In three of these cases, shortening of the femoral neck was noted (table III).

In the 21 cases with abnormal radiological evaluation, the acetabulum appeared shallow with variable thickening of the acetabular floor up to twice of the unaffected side, and enlargement of the femoral head up to 60-70% of that of the normal side (fig 4a, 4b, 4c). The femoral neck was found in 11 of those cases to be thicker and shorter. Interestingly, despite the variable shortening of the femoral neck, the tip of the greater trochanter and thus the abductor mechanism of the hip were always at the same level as the normal side since the neck shortening was compensated by the appropriate degree of thickening of the acetabular floor and the enlargement of the femoral head. In the two cases with a congruent hip joint, the femoral neck

Table II. — Catterall Group II and the “risk signs” : Preoperative and postoperative data on 35 cases

Year of operation	Catteralls Group II cases		Head “at risk” signs (see footnote)				Operated Hip Joint		Length of the femoral neck			
							Congruity of hip joint	Incongruity of hip joint	normal	shorter	longer	
	Number of cases	Distribution based on risk signs	a	b	c	d						
1989	2	2	+			+	1	1	1	1	-	
1990	8	3	+			+	8	-	8	-	-	
		4				+						+
		1	+	+								
1991	6	3	+			+	6	-	6	-	-	
		2				+						+
		1				+						+
1992	2						1	1	1	1	-	
		2				+						+
1993	2						2	-	1	-	1	
		2				+						+
1994	4	1	+			+	3	1	3	-	1	
		1	+	+								
		2				+						+
1995	3	2				+	3	-	2	-	1	
		1				+						+
1996	4	1	+			+	4	-	4	-	-	
		2	+	+								
		1				+						+
1997	4	2				+	3	1	3	1	-	
		2	+	+								

Footnote : a. Gage’s sign  
 b. Calcification lateral to the epiphysis  
 c. Lateral subluxation  
 d. The angle of the epiphyseal line

was longer and thinner while the periosteal reaction detected in the early postoperative period along the neck of the femur, still existed up until skeletal maturity (fig 3 c, d, e).

**DISCUSSION**

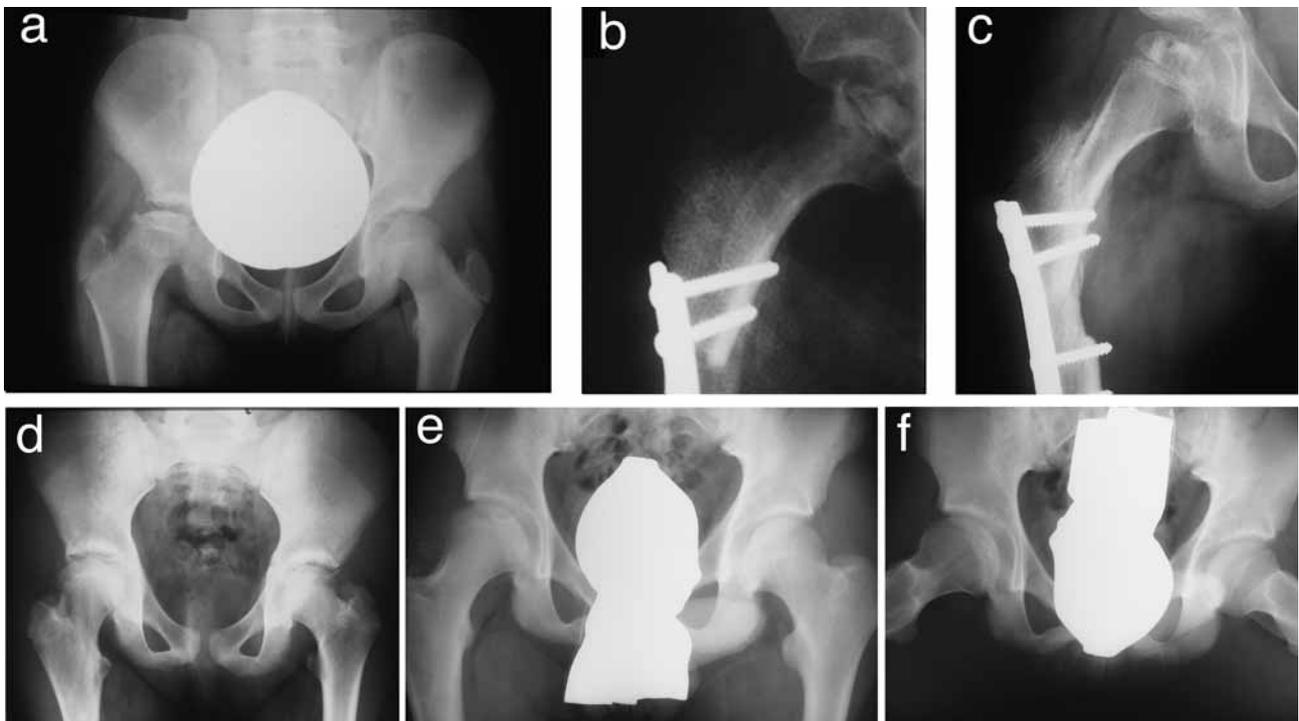
In Perthes disease, the clinician is in position to control only a handful of factors. Age, sex, disease group, and the stage of the disease are predetermined when the patient presents. Early recognition of the patient with poor prognosis through the con-

cept of the head at risk (6) and early treatment is important. The aim of treatment, be it conservative or surgical, is to control the growth disturbance and restore the normal growth mechanism within the femoral neck and head providing for the best environment for the long-term remodelling of the femoral head, toward obtaining a congruent hip joint (1, 2, 4, 11, 12, 15, 17, 18, 22). Many surgical treatments face the criticism that they limit abduction even though they may contain the femoral head. The restriction of abduction may result in secondary acetabular dysplasia in the long term.

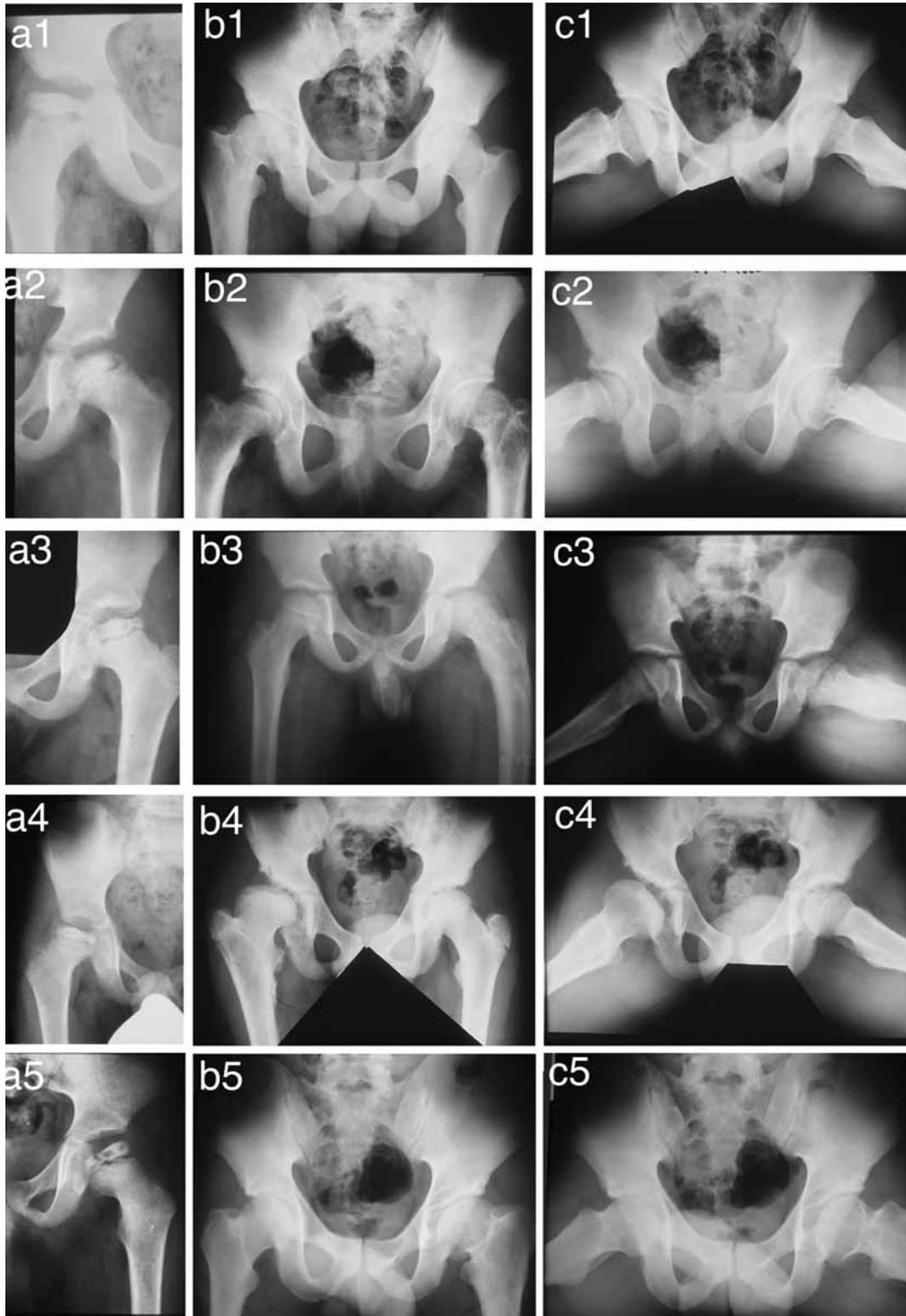
Table III. — Catterall groups III and IV : Pre-operative and post-operative radiographical data on 85 (group II) and 48 (group IV) cases

Group III				Length of the femoral neck		
Year of operation	Number of cases	congruity	incongruity	normal	shorter	longer
1989	—	—	—	—	—	—
1990	—	—	—	—	—	—
1991	6	5	1	5	1	—
1992	12	10	2	12	—	—
1993	16	12	4	2	2	—
1994	18	16	2	17	1	—
1995	17	16	1	16	1	—
1996	8	8	—	8	—	—
1997	8	8	—	8	—	—

Group IV				Length of the femoral neck		
Year of operation	Number of cases	congruity	incongruity	normal	shorter	longer
1989	2	2	—	2	—	—
1990	1	—	1	—	1	—
1991	4	2	2	4	—	—
1992	5	4	1	4	1	—
1993	4	4	—	4	—	—
1994	5	4	1	5	—	—
1995	5	5	—	5	—	—
1996	13	12	1	12	1	—
1997	9	8	1	9	—	—



**Fig. 3.** — a. The left hip of a 6-year old girl with Perthes disease ; b, c. Radiographs at one and three months post-operatively ; d. Hips at 14 years of age ; e, f. Hips at 18 years of age.



**Fig. 4.** — **a1 to a5.** Pre-operative radiographs of five affected hips ; **b 1 to b 5.** Antero-posterior and Lauenstein views (in 2002) ; **c1 to c5.** Antero-posterior and Lauenstein views (in 2002).

The established surgical methods in Perthes' disease are femoral varus rotation osteotomy (1, 2, 15, 17, 22), innominate osteotomy (4, 23, 28) and trochanteric growth arrest (11, 18, 26). Femoral varus osteotomy may lead to residual coxa vara and does not necessarily improve the radiographic result in limited epiphyseal involvement. Neither does the operation have an effect on the acetabular orientation in severe Perthes disease (15). Williams *et al* (29) compared the biomechanical effects of opening or closing wedge varus femoral osteotomy in Perthes disease and concluded that even though they provide containment of the head, they lead to femoral shortening and reduction of power of the hip abductors. After all, containment is a method of treatment not a principle.

For the reconstruction of the residual deformities of the hip joint after Perthes disease and particularly for the correction of shortening of the neck of the femur, proximal displacement of the greater trochanter and coxa vara, several methods have been described (5, 12, 16, 19, 20).

The surgical treatment we describe herein differs from established methods in that it does not only reconstruct the hip joint but also the entire upper end of the femur. The operation provides biomechanical advantages in the short term as it restores anteversion, re-orientates the femoral head into the acetabulum, repositions the greater trochanter, and lengthens the femoral neck and the leg in a single corrective procedure. Furthermore, consistent with previous reports (14), we have the impression that pathological events occurring in the affected femoral head are accelerated by the procedure so that the course of the disease is completed earlier. Thus, this method achieves the principles of treatment – namely, the restoration of movement, reduction of forces through the hip joint, correction of subluxation and revascularisation of the necrotic bone with union of the subchondral fracture.

In the long term the results show so far that the patients had a very good clinical outcome without any functional disability. The radiological assessment showed 147 normal hip joints. In the 21 hips with residual abnormalities (shallow acetabulum, thickening of the acetabular floor, coxa magna, thicker and slightly shorter femoral neck), a normal

abduction mechanism still existed, as the tip of the greater trochanter was in a position similar to that of the unaffected side.

## CONCLUSION

The surgical procedure we described provided 147 radiologically and clinically normal hips in the short and long-term. In 21 patients in the long term, the operation provided leg length equalisation, restored working length of the gluteus medius muscle by maintaining the tip of the greater trochanter at the same level as the opposite leg. All these elements provide a hip with a sound biomechanical background.

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