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Results of treatment of slipped upper femoral epiphysis

A survey of 99 treated hips

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INTRODUCTION

Slipping of the upper femoral epiphysis has at all times offered a difficult orthopedic problem with regard to etiology, early diagnosis and choice of treatment. The problem is particularly important because it affects young patients for whom the result of treatment is vital for their later years.

From time to time other names have been used for this disease, such as epiphyseal fracture, adolescent rickets, bending of the femoral neck, adolescent or epiphyseal coxa vara, arthritis deformans juvenilis and femoral osteochondritis of adolescents.

Paré in 1572 is thought to have been the first to describe slipping of the upper femoral epiphysis (Howorth 1966).

It was not until last century, however, that positive development in diagnosis began, and a growing number of descriptions of cases appeared in the literature. In 1868 Colignon collected all cases presented till then, a total of 10.

Bousseau in 1867 at an autopsy was the first to note slipped upper femoral epiphysis in a 15 year-old boy fatally injured by a cart. The autopsy showed a capital epiphysis completely detached from the femur. Wright in 1887 made a further report from an autopsy affecting a 40 year-old woman. She had suffered a complete slipping of the capital epiphysis in childhood. Müller in 1888 published 4 cases. In one of these the femoral head had been removed because the lesion was considered tuberculous.

At the end of the 19th century more and more reports appeared, each dealing with 3—4 cases. In 1898 Poland published an extensive monograph "Traumatic separation of the epiphysis" containing the cases which had appeared in the literature up to then, 31 in all. He added one case of his own. All these published cases had been diagnosed without radiological confirmation, on the basis of symptoms, the pathological picture of operative or autopsy finding alone. After roentgenography came into use in 1895 more cases were noted and the number of publications increased. However, the disease was still considered fairly uncommon since even at the beginning of the century

publications dealing with only 1—6 cases appeared. In 1926 Key published 24 cases diagnosed at Massachusetts General Hospital. In 1931 Fergusson and Howorth published 70 cases from New York Orthopedic Hospital over 20 years. Howorth's cases by now number more than 200 (1966).

ETIOLOGY

Opinions on the etiology of slipped upper femoral epiphysis have varied considerably in the course of the centuries. Duvernay (1751) supposed that the condition arose from some other disease such as syphilis or tuberculosis. In the 19th century there was much discussion on the etiology of the disease as the number of cases noted increased. Müller (1888) believed that it was an after-effect of rickets, as did Schultz (1892). Trauma was considered an important reason for the origin of slipped upper femoral epiphysis, especially as cases previously published were usually a consequence of trauma.

It has been generally recognised, especially during this century, that most cases occur in patients who are at the strongest stage of growth and are somewhat overweight or abnormally tall, or both. For this reason it is widely believed that the cause of the disease is an endocrine disturbance. On the other hand, not all cases are bilateral. The number of bilateral cases, however, varies considerably in different reports. Howorth (1957), for instance states that 14 per cent of cases are bilateral, Jerre (1950) 41,8 per cent and Klein et al. (1953)41 per cent. But Billing and Severin (1959) in an extensive monograph based on thorough radiological study have come to the conclusion that bilateral cases or their after effects account for as much as 80 per cent.

Löfgren in 1953 examined 16 cases treated for slipping upper femoral epiphysis with an endocrinological background especially in mind. He observed that in all these cases the sella turcica was abnormally small. His material included 2 pituitary tumors. Also, the majority of the male patients had an endocrine defect in the form of overweight. Burrows (1957) also examined the endocrinological background in an extensive study. Urinary ketosteroid secretion was normal. The conclusion was reached from other information and clinical evidence, that one quarter of the boys and almost two thirds of the girls suffered from endocrine disturbance, in addition to those who were overweight.

Harris (1950) published an experimental study of the upper epiphyseal plate of rats tibia. He divided the rats into 3 groups, each comprising ten animals. Group 1 consisted of control animals. In group 2 gonadectomy was performed and 1 mg growth-hormone administered daily. In the third group oestradiol was given 3 times weekly. It was then observed that the strength needed for detachment of the upper tibial epiphysis of rats treated with growth hormone was only half of that required for detachment of the tibial epiphysis of control animals. In oestradiol treated rats this strength was 50 per cent greater than in control animals, and 3 times greater than in rats treated with growth-hormone after gonadectomy. For this reason the author concludes that slipped capital epiphysis in adolescents may have two main causes. First, that sex hormone secretion is abnormally low, as in patients with overweight and underdeveloped genitals and second, that growth-hormone secretion is abnormally high and growth sudden, as clearly appears in tall, thin, quickly growing children. Obviously in such cases no great importance attaches to the hormone secretion value in itself, but to the relation between growth and sex hormone. Thus, if sex hormone secretion is very low, as in patients with overweight, growth hormone secretion may be normal or sub-normal, but it is abnormally high in relation to sex hormone secretion, and may cause weakening of the epiphyseal plate against tangential strain.

Clinical experience, experimental study and endocrinological observation all support the opinion that hormonal factors have a great, perhaps decisive influence on the etiology of slipped upper femoral epiphysis. A normal capital epiphysis may, of course, be detached as a result of powerful trauma, but these cases are very rare.

DIAGNOSTIC ASPECTS

Slipped upper femoral epiphysis usually causes pain in the hip, and more rarely in the knee. Patients are commonly children aged 9—15. An ordinary antero-posterior X-ray shows slipping of the capital epiphysis as follows:

1. Normally the capital epiphysis protrudes over the upper lateral edge of the neck in the antero-posterior x-ray and appears as a prominence outside the femoral neck. The slightest slipping causes this projection to disappear, which is considered by some investigators to be the first symptom (Jerre 1950).

2. When the epiphysis slips backward its thickness (measured from the epiphyseal line to the joint surface) decreases in proportion as the slipping increases.

3. Waldenström states (1939) that even at an early stage of slipped upper femoral epiphysis the surfaces of the epiphysis and metaphysis become irregular and no longer fit together. In the roentgenogram this is seen as an irregularity of the epiphyseal line.

Although in the antero-posterior picture slipped epiphysis can thus be diagnosed in some cases, the lateral view is quite indispensable whenever slipped capital epiphysis is suspected. The lateral exposure can be taken in various positions (Billing and Severin 1959). Some maintain that a pre-slipping stage exists in which the epiphyseal line has merely widened and its outlines are obscure (Fergusson and Howorth 1931, Jerre 1950, Howorth 1957 and 1960). The pre-slipping stage, it is stated, produces symptoms with pain in the hip (Fahey et al. 1965). Waldenström (1939) believes that in such a stage no symptoms are produced and the slipped epiphysis can be detected only from an X-ray picture. Billing and Severin (1959) maintain that slipped epiphysis can be detected at a very early stage as an angle between epiphyseal line and collum which appears in special X-ray exposures.

The degree of slipping of the capital epiphysis in relation to the neck may be expressed in many different ways. In the literature some confusion is caused by the fact that a variety of terms are used. Billing and Severin (1959) express slipping as an angle between epiphyseal line and neck. Some express slipping in inches (Howorth 1957), while others speak only of slight or market slipping (Ferre 1950). More specific measurements have also been published. Some have divided cases into groups of minimal, quarter, half, three-quarter and total slipping (Burrows 1957), others speak of slight, minimal, 1/4—1/3, half, 2/3 (Hall 1957). Newman (1960) classified the position of epiphysis as acceptable or unacceptable. Displacement of the epiphysis has been measured in centimetres by Klein, et al. (1953). Durbin (1960) considers that when slipping is over half the breadth of the epiphysis, i.e. 50 per cent, the prognosis is considerably worse than in milder cases. Most investigators have given up measuring the angle between epiphysis and neck because of uncertain results. The main reason for this uncertainty is that in the X-ray the hip must be in exactly the same position on every occasion, which is impossible because of restricted movements in the hip. (Jerre 1950). For this reason the displacement is perhaps most exactly expressed as a measure of length or, even better, as a relative part of the extent of the epiphysis.

TREATMENT

Conservative treatment

Opinions on the relative merits of conservative and operative treatment are somewhat conflicting. Operative treatment which leads to a moderate or poor result may be criticised on the ground that necrosis of the head may not appear in untreated cases, and in cases of deformity coxarthrosis does not occur until a later age (Howorth 1957). Conservative treatment may in turn be criticised on the grounds that it is usually prolonged and results are often worse than those produced by operative treatment (Green 1945, Howorth 1949, Jerre 1950).

Conservative treatment mainly involves rest in bed, traction, walking on crutches, walking with the aid of a Thomas splint and plaster immobilisation, and a combination of all these.

Jerre in 1950 examined the results of conservative treatment in a follow-up and noted that in 21 cases of slight slipping results were good in 76.2 per cent, fair in 19 per cent and poor in 4.8 per cent. In 20 cases of greater slipping (marked) 5 per cent of results were good, 85 per cent fair and 10 per cent poor. Forrester—Brown (1941) examined 22 cases of conservatively treated slipped epiphysis, part of which were treated by traction, part by closed reduction and part by walking caliper. Follow-up was carried out on 11 patients, only one of whom was able to move freely. Nine had abduction, adduction and rotation deficiency, and all had some degree of flexion deficiency. Howorth (1949) published results on 7 patients who had been treated by traction and then by plaster. In no case was improvement achieved in the position of the epiphysis, and results were poor in 6 cases. Durbin (1960) treated 19 cases conservatively and obtained excellent results in 37 per cent, good in 37 per cent, fair in 5 per cent and poor in 21 per cent. Hall (1957) treated 33 hips conservatively by various methods: he states that manipulation produced some change in the position of the epiphysis in 24 cases, and no change in 9 cases. The best correction of the position was obtained in cases were a sudden slip had occurred. Capital necrosis occurred in three cases where the condition of the epiphysis had improved; it also occurred in two cases where no change had been produced. In Hall's opinion manipulation is justified when performed with in a few weeks after sudden slip.

It thus appears that, although conservative treatment may achieve partially good results, it may also produce necrosis of the head, especially if manipulation or prolonged powerful traction is used. Moreover, conservative treatment is lengthy and results on the whole do not seem noticeably better than those produced by most methods of operative treatment.

Operative treatment

In operative treatment an important question is whether the position of the capital epiphysis can be accepted or not. If the capital epiphysis has slipped considerably, it may be asked whether the condition can be improved. If the position of the head is acceptable the purpose of operative treatment is to prevent further slipping and several methods of fixing the epiphysis are possible. If the slipping is severe the condition may be accepted even then, and a mere fixation may be considered sufficient, or one may try to improve the position of the head in relation to the neck. A further alternative is to improve the position of the head and neck by performing an osteotomy in the neck or in the subtrochanteric or intertrochanteric part of the femur and fixing the head in its position.

Fixation methods

The upper femoral epiphysis may be fixed to the neck by Smith-Petersen nail (Wilson 1938, Wiberg 1941, 1959 Fahey et al. 1965, Lindström 1958) Other methods are by one or more pegs or screws (Fahey et al. 1965, Durbin 1960, Newman 1960, Hall 1957, Hiertonn 1955). Fixation may also be performed by bone pegs (Fergusson and Howorth 1931) or by opening the epiphyseal line and drilling a hole and implanting both cortical bone and cancellous bone (Herndon et al. 1963). Good results have been obtained by all these methods. The large nail has been criticised for its tendency to push the loose head forward, thus causing necrosis or splitting (Wiberg 1959, Howorth 1957). If, on the other hand, the nail penetrates at some point the joint cartilage and is not noticed or removed, arthrosis may develop sooner than usual (Wiberg 1959, Waldenström 1930). For this reason many have advocated the use of thin pins (Moore pins) or screws for fixation (Dunn 1964, Hall 1957).

In Wiberg's material of 185 cases the nail penetrated the joint cartilage in 15 cases; final results were good, however, because the position of the nail was corrected in some of the cases. Capital necrosis appeared in two cases, one of which was only partial.

In Lindström's series (1959) of 51 nailed hips no case of capital necrosis occurred. Four cases were treated by manipulation followed by nailing and in one of these capital necrosis occurred. In Lindström's opinion the Smith-Petersen nail is suitable and causes no complications when the slipping is slight.

In Hall's material (1957) of 48 cases treated by Smith-Petersen nail 5 cases of capital necrosis occurred, but the author attributes them to other causes than the nail. Excellent results were: 68.9 per cent with the Smith-Petersen nail, 80 per cent with Moore pins. Good results were 18.8 per cent with the Smith-Petersen nail, 20 per cent with Moore pins. The latter produced no fair or poor results, but the Smith-Petersen nail produced 8.4 per cent poor.

Newman (1960) performed fixation in 13 cases with the Smith-Petersen nail. One result was poor, but the case had been treated for 3 months by traction. In 2 cases subtrochanteric fracture occurred near the nail. In 26 cases stabilisation was performed with Moore pins: in one case the pin came out and re-slipping occurred, followed by recovery and consolidation in a bad position.

Durbin (1960) achieved the following results by nailing: excellent 57 per cent, good 22 per cent, fair 14 per cent, poor 7 per cent, from a total of 14 hips. 27 hips in his series were fixed with Moore-type pins, and results were: excellent 52 per cent, good 37 per cent, fair 11 per cent, and poor nil.

In Jerre's material consisting of 183 hips capital necrosis occurred in 20 cases, only one of which was a result of nailing, however. Fifteen were the consequence of reduction and plaster immobilisation, and 2 followed closed reduction and nailing. One hundred and two cases were treated with plaster immobilisation.

In Howorth's material of over 200 cases operated by his own methode, the epiphyseal line failed to close in 4 cases, but capital necrosis did not occur in a single instance.

On the basis of the literature alone it appears that Howorth's method as reported by himself produces the best results.

Open reduction and wedge osteotomy

Opinions differ as to when the extent of slipping is such as to necessitate correction of the position of the head. Some maintain that one third of the extent or more causes deformity of the joint later (Hiertonn 1956, Wilson 1938). Others maintain half the extent or more (Durbin 1960), and others 1 cm or more (Klein et al. 1953).

When the epiphysis is considered to have slipped too much by one of the above criteria, the method of treatment depends on whether so-called acute slipping or chronic slipping is invalved. In the former case closed reduction may be attempted, as it is considered that the epiphysis is movable in

very recent slips. Results are often unsatisfactory, however, and cases of capital necrosis have occurred (Jerre 1950, Howorth 1966).

For this reason it is the general opinion that closed reduction should not be performed except in very acute cases. Results are uncertain even then.

Open reduction

In late cases with an unacceptable degree of slip an open reduction or a wedge osteotomy can be performed.

Open reduction has been performed since the latter half of last century, but has been abandoned in many clinics because of capital necrosis. Wilson in 1924 published 7 cases of open reduction, 4 of which were fresh and 3 late slipping. Fergusson and Howorth in 1931 published 11 cases of open reduction, and Badgley et al. in 1948 11 cases, 6 of which produced good results. Klein et al. in 1948 reported 16 cases and Friberg (1948) 12 cases with one caput necrosis. In 1966 Howorth reported 16 cases in which plaster was used after open reduction: 5 were good, 6 fair and 5 poor. Seven were nailed after open reduction, and of these 5 were good, 1 fair and 1 poor. In the former group there was 1 case of caput necrosis and 7 cases of cartilage necrosis. In the latter there were 6 cases of cartilage necrosis and none of caput necrosis. Dunn (1964) reported 23 open reductions in which a wedge osteotomy of the neck was performed in the same operation. Nineteen of these led to a good result. In one case caput necrosis appeared, and in one case partial necrosis after nailing. Cartilage necrosis appeared in two cases. Open reduction is nowadays considered by some to be unsatisfactory because of the operative risk and technical difficulties (Howorth 1966).

Wedge osteotomy

Howorth in 1966 made a thorough assessment of the literature, in which some 400 wedge osteotomies are reported by various authors and caput necrosis recorded in 30 per cent. He added his own material of 9 cases: after osteotomy 4 of these were immobilised in plaster, and 5 with Smith-Petersen nail. Results at follow-up were good in 5 cases, fair in 3, poor in one case. Caput necrosis occurred in 2 cases and carrtilage necrosis in one.

Wiberg in 1955 reported 12 cases, only one of which gave rise to caput necrosis, the remainder being good. In his opinion, however, the operation should be limited to rare cases. Hiertonn also in 1955 reported 38 hips operated in the same way: there were 5 cases of caput necrosis and 9 of partial caput necrosis. Results were good in 24 cases.

Linström in 1958 reported 24 wedge osteotomies with 2 caput necrosis, 1 traumatic arthritis and 4 coxarthrosis.

Other osteotomies

Subtrochanteric osteotomy and intertrochanteric osteotomy are indicated mainly in the late stage of slipped capital epiphysis in order to correct varus and external rotational deformity (Howorth 1966).

ASSESSMENT OF RESULTS

In the assessment of results confusion and difficulty have been caused by the fact that follow-up intervals have differed in length, methods of treatment have varied greatly, and different methods have often been used in the same case. Also the division of cases into "excellent", "good", "fair", "poor" has sometimes been subject to variation.

The patient's own assessment is used as first criterion. Pain, whether at rest or under strain, is important. Second to be used are results of objective follow-up examination: most important is the mobility of the hip. As a rule mobility is assessed in various directions, with points awarded for the degree of mobility attained. Methods of calculation available are given by Gade (1947) and Fergusson and Howorth (1931). According to Gade values for a normal hip vary 85—100 points. According to Fergusson and Howorth the index for a normal hip should be 85—95 (Fergusson and Howorth 1931. Howorth 1966). In clinical examination attention is also paid to limping, discrepancy of length in limbs and the patient's ability to perform various activities (Hall, Howorth, Newman).

In X-ray examination attention is given to the form of the femoral head and the joint surfaces, also to possible secondary osteoarthritis or necrosis of the head or its cartilage.

PRESENT MATERIAL

The material comprises all cases of slipped upper femoral epiphysis treated at the Orthopedic Hospital of the Invalid Foundation, Helsinki in the period 1947—1965. This makes a total of 80 patients, 55 boys and 25 girls.

Table 1 shows the distribution of the patients according to the side affected.

Table 1

Side affected

Affected Side	Number of patients	Boys	Girls
Left	41	27	14
Right	20	16	4
Bilat.	19	12	7
All	80	55	25

The material contained 21 boys and 8 girls who were clearly overweight. For part of these cases an endocrine defect was clinically evident. One of the boys was also suffering from pituitary tumor, and had received radiotherapy. The height of this boy at the time of follow-up was 218 cm or 7 ft 3 ins. One girl also had a brain tumor combined with hypopituitarism and one boy a clearly diagnosed endocrine disturbance.

Patients sought treatment for various reasons. Table 2 analyses the symptoms concerned.

Table 2

Reason for seeking treatment

Symptoms	Number of patients	Boys	Girls
Pain in hip	35	24	11
Limping	8	4	4
Pain in hip + limping	33	24	9
Pain in knee only	4	3	1
All	80	55	25

32 patients reported injury either immediately before seeking treatment or earlier, but in most cases this was a mild one, such as slipping on the stairs, falling from a bicycle or falling when walking. Only 6 patients sought treatment immediately, in the other cases the symptoms were of several months' duration. Four patients complained of pain in the knee. In 17 cases the patient had been treated elsewhere either on an incorrect diagnosis or no diagnosis had been reached. In several cases no X-ray had been taken, or only an antero-posterior one. In some of these cases no distinct diagnosis had been made. A radiograph taken in a Lauenstein position clearly showed slipped epiphysis in all these 17 cases.

Degree of slipping

In the present material the degree of slipping was estimated as a displacement of the capital epiphysis according to its extent in relation to the femoral neck.

Slipping was estimated always from a lateral X-ray taken in the so-called Lauenstein position. Especially in bilateral cases it was possible to follow the changes in the epiphyseal line of the unaffected hip when the patient came for re-examination of the other hip, which had been operated on or treated earlier (Figs. 1 and 2). Slipped epiphysis was then diagnosed at a very early stage, when displacement was either non-existent or extremely slight (Figs. 1, 2, 4). This type of slipped epiphysis was marked as slight. Otherwise slipped epiphysis was classified from the lateral exposure as under 1/3 (Fig. 7), under 1/2 (Fig. 5 and 6), over half (Figs. 8—10, 12 and 13), and complete (Fig. 11). When secondary callus had formed in the lower posterior part of the neck between it and the head, the degree of slipping was estimated as it had evidently been before callus formation.

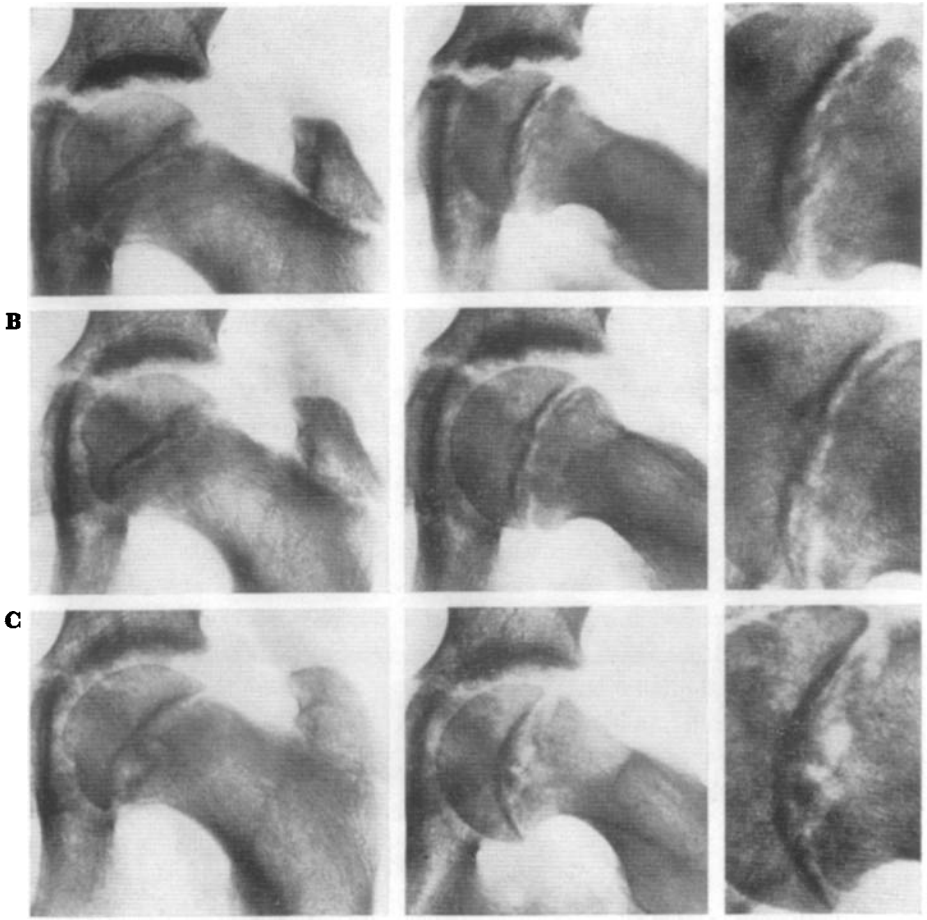

Fig. 1. Left hip of a boy aged 14 at the time of nailing of the right hip 29. 3. 60.
A. — In the left hip the epiphyseal plate is regular. The patient had no symptoms in this hip. Lateral view on the right. Enlarged view on its right side.
B. — Left hip 3 months after X-ray in A. In the middle of the epiphyseal plate in the lateral view the start of loosening in the form of irregularity. No displacement as yet. The antero-posterior view does not show any sign of beginning of slip. The patient did not feel pains in the hip. The enlarged view of the epiphyseal plate on the far right.
C. — The patient felt slight pain in the left hip. The antero-posterior view is still normal. Roentgenogram taken 5 months after A and 3 months after B. The epiphyseal plate is irregular especially in the middle of the lateral view. Slight slip. The epiphysis was fixed by nailing (Fig. 4.) In this case the patient felt slight pain at the time of the beginning of slipping but in the lateral view signs of this could already be seen before that.

Symptoms and earlier treatment

Table 3 shows duration of symptoms at various degrees of slipping.

Among the bilateral cases were 11 in which slipped epiphysis was detected at an early stage when the patient came for re-examination of a hip that

Table 3

Duration of symptoms

Degree of slipping	Number of hips	Symptoms: Under 1 month	1—2 m	2—6 m	6—12 m	Over 1 year
Slight	18	9	0	4	4	1
Under 1/3	26	0	1	11	10	4
Under 1/2	24	4	1	8	5	6
Over 1/2	29	1	0	14	7	7
Complete	2	0	0	1	1	0
All	99	14	2	38	27	18

had been treated earlier. Six of these had pains, five did not. Ten cases in which the symptoms had lasted less than 6 months had been in traction earlier. In ten cases with symptoms lasting less than 6 months the slipping had not been diagnosed, and one had been given operative treatment elsewhere. The remainder had received no previous treatment. In one case where the symptoms had lasted over a year the patient had been treated for tuberculosis of the hip elsewhere. In 5 cases where the symptoms had lasted over 6 months traction treatment had been given, in 5 cases slipped epiphysis had not been diagnosed, in 2 cases operative treatment had been given. One of these was a case in which open reduction had been attempted elsewhere. The attempt failed and was followed by complete slipping.

The time interval between the slipping in the first affected hip and the slipping in the other hip in bilateral cases is shown in Table 4.

Table 4

Time interval between first and second hip in bilateral cases

Interval between slipping	No.Hips.	Boys	Girls
Under 1 m.	6	4	2
1—2 m.	3	1	2
2—6 m.	2	2	0
6—12 m.	3	3	0
Over 12 m.	5	2	3
All	19	12	7

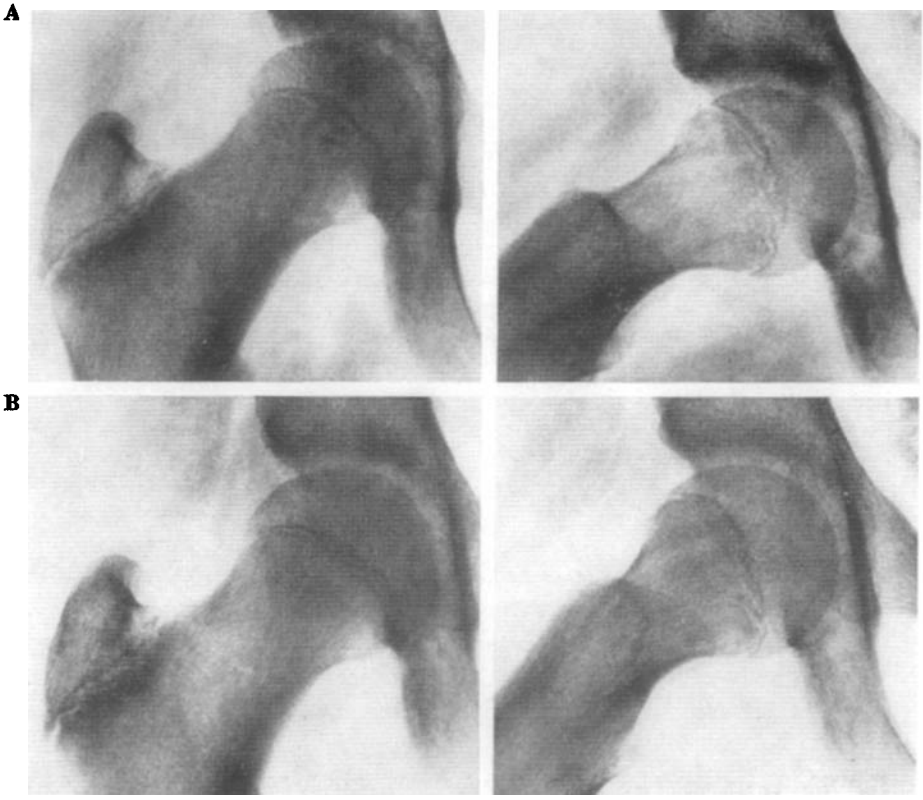

Fig. 2. Right hip of a boy aged 13 at the time of nailing of the left hip 14. 9. 60.
A. — The epiphyseal line is regular, except in the middle in the lateral view.
B. — Three months later, after nailing of the other hip and bed rest the irregularity in the middle of the epiphyseal plate has disappeared and the position of the epiphysis is concentric.

In 6 cases the interval between slipping in the first and in the second hip was less than 1 month, and these were mainly cases in which both hips were operated on within a shor period. In one case where the interval was 6 months the patient had been in consultation at our out-patient department, when right hip had a slip of 1/3 and the left merely a very slight slip. An operation was not considered necessary and the patient was given crutches and allowed to move with their aid. On the patient's re-appearance after six months the slipping had increased, especially on the left side, where it had been quite minimal at the earlier visit. Moore pins were used for fixation on the left side. The epiphyseal plate on the right was considered closed.

Table 5 shows treatment received by patients elsewhere before coming to hospital.

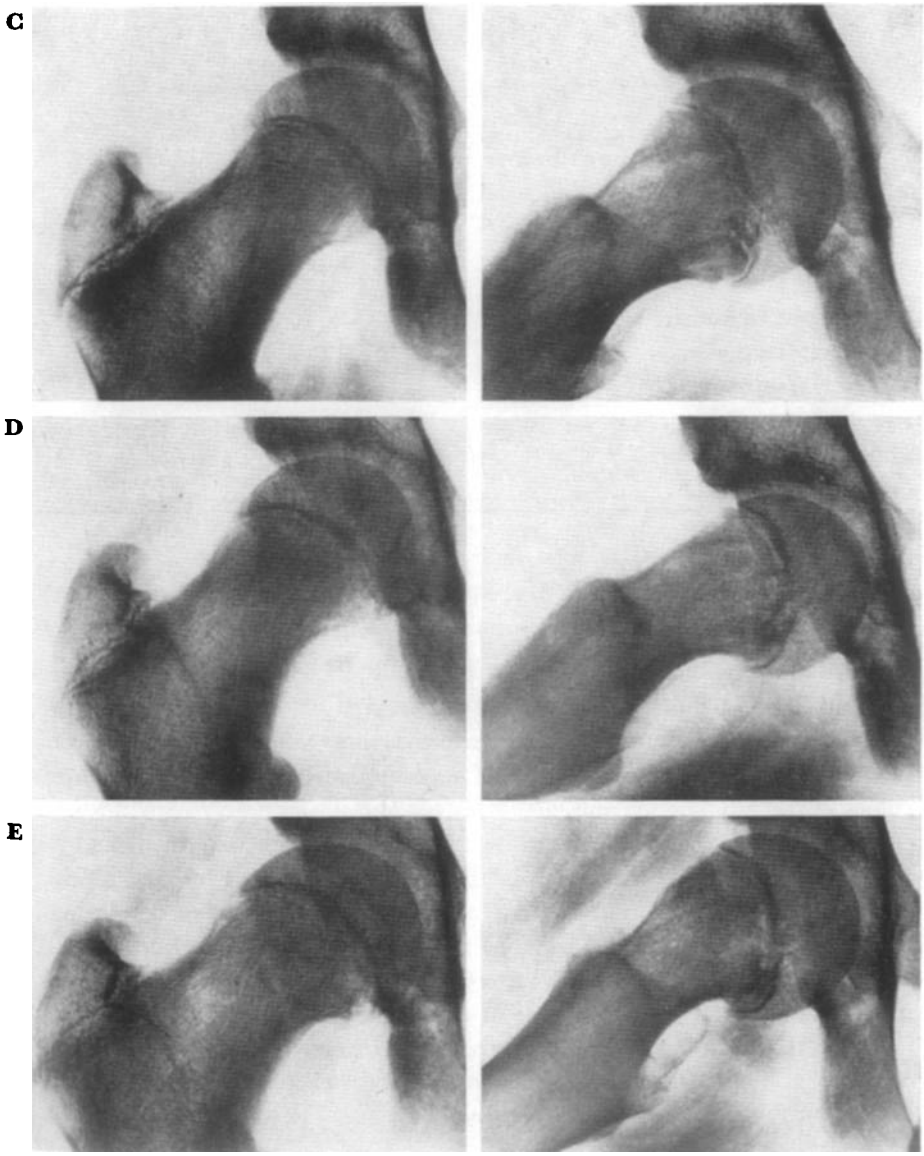

Fig. 2. **C.** — Three months later. The epiphyseal line is more irregular in the lateral X-ray than in previous roentgenogram. The patient had no symptoms. This X-ray was taken at the same time as the control X-ray from the other, nailed hip.
D. — Five months later there is a clear slip seen in the lateral X-ray. The irregularity of the epiphyseal line is also evident. The patient still felt no pain in this hip. In the antero-posterior X-ray the "hump" in the upper corner has disappeared, indicating a slip.
E. — Two months later. The slip is even more advanced. In the lateral view the protruding upper corner has resorbed and a corresponding amount of secondary callus has formed in the lower part of the neck in the lateral view. The hip was nailed although the boy felt no pains in his hip even at this stage of the slipping.

Table 5

Treatment before coming to hospital

Previous Treatment	Number of patients	Boys	Girls
No previous treatment	36	26	10
Incorrect diagnosis	17	12	5
Traction treatment	14	7	7
Rest in bed	8	6	2
Other treatment	2	1	1
Operative treatment	3	3	0
All	80	55	25

There were 17 cases of incorrect diagnosis elsewhere, 4 of which were bilateral. Ten of these patients had been treated on an incorrect diagnosis elsewhere, and 7 had received no treatment before coming to hospital. One case had been considered a fracture. One case had been mistaken for tuberculosis of the hip, one for muscular paralysis and 2 had been treated for muscular sprain. One was thought to be the result of excessive growth and not X-rayed although there was pain in the hips. On arrival at hospital slipping was under 1/3 on both sides. In one case nothing was detected despite pain in the hip, but 2 weeks bed rest was prescribed: slipping was less than 1/2. In 3 cases the patient was treated as a Calvé-Legg-Perthes disease by Thomas splint or rest. In 36 cases the patient came straight to hospital without previous treatment with a correct diagnosis. Other treatment given in this group consisted of Thomas splint in one case and crutches in an other. Operative treatment elsewhere consisted of one nailing, one wedge osteotomy and one attempted open reduction.

Table 6 shows the age of patients on coming for treatment.

Table 6

Age at time of operation

Age	Number of patients	Boys	Girls
Under 10 years	1	1	—
10—11 years	1	—	1
11—12 years	11	3	8
12—13 years	15	6	9
13—14 years	16	10	6
14—15 years	11	11	—
Over 15 years	25	24	1
All	80	55	25

At the time of operation the youngest patient was aged 9 years the oldest 37 years. The last-mentioned case had a residual stage of the slipped femoral epiphysis, and an intertrochanteric osteotomy was performed. Mean age of patients at the time of operation was 14.4 years. Mean age of girls was 12.6 years and that of boys 15.2 years. Six patients had sustained a trauma before admission to hospital. In 4 of these cases the degree of slipping was less than half the extent of the epiphysis, in one case over half, and in one case the slipping was complete. In the two latter cases a subcapital wedge osteotomy was performed, and in one of the cases where the slipping was less than half the extent of the capital epiphysis an open reduction was performed. The others were fixed by nailing or with bone pegs by Howorth's method.

METHODS OF TREATMENT

Of the 80 patients in the present material 19 had a bilateral slip so that the total number of hips treated was therefore 99. The treatment given may be divided roughly into two main groups: conservative and operative. Table 7 shows the number of hips treated conservatively and operatively.

Table 7

Conservative and operative treatment.

Degree of slipping	No.Hips.	Treatment	
		operative	conservative
Slight	18	17	1
Under 1/3	26	22	4
Under 1/2	24	23	1
Over 1/2	29	25	4
Total	2	1	1
All	99	88	11

NON-OPERATIVE TREATMENT

Traction and closed reduction

In earlier years traction before operation was considered a routine treatment. In the later years it has not been practiesed any more. Traction was mentioned as being used only in two cases in this material at our hospital and in 14 cases at another hospital.

Closed reduction was attempted under anaesthesia in 4 cases at another hospital before coming for treatment and in 6 cases closed reduction was attempted at our hospital. The capital epiphysis was fixed in all cases after manipulation. Only in 4 cases of these 10 manipulated cases was the position of the capital epiphysis considered better after closed reduction. All these

4 cases were those in which an obvious recent slipping had taken place. In two cases the closed reduction was performed a few days after sudden exacerbation of pain in the hip in connection of a trauma. Two cases were manipulated in a few weeks after such an accident.

Conservative treatment

The conservative treatment group contains only 4 patients who actually received conservative treatment at our hospital. Six patients had been treated elsewhere or had not been diagnosed and at the moment of consultation were unsuitable for any kind of treatment mostly because of closing of the epiphyseal plate.

One of these was the case in which an open reduction had been attempted while the degree of slipping was less than half the extent of the capital epiphysis. The operation was unsuccessful and resulted in a complete slipping which was not corrected. The patient was sent to our hospital a few years after this operation and the epiphyseal plate was already closed and no further operation was considered indicated. The result was later regarded as poor.

In 3 cases the patient had been treated for an incorrect diagnosis or the slipping had not been diagnosed. One of these had been treated for tuberculosis of the hip for one year with bed rest. The degree of slipping was slight and as the epiphyseal plate had already closed, there was no indication for further treatment. The result was good. In one further case the patient had pain in the hip but no radiological examination had been performed. The degree of slipping was in this case more than half the extent of the capital epiphysis and as the epiphyseal plate had closed in this case too, no treatment was considered necessary. The hip was stiff at the time of follow-up. The third case with an incorrect diagnosis had received no treatment. This was a bilateral slipping in which both epiphyseal plates had closed on arrival at the hospital. One hip was left uncorrected but in the other a subtrochanteric osteotomy was performed. Three further cases were bilateral cases in which one hip had already stabilised, so that no treatment was given. The other hips were treated as follows: nailing was performed in one case; open reduction was attempted in one case; wedge osteotomy was performed in one case.

Only four patients were given actual conservative treatment: in one case a Thomas splint was used, in another closed reduction was attempted and the hip immobilised in plaster for a month, and in two cases the patient was

allowed to move with elbow crutches. The fourth case had attended the outpatient department of our hospital, when a slip of 1/3 was found in one hip and merely a very slight slip in the other. As previously mentioned operative treatment was not considered necessary and the patient was allowed to move with elbow crutches, but when he reappeared at the hospital six months later the slipping had greatly increased especially on the left side, where there was previously only a brightness of the epiphyseal line. The slipping was less than 1/3 on both sides. The left side was then considered so acute that it was fixed with Moore pins, but on the right side the epiphyseal line was considered to have closed. The slip had not increased in this hip.

OPERATIVE TREATMENT

Table 8 shows to what extent various operative methods were used in varying degrees of slipping.

Table 8

Operative methods

Type of operation	No.Hips	Degree of slipping				
		Slight	Under 1/3	Under 1/2	Over 1/2	Complete
Nailing	51	17	20	12	2	—
Howorth	15	—	2	5	8	—
Wedge ost.	9	—	—	2	6	1
Intertr. or subtr.ost.	7	—	—	2	5	—
Open reduction	4	—	—	2	2	—
Other oper.	2	—	—	—	2	—
All	88	17	22	23	25	1

In earlier years an ordinary Smith-Petersen or vitallium nail was used but in the last few years these have been replaced by smaller nails intended for children. Fixation by nailing without reduction was generally performed when the slipping was less than half the extent of the epiphysis. Intertrochanteric and subtrochanteric osteotomy was performed in order to correct position, mainly in the residual stage of the slipping. Other operations consisted of Judet arthoplasty, performed after an unsuccesful open reduction; in the other case a drilling operation was performed. In recent years nailing and

Howorth operation have become more common at our hospital, while wedge osteotomy and open reduction are no longer performed.

After nailing no post-operative plaster was used. Routine treatment after nailing was a follows: during the first 10 days the patient was allowed to get up and use elbow crutches; he was allowed full weight bearing on the operated limb only after 2—3 months. In the present material 33 patients were in bed for less than one month after nailing: also less than a month in bed were 12 patients after Howorth operation, one wedge osteotomy, one open reduction and one drilling operation. The other patients were more than a month in bed: most had been operated in previous years, when the immobilisation time was longer.

FOLLOW-UP EXAMINATION

The follow-up examination was performed in 1967. The number of patients appearing at the examination was 79. 19 were bilateral, so that the total number of hips was 98. One patient had died of brain tumor 2 years after operation. The shortest period of observation was one year and the longest 19 years, with a mean of 6.7 years. The youngest patient at follow-up was 13 years and the oldest 40 years with a mean age of 21.6 years.

RESULTS

Assessment of results

Results were assessed by clinical examination of patients. Particular attention was paid to the patient's own estimation of the result, pains felt at rest or under strain, ability to work, and the patient's opinion in general. Secondly the degree of mobility of the hip was assessed by clinical examination and expressed according to Gade. Thirdly, X-ray examination was carried out, with exposures taken in the antero-posterior and lateral or so called Lauenstein positions in all cases.

Table 9

Assessment of Results

	Patient's estimation	Pain	Function	Movement index (Gade)	Radiographic appearance of hip
Excellent	Normal	None	Unrestricted	85 or over	Virtually normal hip, viable head, good joint space
Good	Good hip, not quite normal	Does not interfere	Slightly restricted	75—85	Concruent surfaces viable head, good joint space
Fair	Some trouble	Stops some activities	Definitely restricted	50—75	Some irregularity, slipping of head, narrowed joint space
Poor	In some cases troublesome	Partly disabling	Poor	Under 50	Joint space lost or necrosis of head.

The result was considered excellent when the Gade mobility index was 85 or more. In these cases the X-ray showed a virtually normal hip and the patient felt no discomfort. In unilateral cases the result was compared with the normal hip. Mobility then had to be at most 10 points under the value estimated for the normal hip.

The result was considered good when the Gade mobility index was 75—85. The patient might have slight pain after strain, and the X-ray might show slight changes. In order to simplify the comparison of results the excellent and good cases are grouped together in the tables.

The result was considered fair if the mobility index was 50—75. The patient felt pain after strain, and the X-ray showed moderate changes in the joint surfaces.

The result was considered poor if mobility was 50 or less. In such cases the X-ray showed marked changes and the patient might feel pain even after slight strain. In the present material no patient felt sufficient pain to incapacitate him completely. The highest Gade index obtained for a healthy hip in this series was 91.

NON-OPERATIVE TREATMENT

Traction

Traction was used in 14 cases at another hospital before coming for treatment and in two cases in this hospital.

In those 14 patients treated with traction elsewhere the degree of slipping was slight in one case, under 1/3 in 3 cases, under 1/2 in 3 cases and over 1/2 in seven cases (Table 10). Of those patients treated with traction at our hospital the degree of slipping was under 1/3 in one case and complete in one case. The table 10 shows the result of different types of treatment after pre-operative traction.

In those cases where the result of traction could be controlled it had not changed the position of the epiphysis. As can be seen in Table 10 the results of treatment according to degree of slipping are approximately the same as in the rest of the series. (Tables 10 and 17). This means that the traction had not much influenced the result of treatment.

After preoperative traction the epiphysis was fixed in seven cases according to Howorth, in five cases a simple nailing was performed and in two cases a wedge osteotomy was performed after which the capital epiphysis was fixed by Smith-Petersen nail. In one case an arthroplasty was performed.

Table 10

Results in cases of preoperative traction

Degree of slipping	No.	Results: Excellent or good	Fair	Poor
Slight	1	1	0	0
Under 1/3	4	3	1	0
Under 1/2	3	3	0	0
Over 1/2	7	5	0	2
Complete	1	0	1	0
All	16	12	2	2

The degree of slipping in the hips operated according to Howorth was over half of the extent of the epiphysis in five cases, under half in one case and under a third in one case. In one of these cases the result of treatment at the time of follow-up was considered as poor, the other as excellent or good.

The degree of slipping in the cases in which a wedge osteotomy was perfomed was over half in one case and complete in one. Both cases were considered as good at the time of follow-up. In those fixed by nailing the degree of slipping was slight in one case, under 1/3 in two and under 1/2 in two cases. They were all considered as good at the time of follow-up. In two cases a closed reduction was attempted after a traction treatment at another hospital. The position of the head improved.

Closed reduction

In 4 cases in this series a closed reduction was attempted at another hospital. In six further cases a closed reduction was performed at our hospital. Only in four of these ten cases was the position of the capital epiphysis regarded as better by the surgeon after manipulation. These four cases were all recent slippings in which the closed reduction was attempted in a few days after accident, in two cases, however, a few weeks. Fig. 3 shows one case in which the position was regarded as better after a closed reduction, but in which a necrosis of the head resulted.

Table 11 shows the results of different types of treatment after preoperative closed reduction.

Table 11

Results of treatment after preoperative closed reduction

Degree of slipping	No.	Results Excellent or good	Fair	Poor
Slight	0	0	0	0
Under 1/3	1	0	1	0
Under 1/2	4	1	2	1
Over 1/2	5	1	2	2
Complete	0	0	0	0
All	10	2	5	3

As the table shows, the results are no better than in the rest of the series, and in some respects they are probably worse. (Table 11 and 17).

The result at the time of follow-up in those four cases in which the position was regarded as better after manipulation, was good in one case, fair in two cases and poor in one case. The distribution of results according to the degree of slipping is thus somewhat worse than in the rest of the material. As the number of cases of closed reductions is very small, no accurate conclusions can be made, but in this group there were more poor cases than in the whole material. The method of fixing the epiphysis after manipulation in the poor cases was nailing in one case (Fig. 3) and Howorth operation in one case. The third case was manipulated first, after which an open reduction was attempted and the head later replaced by the Judet prothesis. An arthrodesis was performed at another hospital later. In the first two cases a necrosis of the femoral head resulted, with stiffening of the joint.

It seems, therefore, that the result of an attempted closed reduction is uncertain and contains a considerable risk of necrosis of the femoral head. If it is attempted it must preferably be done in a very recent slipping.

Conservative treatment

The group in which the treatment was considered as conservative because no operations were performed contained two cases considered as poor at follow-up. In one of these an open reduction had been attempted at another hospital. The patient came for consultation a few years later when the epiphyseal plate had already closed, the joint was stiff and no further operations

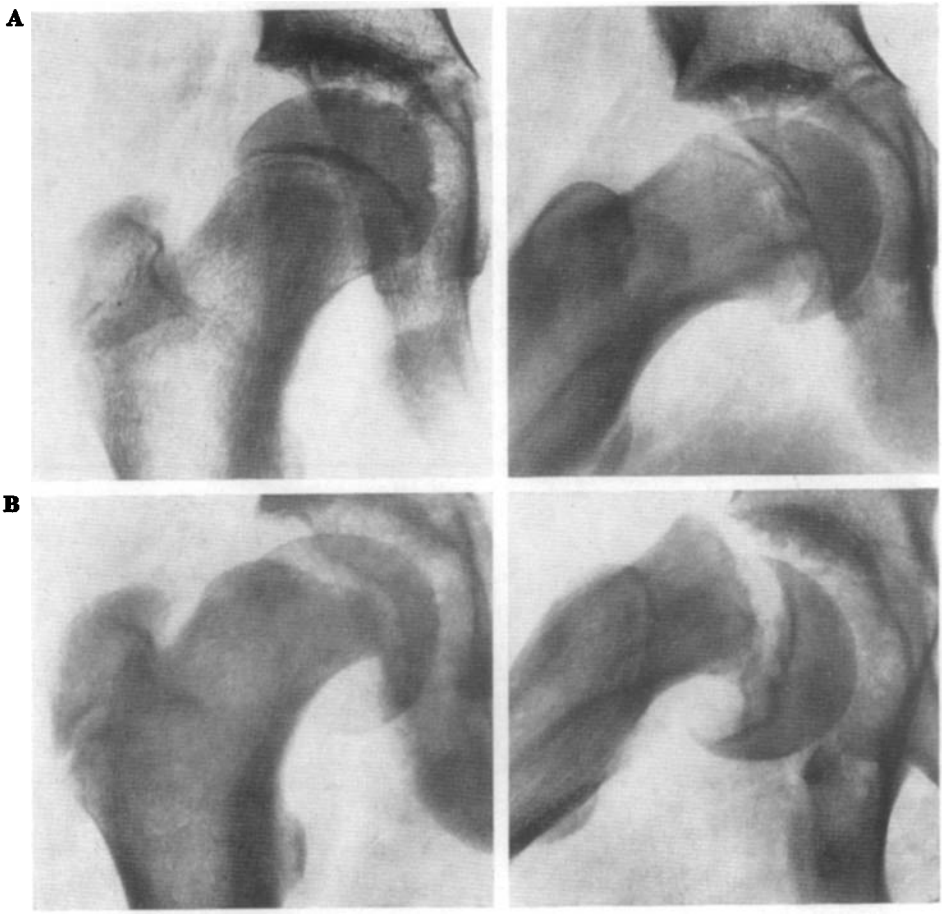

Fig. 3. Right hip of a girl aged 12 at the time of nailing and closed reduction.
A. — The patient felt pain in the right hip and an X-ray was taken at another hospital in both positions. No signs of a slip was seen and the patient was sent home. In the lateral X-ray a slight slip is clearly visible.
B. — The patient had fallen two days after the previous X-ray was taken and the pain in the right hip became worse. In a new X-ray a market slip was seen and the patient was admitted to the hospital for nailing.

were indicated. The other was a neclected case in which the degree of slipping was more than half the extent of the epiphysis. This had not been diagnosed. On arrival at the hospital the epiphyseal plate had closed. The Gade mobility index was 12 in the first case and 46 in the other.

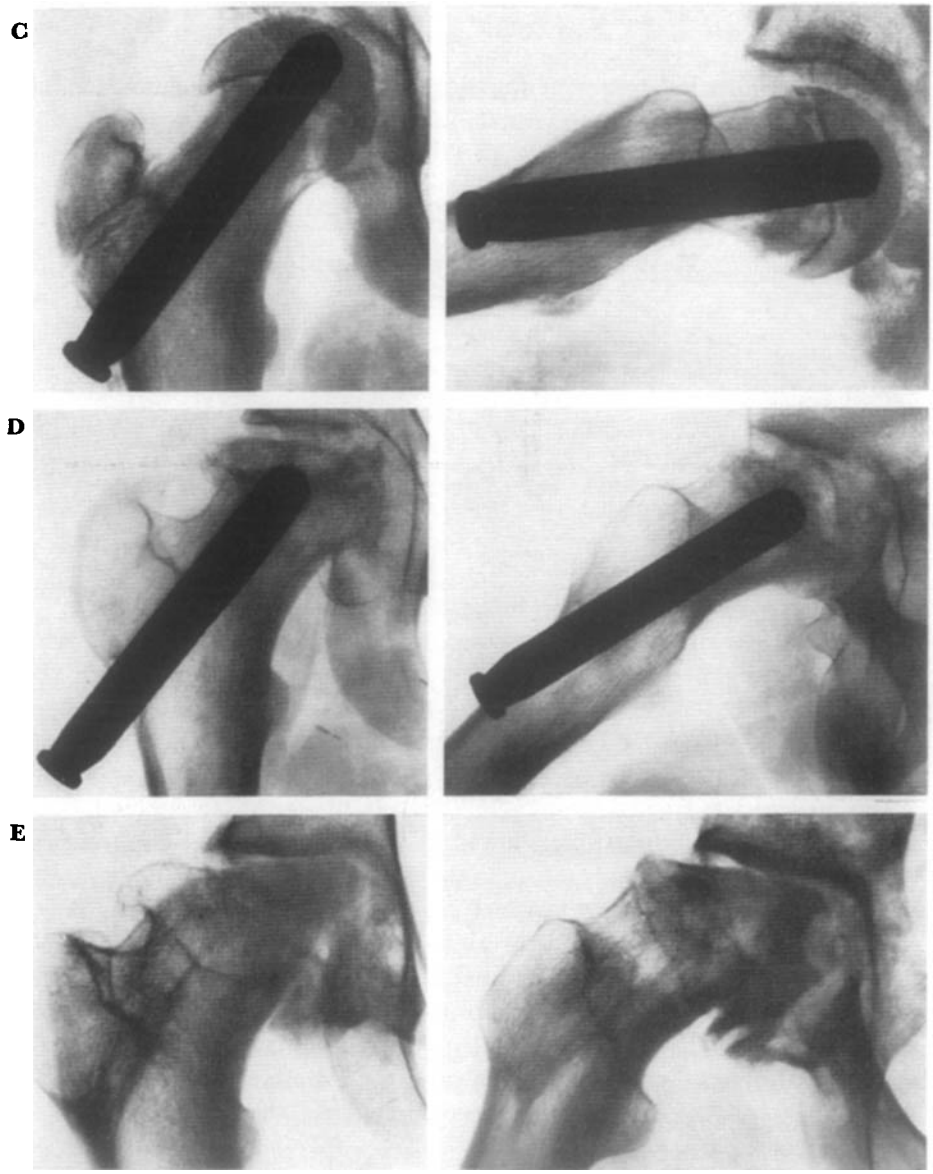

Fig. 3. **C.** — As this was a very recent case a closed reduction was performed and the epiphysis fixed by nailing. The position of the head is very good indeed. The nail is in a good position.
D. — A necrosis of the epiphysis developed in the middle of the epiphysis 8 months later and the nail had to be removed exactly a year after nailing. However, the necrosis of the head increased.
E. — Eight years after nailing the femoral head was quite irregular and the hip was stiff. A subtrochanteric osteotomy was performed at another hospital and at the follow-up ten years after nailing the Gade index for the right hip was 56 and 85 for the left hip which was also nailed. The result in the right hip was regarded as poor because of the appearance in the X-ray. This was the only poor result among 51 nailings.

Table 12 shows the results at the time of follow-up examination in the cases in which no operations were performed.

Table 12

Results of conservative treatment

Degree of slipping	No.	Results Excellent or good	Fair	Poor
Slight	1	1	0	0
Under 1/3	4	2	2	0
Under 1/2	1	0	1	0
Over 1/2	4	1	2	1
Complete	1	0	0	1
All	11	4	5	2

Three of these patients were treated elsewhere either by traction, immobilisation in plaster or immobilisation in bed. The result was excellent in one case, fair in two.

One patient was treated by immobilisation in plaster at our hospital. The result was fair. The others were allowed to move either with elbow crutches or with a Thomas-Splint.

The conservative treatment was used in earlier years. The number of these cases is so small that no conclusions can be drawn. It looks as if the distribution of results was the same as in the rest of the material depending on the degree of slipping. As at least one of these patients had become worse and the degree of slip had increased during walking with elbow crutches it is obvious that fixing the epiphysis at an early stage diminishes the risk of further slipping and a poorer result. A conservative treatment seems therefore to be seldom justified.

OPERATIVE TREATMENT

Results by nailing

Table 13 shows the result of treatment according to degree of slipping in cases where the capital epiphysis was fixed by nailing.

Table 13

Results by nailing

Degree of slipping	No. Hips	Results: Excellent or good	Fair	Poor
Slight	17	17	—	—
Under 1/3	19	16	3	—
Under 1/2	11	10	1	—
Over 1/2	3	1	1	1
Complete	—	—	—	—
All	50	44	5	1

When a Smith-Petersen or vitallium nail is used, the literature records cases in which the nail pushes the capital epiphysis forward before the nail. It is also possible that a thick nail may split the epiphysis. In the present material complications of this type did not occur in a single case (Figs. 4—6). In 3 cases, however, the nail was driven too far and penetrated the joint cartilage of the epiphysis. In only one case was necrosis of the epiphysis observed at follow-up examination. (Fig. 3.) A closed reduction had been performed in connection with nailing. In this case the caput had slipped about half the extent, and closed reduction was performed during the operation. The patient felt no subjective discomfort worth mentioning. The Gade mobility index was 56, but because of changes in the X-ray the condition as a whole was considered poor (Fig. 3). In the 3 cases, in which the nail had penetrated the joint cartilage, no signs of this could be seen in the follow-up X-rays.

In 2 cases the nail came out and the patient had to be operated again. In one of these cases one month had elapsed since the operation and in the other case 5 months. In the latter the slipped epiphysis was bilateral and the nail came out on both sides: it therefore had to be driven in again several months later. In one case it was observed that the nail did not fix the epiphysis and the patient was re-operated 6 weeks after the first operation.

In only one case were Moore pins used. In this case a postoperative X-ray control showed that these were placed in the dorsal part of the femoral neck, where they did not fix the epiphysis. It was therefore necessary to remove them five weeks after operation. The condition healed nevertheless with a good result.

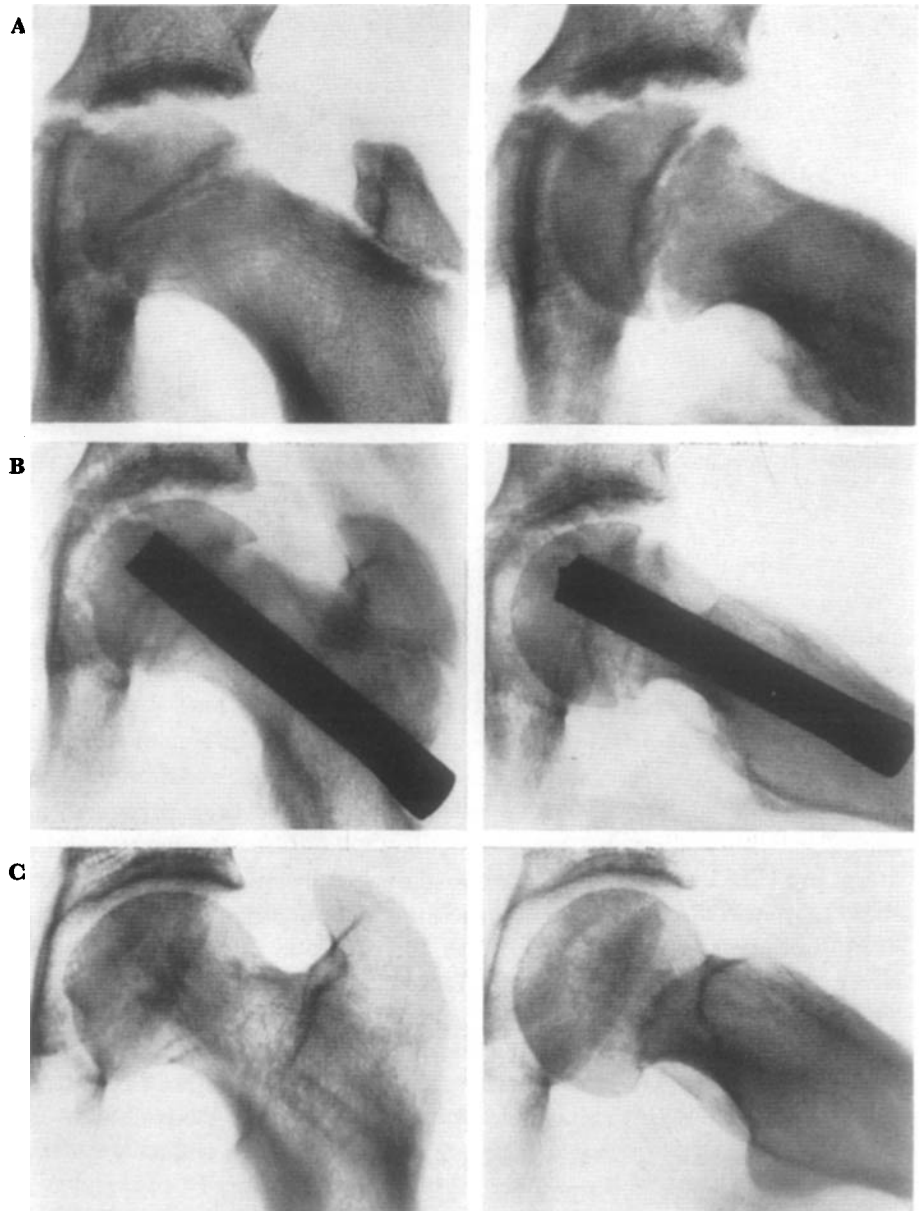

Fig. 4. Left hip of a boy aged 14 at the time of nailing. This is the same case as in Fig. 1.
A. — The degree of slipping was regarded as slight and the capital epiphysis fixed with a vitallium nail.
B. — Two months after nailing.
C. — Six years 3 months after operation at the follow-up examination. The patient had done his military service. No pains, no limb. No discrepancy of the legs. The Gade index over 85 in both hips. The result was regarded as excellent.

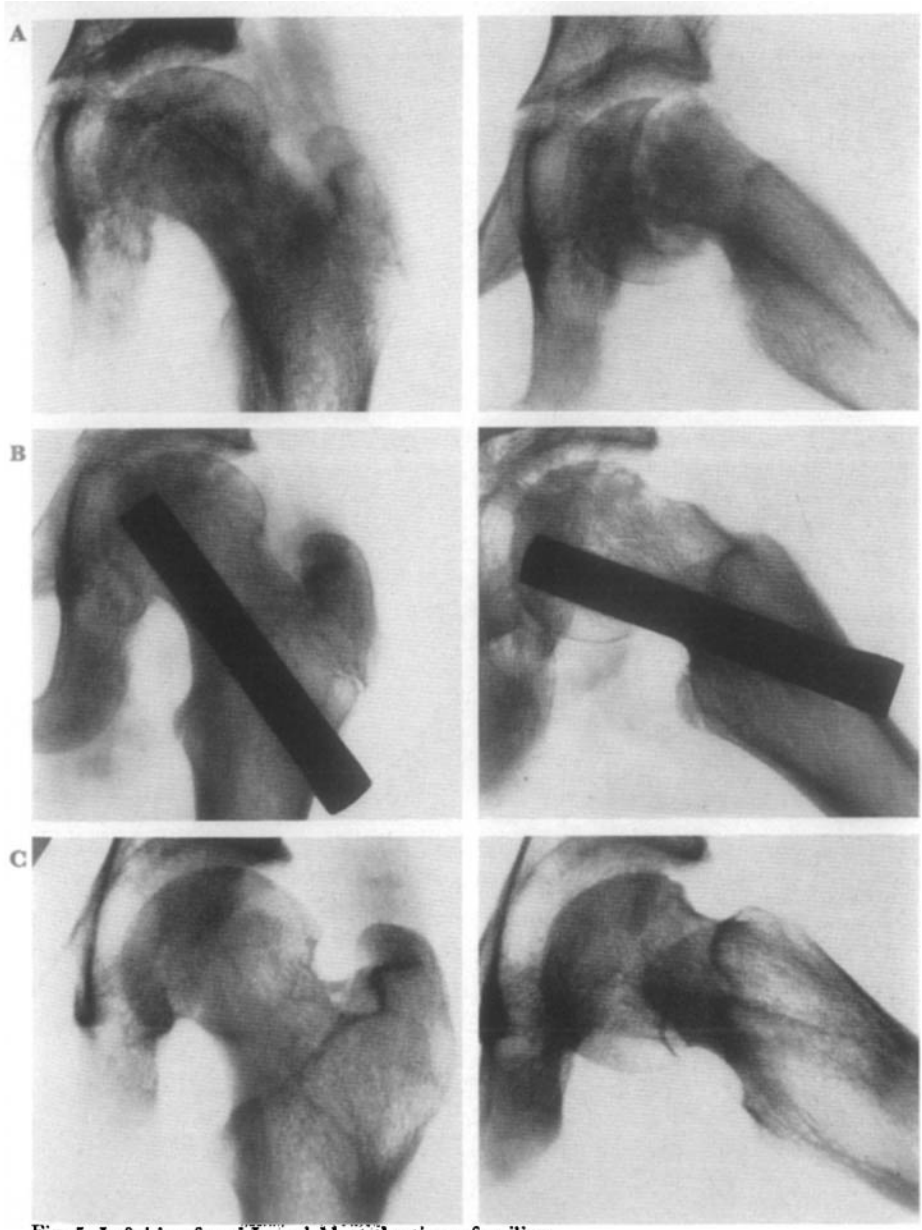

Fig. 5. Left hip of a girl aged 11 at the time of nailing.
A. – The degree of slipping was considered to be less than half of the extent of the epiphysis. The lateral view on the right.
B. – The epiphysis was fixed with a vitallium nail without an attempt at closed reduction. Closed reduction had been attempted at another hospital previously without success. This X-ray was taken 3 months after nailing and as can be seen in the lateral view the protruding part of the neck in its upper corner has resorbed.
C. – At the follow-up 3½ years after operation the hip movements were free except for the slight restriction of the internal rotation. No discomfort. No limp. Index of mobility according to Gade was over 85. The result was considered excellent.

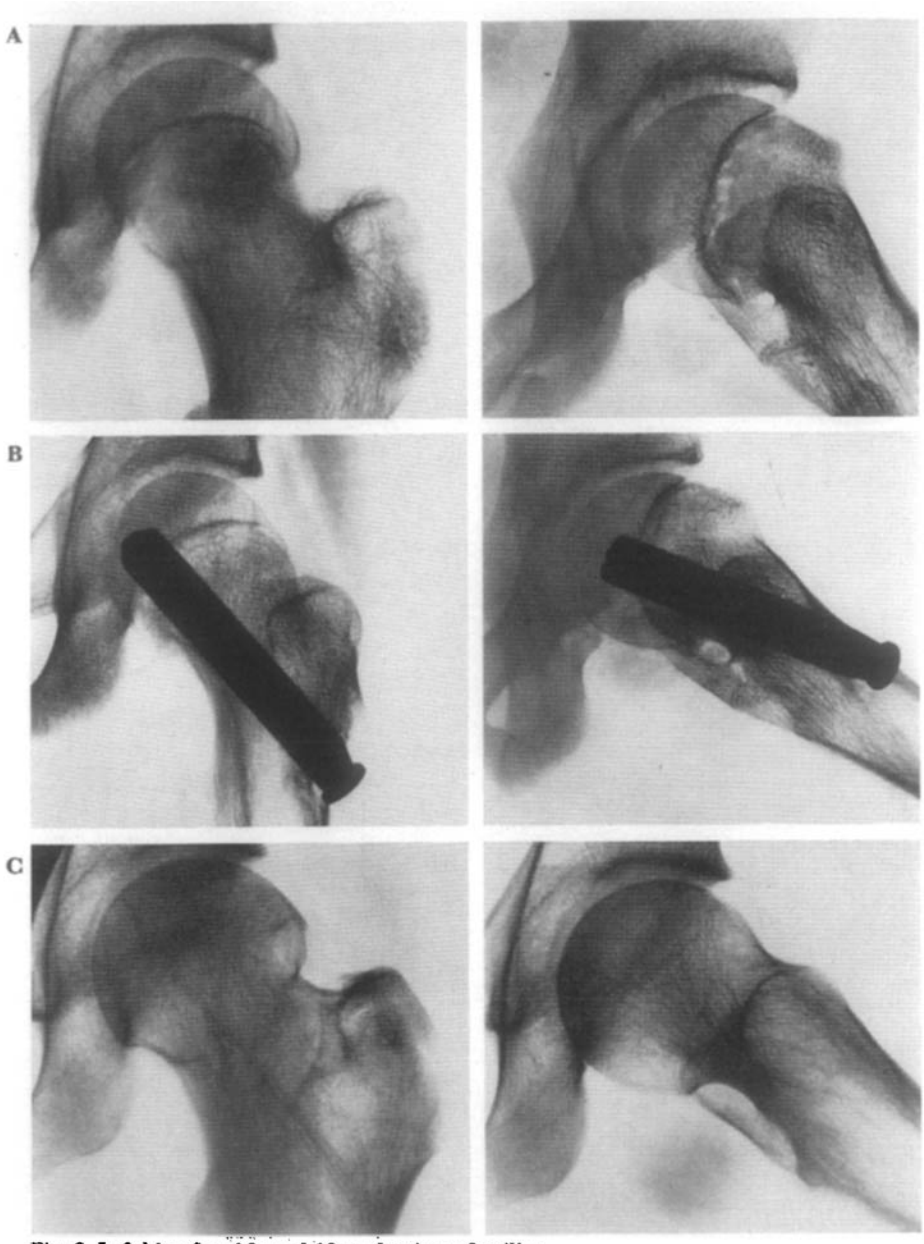

Fig. 6. Left hip of a girl aged 12 at the time of nailing.
A. — The degree of slipping was considered as less than half of the extent of the epiphysis. The slipping can be seen in the antero-posterior X-ray too.
B. — The epiphysis was fixed with a Smith-Petersen nail. The X-ray was taken two months postoperatively.
C. — Nine years after operation. No discomfort. Plays tennis and other sports like skiing, and swimming. No limp. No discrepancy of the legs. Index of motion according to Gade 85. The result was regarded as excellent

Howorth's operation

The Howorth operation or bone pegging has been practised at our hospital since 1961. Up to the end of 1965 a total of 15 operations according to this method had been performed. The number is now somewhat higher. The indication for this kind of fixing of the epiphysis has been a slipping of at least 1/3 of the extent of the capital epiphysis, usually more. The operation is in our opinion simple and easy to perform. The postoperative mobilisation of the patient is quick. The patients have been allowed to move with elbow crutches in 2—3 weeks after operation without weight bearing and full weight bearing is allowed according to signs of closure of the epiphyseal plate in the X-ray. This has usually been in 2—3 months postoperatively. The passive and active joint movements are begun during the first postoperative week. (Figs. 7 and 8).

Table 14 shows the results of Howorth operation at the time of follow-up examination according to the degree of slipping.

Table 14

Results with Howorth operation

Degree of slipping	No.	Results Excellent or good	Fair	Poor
Slight	0	0	0	0
Under 1/3	2	2	0	0
Under 1/2	5	2	2	1
Over 1/2	8	7	0	1
Complete	0	0	0	0
All	15	11	2	2

In one case regarded as poor at the follow-up, a closed reduction had been attempted previously at another hospital without result. The degree of slip was under 1/2 but was mostly backwards so that the position of the leg was in external rotation. Possibly a subtrochanteric correction osteotomy should have been indicated. This was not performed, however. At the follow-up almost 4 years after operation the movements of the hip were the same as before the operation except for rotations, which were absent. The patient had no symptoms but in the X-ray a slight arthrosis was evident. The Gade mobility index was 45.

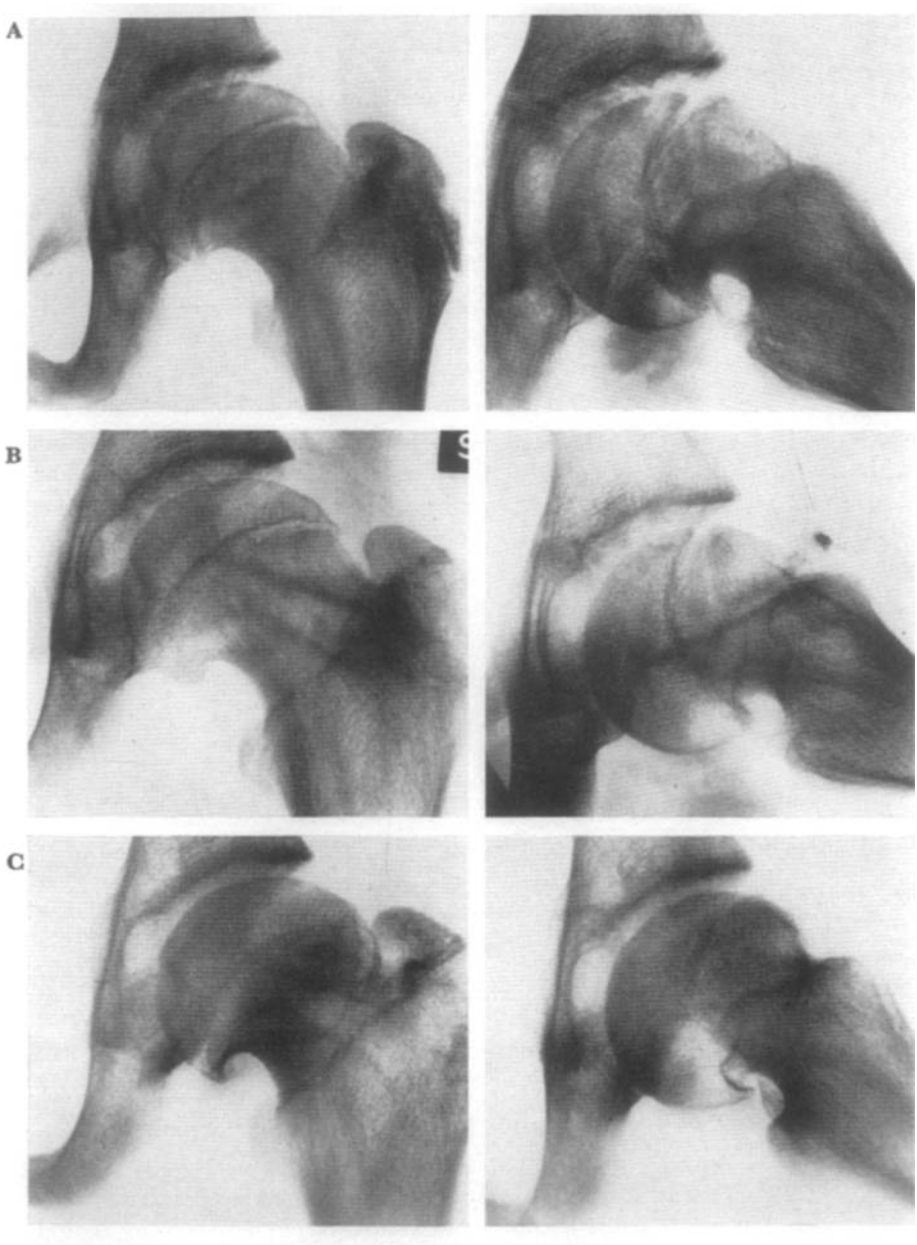

Fig. 7. Left hip of a boy aged 13 at the time of Howorth operation.
A. — The degree of slip was regarded as less than third of the extent of the epiphysis. Adduction and internal rotation were limited before operation. The left leg was 1 cm shorter than the right.
B. — 3½ months after bone pegging operation according to Howorth.
C. — 2 years and 5 months after operation at follow-up. No discomfort. The internal rotation limited. Walks without limp. The index of motion 77.5. The result was regarded as good.

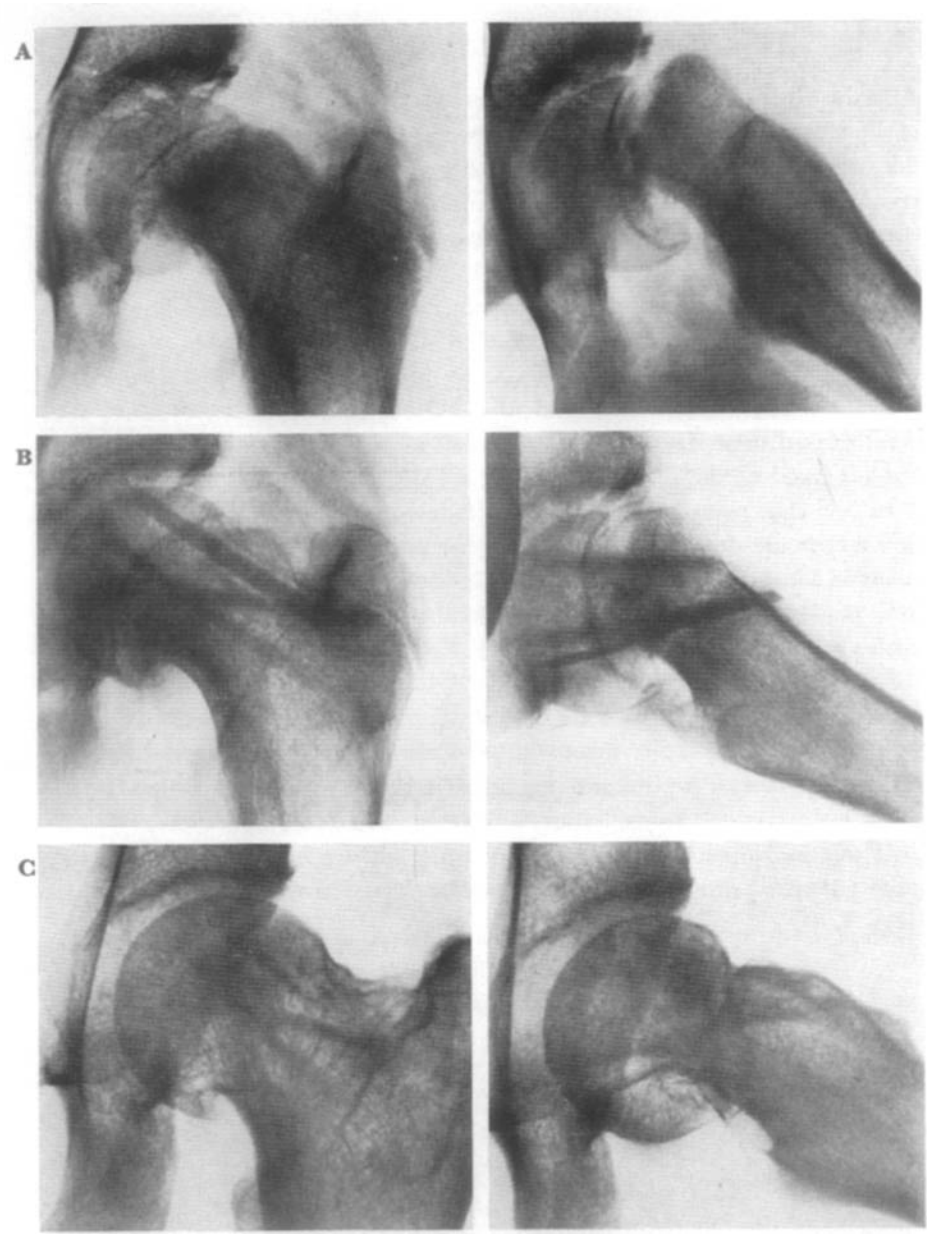

Fig. 8. The left hip of a girl aged 12 at the time of Howorth operation.
A. — The degree of slip was regarded as over half of the extent of the epiphysis. The internal rotation was absent before operation.
B. — Three months after Howorth operation. The bone pegs are clearly seen.
C. — Four years 7 months postoperatively. No discomfort. Works in a shop as a salesgirl. No limp. No discrepancy. All movements are free, including the internal rotation. Gade index 85. The result was regarded as excellent.

In the other case regarded as poor there was nothing exceptional. The degree of slip was over 1/2. The patient was 4 weeks in bed postoperatively and began full weight-bearing in 4 months. Later a subtrochanteric osteotomy was regarded as indicated for varus-external rotation deformity, but for some reason this was not performed. Obviously this would not have improved the mobility, which poor was very already preoperatively. There were only 30 degrees of flexion while other movements were absent. At the follow-up only 15 degrees of flexion were observed. The Gade mobility index was 9. The patient had no symptoms. In the X-ray of the hip there was a superficial necrosis of the femoral head and acetabulum similar to the so-called Waldenström's disease. In both cases regarded as poor no obvious reason for this was observed at the operation itself.

In one case regarded as fair at the follow-up an attempt of closed reduction was made during the operation. The position of the head could not be changed however. In a postoperative X-ray one tibial graft was observed to have penetrated the surface of the femoral head into the joint. At the follow-up 5 years after operation the femoral head was deformed in the X-ray but the tibial grafts had resorbed.

In both cases regarded as fair a subtrochanteric osteotomy was performed. The Gade mobility index was 61 in one case and 66 in the other. The latter was a patient with a pituitary tumour. His height at the follow-up was 218 cm. He was treated by radiotherapy before orthopedic operations.

As our indications for Howorth operation have occurred in patients with more advanced slippings the results can be regarded as good in our opinion (Figs. 7, 8).

Wedge osteotomy

In nine cases in this material a wedge osteotomy of the femoral neck was performed. The wedge was taken from the middle of the neck with its base in the upper anterior part so that the varus external rotation deformity could be corrected. In five cases a postoperative immobilisation in a plaster hip spica for from 6 to 8 weeks was used. The fragments were fixed in all cases with a Smith-Petersen nail. In one case the nail came out of the neck after 4 weeks and the patient had to be operated again. An intertrochanteric correction osteotomy was done at the same time as refixation of the fragments. The result in this case was excellent six years later at the follow-up.

The results at the follow-up according to the degree of slipping are shown in Table 15.

Table 15

Results with wedge osteotomy

Degree of slipping	No.	Results Excellent or good	Fair	Poor
Slight	0	0	0	0
Under 1/3	0	0	0	0
Under 1/2	2	2	0	0
Over 1/2	6	6	0	0
Complete	1	0	1	0
Total	9	8	1	0

All these osteotomies were performed between 1957—1960. As reports by different authors were less encouraging they have not been performed since. As can be seen in Table 15 the results at the follow-up in this small group of wedge osteotomies are surprisingly good and correspond to results reported recently by Dunn (1964) and others (Figs. 9, 10 and 11). It is unlikely however that an osteotomy of the neck should be indicated in cases where the degree of slipping is small, as the results without such an osteotomy in these cases are excellent or good even in this material.

Open reduction

Open reduction here means an operative repositioning of the epiphysis of the femoral head without resection of the neck.

The open reductions were performed in 1954—1963, and they were four in all.

After open reduction the femoral head was fixed with McLaughlin nail in two cases, with Smith-Petersen nail in one case and was left without internal fixation in one case. Plaster immobilisation was used in two cases.

One case was regarded as excellent at follow-up 11 years after operation. The Gade mobility index in this case was over 85. The patient had been classified as a Grade A during the military service. He had no symptoms, no limp, no discrepancy. The radiologic appearence of the head was good.

The result in two cases was regarded as good. The Gade mobility index was 81 in one patient and 75 in the other. They had no symptoms. One of them came to follow-up 13 years after operation the other 6 years after operation. Despite the lack of symptoms they were not accepted for military service. The head was slightly deformed in both cases in the X-ray (Fig. 12).

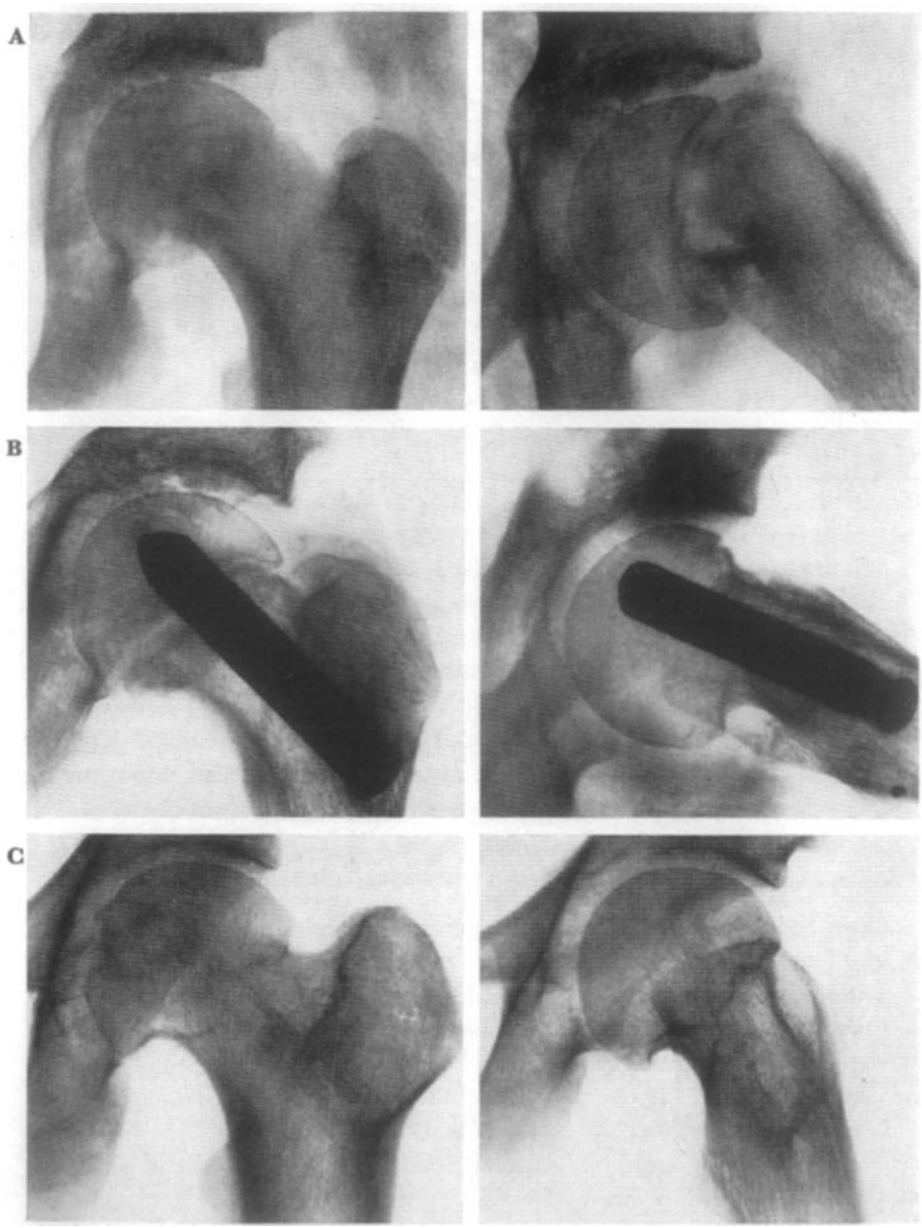

Fig. 9. The left hip of a boy aged 14 at the time of a wedge osteotomy.
A. — The degree of slip was regarded as over half of the extent of the epiphysis. The boy felt pain in the hip for 6 months.
B. — One month after a wedge osteotomy. The fragments were fixed with a Smith-Petersen nail and a plaster hip spica was applied for a month.
C. — Nine years 6 months postoperatively. No discomfort. Slight limp. The left leg is 2 cm shorter. Except for internal rotation the hip movements are free. Index of mobility 77. Result was considered good.

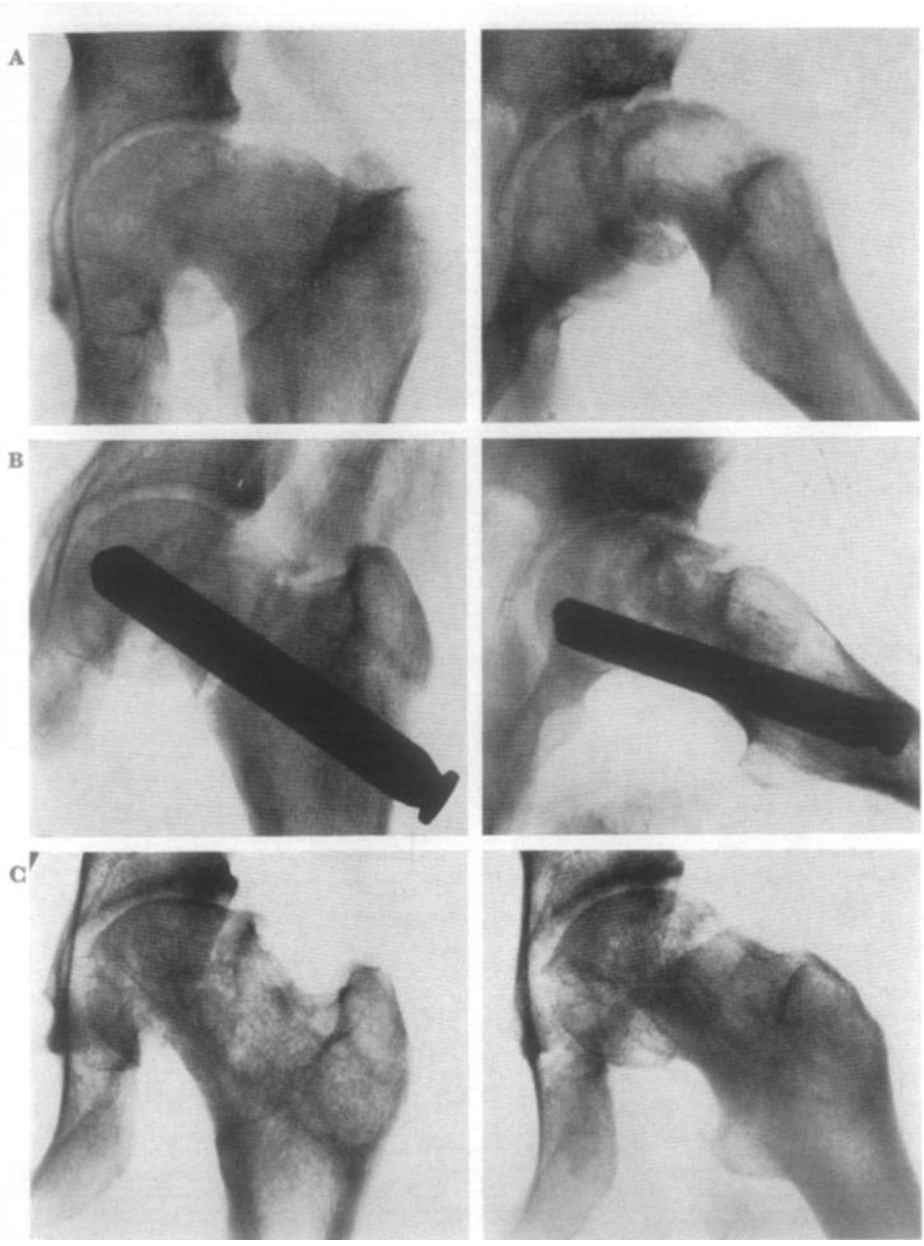

Fig. 10. The left hip of a girl aged 14 at the time of a wedge osteotomy.
A. — The degree of slip was estimated as over half of the extent of the epiphysis. Rotations and abduction were absent before operation. The left extremity was 2 ½ cm shorter.
B. — A few weeks after a wedge osteotomy and fixation with a Smith-Petersen nail.
C. — Eight years 5 months after operation. Walks almost without a limp. The left leg is 1 ½ cm shorter. The internal rotation is limited, otherwise hip movements are free. No discomfort. Index of mobility 85. The result was regarded as excellent.

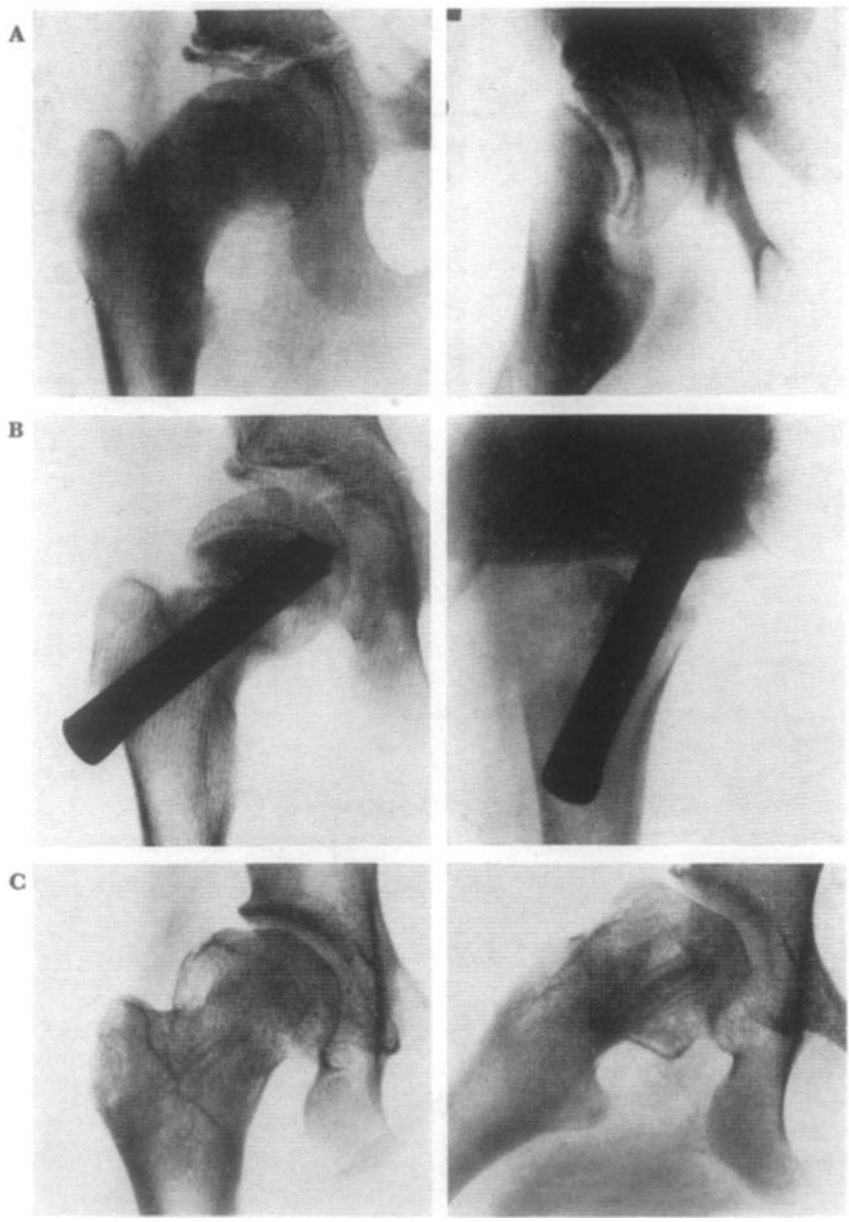

Fig. 11. Right hip of a girl aged 11 at the time of a wedge osteotomy.
A. — The degree of slip was complete. Traction was applied for one month without effect.
B. — One week after a wedge osteotomy and fixation with a vitallium nail. A slight necrosis of the epiphysis was noticed a few months after operation and a Thomas splint was used. The nail was removed two years after operation.
C. — Seven years after operation. No discomfort. Walks with a slight limp. No discrepancy of the legs. The rotations are restricted. Gade index 70. The result was regarded as fair.

The result in one case was regarded as poor at the follow-up. In this case the fragments were fixed with a McLaughlin nail which obviously penetrated the surface of the femoral head into the joint. This was evident in the special control X-rays after operation. The nail was left in place, however, and resulted in cartilage necrosis of the femoral head. At the follow-up 4 years after operation the patient felt pains on strain. The Gade mobility index was 54 but because of the appearance in the X-ray the result was regarded as poor (Fig. 13).

Thus the results in three of four cases were excellent or good after 6—13 years follow-up. Only one result was regarded as poor and even in this case the reason for a poor result was not the open reduction itself but a nail penetrating the joint cartilage. The number of operations is so small, however, that no further conclusions can be made according to the value of this operation, or the risk involved.

ALL TYPES OF TREATMENT

The result with all types of treatment summarised are shown in Table 16.

Table 16

Results with different types of treatment

		Results		
Treatment	No.Hips	Excellent or good	Fair	Poor
Nailing	50	44	5	1
Howorth oper.	15	11	2	2
Wedge ost.	9	8	1	—
Open reduct.	4	3	—	1
Other oper.	9	1	7	1
Cons.treat.	11	4	5	2
All	98	71	20	7

The group "other operations" contains 7 subtrochanteric and intertrochanteric osteotomies, one drilling operation and the previously mentioned Judet arthroplasty after an unsuccessful open reduction. In the present material 5 other intertrochanteric or subtrochanteric osteotomies were performed after nailing or Howorth operation. These have not been mentioned separately, however. The Judet arthroplasty led to a poor result. It was performed, as mentioned, in connection with an unsuccessful attempt at open reduction, and the arthroplasty itself produced a painful condition later.

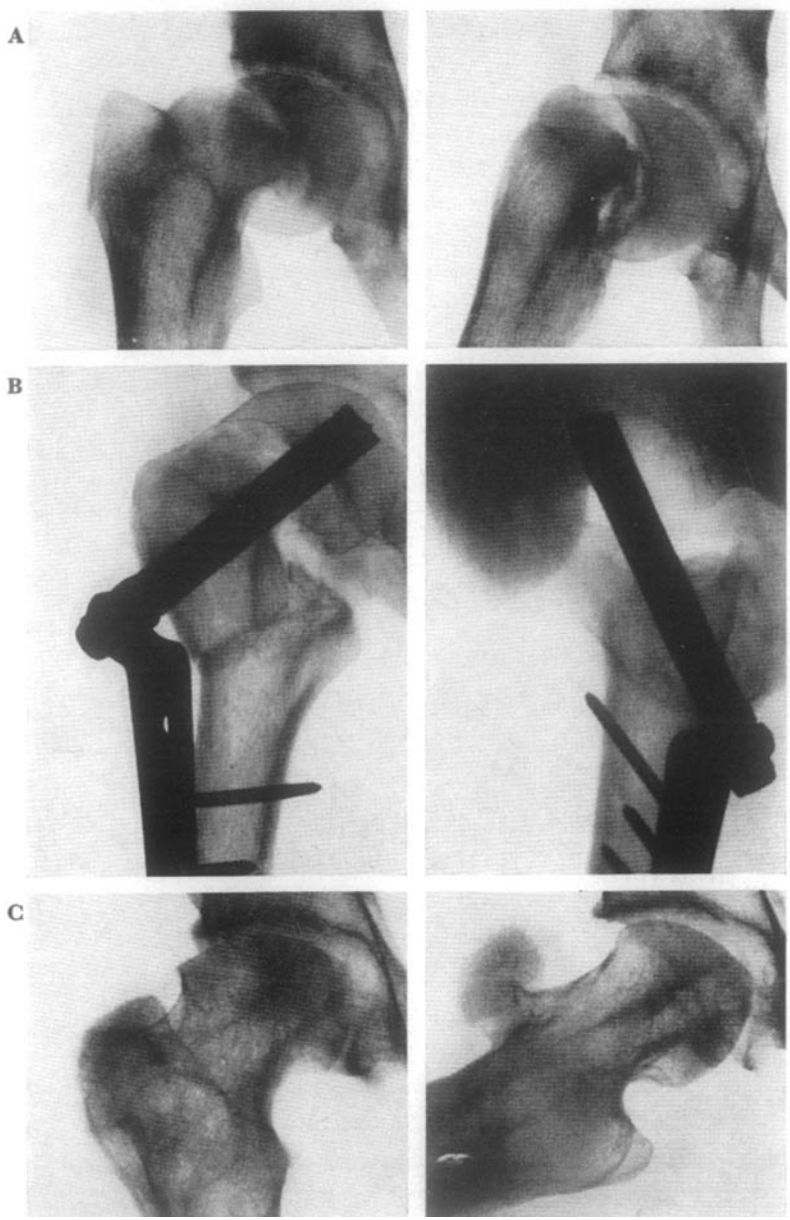

Fig. 12. The right hip of a boy aged 15 at the time of open reduction and an intertrochanteric osteotomy.
A. — The degree of slip was over half of the extent of the epiphysis.
B. — One month after an open reduction and an intertrochanteric osteotomy. Plaster hip spica was used for one month. The fragments were fixed with a McLaughlin nail.
C. — Seven years after operation. No discomfort. Walks with a slight limp. The right lower extremity is 1 cm shorter. The index of motion is 81. The result was regarded as good.

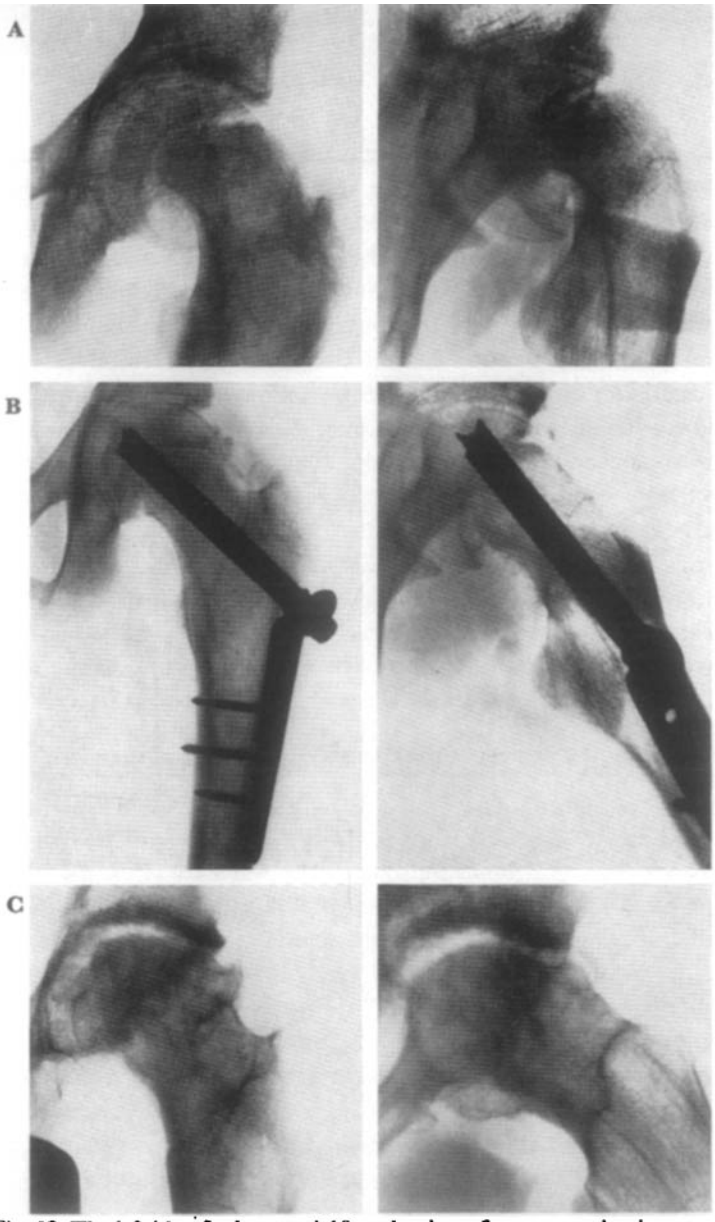

Fig. 13. The left hip of a boy aged 16 at the time of an open reduction.
A. – The degree of slip was over half of the extent of the epiphysis. All hip movements were restricted.
B. – Three weeks after an open reduction and fixation with a McLaughlin nail. The nail seems to be in place but in tangential X-ray it was seen to penetrate the joint surface of the epiphysis. As the patient did not have any symptoms the nail was left in place for four months, and then removed.
C. – At the follow-up three years 8 months postoperatively. The patient felt pain in the hip after walking. Walks with a limp. The left lower extremity is 1 cm short. The rotations are absent. Abduction and adduction 10 – 15 degrees. Gade index 54. Signs of cartilage necrosis in the X-ray, similar to the so-called Waldenström's desease. The result was regarded as poor.

Denervation was carried out later, but brought no relief. Eventually arthrodesis was performed at another hospital. The result was naturally considered poor. In the two conservative cases with poor results, the patient on whom operative reduction had been attempted elsewhere came for follow-up examination 6 years after the original operation without the slighest discomfort. There was a 5 cm shortening of the lower limb, the Gade mobility index was 12, and the X-ray picture showed that the capital epiphysis had almost disappeared. The other patient came for follow-up 9 years after the original visit. There had been a slipping of over half the extent of the epiphysis. He had advanced stiffness in the hip. The X-ray showed that the head was completely deformed. The Gade index was 46. The result was considered poor.

As shown earlier in the literature, the extent of slipping has an important effect on results. Table 17 therefore shows the whole material classified according to degree of slipping, irrespective of treatment.

Table 17

Result with all types of treatment according to displacement

		Results		
Degree of slipping	No.Hips	Excellent or good	Fair	Poor
Slight	18	18	—	—
Under 1/3	25	20	5	—
Under 1/2	24	16	7	1
Over 1/2	29	17	7	5
Complete	2	—	1	1
All	98	71	20	7

Although operations in this series have been performed by several different methods and by different surgeons over a period of 20 years, and although some cases have remained untreated because of neglect or incorrect diagnosis or have been treated conservatively, it appears that the extent of slipping has a vital influence on results. Thus in cases which have been considered satisfactory or poor at follow-up, slipping has usually been half or more than half the extent of the capital epiphysis. This is natural, because deformity resulting from considerable slipping and disturbance in development of the femoral head obviously has an adverse effect on the result, regardless of treatment.

DISCUSSION

The etiology of the slipped upper femoral epiphysis is quite evidently connected with hormonal influence at least in some respect. Roughly 30 per cent of the patients in this material were overweight or even more clearly had an endocrine disturbance. As Harris (1950) observed an excess of the growth hormone may weaken the epiphyseal plate and the sex hormone strengthens it against tangential strain. The tallest boy in this material was 218 cm or 7 ft 3 ins. It is naturally of some importance that not all cases of slipped epiphysis are bilateral. On the other hand the diagnosis of very slight slip which may recover without treatment is very difficult. Using a careful and thorough technique of examination Billing and Severin (1959) found evidence of a bilateral slip in 80 per cent of cases. A mere weakening of the epiphyseal plate without displacement may even then escape diagnosis. (Figs. 1, 2.) Thus a very high percentage of cases are after all bilateral.

If a lateral radiograph is taken, the diagnosis of a slipped femoral epiphysis is in most cases easy. This is often neglected however, and in an anteroposterior radiograph a slight slip can only be diagnosed with difficulty despite the typical signs described by Jerre (1950) and Waldenström (1939).

Howorth (1966) has stated that there exists a so-called preslipping stage in which there is only swelling of the synovial membrane and villous formation. In this material there were 11 hips in which the only sign of a slip was widening or irregularity of the epiphyseal line in the lateral X-ray or a slip of 1—2 mm only. Six of these patients felt pains in the hip but five did not. Thus obviously a preslipping stage may exist without symptoms.

Traction did not seem to affect the result of treatment in this material. Its use has therefore been abandoned at our hospital in the preoperative treatment of a slipped epiphysis.

Closed reduction was successful in four cases out of ten in this material. Of these four cases in which the closed reduction was considered to have improved the position of the head, only one was regarded as good at the follow-up. One was poor and two fair. It seems to us that a closed reduction

is only indicated, if the slip is very recent and the degree of slipping is at least half the extent of the capital epiphysis, since results by nailing or Howorth operation without reduction are reasonably good in mild cases. On the other hand, if the slipping is severe or complete, the position of the head should be corrected either by closed reduction or better still with a wedge osteotomy.

The number of cases of open reductions and wedge osteotomies is very small, so that absolute conclusions cannot be drawn from the results obtained. It seems, however, as if a wedge osteotomy might have a place in the treatment of a severe slip if the operation can be performed by a skilled surgeon.

The Howorth operation was regarded as an easy and safe procedure. The result in two cases regarded as poor at the follow-up may result from other causes than the operation method itself, probably too wide an exposure at operation. In most cases operated according to Howorth the degree of slipping was more than half the extent of the capital epiphysis, and this of course affects the result.

The results by nailing with a Smith-Petersen nail in this series are mostly good. Complications that might occur with a trifin nail were observed only in very few cases and recovered without treatment in most of them. Only one case in 50 was regarded as poor at the follow-up, and in this case a closed reduction had also been performed. In recent years, we have used only thin nails intended for children. The only complication that occurred was that the nail reached too far and penetrated the joint cartilage. This of course can be prevented with proper operation technique and with a careful X-ray control.

Follow-up examination showed that the fixation of the epiphysis is indicated in cases of slight and moderate slipping because its neglect may allow an increase of slipping later and affect the result adversely. In the entire material the results were much better with any type of treatment in cases of slight or moderate slip. The more severe the slip the less favorable is the result. Therefore an early diagnosis of a slipped upper femoral epiphysis is the surest guarantee of a good result, as it is in the treatment of many other conditions in medical practice.

SUMMARY

The authors have analysed a total of 99 treated hips with a slipped femoral epiphysis, of which 98 were re-examined at follow-up. The average observation time was 6. 7 years. The longest observation time was 19 years. There were 19 bilateral cases. The degree of slipping was assessed from a lateral X-ray. Slipping was classified as slight, under 1/3, under 1/2, over 1/2 and complete slipping.

Fifty-one hips were treated by nailing, and 50 of these patients appeared for follow-up. Fifteen hips were treated by Howorth's bone pegging operation, 9 by wedge osteotomy, 4 by open reduction, 7 by intertrochanteric or subtrochanteric osteotomy. One was treated by Judet arthroplasty and one by drilling. Eleven cases were treated conservatively, i.e. no operation was performed. Actual conservative treatment was given to 4 patients only. The remainder had been operated on in other hospitals or neglected.

Results were assessed from the patient's own estimation, from clinical examination and from X-rays. In clinical examination the Gade index was used. An index of 50 or less was considered poor.

At follow-up examination of the 50 nailed cases 44 were excellent or good, 5 fair and only one was poor. Of those 15 operated by the Howorth method 11 were excellent or good, 2 fair and 2 poor. After wedge osteotomy 8 cases were good or excellent, one was fair and none poor. After open reduction 3 were excellent or good, one was poor. The present material showed that the extent of the slipping had a marked effect on the result of treatment: when the slipping was less than half the extent of the epiphysis excellent or good results were achieved in 54 cases of 67 (80.6 per cent), fair in 12 (17.9 per cent) and poor in only one (1.5 per cent), regardless of the type of treatment or the method of operation. When the slipping was over half, however, 17 cases out of 31 (54.8 per cent) were excellent or good, 8 fair (25.8 per cent) and 6 poor (19.4 per cent). In the whole material 71 cases out of 98 (72.5 per cent) were excellent or good, 20 fair (20.4 per cent) and 7 poor (7.1 per cent).

REFERENCES

BADGLEY, C. E., ISAACSON, A. S., WOLGAMOT, J. C. and MILLER, J. W.: (1948) Operative therapy for slipped upper femoral epiphysis.
J. Bone Jt Surg, *30 A:* 19—30.

BILLING, L. and SEVERIN, E.: (1959) Slipping epiphysis of the hip.
Acta radiol, *175:* 5—76.

BOUSSEAU, M.: (1867) Disjonction épiphysaire traumatique de la tête du fémur.
Bull. Soc. anatomique de Paris. *42:* 283—286.

BURROWS, H. J.: (1957) Slipped upper femoral epiphysis. Characteristics of a hundred cases.
J. Bone Jt Surg. *39 B:* 641—658.

COLIGNON, J.: (1868) Thèse de la disjonction traumatique des épiphyses.
No. 226 Paris Thesis.

DUNN, D. M.: (1964) The treatment of adolescent slipping at the upper femoral epiphysis.
J. Bone Jt. Surg. *46 B:* 621—629.

DURBIN, F. C.: (1960) Treatment of slipped upper femoral epiphysis.
J. Bone Jt Surg. *42 B:* 289—302.

DUVERNEY, G. I.: (1751) Traité des maladies des os, Vol. 1. chap 8, pp. 355—375.

FAHEY, J. J. and O'BRIEN, E. T.: (1965) Acute slipped capital femoral epiphysis. Review of the literature and report of ten cases.
J. Bone Jt Surg. *47 A:* 1105—1127.

FERGUSON, A. B. and HOWORTH, M. B.: (1931) Slipping of upper femoral epiphysis. A study of seventy cases.
J. Amer. Med. Ass. *97:* 1867—1872.

FRIBERG, S. (1948) Open reduction for slipping of the upper femoral epiphysis.
Acta orthop. scand. *17:* 187—194.

FORRESTER-BROWN, M.: (1941) Slipping of the upper femoral epiphysis. End results after conservative treatment.
J. Bone Jt Surg. *23:* 256—262.

GADE, H. G.: (1947) A Contribution to the surgical treatment of osteoarthritis of the hip-joint: a clinical study.
Acta chir. scand. *95:* suppl. 120.

GREEN, W. T.: (1945) Slipping of the upper femoral epiphysis.
Arch. Surg. *50:* 19—32.

HALL, J. E. (1957) The results of treatment of slipped femoral epiphysis.
J. Bone Jt Surg. *39 B:* 659—673.

HARRIS, W. R.: (1950) The endocrin basis for slipping of the upper femoral epiphysis. An experimental study.
J. Bone Jt Surg. *32 B:* 5–11.
HERNDON, C. H., HEYMAN, C. H. and BELL, D. M.: (1963) Treatment of slipped capital femoral epiphysis by epiphyseodesis and osteoplasty of the femoral neck. (A report of further experiences).
J. Bone Jt Surg. *45 A:* 999–1012.
HIERTONN, T.: (1955) Wedge osteotomy in advanced femoral epiphyseolysis.
Acta orthop. scand. *25:* 44–62.
HOWORTH, M. B.: (1949) Slipping of the upper femoral epiphysis.
J. Bone Jt. Surg. *31 A:* 734–747.
HOWORTH, M. B.: (1957) Slipping of the upper femoral epiphysis.
Clin. Orthop. *10:* 148–173.
HOWORTH, M. B.: (1965) Slipping of the capital femoral epiphysis.
Amer. Jour. Orthop., Jan.-Apr.
HOWORTH, M. B.: (1966) Symposium on slipped capital femoral epiphysis.
Clin. Orthop. Research. *48:* 10–87.
JERRE, T.: (1950) A study in slipped upper femoral epiphysis.
Acta orthop. scand., suppl. 6.
KEY, J. A.: (1926) Epiphyseal coxa vara or displacement of capital epiphysis of femur in adolescence.
J. Bone Jt Surg. *8:* 52–117.
KLEIN, A., JOPLIN, R. J., REIDY, J. A. and HANELIN, J.: (1953) Management of the contralateral hip in slipped capital femoral epiphysis.
J. Bone Jt Surg. *35 A:* 81–87.
LINDSTRÖM, N.: (1958) Surgical treatment of epiphyseolysis capitis femoris.
Acta orthop. Scand. *28:* 131–146.
LÖFGREN, L.: (1953) Slipping of upper femoral epiphysis, signs of endocrine disturbance, size of sella turcica and two illustrative cases of simultaneous slipping of upper femoral epiphysis and tumor of the hypophysis.
Acta chir. scand. *106:* 153–165.
MÜLLER, E.: (1888) Über die Verbiegung des Schenkelhalses im Wachstumsalter.
Beitr. z. klin. Chir. *4:* 137–148.
NEWMAN, P. H.: (1960) The surgical treatment of slipping of the upper femoral epiphysis.
J. Bone Jt Surg. *42 B:* 280–288.
POLAND, JOHN: (1898) Traumatic separation of the epiphyses. London, Smith Elder and Co.pp 615–661.
SCHULTZ, J.: (1892) Zur Kasuistic der Verbiegungen des Schenkelhalses.
Ztschr. orthop. Chir. *1:* 49.
WALDENSTRÖM, C. H. (1930) On necrosis of the joint cartilage by epiphyseolysis capitis femoris.
Acta chir. scand. *67:* 936–946.
WALDENSTRÖM, H.: (1939) Om epifysglidning i höften. Esselte AB. Stockholm.
WIBERG, G.: (1941) Epiphyseolysis capitis femoris.
Acta orthop. scand. *12:* 179–213.
WIBERG, G.: (1955) Wedge osteotomy in serious slipping of the upper femoral epiphysis.
Acta orthop. scand. *25:* 63–67.

WIBERG, G.: (1959) Consideration on the surgical treatment of slipped epiphysis with special reference to nail fixation.
J. Bone Jt Surg. *41 A:* 253–261.
WILSON, P. D.: (1924) Displacement of upper epiphysis of the femur traeted by open reduction.
J.A.M.A. *83:* 1749–1756.
WILSON, P. D.: (1938) The treatment of slipping of the upper femoral epiphysis with minimal displacement.
J. Bone Jt Surg. *20:* 379–399.
WRIGHT, G. A.: (1887) Hip disease in childhood.
p. 239, Longmans, London.