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A STUDY IN SLIPPED UPPER FEMORAL EPIPHYSIS

WITH SPECIAL REFERENCE TO THE LATE
FUNCTIONAL AND ROENTGENOLOGICAL
RESULTS AND TO THE VALUE
OF CLOSED REDUCTION

BY

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PREFACE

Ever since the end of the last century slipped upper femoral epiphysis has attracted much attention. At several congresses this disease of the hip was the chief subject of discussion or was at least given a prominent position. It has been the subject of much research and has been viewed from various angles in a very large number of publications.

Nevertheless, our knowledge of many aspects of the condition is still fairly incomplete. The etiology of the disease is still obscure. There is still cleavage of opinion on certain diagnostic points. Neither is there unanimity from the therapeutic point of view, and finally, how the prognosis will be a long time after the onset of the condition is an unknown factor.

When I joined the staff of the Orthopaedic Clinic, Lund, in 1947, the chief of that clinic, Professor Gunnar Wiberg, M. D., awakened my interest in these problems, and in autumn 1947 I commenced the present investigation.

Already at an early stage so many problems concerning this disease arose that a considerable limitation proved necessary.

The main purposes of the present investigation were therefore only, on the basis of a careful clinical and roentgenological re-examination of a relatively large number of cases, to elucidate a) the late functional and roentgenological results observed not only in early adulthood but also in relatively advanced age and b) the value of closed reduction.

The etiology, the pathological anatomy, the symptomatology and technical details of various forms of treatment will therefore not be discussed at all, and diagnostic aspects will be described only in so far as they are of importance for the establishment of a definite diagnosis according to the principles adopted in the present study.

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Chapter I

HISTORY

BROUSSEAU seems to have been the first to have described a separation of the epiphysis in the hip. In 1867 he gave an account of a case in which a 15-year-old boy had been run over by a cart and sustained such serious injuries that he soon died. Autopsy showed a complete separation of the epiphysis from the femoral neck.

This report was soon followed by communications of other authors of so-called traumatic separation of the upper femoral epiphysis which, however, in no respect was regarded as differing from ordinary traumatic epiphyseal separation in other joints. In 1898 POLAND was able to collect 31 cases of this kind from the literature.

Already before BROUSSEAU's above-mentioned publication WERHNER (1847) and ZEIS (1851), for example, had described anatomical preparations with a deformity of such an appearance as might probably be referable to an earlier slipped upper femoral epiphysis.

MONKS (1886) gave a detailed description of the clinical picture presented by a 16-year-old boy with a disease of the hip. He discussed the etiology and concluded the most probable diagnosis to be arthritis deformans. KEETLEY (1888) reported a case with similar symptoms and signs in a 20-year-old female: he was of the opinion that the disease was a consequence of rachitis. But, judging by the descriptions, there is reason to suppose a slipped upper femoral epiphysis in both of these cases.

MÜLLER (1888) described a hip disease he had observed in 4 patients during adolescence. He presented a detailed descrip-

ion of the clinical picture which was in all respects typical of slipped upper femoral epiphysis. He gave a detailed account of the gross and microscopic patho-anatomy of 1 of these cases in which the hip joint was resected, and inter alia described a deformity typical of slipped upper femoral epiphysis. He emphasized that in these cases there was no separation in the epiphyseal line but that the disease in these 4 patients constituted a hitherto undescribed clinical entity which he called "Verbiegung des Schenkelhalses im Wachstumalter."

KOCHER (1894) published 3 cases of exactly the same type as those reported by MÜLLER. On the basis of resected preparations he demonstrated that the deformity was not due to a bend of the femoral neck as a whole but to a bend localized solely to the junction between the femoral head and neck. In analogy with pes varus he suggested the name coxa vara for the condition, which he conceived as an occupational disease due to an "übermässige Belastung in einer bestimmten Stellung" occurring particularly among cheese-makers.

HOFMEISTER (1894), who collected no fewer than 45 cases, practically all from a single clinic, stressed that the condition was by no means uncommon, but that formerly the disease had usually been mis-diagnosed, generally as tuberculous coxitis. Apparently independent of KOCHER this author also suggested the name coxa vara.

SPRENGEL (1898 and 1899) showed that a so-called traumatic separation of the epiphysis may be the cause of the above-mentioned deformity described by MÜLLER and others, "dass das typische klinische und anatomische Bild der Coxa vara nicht bloß durch statische Veränderungen sondern auch traumatisch zu Stande kommen kann durch traumatische Lösung der Kopfepiphyse des Femur und Wiedervereinigung mit dem Schenkelhals an abnormer Stelle". He also pointed out that the trauma necessary for causing a so-called traumatic separation of the epiphysis need not be so very heavy. He suggested the name coxa vara traumatica for such cases.

For several years after SPRENGEL's paper coxa vara adolescentium and coxa vara traumatica were thought to be 2 dif-

ferent clinical entities of different pathogenesis. HELBING (1906), for example, wrote: In coxa vara traumatica the deformity is due to a displacement of the epiphysis in relation to the neck, whereas in coxa vara the deformity is caused "bald durch eine Abbiegung an dem Ansatzpunkte des Schenkelhalses am Schaft, bald durch eine Gestaltsveränderung an der Verbindung des Kopfes mit dem Schenkelhals."

But already soon after SPRENGEL's publication voices were also heard stating that coxa vara adolescentium was only a consequence of an epiphyseal separation. LORENZ (1909), for example, claimed that idiopathic, essential or static coxa vara was only a deformity following a healed epiphyseolysis capitis and that the name coxa vara as a clinical expression was by no means justified.

During the following years the relation between epiphyseolysis capitis femoris and coxa vara was the subject of much discussion. Even as late as 1926 this problem was still of current interest, as will be evident from the fact that it was the subject of a detailed study that year in a thesis from the Orthopaedic Clinic, Lund, by FRISING, entitled, "The relation between epiphyseolysis capitis femoris and coxa vara".

In this study FRISING concludes *inter alia*:

that the primary deformity in coxa vara is localized to the epiphyseal line and that the other deformities belong to later stages, i. e. are secondary,

that in addition to pure epiphyseal fractures there are also spontaneous epiphyseal separations with interruption of continuity and deformities in the region of the epiphyseal line without any demonstrable interruption of continuity,

that an epiphyseal fracture in a given case cannot be distinguished from a spontaneous epiphyseal separation with interruption of continuity,

that spontaneous epiphyseal separation with interruption of continuity and deformities in the region of the epiphyseal line without any demonstrable interruption of continuity are probably only different types of one and the same disease.

Thus in essential respects FRISING's conclusions agree with

the now generally accepted opinion, namely, that the initial stage of the disease always consists of a slipping of the upper femoral epiphysis which can occur without any trauma at all, without giving any symptoms at all, and that this slipping only secondarily gives rise to a coxa vara on account of secondary changes in the region of the femoral head and neck.

Chapter II

DIAGNOSTIC ASPECTS

Opinions differ as to the establishment of the diagnosis of slipped upper femoral epiphysis.

BRAGARD (1940), for example, claims that early stages of slipped upper femoral epiphysis occur with symptoms and signs such as pains, limited mobility and limp without any pathologic x-ray findings, and that the condition can be diagnosed on clinical grounds alone even in the presence of a normal roentgen picture.

Like most others, FERGUSON and HOWORTH (1931) believe in the occurrence of a pre-slipping stage, i. e. a stage with symptoms and signs before any slipping has taken place, but point out that the condition in this stage will nevertheless always be revealed in the roentgenogram by characteristic changes, namely a widened epiphyseal line, structural changes and decalcification of the metaphysis. These changes are, in their opinion, due to a specific pathological process in and about the epiphyseal line.

The existence of a pre-slipping stage is denied by many and most staunchly by WALDENSTRÖM (1939), who asserts that the condition gives no symptoms, that signs are not elicitable until the epiphysis has slipped, and that such slipping can always be visualized by a careful roentgen examination including lateral views.

It is practically generally accepted that if the extent of the displacement is but slight, it will be easiest to recognize in lateral roentgenograms, because when the epiphysis slips, it usually does so first in a backward direction. In lateral views displacement will be revealed by a manifest sidewise shift of

the epiphysis in relation to the femoral neck, usually easiest to detect behind. However, if the epiphysis has slipped but very slightly, a thorough analysis of the roentgen picture may be necessary to reveal the condition.

As just mentioned, initially the epiphysis generally slips backward, and therefore displacement will not be seen in the frontal views as a manifest sidewise shift of the epiphysis until the condition is fairly advanced. But even a relatively slight displacement will usually give a typical frontal picture, the three most important characteristics of which will now be described.

1. Normally the head of the epiphysis bulges over the supero-lateral border of the femoral neck, and in anteroposterior views appears as a prominence, generally known as the hump or the shoulder. Slight epiphyseal displacement is sufficient to cause this hump to disappear, and, according to POMERANZ (1938), "the loss of the hump" is often the first sign of slipping.

2. As seen in the frontal picture, the epiphysis depth apparently decreases with increasing backward displacement of the epiphysis.

3. According to WALDENSTRÖM (1939), already in an early stage of slipped upper femoral epiphysis the surfaces of the epiphysis and metaphysis become irregular and no longer fit each other. In the roentgenogram this is seen as an irregularity and a widening of the epiphyseal line.

In order to avoid the inclusion of misinterpreted cases in the series selected for the investigation, only cases that had been roentgenologically confirmed were accepted, and then only after the author had convinced himself of the correctness of the diagnosis by personal inspection of the roentgenograms. In no instance did the author content himself with roentgen reports alone: those cases in which roentgenograms were not available were rejected.

In the presence of a distinct loss of the hump, or distinctly decreased epiphysis depth, or obviously widened epiphyseal line, a definite diagnosis can, in the opinion of the author, very well be established from frontal views alone. It is, however,

sometimes difficult to decide whether any one of these signs should by itself be regarded as sufficiently pronounced to justify the diagnosis. Therefore, *only those cases were accepted in which anteroposterior or lateral views exhibited a manifest sidewise shift of the epiphysis in relation to the femoral neck.*

In view of the stringency of these roentgenographic criteria, one might have expected that a fairly large percentage of cases would have to be rejected. That this was not the case will be apparent from table I, page 17, which shows that only 13 cases had to be refused on account of "no definite signs of slipping observable in spite of technically satisfactory roentgenograms". In most of these 13 cases the roentgenograms showed nothing abnormal: in some, however, the anteroposterior views showed features slightly suggestive of one or more of the signs described above, but in the author's opinion these features were, however, not distinct enough to justify a definite diagnosis by themselves in any of these cases. Neither did lateral radiograms, in the cases where such views were available, show any manifest sidewise shift of the epiphysis in relation to the femoral neck. Only in 2 instances among the last-mentioned cases were lateral roentgenograms unavailable. In 1 of them the epiphyseal line was possibly a little widened and the hump possibly a little less prominent; in the other case epiphysis depth appeared to be slightly less than on the normal side.

Chapter III

AUTHOR'S SERIES

The cases forming the basis of the present investigation were collected from the Orthopaedic Clinic, Lund, the Orthopaedic Clinic, Malmö, and the Vanförestalt (Orthopaedic Hospital), Hälsingborg.

Only cases diagnosed at least 3 years before the present re-examination were accepted. As the re-examination was practically finished by the end of 1948, the series comprises no patients that were seen for the first time at any of the above hospitals after 1945.

Furthermore, only such cases were included as were so recent when first examined that the epiphyseal line was not completely closed.

The series comprises only those cases in which the diagnosis could be definitely verified roentgenologically in the manner described in the preceding chapter.

When collecting the cases all registers of in-patients, all registers or case records of out-patients (all case records at the Vanförestalt, Hälsingborg) from the commencement of the activity of the respective departments until 31. 12. 45 were perused. At the Orthopaedic Clinic, Malmö, where roentgenograms have been kept only for the years 1919 to 1923 and then again since 1931, this perusal did, however, not include the years 1924—30. In order not to miss any of the cases of slipped epiphysis, notes were made of all cases diagnosed as slipped epiphysis, epiphyseolys. capit. femor., coxa vara adolescent., etc. which are accounted for in table I and secondly, of all those diagnosed as stat. post. epiphyseolys. capit. femor., deformat. post. epiphyseolys. capit. femor., coxa vara posttraumatic., coxa vara post fractur. coll. femor., coxa vara congenit., coxa vara rachitic. and coxa vara. Careful study of the roentgenograms available of the cases in this latter group revealed only 1 instance of definite slipped epiphysis with the epiphyseal line still open. Together with the 165 cases accounted for in table I then, the series comprises 166 cases.

Table I
The Material

Diagnosed as:	Treated at	Excluded because:								Nr. of patients excluded	Nr. of patients included in the present series
		Nr. of patients	epiphyseal line completely closed	secondary changes prevent establishment of definite diagnosis even though epiphyseal line not yet closed	quality of roentgenograms does not permit a definite diagnosis	no definite signs of slipping observable in spite of technically satisfactory roentgenograms	roentgenograms before epiphyseal closure unavailable	roentgenograms definitely show other conditions, e. g. congenital or rachitic coxa vara	patient treated earlier at one of the other hospitals from which the cases were collected and therefore accounted for in those series		
Epifyseolys. capit. femor. Lys. capit. femor. Slipped upper fem. epiphysis.	L ¹ M ² H ³	77 14 91	2 1 6	1 1	 3	 	 	1 1 11	1 2	5 4 23	72 10 68
Coxa vara post epifyseolys. capit. femor. Coxa vara epifyseolytic. Coxa vara adolescent.	L M H	4 6 11	 1 5	 	 1	 	 	 1 2	 1 2	0 3 11	4 3 0
Epifyseolys. capit. femor. incip., epifyseolys. capit. femor? Lys. capit. femor? Slipped epiphysis?	L M H	15 3 19	4 1 5	 	 6	8 1 4	 2	1 1 	 1	13 3 18	2 0 1
Epifyseolys. capit. femor. sanat., inveterat. seu chronic.	L M H	10 1 1	3 	 	1	 	1 	1 	1 	6 1 0	4 0 1
Total	L M H	106 24 122	9 3 16	1 0 1	0 3 10	8 1 4	1 0 3	3 3 13	2 1 5	24 11 52	82 13 70
Total		252	28	2	13	13	4	19	8	87	165

¹ The Orthopaedic Clinic, Lund. ² The Orthopaedic Clinic, Malmö.

³ The Vanförestalt, Hälsingborg.

The following formulae were used for the statistical computations:

To calculate:

the arithmetical mean (M):

$$M = M_0 + \frac{\sum p(x - M_0)}{n}$$

where M_0 is the provisional mean, p the number of cases in each class, x the class centre and n the number of observations.

the standard deviation (σ):

$$\sigma = \sqrt{\frac{\sum p(x - M_0)^2}{n} - b^2}$$

where b is the difference between the true (M) and the provisional (M_0) means.

the standard error of the mean (ε_M):

$$\varepsilon_m = \frac{\sigma}{\sqrt{n}}$$

the standard error of percentages (ε_p):

$$\varepsilon_p = \sqrt{\frac{P(100-P)}{n}}$$

where P is the percentage.

the standard error of differences ($\varepsilon_{\text{diff.}}$):

$$\varepsilon_{\text{diff.}} = \sqrt{\varepsilon_{M_1}^2 + \varepsilon_{M_2}^2}$$

where ε_{M_1} and ε_{M_2} denote the standard error of the respective means.

When the number of observations was less than 30, n has been changed to $n-1$ (but naturally not in the calculation of the arithmetical mean).

In this study a difference was said to be statistically significant if it was 3 times the standard error and statistically probable if it was 2.5 times the standard error.

Of the 166 cases in the present series 83¹ (50 per cent) were treated at the Orthopaedic Clinic, Lund, 13 (about 8 per cent) at the Orthopaedic Clinic, Malmö, and 70 (about 42 per cent) at the Vanförestalt, Hälsingborg.

Of these 166 patients 147 (about 89 per cent) were in-patients and 19 (about 11 per cent) out-patients only.

The sex distribution is given in table II, from which it will be seen that 138 (about 83 per cent) of the patients were males and 28 (about 17 per cent) females. The difference is statistically significant.

Table II shows that 38 cases (22.9 per cent) were classed as bilateral.²

The figures regarding bilaterality given in table II were those found by the author on examination of all available roentgenograms taken during adolescence before closure of the epiphyseal line. According to the hospital records 37 cases had been diagnosed as bilateral. However, in 3 of these, 1 of which had been diagnosed as *lys. epifys. capit. femor. sin. (et dx?)* and the second as *epifyseolys. capit. femor. dx. + suspic. epifyseolys. capit. femor. sin.*, and the third as *epifyseolys. capit. femor. dx. et epifyseolys. capit. femor. sin. incip.*, examination of the roentgenograms taken at the time of treatment showed no evidence of slipped upper femoral epiphysis on the suspected side. These 3 hips were therefore not included in the series, and the cases were consequently classed as unilateral (Cases 1050, 1078 and 1403).

On the other hand, 4 cases which were diagnosed at the time of treatment as unilateral, showed slight but nevertheless definite signs of slipped epiphysis also in the other hip. They were therefore classed as bilateral (Cases 1022, 1031, 1058 and 1208).

Table II shows that 94 (73.4 per cent) of the unilateral cases were left-sided and that 34 (26.6 per cent) were right-sided. The difference is statistically significant.

Of the 38 bilateral cases 20 showed definite signs of a slipped epiphysis on both sides already at the first roentgen examination. In 13 (72.2 per cent) of the remaining cases it was the left epiphysis that slipped first and in the other 5 (27.8 per cent)

¹ Of these 83 cases 22 have been published earlier by FRISING (1926).

² The ratio between the frequency of bilateral and unilateral cases will be discussed in detail in chapter XI.

Table II

Sex-distribution and frequency of left, right, and bilateral cases

	Left	Right	Bilateral	Total Nr. of patients	Total Nr. of hips
♂	80	26	32 ^{1 2}	138	167
♀	14	8	6 ³	28	33
Total Nr. of patients	94	34	38	166	
Total Nr. of hips	94	34	72		200

¹ In this group 2 of the patients who had been treated at the Vanförestalt, Hälsingborg, for slipped upper femoral epiphysis in one hip had been treated previously at other hospitals for the same condition in the other hip, but when first seen at the Vanförestalt the epiphyseal line in these last mentioned hips was completely closed. Like unilateral cases, these 2 hips were excluded from the present series, while those hip joints for which the patients were treated at the Vanförestalt, Hälsingborg, were included. In table II these 2 cases have been classed as bilateral (Nr. 3068 and Nr. 3072).

² One of the patients in this group was treated at the Orthopaedic Clinic, Lund, in 1943 for a slipped right epiphysis, and in 1946 for a slipped left epiphysis. In analogy with the procedure adopted for unilateral cases, the left hip was excluded from the present series. In table II this case is classed as bilateral (Case Nr. 1088).

³ One of the patients in this group was treated at the Vanförestalt, Hälsingborg, for a slipped left epiphysis. After she left this hospital she was later re-hospitalized elsewhere for a slipped epiphysis of the other hip joint. In table II this case is therefore classed as bilateral, but only the left hip is included in the present series (Case Nr. 3035).

the right. It therefore seems as if the left hip is the first to be affected in bilateral cases. However, the number of cases from which these figures were obtained was very low and the difference was not statistically significant or probable.

In the above mentioned 18 cases the maximum interval noted between involvement of either hip was at most 43 months (average, 20 months). If this interval in the 20 cases in which both hips were manifestly affected on the occasion of the first examination be regarded as nil, the average interval in respect

of the 38 cases would be 9.5 months. These figures denote only the interval between the primary roentgenological diagnosis of the condition in either hip, and do not claim to represent exactly the elapse between the onset in one hip and in the other.

According to HUC (1930) this interval is generally 6—22 months, WATSON-JONES (1944) gives at most 18 months, KLEIN, JOPLIN and REIDY (1948) $7\frac{1}{2}$ —28 months, and FAIRBANK (1948) 6—36 months. NICOLAYSON (1940) described a case in which the corresponding interval was 4 years.

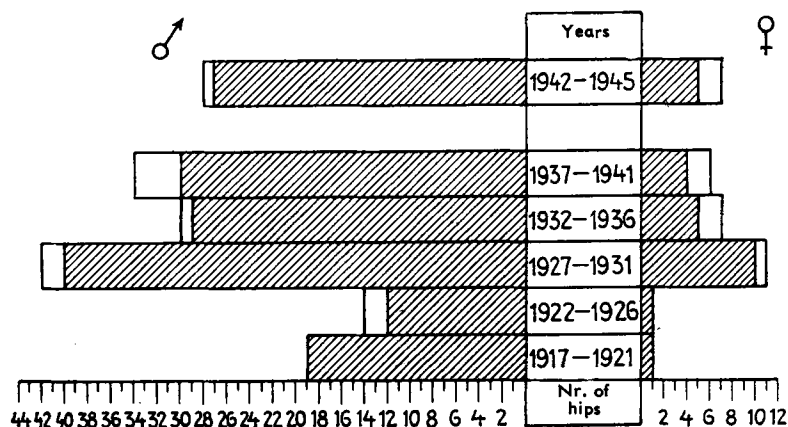


Fig. 1. Distribution of the series in 5-year-periods

Lined = re-examined patients.

The distribution of the cases in year-periods³ (Fig. 1) shows relatively different frequencies in the various 5-year-periods. This difference was in fact slightly greater between certain periods than that apparent from Fig. 1, since, as mentioned on page 16, the series included no cases from the Orthopaedic Clinic, Malmö, for the period 1924—1930. However, as the number of cases from the Orthopaedic Clinic, Malmö, constituted only a small percentage of the entire series, the exclusion of these years had no essential influence on this

³ Calculated as from the time the diagnosis was first established roentgenologically, which in the present series was as a rule at the first examination.

distribution. The differences in frequency recorded in the different periods were, however, not surprising, because most of the cases came from the Orthopaedic Clinic, Lund, and from the Vanförestalt, Hälsingborg, to where they had been referred by other hospitals. Therefore, in a series like the present one, the frequency curve will depend to a great extent on the opinion held at various hospitals as to the most suitable sort of treatment, as to whether the case calls for treatment by a

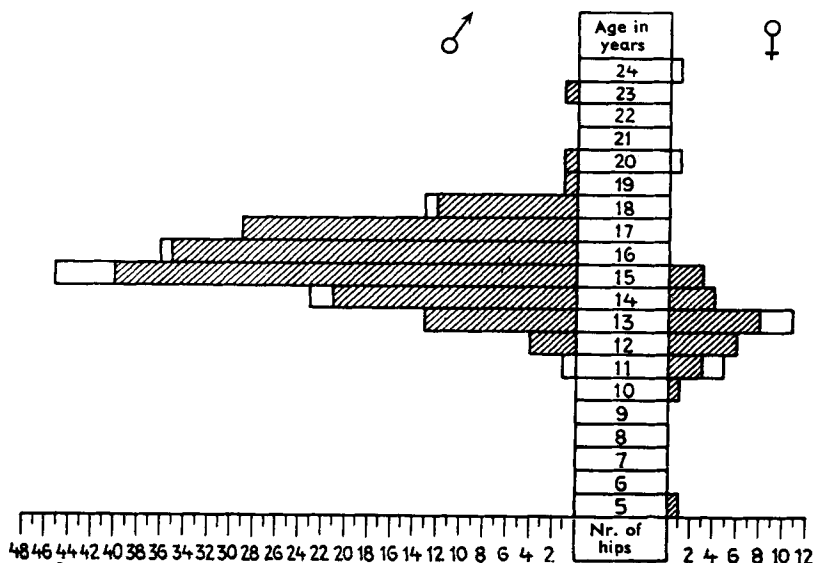


Fig. 2. Age distribution
Lined = re-examined patients.

specialist etc. which opinion may, of course, change from time to time. The greater number of cases in the last periods than in the first 2 periods was probably due mainly to the fact that people formerly did not seek medical advice so often as they do nowadays. An improved diagnosis also among non-specialists and a more frequent consultation with orthopaedic surgeons may also have contributed to the increase in the figures of the last year-periods.

Table III

Comparison of the cases from the Orthopaedic Clinic, Lund, the Orthopaedic Clinic, Malmö, and the Vanförestalt, Hålsingborg, with respect to sex distribution, frequency of left, right, and bilateral cases and with respect to age distribution

Cases from	♂	♀	Left	Right	Bilateral	Age in years	
						♂	♀
Orthopaedic Clinic, Lund	73 (88.0%)	10 (12.0%)	44 (71.0%)	18 (29.0%)	21 (25.3%)	16.1±0.2	14.5±1.5
Orthopaedic Clinic, Malmö	9 (69.2%)	4 (30.8%)	7 (70.0%)	3 (30.0%)	3 (23.1%)	15.5±0.5	12.8±0.4
Vanförestalten, Hålsingborg	56 (80.0%)	14 (20.0%)	43 (76.8%)	13 (23.2%)	14 (20.0%)	16.0±0.2	13.1±0.3

The age distribution⁴ (Fig. 2) shows the lowest and highest ages among the males to be 11.5 years and 23.4 years and 5.6 years and 24.0 years among the females. The average age of the males was 16.0 ± 0.1 years and of the females 13.5 ± 0.5 years. The difference is statistically significant.

The collections from the 3 hospitals in which the patients in the present series had been treated show fairly good agreement regarding the sex distribution, the frequency of left, right and bilateral cases, and the age distribution. (Table III.) Statistically the greatest difference in any of these respects, (the difference in sex distribution between the collections from the Orthopaedic Clinics of Lund and Malmö) was 1.4 times the standard error.

It is not possible to make a detailed comparison of the sex and age distribution and of the incidence of left and right-sided cases in the present series with the figures given in the papers of earlier authors⁵ because all fairly large collections of earlier date in which such details have been given, differ in

⁴ See note 3 page 21.

⁵ The relative incidence of unilateral and bilateral cases is discussed in chapter XI.

essential respects from the present series. But some examples of previous publications will nevertheless be mentioned.

As to sex distribution, BROGDEN (1935) found that 47.4 per cent of 57 cases were males, FERGUSON and HOWORTH (1931) 55.7 per cent of 70, KLEIN, JOPLIN and REIDY (1943) 68.8 per cent of 32, SCOTT (1936) 68.9 per cent of 38, BADGLEY, ISAACSON, WOLGAMOT and MILLER (1948) 73.0 per cent of 66, PONSETI and BARTA (1948) 76.7 per cent of 73, MAC AUSLAND (1935) 80 per cent of 45 and HEYMAN (1949) 83.3 per cent of 42. KEY (1926) collected 250 cases from the literature, WALDENSTRÖM (1939) 400, and LÜTKEN (1939) 659 (certainly several cases published earlier are included in all of these 3 large collections). The proportion of males was 76.8 per cent in KEY's 250, 66.7 per cent in WALDENSTRÖM's 400, and 63.8 per cent of 423 cases in LÜTKEN's series.

HOWORTH (1941) found that the left hip was affected in 56.0 per cent of 113 unilateral cases, MAC AUSLAND (1935) in 56.1 per cent of 43, MÜLLI (1938) in 66.7 per cent of 57. The corresponding figures for the 3 large collections already mentioned are 63 per cent of 100, 66.7 per cent of 340, and 59.3 per cent of 300.

In earlier publications the age distribution has usually been given in such a way that exact comparisons with the figures recorded in the present series was not possible. As far as one can judge, however, the figures published earlier agree well with those of the present series. Like the author, practically all earlier investigators found that the slipping begins earlier in life in females than in males.

It will be seen from the figures referred to above that the sex distribution varied considerably from one author to another, while there was better agreement as to the frequency of the disease in the left and right hip respectively in unilateral cases. Table II shows that both the predominance of males (83 per cent) and that of the left hip in unilateral cases (73.4 per cent) were much greater in this series than in most earlier publications.

However, in at least the majority of previously published collections the sources of error are numerous. Series of less

recent date contain usually not only true cases of slipped epiphysis, but also cases of congenital coxa vara and rachitic coxa vara, and these earlier series are probably also included in the 3 large collections of KEY, WALDENSTRÖM and LÜTKEN. Later series consist only exceptionally of exclusively recent cases, but definite details in this respect are usually lacking. Several series include a surprisingly large number of cases in the so-called "pre-slipping" stage, the existence of which is denied by many authors, e. g. WALDENSTRÖM (1939) and WATSON-JONES (1944). Therefore one cannot help suspecting incorrect diagnoses. Most series are published to illustrate a certain aspect of a problem, e. g. etiology, the results of treatment etc., and therefore often comprise only a selection of the cases from a hospital, and therefore cannot be used for comparison in the respects under discussion. Such selected series are probably also included in the 3 large literature collections just mentioned. Nearly all of the individual series published are also very small.

Next to HOWORTH's (1949) series in which, however, no figures on the points under discussion are given, the present one is the largest uniform collection of its kind ever published. The author's series is based on all cases treated at the 3 hospitals from which the present material was obtained, and the diagnosis of all the cases included is certain. Only cases so recent that the epiphyseal line had not yet closed were accepted. For these reasons it is assumed that the present series gives a more reliable picture of the sex distribution and the ratio between the frequency of left- and right-sided cases respectively than previous series and can be regarded as definitely representative, at any rate of the geographical area from which it was collected.

In 1 instance in the present series a definite slipping of the epiphysis was seen in a 5,6-year-old girl. This case has already been reported in the Swedish literature by FRISING (1926), but since no other definite case has apparently been described in so young a person, a brief account of it will be given below.

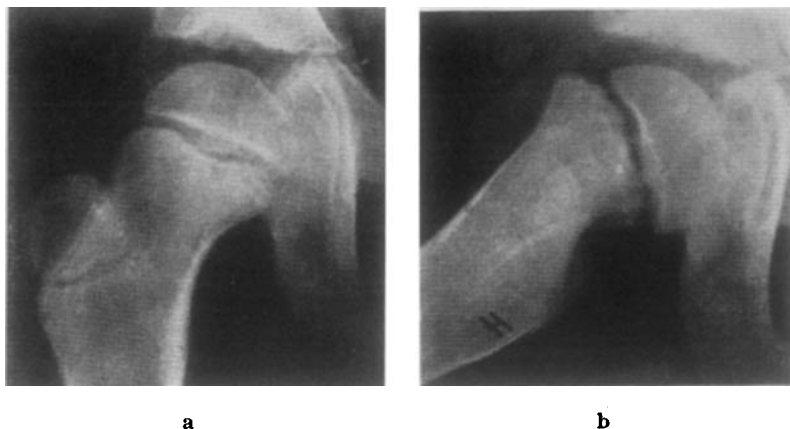


Fig. 3 (Case Nr. 1020)

- a) Frontal view of right hip 28.10. 1924: distinct widening of the epiphyseal line and manifest medial shift of the femoral epiphysis.
 b) Lateral view of right hip 28. 10. 1924: distinct posterior epiphyseal displacement.

Case Nr. 1020 M. A. ♀ born 27. 3. 19. Previously healthy. Since August 1924 intermittent, later constant limp. No pain, no trauma known. Admitted to the Orthopaedic Clinic, Lund, 31. 10. 24. Hormonal disturbance of type seen in dystrophia adiposo-genitalis. Weight: 31 kg. Height: 125 cm. Hip movements painless. Internal rotation and abduction distinctly decreased. Roentgenograms: Fig. 3.

Some cases of familial incidence of slipped upper femoral epiphysis, of which isolated instances have been published by various authors (KIRMISSON, 1918; THRAP-MEYER, 1940; PACHER, 1944, and others) were seen in the present series and are described below. The hospital records contained notes as to hereditary factors in a few cases only. However, at the re-examination all the patients were carefully questioned on this point. The familial incidence in this series must therefore be considered as representing that among only the 153 patients who were re-examined (in none of the records of the 13 cases not re-examined were there any notes of hereditary factors).

Case Nr. 1301. ♂ Slipped left epiphysis at 14 years; father of case Nr. 1094 ♂ slipped left epiphysis at 12 years.

Case Nr. 1062. ♂ Slipped left epiphysis at 15 years; brother of case Nr. 1090 ♂ bilaterally slipped epiphysis at 15 years.

Case Nr. 3049 ♂ Slipped left epiphysis at 17 years; brother of case Nr. 3058 ♂ slipped left epiphysis at 18 years.

Case Nr. 3102 ♀ Slipped right epiphysis at 12 years. A brother was treated at another hospital at 15 years for a slipped right epiphysis (diagnosis confirmed by the author on the basis of the roentgenograms from that hospital).

Case Nr. 2006. ♀ Slipped left epiphysis at 12 years and slipped right epiphysis at 13 years. Mother was treated at the Surgical Clinic, Lund, at 15 years of age in 1913 under the diagnosis of coxitis. The roentgenograms have not been kept but the roentgen report strongly suggests a slipped epiphysis.

A further 14 patients reported that a near relative had had trouble with one or both hips, and possibly in at least some of these cases the probable etiology could have been deduced from a re-examination of the persons concerned; this, however, was altogether beyond the scope of the investigation.

The question of the part played by trauma and endocrine disturbances in the slipping of the epiphysis has been given a prominent position in the literature. In the case records of the present series, only scanty and indefinite notes had been made on these points, and in many cases none at all.⁶ Since these questions are only of essential interest as regards the etiology, which is not dealt with in this study, no further analysis of the series was made in this respect.

In 1 case in which the patient died, the slipping of the epiphysis could be related to the disease which led to the patient's death. A short description of the case is therefore merited.

Case Nr. 1049. E. A. ♀ born 24. 4. 10. At 15 years severe impairment of vision of the right eye and temporal hemianopsia of the left eye. Recovered nearly normal vision and visual fields after 2 months.

⁶ At the re-examinations the author tried at first to complement the records regarding trauma, but the patients had usually a very poor recollection of details of any trauma they might have sustained, often many years previously.

At 20 years, slipped left epiphysis. Physical appearance of a girl of 10 years. Axillary and pubic hair completely lacking. Menarche not yet appeared.

At 24 years, slipped right epiphysis. No change in physical appearance.

At 25 years: Cerebral tumour. Operation. Mors. Autopsy: At the site of the basal ganglions a large tumour compressing the hypothalamus downwards. The simultaneous marked distension of the ventricles had caused severe atrophy of the hypothalamus and infundibular region. The hypophysis was extremely concave and degenerated into a small thin plate, rich in connective tissue.

Different forms of treatment had been used in the present series (Table IV).

Table IV

Forms of treatment

Several hips were treated by more than one method. These hips are accounted for under all the methods they have been treated by. The

bracketed figures denote the number of hip joints treated solely by the listed method.

Forms of treatment	Nr. of hips
Walking sticks, crutches, bed rest to spare the joint, or no treatment	47 (47)
Traction	29 (11)
Plaster of Paris without previous reduction	8 (4)
Osteosynthesis with a three-flanged nail without previous reduction	5 (3)
Closed reduction+plaster of Paris ⁷	102 (77)
Closed reduction+osteosynthesis with a three-flanged nail	4 (3)
Closed reduction without subsequent fixation	11 (7)
Open reduction+plaster of Paris	5 (1)
Open reduction+osteosynthesis with a three-flanged nail	3 (1)
Mobilisation of the hip joint under anesthesia+plaster of Paris	11 (0)
Correction of malposition under anesthesia+plaster of Paris	7 (3)
Subtrochanteric or intertrochanteric osteotomy	7 (3)
Arthrodesis of the hip joint	2 (0)
Arthroplasty of the hip joint	1 (0)
Extirpation of the epiphysis	1 (1)

⁷ In the present study the term *closed reduction* is to be understood as: attempted closed reduction under anesthesia.

In 1 case open reduction after instrumental separation of the epiphysis from the femoral neck was done without subsequent internal fixation. As roentgen control showed an unsatisfactory position, closed reduction was attempted twice. In another case in which closed reduction did not produce the desired result open reduction was performed after instrumental separation of the epiphysis from the femoral neck without subsequent internal fixation. As later roentgen examination still showed an unsatisfactory position, closed reduction was repeated. The closed reductions performed in these two cases after previous open reductions have not been included among the other closed reductions in the present investigation.

Twenty-eight hips were subjected to closed reduction more than once (22 twice, 4 three times, 1 four times and 1 five times).

Judging by the literature, a re-displacement in one and the same hip seems to be fairly common. WILSON (1936) states, for example, that of 10 cases which he saw during the so-called pre-slipping stage, all except one developed a re-displacement. In FERGUSON and HOWORTH's (1931) collection only 3 of 31 cases diagnosed during the so-called pre-slipping stage reached the residual stage without any displacement. FRIEDRICH (1932), however, is of the opinion, an opinion, however, in which he seems to be rather alone, that a re-displacement after the diagnosis has once been established is rare, for, in his opinion, maximal slipping has occurred already by the time the patient first seeks medical advice.

The range of time in which a re-displacement is possible is claimed by WALDENSTRÖM (1939) to be about 1 year. STOVALL (1949) claims that the risk is present until the epiphyseal line is completely closed, which, according to him occurs within 1 to 3 years from the onset. In the above 9 cases in which WILSON observed a re-displacement it occurred within 2 to 33 months (average 11.8 months) from the time of commencement of treatment.

The importance of the position of the hip joint during the roentgen examination for a correct evaluation of the primary results after closed reduction is discussed in chapter IV. The considerations described there must, of course, also be given attention when deciding whether any roentgen-

ologically apparent increased displacement is real or only illusory.

A definite re-displacement was seen in 20 hips in the present series. Unfortunately the roentgen examinations were practically always made at such long intervals that it was not possible to date such a displacement with any degree of accuracy. Neither was this usually possible from clinical data.

In 5 of these 20 cases the re-displacement was, however, acute. Therefore, here it could be dated exactly. The interval between the time when the condition was first confirmed roentgenologically and the acute re-displacement was 2 years, 1 year and 4 months, 6 months, 2 weeks and 2 days respectively. The duration of symptoms before the roentgenological diagnosis was 2 weeks, a few months, 6 to 7 days, 1 month and 18 days respectively.

Among the remaining 15 cases a re-displacement in the same hip joint had occurred definitely more than 2 years after the diagnosis had been roentgenologically verified in 1 case (at least 2 years 1 month and 6 days, at most 2 years 4 months and 13 days) and more than 1 year after this time in another 2 cases. The duration of the symptoms before the roentgenological diagnosis in these cases was nil, about 3 months and about 1 month. In 7 of the cases the re-displacement occurred definitely within 1 year of the occasion when the diagnosis was first roentgenologically verified. In 5 cases it could not be determined whether the interval between these occasions was more or less than 1 year.

In 2 cases in which closed reduction produced the desired result there was a re-displacement within 2 and 3 weeks respectively during fixation in plaster of Paris. In 1 case the re-displacement was seen within a period during which the patient had been ordered bed rest at home. In 3 cases the patients had been in bed for some time during the period within which the re-displacement had developed. During the greater part of this time, however, these 3 patients had been walking without any weight relieving braces. The other 14 cases had received no treatment at all during the period within which the re-displacement had developed.

PRIMARY RESULTS AFTER CLOSED REDUCTION

The establishment of any effect of closed reduction calls for a meticulous and very critical evaluation of the roentgenograms. The position of the epiphysis in relation to the femoral neck, as observed in the roentgenogram, will depend to a great extent on the position of the hip joint at the roentgen examination. MAU (1927) showed in skeletal preparations that if the hip joint is examined roentgenologically in an internally rotated and abducted position, the roentgenogram will show an illusory improvement in the position of the slipped epiphysis, and that if internal rotation is great enough, this illusory improvement may be so marked as to convey the impression of complete correction or even over-correction.

On the basis of roentgenological studies on skeletal preparations the present author is able to confirm that the position of the hip in the plane of rotation is of great importance in the interpretation of the roentgenographic appearance of a slipped epiphysis. On the other hand, however, the author cannot share MAU's opinion as to the importance of abduction. The apparent change in the position of the epiphysis is due to rotation of the femoral neck about its long axis and, as may be observed in an ordinary skeletal preparation, movements in the abduction-adduction plane involve no such rotation, whereas movement in the plane of flexion-extension as well as in the plane of rotation does involve rotation of the femoral neck about its longitudinal axis and therefore also causes an apparent change in the position of the epiphysis. In the usual form of displacement of the epiphysis, which is generally most pronounced in a backward direction, a change in the position

of the hip joint from flexion towards extension will cause an illusory improvement of the displacement in the roentgenogram as will also a change in the position of the hip joint from external towards internal rotation. This is illustrated in Fig. 4. This shows that epiphysis depth decreases simultaneously with decreasing sidewise displacement of the epiphysis. It seems as if this phenomenon, which is of great importance in the interpretation of roentgenograms taken after closed reduction, has usually not been given sufficient attention by earlier workers in this field.

Before the publication of MAU's above-mentioned observations roentgenograms of slipped epiphyses were surely very often misinterpreted. The internally rotated position, in which the hip was fixed in plaster of Paris after closed reduction, produced an illusory improvement in the position of the epiphysis. It was therefore generally believed that closed reduction usually led to the desired result. When, after a period of fixation, the plaster of Paris was removed, and the hip examined roentgenologically again but this time not in an internally rotated position, the displacement of the epiphysis in relation to the femoral neck was again obvious. This was then looked upon as a re-displacement. Closed reduction was possibly repeated once or more with subsequent fixation in plaster of Paris in an internally rotated position and again seemed to be successful as long as the hip was kept in this position.

Since MAU's paper on the importance of the position of the hip joint at roentgen examination in the appraisal of the results of closed reduction there has been much discussion in the literature as to the possibilities of reducing an epiphyseal displacement by closed reduction. Here opinions differ considerably.

According to MAU, roentgenological signs of a successful reduction should be viewed with extreme caution: only when the hip is examined roentgenologically in exactly one and the same position in the plane of rotation both before and after reduction can the results be properly evaluated. He does not think reduction by the closed method to be quite impossible,

**Lateral view****30° flexion and 20° external rotation****0° flexion and 20° external rotation****0° flexion and 0° rotation****0° flexion and 10° internal rotation****0° flexion and 20° internal rotation**

Fig. 4. Skeletal preparation in which the epiphysis was separated from the femoral neck and re-attached in an essentially backwardly displaced position.

but points out that the possibilities of the method was certainly over-estimated earlier.

WALDENSTRÖM (1934 and 1939) is of the opinion that both frontal and axial views with the hip in exactly one and the same position both before and after closed reduction are absolutely necessary for an evaluation of the results. He says that those cases "in which it is possible by external manipulation to move the epiphysis towards the metaphysis in the gliding zone are so exceedingly few that they should not be reckoned with at all."

WILSON (1936) is of the opinion that complete reduction is rarely obtainable by closed methods. He supports his opinion on the fact that at operations he usually found the epiphysis so firmly united with the femoral neck that instrumental separation was necessary before any reduction could be performed.

KEY (1926) reported a series of 24 cases, in 13 of which one or more attempts had been made to reduce the displacement by the closed method. In none of these cases was a normal position of the epiphysis obtained.

LINDEMANN (1930) described 20 cases treated by closed reduction and fixation in plaster of Paris: in none of them was complete reduction obtained, only in 2 could an improvement in the position of the epiphysis be observed.

In contrast hereto, many authors maintain that it is often possible by closed reduction, at least in relatively recent cases, to restore a normal position between the epiphysis and the femoral neck (FRIEDRICH, 1932; FELSENREICH, 1938; BENTZON, 1932 and 1939, and others).

BADGLEY (1929) claimed primarily successful results by closed reduction in 9 of 16 hip joints, HASS (1930) in 24 (he does not say of how many), PITZEN (1930) in 8 of 12, and WOLF (1947) in 6 of 20. PONSETI and BARTA (1948) claim a "complete or partial reduction" in 11 of 13 cases with an acute displacement with fracture-like symptoms and signs. In none of these 13 cases was the interval between the acute displacement and reduction more than 3 weeks.

In the opinion of the present author, two roentgenograms taken at right angles to one another after the closed reduction are necessary to confirm a *normal position* of the epiphysis. When the epiphyseal displacement before reduction is very pronounced, however, a frontal view alone, even if taken in an internally rotated position of the hip, may be sufficient to show with certainty that the reduction has led to a *considerable improvement* of the position of the epiphysis, namely if the sidewise shift of the epiphysis has been eliminated and the epiphysis depth is nevertheless normal or only slightly decreased (Figs. 5 and 6).

Fig. 7 is an illustration of unsuccessful closed reduction.

In the evaluation of the primary results of closed reduction in the present series meticulous attention was always given to the importance of the position of the hip at the roentgen examination. It could thereby be demonstrated that closed reduction had produced a considerable improvement or a normal position of the epiphysis in relation to the femoral neck in 24 of the 117 hips given this form of treatment.⁸ This figure includes no cases in which the results were in any respect uncertain, and as the roentgenograms in a number of cases were not technically good enough to permit reliable evaluation of the primary results, the figures just given must probably be regarded as too low.

Of these 24 cases 20 were subjected to closed reduction once, 3 twice, and 1 five times. In 22 cases the only treatment given (in connection with the reduction) was subsequent fixation in plaster of Paris (20 cases) or by osteosynthesis (2 cases). In 1 case closed reduction was followed by a brief period of traction and plaster of Paris and afterwards by fixation in plaster only. In this case, however, the improvement in the position of the epiphysis could be observed roentgenologically immediately after the closed reduction. No further change in

⁸ In the present series no improvement in the position of the epiphysis was seen in any of the hips treated by methods other than closed or open reduction.



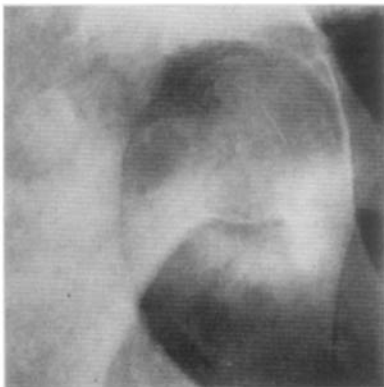
5 a



5 b



6 a



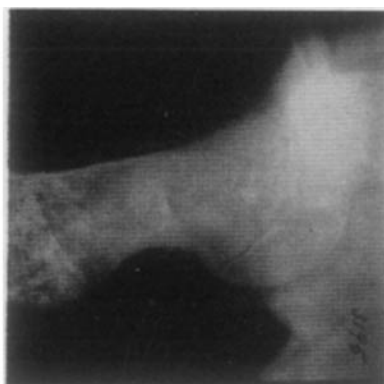
6 b



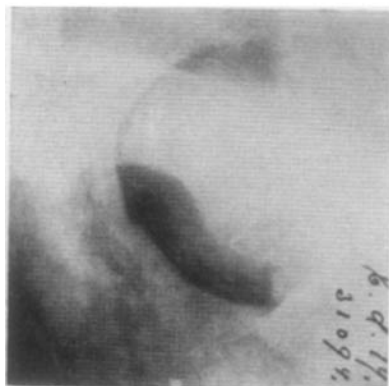
7 a



7 b



5 c



6 c

Fig. 5 (Case Nr. 1073)

a) Frontal view 29.4.1937 in considerable external rotation shows marked displacement without signs of callus.

b) Frontal view 30.4.1937 in much more internally rotated position after closed reduction that day shows a normal position of the epiphysis in relation to the collum and normal epiphysis depth. This picture alone unequivocally proves that an improvement in the position of the epiphysis has occurred, but it does not provide definite evidence of a normal position.

c) Axial view 30.4.1937 (together with the frontal view) provides proof of a practically complete restoration of a normal position.

Fig. 6 (Case Nr. 3021, right hip)

a) Frontal view 19.10.1929 in considerable external rotation shows a marked displacement without signs of callus.

b) Frontal view 19.10.1929 in considerable internal rotation after closed reduction the same day no longer shows any sidewise shift of the epiphysis. The epiphysis depth seems to be slightly decreased. This decrease is, however, so small that here, too, the frontal view alone is sufficient to prove that a real im-

provement in the position has occurred but by no means does it provide evidence of a normal position.

c) Axial view 23.10.1929 provides (together with the frontal view) proof of a practically normal position.

Fig. 7 (Case Nr. 1009, right hip)

a) Frontal view 3.5.1922 in considerable external rotation shows a marked displacement with slight callus formation.

b) Frontal view 26.5.1922 after closed reduction on 3.5.1922 and 19.5.1922, taken in a much more internally rotated (and also abducted) position, no longer shows any sidewise shift of the epiphysis, but the epiphysis depth is now only about half of what it was before. The apparent improvement may be explained completely by the changed position of the hip joint and by no means provides evidence of a real improvement in the position of the epiphysis. (Unfortunately no axial view was taken.)

position after traction could be detected in the roentgenogram. One case was treated a short time with traction between two attempts at closed reduction.

In the hospital records technical details as to how the reduction was performed are unfortunately not given in most cases. In 2 instances, however, it was noted that reduction was performed by traction under anesthesia with the patient on a traction table. In most cases, however, manipulation under anesthesia seems to have been used.

In 19 of the above 24 cases the displacement was acute and had given such severe symptoms and signs that, judging by the records, they could almost be compared with those of a fractured femoral neck (hereinafter called "fracture-like symptoms and signs"). As a rule the acute displacement had occurred after trauma, which was, however, usually claimed to be only slight. Some of the patients reported typical but slight symptoms on some earlier occasion. In all of these hips the displacement of the epiphysis in relation to the femoral neck was marked and the roentgenogram showed no signs of callus formation. The interval between the acute displacement and the (first) closed reduction varied from 1 to 16 days (average 5.9 days). The series as a whole includes also another 9 cases with the same clinical picture. All these cases had been subjected to closed reduction. All of them exhibited marked epiphyseal displacement, 7 without and 2 with roentgenological signs of callus. The interval between the acute displacement and the (first) closed reduction was 1 to 6 days (average 3.1 days).

In 2 of the 24 cases there was an insidious onset not associated with any trauma: the symptoms gradually increased and on admission the patients exhibited fracture-like symptoms and signs. In both cases there was marked displacement without roentgenological signs of callus. The interval between the onset of symptoms and the closed reduction was 12 and 17 days respectively. The series as a whole also includes 3 more cases of the same type. All 3 were treated by closed reduction. In all of them roentgenograms showed marked displacement without signs of callus. The interval between the

onset of symptoms and the (first) closed reduction was 8, 13 and 16 days respectively.

In 1 case the information available from the records was very sparse. However, it seems as if here, too, the onset had been insidious and the symptoms gradually increased to such an extent that on admission the patient presented fracture-like symptoms and signs. In this case the roentgenogram showed marked displacement without signs of callus formation. The time of onset of the symptoms could not be deduced from the case-record.

In 1 case a trauma was followed by such severe symptoms that the patient was unable to walk. This incapacity gradually passed off after a few days. The roentgenogram showed marked displacement with sparse callus (the patient had had mild symptoms for a few weeks half a year earlier). The interval between the onset of symptoms and the closed reduction was 17 days.

In 1 case there was an insidious onset not associated with any trauma: the symptoms gradually increased but the symptoms and signs never became so severe that they could be termed fracture-like. In this case the roentgenogram showed marked displacement with obvious callus formation. The interval between the onset of the symptoms and closed reduction was as much as 3 months.

In the present series then closed reduction produced considerable improvement or normal position of the epiphysis in relation to the femoral neck in 19 (73.1 per cent) of 26 cases with an acute displacement with fracture-like symptoms and signs without roentgenological signs of callus formation, in 3 (50.0 per cent) of 6 cases which in spite of insidious onset nevertheless showed fracture-like symptoms and signs on admission (in none of these 6 cases were there roentgenological signs of callus formation), but only in 2 (2.4 per cent) of the 83 cases which on admission did not present fracture-like symptoms and signs.

Chapter V

EARLY COMPLICATIONS

Aseptic necrosis of the femoral head. If the nutrition to the femoral head becomes inadequate on account of damage to the supplying vessels, there will develop aseptic capital necrosis, total or partial, depending upon the extent of the vascular damage.

As to the nutrition of the femoral head, blood vessels from three different sources may be taken into consideration, namely the capsular vessels, the vessels in the ligamentum teres and vessels in the spongiosa of the femoral neck, i. e. branches from arter. nutric. in the femoral shaft. The capsular vessels, called also the retinacular vessels, arise from the medial and lateral femoral circumflex arteries and then run in a medial direction along the surface of the femoral neck, deep to the reflected cuff of synovial membrane up to the epiphysis (TUCKER 1949). It is generally agreed that these vessels are responsible for the greater part of the blood supply to the epiphysis. The existence and calibre of the vessels in the ligamentum teres and the existence of such vessels in the spongiosa of the femoral neck passing through the epiphyseal line seem to vary from one individual to another, and also with the age. Opinions vary considerably as to the importance of these two last mentioned groups of vessels for the blood supply of the epiphysis.

In patients with a slipped upper femoral epiphysis closed reduction is, according to WALDENSTRÖM (1934 and 1939), WILSON (1936), WATSON-JONES (1944), and others, often the direct cause of an aseptic capital necrosis due to damage of the vessels in the ligamentum teres. Several authors such as WALDENSTRÖM (1934), MOORE (1945), FOLEY (1946), and others have stressed the great risk of an aseptic capital necrosis that open reduction involves. AXHAUSEN (1922, 1924 and 1926) claims that in acutely slipped epiphyses vascular damage re-

sulting in aseptic capital necrosis may arise already during the displacement. MOORE (1945) states that damage of the blood vessels in the visceral capsule or in the ligamentum teres with resultant aseptic capital necrosis may arise not only in connection with such therapeutic measures performed for "replacing and fixing the epiphysis in its normal position on the neck of the femur" but also during the period of gradual slipping.

Roentgenologically the aseptic necrosis causes an increased density of the necrotic epiphysis (or of necrotic parts of the epiphysis) in relation to surrounding parts of the bone.

The reason for this difference is that the surrounding parts are the site of diffuse decalcification, while those parts of the bone shut off from the circulation retain their normal content of calcium and therefore also normal density in the roentgenogram. The increased density, as seen in the roentgenogram, in the necrotic parts is thus not real but only illusory, due to a contrast effect (WATSON-JONES 1944).

WATSON-JONES states that these roentgenological features appear during the 2nd, 3rd, or 4th month, and then disappear again, when the previously decalcified areas will again exhibit normal calcium content. According to PHEMISTER (1934), in aseptic capital necrosis following fractures of the femoral neck the increased density of the necrotic part will be seen within 2 to 5 months.

The necrotic epiphysis (or necrotic parts of it) is regenerated by "creeping substitution". Vascular tissue grows into necrotic areas. Necrotic bone substance is resorbed and simultaneously new bone is formed by bone-forming cells. The form and architecture of the epiphysis remain unchanged during this creeping substitution. However, the new-formed bone tissue is not so strong as normal bone substance. Throughout the regeneration process, which generally lasts several months or even years, the bone substance may collapse under the weight of the body or possibly even on account of muscular pull only.

The collapse of bone substance will give a typical roentgen picture before secondary changes have blurred the details and thereby permit a definite diagnosis even in this stage.

The frequency of aseptic capital necrosis among cases of slipped epiphysis treated by closed reduction is claimed by WALDENSTRÖM (1939) to be about 20 per cent, and WATSON-JONES (1944) gives a frequency of at least 25 per cent. Among 20 patients with an "acute slipping or fracture separation" PONSETI and BARTA (1948) were able to demonstrate aseptic capital necrosis in 8 of 13 treated by closed reduction, in 1 of 5 treated only conservatively, and in the only case in their series that was treated by open reduction (1 case that was treated by intertrochanteric osteotomy showed no signs of aseptic necrosis). MOORE (1945) observed aseptic capital necrosis in 1 of 29 cases with a "minimal" epiphyseal displacement (this case had received no treatment), in 4 of 23 cases with a "moderate" displacement (3 cases had not received any treatment, 1 had been treated with a caliper-brace) and in 2 of 3 cases with "fracture separation" (1 had been treated by traction, 1 by closed reduction). MOORE also collected 87 literature cases treated by open reduction. Among these aseptic capital necrosis was reported in 13 per cent and poor results in over 50 per cent.

In the present series 20 hips showed aseptic capital necrosis. In 15 cases the diagnosis was established at an early stage on the basis of increased density of the roentgen shadow in the necrotic area, in the remaining 5 cases during a later stage, here on the basis of an at least relatively recent typical collapse of the necrotic bone. Several of the cases in the present series were not at all examined roentgenologically during the period in which any capital necrosis might have been recognizable by the above-mentioned roentgenological characteristics. In several other cases the roentgen examinations during this period were very sporadic. Therefore, one might suspect the frequency of aseptic necrosis as found by the author in the present series to be too low.

Of these 20 cases with aseptic capital necrosis 1 was treated by osteosynthesis with a three-flanged nail without previous reduction, 2 by arthrotomy and open reduction after instru-

mental separation of the epiphysis from the femoral neck,⁹ 15 by closed reduction + plaster of Paris,¹⁰ and 2 by closed reduction + osteosynthesis with a three-flanged nail.

In the case treated with osteosynthesis with a three-flanged nail without previous reduction the aseptic necrosis was limited to a small area near the tip of the nail. In the other cases the necrosis had involved the entire, or at least the major part of, the epiphysis.

In the present series of 200 hips then, aseptic capital necrosis was demonstrated in 20 (10 per cent) and in 17 (14.5 per cent) of the 117 hips subjected to closed reduction. Of the 28 hips subjected to more than one attempt of closed reduction aseptic necrosis was observed in only 3 (10.7 per cent).

Among the 24 hips described in the previous chapter, i. e. in which closed reduction produced the desired result, aseptic capital necrosis was diagnosed in 10 (41.7 per cent) but only in 7 (7.5 per cent) of the 93 hips in which any definite improvement in the position of the epiphysis could not be observed after closed reduction.

Of the above-mentioned 24 cases in which reduction was primarily successful the percentage of acute slipping was remarkably large as compared with the series as a whole. It might therefore be feasible that this mode of development and not the improvement in the position of the epiphysis during reduction was the cause of the demonstrated difference.

In the present series 28 hips had given acute fracture-like symptoms. All these hips were treated by closed reduction and primarily successful results were obtained in 19 instances. Among these 19 cases¹¹ aseptic necrosis was observed in 9

⁹ One of these had been treated earlier by traction, the other with immobilization in a plaster spica without previous reduction. One in which roentgen control after the open reduction showed an unsatisfactory position, was subjected to closed reduction on two later occasions.

¹⁰ Two of these had been treated by traction for a short period between two attempts at closed reduction.

¹¹ The interval between the acute displacement and the (first) closed reduction was on the average 5.9 days.

(47.4 per cent) but only in 1 of the 9 (11.1 per cent) cases¹² in which any improvement in the position of the epiphysis after reduction could not be observed. Hence, even if only such cases be taken into account that showed an acute displacement, the difference mentioned above will be approximately just as large as for all the cases in which aseptic capital necrosis developed after closed reduction. The difference between 41.7 per cent and 7.5 per cent is statistically significant. *Closed reduction producing an improvement in the position of the epiphysis in relation to the femoral neck involves a greater risk of aseptic capital necrosis than does closed reduction producing no change in the displacement of the epiphysis.*

This fact, which has apparently not been mentioned earlier in the literature, seems to be in disagreement with the assumption that the cause of aseptic capital necrosis is *always* to be sought in injury to the vessels in the ligamentum teres.

Whether an acute displacement can already in the course of its development sometimes injure the vessels to such an extent as to give rise to aseptic capital necrosis, cannot be decided on the basis of the present series, because closed reduction was performed shortly after the acute displacement in all of the 28 cases with this clinical picture.

Necrosis of the joint cartilage. Under this name WALDENSTRÖM (1930) has described 3 cases in which he observed a considerably narrowed articular space in the roentgenogram without co-existent signs of capital necrosis. All 3 cases had been treated earlier by closed reduction and immobilisation in a plaster spica. Some time after reduction mobility seemed to be satisfactory, but after a few months there was gradually increasing stiffness that finally resulted in ankylosis. In 1 of these cases a decrease in the height of the articular space was observed already 5 months after the reduction, in the other 2 not until after several months. The outline of the articular surface remained normal for a fairly long time, after which it

¹² The interval between the acute displacement and the (first) closed reduction was on the average 5.2 days.

gradually became irregular. One of these cases was subjected to operation (arthroplasty) 9 months after the reduction. At operation it was observed that the joint cartilage had "absolutely disappeared on the acetabulum until fovea centralis but that there remained a thin layer in some other places".

An apparently analogous case has been published by MOORE (1945). In a patient with bilateral epiphyseal displacement, "minimal" on one side and "moderate" on the other, mobility became increasingly limited and finally fibrous ankylosis developed in both hips. Roentgen examination showed a narrowed articular space and an irregular outline of the articular surface of the epiphysis and at the same time marked atrophy. Both hips had been treated by traction and cast.

PONSETI and BARTA (1948) have reported another 3 cases with this complication. In 1 of them there was extremely limited mobility and, roentgenologically, a narrowed articular space already on admission after 5 months' symptoms. After closed reduction without any primarily successful result roentgenograms taken 6 and 12 months later showed a progressive narrowing of the articular space and an irregular outline of the articular surface of the epiphysis. Similar roentgenological changes and marked limitation of mobility occurred also in the untreated contralateral hip, which showed a "minimal" displacement. In the second case there developed marked limitation of mobility and the roentgenogram revealed a marked narrowing of the articular space 4 months after drilling and osteosynthesis without reduction. The third case was subjected to closed reduction 5 months after an acute displacement, without any primarily successful result. One year later there was marked limitation of mobility and the roentgenogram showed a considerable narrowing of the articular space and an irregular outline of the articular surfaces of the epiphysis and of the acetabulum. Clinically, the contralateral hip showed nothing abnormal but roentgen examination revealed a marked narrowing of the articular space. In none of these 3 cases were there roentgenological signs of aseptic capital necrosis. In the first case one of the hips was operated on

(arthroplasty). At operation the cartilage of the epiphysis was found to be eroded and pitted, particularly in the area of the fovea centralis. Twelve years after the onset of symptoms the other hip of this patient was found to have fairly good mobility, and roentgenologically "a wide joint space" but the outline of the articular surface of the epiphysis was still irregular. In the other 2 cases, however, no clinical or roentgenological signs of improvement could be observed at the last examination 3 months and 14 months respectively after the primary roentgenological demonstration of the changes in question.

Judging by the literature, this complication is surely not rare. However, most authors have not clearly distinguished the complication from aseptic capital necrosis on one hand, and from a secondary arthrosis deformans, on the other hand. Other authors have, without, however, going into detail into this question, casually mentioned such changes in the hip as may probably be identical with those discussed here (BALENSWEIG, 1926; KLEIN, JOPLIN and REIDY, 1948; MARTIN, 1948, and others). Also WILSON (1949) probably refers to this type of complication when he said: "Many surgeons have noted the development of arthritis, following operations to correct the deformity. In such cases there is no actual necrosis of the epiphysis or absorption of it, but the joint cartilage space becomes narrowed and the hip becomes fixed".

In the present series 9 hips exhibited a picture that in all essential details seemed to coincide with that described by WALDENSTRÖM, MOORE, and PONSETI and BARTA.

All of them showed marked atrophy of the femoral head and the acetabulum and the surrounding parts of the skeleton, and an extremely narrowed articular space, which was in some cases almost completely obliterated (Fig. 8). These changes were observed 0—9 months after the first roentgenological diagnosis. In 1 case also the articular space in the contralateral hip was markedly narrowed and mobility distinctly limited on that side, too, although several roentgen examinations had never revealed signs of epiphyseal displacement in this hip joint. In 7 cases a more or less marked irregularity of the

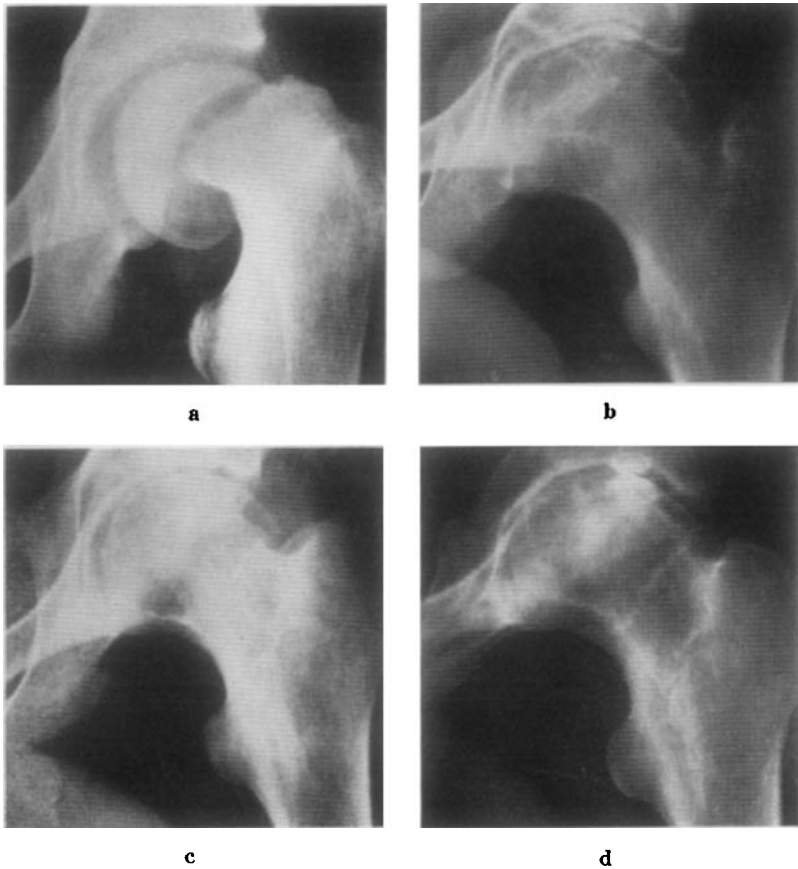


Fig. 8 (Case Nr. 3112)

a) Frontal view 20. 9. 1945. Marked displacement without signs of callus. Normal density in femoral head and neck and acetabulum. Articular space of normal height.

b) Frontal view 22. 12. 1945 after closed reduction 22. 9. 1945 + plaster of Paris until 21. 12. 1945. Considerable atrophy of acetabulum, femoral head and neighbouring parts of the skeleton. Distinctly narrowed articular space.

c) Frontal view 2. 4. 1946. (No treatment in the meantime.) About the same degree of atrophy as observed at examination on 22. 12. 1945. Further reduction in height of articular space. Outline of the articular surface of the epiphysis still even.

d) Frontal view 4. 11. 1946. Atrophy seems to have diminished at least in some areas. Still further reduction in the height of the articular space. Outline of the articular surface of the epiphysis is irregular.

outline of the articular surface of the epiphysis appeared within $2\frac{1}{2}$ to 10 months of the occasion when the changes in question were first observed in the roentgenogram. The 2 cases in which no such changes could be observed were followed-up roentgenologically only for 2 and 4 months respectively after the first appearance of the changes in the roentgenogram.

Clinically, a progressive marked limitation of mobility of the hip joint was observed in all of these cases.¹³ In 7 cases the temperature was recorded both in the morning and in the evening for some time during the period in which the roentgenological changes developed or progressed and in all these cases normal values were recorded throughout. The sedimentation rate was determined in only 3 cases during the above-mentioned period. In one of these patients the S. R. was measured on only 1 occasion and was then found to be 22 mm per hour, in the other 2 cases the S. R. was measured on several occasions and always found to be normal.

As to the extent of epiphyseal displacement in adolescence the present series has been divided into 2 groups, namely slight and marked displacement (p. 67). All of the 9 cases described here showed a marked displacement, which, however, does not produce a statistically significant or probable difference (in relation to the occurrence among cases with slight displacement).

Two cases had received no treatment at all before the roentgenological diagnosis of the changes, 1 case was treated with fixation in plaster of Paris for some weeks without previous reduction, 1 with traction for 7 to 8 weeks, and 5 by closed reduction + plaster of Paris for 7 to 13 weeks. Hence, judging by the present series, this complication does not seem

¹³ In nearly all of the hospital records information in this respect was extremely sparse. In addition hereto, the examinations had been carried out by several different examiners. It was therefore regarded as useless to try properly to assess the deficiency of mobility on the basis of the information available from the records. In 6 instances, however, the deficiency of mobility was so extreme that besides the ordinary physical treatment also active measures were regarded as indicated, namely in 5 cases mobilisation under anesthesia and in 1 case arthroplasty.

to occur more frequently after closed reduction than after other forms of treatment.

In 3 of these 9 cases an increase in the height of the articular space was observed 8 months, 1 year, and 1 year and 5 months after the occasion when the decrease was first observed. The other 6 cases were followed up roentgenologically for 2 months to 1 year and 3 months after the time when the decrease was first observed, but no increase in the height of the articular space could be detected. In no instance was it possible to demonstrate a regression of an irregularity once established in the outline of the articular surface of the epiphysis.

Different opinions have been presented as to the cause of this complication. WALDENSTRÖM (1930) says that as the major part of the joint cartilage in the acetabulum, too, has undergone necrosis, the complication cannot be attributed to injury to the vessels supplying the femoral head. According to "recent investigations," the joint cartilage receives its nourishment not from bone tissue underneath the cartilage but from the synovial fluid. This fluid is probably produced from "the attachment of the capsule on the upper part of the collum". Necrosis of the joint cartilage would then, in his opinion, depend upon injury to that part of the capsule, probably caused by the closed reduction. MOORE (1945) stresses that the fact that the epiphysis shows atrophy argues against aseptic capital necrosis being an etiological factor in the arisal of this complication. He believes that the most logical explanation for this complication should be sought in a severe unspecific inflammatory reaction. After microscopic examination of material obtained at arthroplasty WILSON (1949) concludes that the "loss of the joint cartilage is the result of a limited or partial avascular necrosis, which is followed by revascularization in the subchondral area of the bone". Finally, PONSETI and BARTA (1948) clearly admit that they can find no reasonable explanation for this complication.

The present series does not lend itself very well to the study of the cause of the complication discussed above.¹⁴ Notes of interest in this question are extremely sparse in the hospital records. Laboratory examinations were not at all satisfactorily comprehensive. As a rule roentgen examinations were only sporadic. Only on one occasion was an intra-articular operation performed. In the operation report of this case it is stated only

¹⁴ The author did not observe any of these cases during the time of arisal or progression of the roentgenological changes.

that the cartilage in the acetabulum had disappeared completely and that the cartilage of the epiphysis exhibited necrotic changes. No microscopic examination was made. It is therefore unfortunately impossible for the author to draw any definite conclusions as to the etiology of this complication.

Femoral fracture in connection with closed reduction. Already in 1911 DREHMANN stressed the risk of this complication, although he himself did not report any instance of it. LÜTKEN (1939) described a case in which closed reduction caused a spiral fracture of the femoral shaft. He also mentioned that he was unable to find any earlier reports of such cases in the literature. Neither could the present author find any further publications in the literature, neither before nor after LÜTKEN's paper. This does not, of course, permit the conclusion that such a complication should be an extreme rarity.

In the present series closed reduction caused an oblique fracture through the lower part of the femoral shaft in 1 case. The fracture healed within a normal time and without complications and without resultant malposition.

Driving away of the epiphysis from the femoral neck by nailing. WILSON (1949) states that the epiphysis had been driven away from the neck when the nail was introduced in 1 instance in his series consisting of more than 70 cases nailed in situ. The result was an aseptic capital necrosis. The present author was unable to find further descriptions of this complication in earlier literature on slipped upper femoral epiphysis. In the present series the epiphysis was driven away from the neck by the nail in 1 case, the result being a diastasis almost 1 cm. wide between the epiphysis and the femoral neck. This complication occurred in a case with only slight symptoms that had commenced insidiously 3 weeks earlier without any known trauma. The roentgenogram showed slight displacement without signs of callus. No measures were taken against the diastasis. The patient left bed after 8 days and after a few more days weight bearing was permitted. According to a note in the case record 16 days after the operation, he was able to walk with hardly any impairment. Roentgen examination about

a week after the operation showed no reduction in the width of the diastasis. At the following roentgen examination 1 month later it had disappeared completely. No signs of aseptic capital necrosis or of other complications were seen in this case, which healed uneventfully.

No other complications of importance were observed in the present series.

THE RE-EXAMINATION

To trace the 166 patients forming the basis of the investigation proved difficult owing to a frequent lack of personal details in the registers and record cards. All cases except one, however, were finally traced.

Since last discharged from hospital 7 patients had died (one from an accident, one from pulmonary tuberculosis, one from pulmonary tuberculosis and intestinal tuberculosis, one from pneumonia, one from chronic nephritis, one from sepsis and one from cerebral tumour).

Of the remaining 158 patients 153 were re-examined both roentgenologically and clinically by the author personally. Of the other 5, two were living abroad and the other 3 refused to submit themselves to re-examination.

Those patients living within a reasonable distance from Lund or Hälsingborg were requested by letter or by telephone — and in the event of non-cooperation, by a personal visit — to present themselves at the Orthopaedic Clinic, Lund, or at the Vanförestalt, Hälsingborg. In this manner altogether 122 (about 73 per cent of the entire series) individuals were re-examined. The other 31 (about 19 per cent of the entire series) were living so far away from Lund and Hälsingborg that they could hardly be requested to travel such a distance simply for a scientific re-examination. In the autumn of 1948 the author therefore toured the local hospitals of these patients to examine them personally there. In this manner all the 31 patients were re-examined clinically and roentgenologically.

Of the 166 individuals (200 affected hip joints) 153 (183 hip joints) were re-examined, which means 92.2 per cent of the individuals (91.5 per cent of the hip joints).

The shortest interval between the first roentgenographic verification of the condition in adolescence and the re-examination was 3.0 years and the longest 31.4 years, the average being 15.5 ± 0.6 years. The interval in 26 cases was more than 25 years.

EXAMINATION TECHNIQUE

All symptoms reported were noted, special attention being given to undue fatigue, aching pain, pain on movement and on weight bearing. The patients were questioned carefully in order to find out whether any one or more of the symptoms were constant, intermittent, or only occasional: whether they occurred only after exertion of the hip: whether they were influenced by changes in the weather: how severe they actually were, etc.

The symptoms reported must, of course, be assessed with certain caution. The level of the threshold of pain varies from one individual to another with the result that what one patient may perceive as a slight aching pain in the hip may be felt by another as moderate or even extreme pain. A defective hip joint will naturally give more trouble to a person whose occupation obliges him to walk or be on his feet all day than to a person with a sedentary occupation. Moreover, some patients may for some reason or other purposely give wrong or misleading answers. Nevertheless, on the whole, the symptoms claimed are of good help when judging the late functional results.

All the patients were asked how much they thought they were handicapped in their work by their trouble: whether their income was less than that of other people doing the same sort of work: whether their disease had induced or forced them to change their occupation, and whether they had purposely chosen an occupation in which the hip might be spared. Their present and any previous occupations, and hobbies, liable to put a strain on the hip were likewise noted and as far

as males were concerned, also details of any previous military service.

Hereditary factors of importance were inquired into.

Trendelenburg's sign was tested in the usual manner with the patient completely nude: the sign was said to be positive if the patient was unable to maintain the pelvis at least horizontal. No attempts were made to measure the sign quantitatively as suggested by KNORR (1926), for example. In those cases in which the pelvis could not be placed in the horizontal plane owing to adductional contracture of the hip joint Trendelenburg's sign was said to be "uncertain", (marked ? in the tables) unless, of course, the sign was obviously positive in spite of the contracture.

When being examined for the presence and/or degree of severity of a limp the patients were completely nude. If no limp could be recognized, the patients were again examined but this time with their shoes on, to detect any slight limp not detectable by the eye but only by the ear. Needless to say, care was taken to judge the degree of the limp in all cases as uniformly as possible.

Before measurements of the legs were taken any malposition of the pelvis was carefully corrected and, in the event of some contracture preventing the leg from being placed in the mid position, the other leg was placed in a corresponding position during measurement.

After corresponding landmarks had been made bilaterally in the skin over the anterior superior iliac spine and over the lower border of the external malleolus, the lengths of the legs were measured from the above-mentioned points. (The following distances were also noted: anterior superior iliac spine — lateral articular space of the knee joint: anterior superior iliac spine — tip of the trochanter: tip of the trochanter — lower border of the external malleolus).

The sources of error attending this measuring method are considerable. Particularly in obese individuals, it is difficult to determine corresponding points of the anterior superior iliac spines by palpation. A slight malposition of the pelvis will also

result in relatively considerable erroneous measurements, and as both legs of one and the same individual are not always normally of exactly equal length, the significance of small differences will be of still less importance.

In cases with apparent shortening due to adduction contracture or apparent lengthening due to abduction contracture the difference was measured from the lower border of the internal malleolus on one side to the corresponding point on the other side, care being taken to place the hip in a position deviating as little as possible from the mid-position. The distance measured was checked, with the patient standing, by placing wooden blocks of known thickness under the apparently shortened leg (or under the sound leg, in the event of apparent lengthening) until the difference between the lengths of the two legs was made up for.

The circumference of the thigh was always measured 15 cm. above the base of the patella. (The largest circumference of the calf was also measured.)

Even though it is possible practically exactly to determine and mark the points on either thigh equidistant from the base of the patella, the actual performance of the measurements is of importance. As the thigh tapers distally the measurements should be made along a plane perpendicular to the longitudinal axis of the thigh, otherwise errors in both directions will result. In the event of a shortening of the leg the points equidistant from the base of the patella will not be situated in positions corresponding to the thigh as a whole. Furthermore, as the thighs of normals are certainly not always of quite equal circumference, no significance should be attached to small differences.

The figures obtained by the measuring methods employed in this study do not denote the absolute shortening of the leg or the absolute decrease in the circumference of the thigh but only differences between the measurements of either side. Therefore if, as may possibly occur in bilateral cases, the shortening of the leg and/or the shrinking of the thigh is equal in either limb, the method will fail to reveal the change. In

bilateral cases with a measurable shortening or atrophy the measurement obtained will be too low if the other limb has also undergone such alterations. Finally, a shortening of the leg or decreased circumference of the thigh of the less changed side remains concealed.

Therefore, as to limping, which in the present series was due partially to shortening of the leg, also the sources of error just mentioned made themselves felt. In bilateral cases without any detectable limp there might have been an equal shortening of both legs. If instead thereof such a case had shown a normal hip joint without any shortening of the leg on one side, the shortening on the other side might have been marked enough to produce a limp. In a bilateral case with, for example, right limp, it cannot be said (a) whether the limp would not have been more pronounced if the other leg had possibly not been shortened, too, (b) whether a possible shortening of the left leg might have been sufficiently pronounced to produce a left limp, if the right hip joint had been unaffected and the right leg not shortened.

These sources of error present in the evaluation of shortening of the leg, muscle atrophy, and limp in bilateral cases always affect the results in the same direction, i. e. the registered shortening, atrophy, and limp, may be under-estimated. It might therefore seem as if the hip joints in such cases in which the contra-lateral hip joint is also affected might be judged too favourably in the grouping of the late functional results given on page 63. However, not only shortening of the leg, muscle atrophy and limp, but also several other signs and symptoms decided to which group a hip joint was allocated. This considerably decreases the affect of the sources of error just mentioned. In the present series only 6 unilateral cases, which in the above respects might have been judged harder than the bilateral cases, were degraded solely on account of the shortening of the leg, muscle atrophy, or limp so that this source of error could in reality be practically ignored.

As to the mobility of the hip joint, extension was tested with the patient lying prone on the examination table, motion in

other planes being tested with the patient in the supine position. The range of rotation was tested both with the hip fully extended and with the hip flexed to the right angle, unless, of course, prevented by contracture (I. f. m. page 60 was calculated according to the value obtained for rotation with the hip extended.) The mobility was measured with the aid of an ordinary goniometer, which was considered to give sufficient accuracy for the purpose in question. Only passive motion was recorded.

Finally, every patient was examined for other symptoms that might reasonably be related to the slipped upper femoral epiphysis. Those patients in whom such symptoms were observed were then submitted to a thorough examination.

At the roentgen examination the frontal views were taken with both hips on one and the same film with the patient in the anatomical position, i. e. the legs fully extended and parallel, the knee caps facing upwards. Many patients were, however, unable to assume this position owing to contractures. In these cases the legs were placed as near the anatomical position as possible.

Roentgenograms in the Lauenstein's position were also taken of both hips on one and the same film. In many instances it was not possible to place the hip even approximately in the correct Lauenstein's position owing to limited mobility, with the result that several roentgenograms did not represent a true lateral picture of the femoral head and neck but an oblique view. In some cases in which mobility was very severely restricted or absent the author contented himself with frontal pictures. Only in a few instances were axial pictures taken.

The focus-film distance employed throughout was 90 cm.

Chapter VIII

LATE FUNCTIONAL RESULTS

The series was divided into 3 groups according to the late functional results as judged by all verbally reported symptoms, all signs elicited, and any impairment of working capacity.

Evaluation of the extent of limitation of mobility presents special difficulties and will therefore first be discussed.

The functional value of mobility of the affected hip was estimated by a modification of a method described by FERGUSON and HOWORTH (1931). This method is based upon the fact that the mobility of the hip in one direction, e. g. flexion, is of greater functional value than in another direction, e. g. adduction. Multiplication of the measured mobility in different directions by factors assigned by these authors according to the functional value of motion in the respective directions in question and the addition of the products thereby obtained gives the index of function, i. e. an expression denoting the gross functional value of the mobility of the hip.

But, as pointed out by GADE (1947), this system does not take into account within which sector of the plane of mobility the hip can be moved. He therefore modified the method by choosing different factors for different sectors in one and the same plane of movement. For estimating the functional value of possible flexion, for example, he uses a factor of 0.6 for the first 45° from full extension, 0.4 for the following 45° to the right angle, and 0.1 for all further flexion. GADE also estimates the functional value of mobility in different directions in a somewhat different manner than FERGUSON and HOWORTH. The scheme suggested and employed by GADE is given in Fig. 9.

A considerable imperfection of these two index systems is that proper regard is not paid to contractures (GADE reports the contractures in his series separately). According to the index system of FERGUSON and HOWORTH, a hip joint with 75° flexion, 10° extension, 10° abduction, 10° adduction, 30° external rotation and 10° internal rotation, would have the same index as a hip joint with 90° flexion, 10° extension,

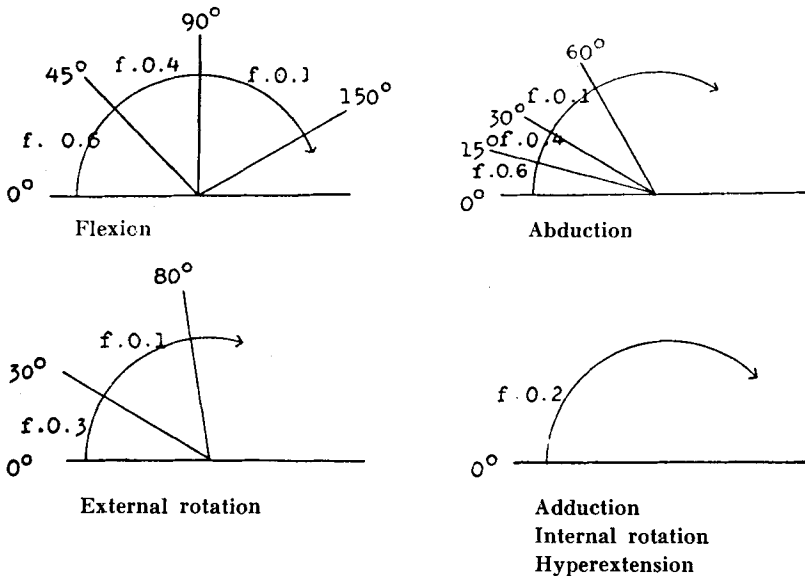


Fig. 9

Diagram for illustration of the calculation of i. f. m. (index for the functional value of motion). (After GADE.)

10° adduction contracture, 30° external rotation, and 10° internal rotation. According to GADE's system a joint capable of 70° flexion, 10° extension, 10° abduction, 10° adduction, 30° external rotation and 10° internal rotation would have the same index as a hip joint with 90° flexion, 10° extension, 10° adduction contracture, 30° external rotation and 10° internal rotation. Now, these hip joints compared and chosen for purposes of example can by no means be regarded as having equal functional value. That they nevertheless are given

the same index will suffice to illustrate the serious imperfection of these two index systems.

In the present investigation attempts were made to eliminate this methodological source of error in the following manner. Any deficiency of mobility of the hip was given a minus value. An adduction contracture of 10° , for example, was recorded as abduction -10 . Every deficiency of mobility was given a factor much higher than that assigned to the scope of positive mobility. The reason for this was the great importance of contractures in the impairment of the function of the hip. Whether the order of these factors selected is the most suitable, is, of course, a matter of opinion, this also applying to the factors used in the assessment of the scope of positive mobility.

In the present study the factors chosen for judging deficiencies of mobility were as follows:

- Deficiency of abduction: 2.0 for the first 10° .
4.0 for all further degrees.
- Deficiency of extension: 0.5 for the first 15° .
1.5 for the following 15° .
2.0 for all further degrees.
- Deficiency of internal rotation: 0.3 for the first 30° .
1.0 for the following 15° .
2.0 for all further degrees.

In the present series no deficiency of flexion or external rotation was observed. Deficiency of adduction was seen in 3 instances. In all of these cases, however, the index for the functional value of motion (i. f. m.) was already negative on account of other contractures. Therefore no factor was chosen for deficiency of adduction (nor for deficiency of flexion or external rotation).

The scope of positive mobility was assessed in exact accordance with GADE's method, use also being made of exactly the same factors (Fig. 9).

In the event of any deficiency of mobility, this deficiency measured in degrees was multiplied by its appropriate factor. The product thus obtained was subtracted from the sum of

the products obtained on multiplication of the positive mobility in the various directions by respective factors.

When judged by this method the i. f. m. of severely impaired hips will be a negative value. In the present study these negative values were not graded but all regarded as zero.

The example described on page 60 in which the deleterious effect of an adduction contracture could be compensated by a slight increase of flexion so that the i. f. m. remained unchanged, the hip joint without contracture would, according to the method employed in the present investigation, have an index of 58, and the hip joint with an adduction contracture of 10° , an index of 38, which will give a better idea of the functional value of the hip.

According to FERGUSON and HOWORTH, the index of function of a normal hip is 90—110. GADE writes: "these factors applied to a case of normal mobility in the hip joint will give a functional index of about 100." In order to form a personal opinion of the normal i. f. m. as measured by the method adopted for the present study, the author estimated the i. f. m. of the healthy hip in unilateral cases. As will be discussed in detail in chapter XI, among the 119 cases originally diagnosed as unilateral the roentgen re-examination revealed such definite changes in the "healthy" hip in 30 cases that it must be assumed that here, too, the epiphysis had slipped earlier. In 3 other cases the roentgenogram of the "healthy" hip exhibited distinct changes but of a nature not permitting any definite deductions as to the cause. These 33 cases were therefore not taken into account when judging the i. f. m. of a normal hip. The i. f. m. as judged by the remaining hips was found to vary from 82.5 to 99.0, the mean being 90.8 ± 0.4 . These figures do not, of course, claim to represent any high degree of accuracy, because the number of cases on which the calculation was based was far too small and, secondly, because also in some of these cases there were probably slight changes but not so marked as to be classed as definitely pathological.

For judging the late functional results FERGUSON and HOWORTH use only the index of function for the following

reason: "as improvement in symptoms accompanies improvement in function, the index offers a fair statement of the outcome of the case." In the opinion of the present writer, this attitude ignores other signs and symptoms far too much.

Therefore, as mentioned earlier, the late functional results in these series were judged not only by the i. f. m. but also by all symptoms and signs and any impairment of working capacity caused by the condition under discussion, the hips being grouped according to the following scheme:

Group I (good result)

- 1) No symptoms at all or only slight fatigue after strenuous activity (called SO in the case reports).
- 2) Real shortening of the leg, max. 1.5 cm.
- 3) Muscle atrophy of the thigh, max. 2.5 cm.
- 4) No limp or very slight, hardly discernible limp (HO).
- 5) I. f. m. more than 80.
- 6) Trendelenburg's sign negative.
- 7) No impairment of working capacity.

Group II (fair result)

- 1) Occasional, slight aching pain and slight pain on movement or weight-bearing, especially after strenuous activity (S+).
- 2) Real shortening of the leg, max. 3 cm.
- 3) Muscle atrophy of the thigh, max. 4 cm.
- 4) Slight to moderate limp (H+).
- 5) I. f. m. 40 or more.
- 6) Trendelenburg's sign positive.
- 7) No impairment of working capacity.

Group III (poor result)

- 1) Occasional, more pronounced aching pain, pain on movement or weight-bearing, especially after strenuous activity. Intermittent or continuous even independent of exercise or activity: Varying degree of aching pain, pain on movement or weight bearing (S++).

- 2) Real shortening of the leg, exceeding 3 cm.
- 3) Muscle atrophy of the thigh, exceeding 4 cm.
- 4) Severe limp (H+++).
- 5) I. f. m. less than 40.
- 6) Impaired working capacity.

When the series is classed according to this scheme group I will contain 69 hip joints, group II, 71, and group III, 43.

In group I, 57 of the hips gave no symptoms at all and 12 slight fatigue after strenuous activity.

Sixty of the hips caused neither visible nor audible limp and the remaining 9 a very slight, hardly discernible limp.

In group II, 29 of the hips gave no symptoms at all, 19 gave slight fatigue after strenuous activity and 23 gave mild symptoms.

Nineteen hips gave no visible or audible limp, 4 a very slight, hardly discernible limp and 47 a slight to moderate limp.

In group III, 7 hip joints gave no symptoms at all, 4 a slight fatigue after strenuous activity, 12 mild symptoms and 19 more pronounced symptoms.

Two of the hip joints gave no visible or audible limp, 2 a very slight, hardly discernible limp, 15 a slight to moderate limp and 23 a severe limp.

The occurrence of other signs in the various groups will be apparent from table V.

In 3 cases not all of the symptoms and signs could be recorded. In case Nr. 1002 the hip was immobilized in a hip spica after a recent arthrodesis of the joint and therefore the signs could not be tested. In one patient (case Nr. 1089), who was very imbecile at the time of the re-examination, symptoms and impairment of working capacity due to the slipped epiphysis could not be assessed. In case Nr. 1301, in which the lower leg of the affected side was amputated after an accident and in which the patient now wore a prothesis, muscle atrophy and limp due to the slipped epiphysis could not be assessed.

At the re-examination a few patients complained of undue fatigue or pains in the lumbar region. (Even if these symptoms had been regarded as directly due to the slipped epiphysis they would nevertheless not have influenced the above grouping).

Table V

Occurrence of real shortening of the leg, muscle atrophy of the thigh, i. f. m., Trendelenburg's sign and working capacity in the various groups

Late functional results	Real shortening of the leg in centimetres			Muscle atrophy of the thigh in centimetres			I. f. m.			Trendelenburg's sign		Working capacity	
	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average	Neg.	Pos.	Decreased	Unaffected
Group I	0	1.5	0.4 ± 0.1	0	2.5	0.6 ± 0.1	80.5	100.5	88.7 ± 0.6	69			69
Group II	0	3.5	1.4 ± 0.1	0	4.0	1.6 ± 0.2	44.5	91.0	70.1 ± 1.3	39	32		71
Group III	0	6.5	2.0 ± 0.2	0	6.0	3.1 ± 0.3	0	85.5	26.7 ± 4.1	20	8	14	19

In all of these cases the back was examined both clinically and roentgenologically. In one instance a spondylolisthesis was detected between LV and SI. In the remaining cases the pains in the back might well be explained as statical by the shortening of the leg.

In some patients there was recurvation and/or valgus of the knee joint, unilateral or bilateral. In all instances these abnormalities were slight and gave the patients no trouble.

As mentioned earlier in chapter III (page 28) several forms of treatment are represented in the present series, which from this point of view has been divided into the three following groups.

1. *Conservative treatment*.¹⁵ This group comprises 47 hips either treated with weight-relieving measures (walking sticks, crutches or rest in bed) or not treated at all. Of these 47 hips 44 were re-examined.

2. *Closed reduction + plaster of Paris*. This group consists of 98 hips. Seventy-seven were treated only by closed reduction + plaster of Paris, while the other 21 received also other

¹⁵ For this therapeutic group the author has adopted the short term "conservative treatment" well aware of the fact that the expression is inadequate.

forms of treatment. Of these 21 hips 7 were treated with traction for a short time between two attempts at closed reduction and 2 with traction + plaster of Paris for some time following the closed reduction, later only with plaster of Paris. Mobilisation under anesthesia on account of rigidity of the joint was performed in 9 cases and correction of malposition under anesthesia + plaster of Paris in 3 instances. In 2 cases arthrodesis of the hip joint was carried out in the later course of the disease. Of the 98 hip joints belonging to this therapeutic group 87 were re-examined.

3. *Various forms of treatment.* All the remaining hips were allocated to this group, which is therefore very heterogeneous from a therapeutical point of view. Of the 55 hips in this group 52 were re-examined.

The comparison of the late functional results obtained by the various methods of treatment will be preceded by a discussion of various other factors feasibly capable of influencing the late functional results.

Extent of epiphyseal displacement in relation to the femoral neck during adolescence. It may be assumed a priori that the late functional results will depend considerably upon the distance the epiphysis has slipped during adolescence. A reliable method for measuring such a distance would therefore be of great value.

Several authors give the displacement in inches or centimetres as measured in the roentgenogram or as a ratio of the distance slipped to the diameter of the femoral neck or to the diameter of the epiphysis (FERGUSON and HOWORTH, 1931; WILSON, 1938; WALDENSTRÖM, 1939, and others).

This method, however, cannot be used in the present series, because many of the cases were not quite recent at the first roentgenological examination. After the slipping those parts of the surface of the metaphysis uncovered by the epiphysis are rapidly resorbed. Simultaneously, in the region where the epiphysis projects beyond the margin of the neck, callus will form. These changes usually cloud the original outline of the

femoral neck and thereby render it impossible to measure the extent of the real displacement.

In chapter IV it was stressed that the degree of displacement of the epiphysis in relation to the femoral neck, as shown in the roentgenogram, will depend considerably on the position of the hip during the examination. Therefore, measurements made in ordinary routine roentgenograms of the hip will not even in recent cases give a true picture of the real displacement.

WALDENSTRÖM (1939) has described a measuring method for less recent cases but admits that it is by no means reliable. According to this method the angle is measured between the axis of the epiphysis — i. e. a line perpendicular to the base of the epiphysis — and the diaphysis in roentgenograms taken in Lauenstein's position. In healthy hips WALDENSTRÖM claims this angle — which he calls the caput angle — to be $10-20^{\circ}$. However, the order of this angle depends to a great extent on the position of the hip during the x-ray examination, even small positional deviations causing relatively large differences in the order of magnitude of the angle in question. As many roentgenograms in the present series did not represent a true lateral view but an oblique one, the caput angle will hardly give even a crude idea of the extent of the displacement.

In view of the unsuitability and unreliability of the methods mentioned above, it was decided like most workers (POMERANZ and SLOANE, 1935; MOORE, 1945; PONSETI and BARTA, 1948, and others) not to express the degree of displacement in units of measure but instead thereof to judge every hip as objectively as possible by the individual roentgenograms, and on the basis hereof to divide the series into two groups: slight displacement and marked displacement. Figs. 10—13 are given to illustrate where the borderline has been drawn between these 2 groups. Among the cases in which secondary changes did not prevent a direct measurement of the displacement in the roentgenogram, case Nr. 1061, left hip (Fig. 10) is an example of the greatest displacement observed, and case Nr. 1084, right hip (Fig. 11) of the slightest displacement in the respective groups. In the same manner case Nr. 1019 (Fig. 12) is an example of

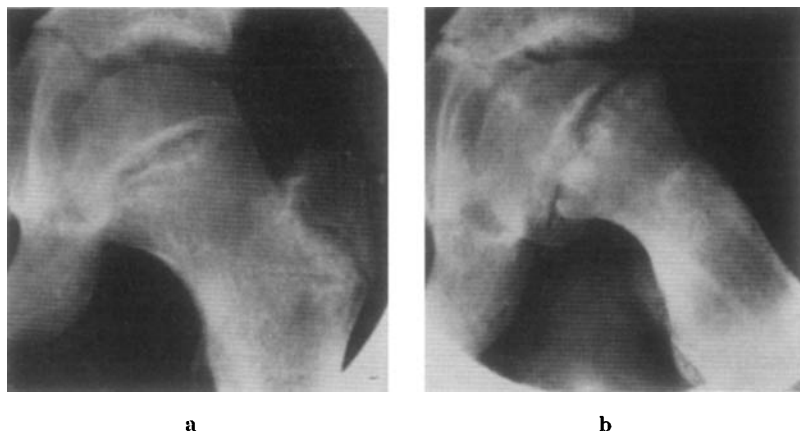


Fig. 10 (Case Nr. 1061, left hip). Slight displacement

- a) Frontal view 12. 12. 1933. Widened epiphyseal line. Epiphysis of normal depth. Possibly slight "loss of the hump" but no definite manifest sidewise shift of the epiphysis.
- b) View in Lauenstein's position 12. 12. 1933. Widened epiphyseal line. No signs of callus. Backward displacement of the epiphysis. In the original picture this displacement was 9 mm as measured behind. Slight retroversion of the epiphysis in relation to the femoral neck.

the greatest displacement and case Nr. 1051 (Fig. 13) of the slightest displacement in the respective groups among those cases in which direct measurement of the displacement in the roentgenogram was not possible because of secondary changes in the region of the femoral head and neck.

In 5 cases (in all of them only frontal roentgenograms were available) the degree of displacement could not be estimated with any satisfactory certainty and the cases were therefore regarded in this respect as uncertain.

Table VI shows to what a considerable extent the late functional results are dependent upon the extent of epiphyseal displacement. Of 53 hips in which the displacement in adolescence was slight 40 (75.5 per cent) were placed in group I at the re-examination and only 3 (5.7 per cent) in group III. Of 125 cases with a marked displacement in adolescence only 27 (21.6 per cent) were allocated to group I and 40 (32.0 per cent) to

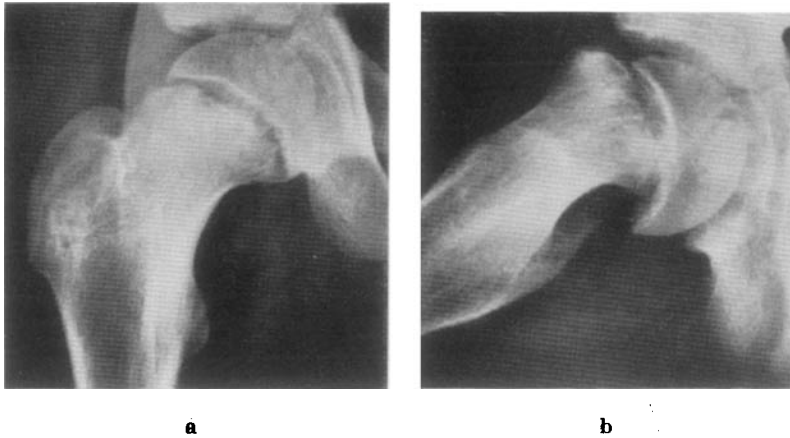


Fig. 11 (Case Nr. 1084, right hip). Marked displacement

- a) Frontal view 4.11.1940. Widened epiphyseal line. Normal epiphysis depth. Inferomedial displacement of the epiphysis.
 b) View in Lauenstein's position 4.11.1940. Widened epiphyseal line. No signs of callus. Backward displacement of the epiphysis. In the original picture this displacement was 11 mm as measured behind. Moderate retroversion of the epiphysis in relation to the femoral neck.

Table VI

Relation between the extent of epiphyseal displacement and the late functional results

Extent of epiphyseal displacement	Nr. of hips	Group I	Group II	Group III
Slight	53	40 (75.5 %)	10 (18.9 %)	3 (5.7 %)
Uncertain	5	2 (40.0 %)	3 (60.0 %)	
Marked	125	27 (21.6 %)	58 (46.4 %)	40 (32.0 %)

group III. The difference between 75.5 per cent and 21.6 per cent is more than 7 times the standard error, and the difference between 32.0 per cent and 5.7 per cent 5 times the standard error. Table XIII, page 77, shows the same tendency towards a deterioration of the late functional results in cases with marked displacement in all the therapeutic groups. The difference between the percentage of cases in group I after slight

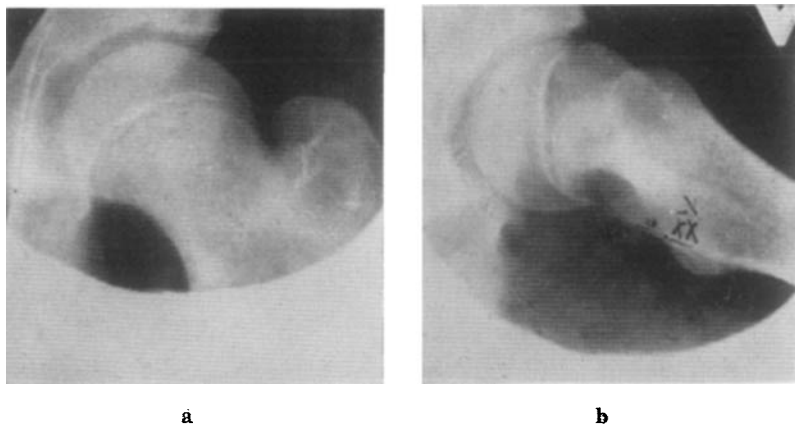


Fig. 12 (Case Nr. 1019). Slight displacement

a) Frontal view 6. 2. 1924. Widened epiphyseal line. Epiphysis depth slightly less than on the healthy side. No definitely manifest change of the hump. No manifest sidewise shift of the epiphysis.

b) View in Lauenstein's position 6. 2. 1924. Widened epiphyseal line. Rich callus formation between the epiphysis and the femoral neck. Backward displacement of the epiphysis. The extent of the displacement cannot be measured on account of secondary changes. Moderate retroversion of the epiphysis in relation to the femoral neck.

and marked displacement respectively is also statistically significant in all the therapeutic groups, while the corresponding difference in group III is statistically significant only for the largest group (not statistically probable for the others).

Age at time of re-examination. It is only to be expected that the late functional results after a disease leading to a deformation of the hip joint will deteriorate with increasing age of the patient. That such deterioration occurs within the age limits represented in the present series was substantiated by the fact that several patients at the re-examination stated that they had noticed a deterioration in the course of the years. An assessment of the time of commencement, rate of progression, relation to degree of deformation etc., of such deterioration could be estimated most accurately in a collection of patients controlled at regular intervals. This was, however, not possible in the present series, because most of the patients had not been examined

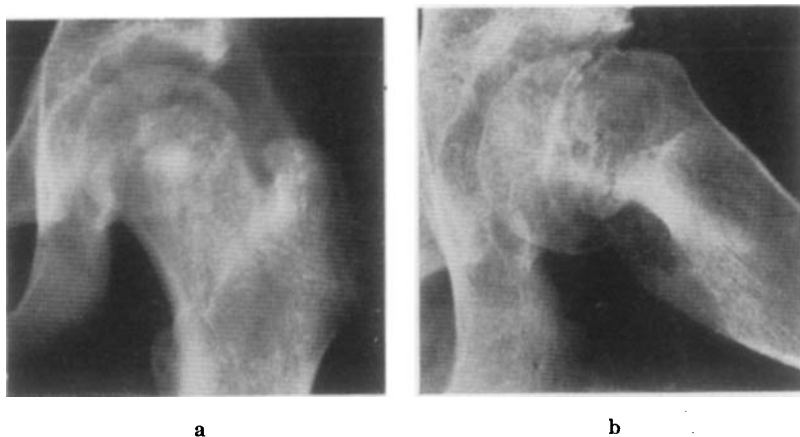


Fig. 13 (Case Nr. 1051). Marked displacement

- a) Frontal view 2. 10. 1931. No widening of epiphyseal line. Considerable decrease in epiphysis depth in relation to the healthy side. No definitely manifest change of the hump. No manifest sideways shift of the epiphysis.
- b) View in Lauenstein's position 2. 10. 1931. Widened epiphyseal line. Rich callus formation between epiphysis and the femoral neck. Bone resorption in anterior region of the neck. Backward displacement of the epiphysis. The extent of displacement of the epiphysis cannot be measured on account of secondary changes. Fairly pronounced retroversion of the epiphysis in relation to the femoral neck.

between the end of treatment in adolescence and the time of the re-examination.

It will be apparent from table VII that the groups with less

Table VII

Average age of the different groups at the time of the re-examination

Extent of epiphyseal displacement	Group I		Group II		Group III		Groups I+II+III	
	Nr. of hips	Average age in years at re-examination	Nr. of hips	Average age in years at re-examination	Nr. of hips	Average age in years at re-examination	Nr. of hips	Average age in years at re-examination
Slight	40	27.3 ± 1.1	10	29.4 ± 3.0	3	34.2 ± 7.2	53	28.1 ± 1.0
Marked	27	27.3 ± 1.3	58	33.1 ± 0.9	40	34.7 ± 1.3	125	32.4 ± 0.7

favourable late functional results show a higher average age at the re-examination. This applies both to those cases with a slight displacement during adolescence and to those with a marked displacement. Among the former cases this tendency is, however, far from statistically significant, among the latter, on the other hand, the difference between the average age in group I and that in group II is statistically significant (also between group I and group III, but not between group II and group III).

Table VIII shows the same tendency to a higher average age in the groups with less favourable late functional results in all the therapeutic groups. The difference is, however, statistically significant only as regards the two largest groups.

In an endeavour to find out whether the above demonstrated deterioration of the late functional results has any tendency to

Table VIII

Relation between the average age of group I, on one hand, and group II+group III, on the other hand, at the time of the re-examination

Extent of epiphyseal displacement	Treatment	Group I		Group II + III	
		Nr. of hips	Average age in years at re-examination	Nr. of hips	Average age in years at re-examination
Slight	Conservative	16	30.1 ± 1.8	5	32.1 ± 4.7
	Closed reduction + plaster of Paris	14	26.7 ± 2.0	5	30.3 ± 4.4
	Different forms of treatment	10	23.5 ± 2.0	3	24.8 ± 6.9
Marked	Conservative	1	32.8	19	33.9 ± 1.5
	Closed reduction + plaster of Paris	16	29.2 ± 1.7	52	35.4 ± 1.1
	Different forms of treatment	10	23.9 ± 1.7	27	30.4 ± 1.2

occur within any definite period of life, the cases were classed in groups according to the age of the patients. But as every age-group must be subdivided a) according to the extent of epiphyseal displacement and b) according to the type of treatment received, the number of cases in comparable groups will be very small and not permit any definite conclusions. However, judging by the analysis made, the deterioration did not seem to show a predilection for any particular period in life but rather to progress gradually during the years of life covered by the present series (table IX).

Table VII shows that at the time of the re-examination the average age of those patients with a slight displacement was lower than that of those in whom the displacement was marked. The difference is statistically significant. This might be explained by the assumption that in later years people with a slipped epiphysis sought medical aid in an earlier stage of the disease, while the displacement was still slight. This is also supported by the observation that the mean age at the time the condition was initially confirmed roentgenologically was lower for those cases in which the displacement was slight than for those in which it was marked (14.8 ± 0.3 years and 15.9 ± 0.2 years, respectively). The difference is statistically significant.

It was mentioned above that the late functional results become worse with increasing age and that the average age was higher among those patients in which the displacement was marked than among those in which it was slight. This fact will influence the difference demonstrated between the late functional results after slight and marked displacement respectively (table VI, page 69). In order to eliminate this factor a comparison was made between the number of cases with slight and marked displacement respectively in different age groups. It was then found that the number of cases with slight displacement is predominant in the very youngest age-groups. In the following age-groups the ratio between these two alternatives remains fairly constant up to the oldest age-groups, when the relative number with marked displacement increases fairly rapidly. Therefore those patients under 20 years of age

Table IX *Influence of age at the time of re-examination on the*

Age in years at re-examination	Conservative treatment			Closed reduction + plaster of Paris		
	Group I	Group II	Group III	Group I	Group II	Group III
15—19				1 (100 %)		
20—24		2 (100 %)		4 (36.4 %)	5 (45.5 %)	2 (18.2 %)
25—29		2 (66.7 %)	1 (33.3 %)	4 (33.3 %)	5 (41.7 %)	3 (25.0 %)
30—34	1 (16.7 %)	4 (66.7 %)	1 (16.7 %)	3 (20.0 %)	5 (33.3 %)	7 (46.7 %)
35—39		5 (100 %)		3 (30.0 %)	4 (40.0 %)	3 (30.0 %)
40—44		4 (100 %)		1 (10.0 %)	2 (20.0 %)	7 (70.0 %)
45—48					4 (44.4 %)	5 (55.6 %)

and those 40 or over have been excluded from table X. The average age of those cases with a slight displacement was thus 29.6 ± 0.8 years, and of those with a marked displacement 30.0 ± 0.5 years, thus practically no difference. The difference both in group I and in group III is admittedly lower than for the series as a whole but is nevertheless statistically significant.

The series was also analysed as regards any effect of the following factors on the late functional results: occupation,

Table X

Relation between the extent of epiphyseal displacement and the late functional results in the age groups 20—39 years.

Extent of epiphyseal displacement	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Slight	37	29.6 ± 0.8	28 (75.7 %)	7 (18.9 %)	2 (5.4 %)
Marked	95	30.0 ± 0.5	22 (23.2 %)	47 (49.5 %)	26 (27.4 %)

late functional results in cases with marked epiphyseal displacement

Different forms of treatment			Total		
Group I	Group II	Group III	Group I	Group II	Group III
3 (60.0 %)	1 (20.0 %)	1 (20.0 %)	4 (66.7 %)	1 (16.7 %)	1 (16.7 %)
4 (44.4 %)	3 (33.3 %)	2 (22.2 %)	8 (36.4 %)	10 (45.5 %)	4 (18.2 %)
1 (10.0 %)	6 (60.0 %)	3 (30.0 %)	5 (20.0 %)	13 (52.0 %)	7 (28.0 %)
2 (22.2 %)	4 (44.4 %)	3 (33.3 %)	6 (20.0 %)	13 (43.3 %)	11 (36.7 %)
	3 (60.0 %)	2 (40.0 %)	3 (15.0 %)	12 (60.0 %)	5 (25.0 %)
	1 (50.0 %)	1 (50.0 %)	1 (6.3 %)	7 (43.8 %)	8 (50.0 %)
			0 (0 %)	4 (44.4 %)	5 (55.6 %)

body weight at time of re-examination and age when the slipping of the epiphysis was first diagnosed. None of these factors, however, seemed to have any definite effect on the late functional results much less a statistically significant one.

In chapter V a description was given of the early complications occurring in the present series.

Table XI

Late functional results after aseptic necrosis of the epiphysis

Of the 20 cases in which this complication was observed 19 were re-examined. The case in which the aseptic necrosis of the epiphysis was limited to a small area near the tip of the nail (p. 43) is not included in this table (this case has been placed in group I).

Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
18	33.3±2.0	1 (5.6 %)	3 (16.7 %)	14 (77.8 %)

Table XI shows that *the late functional results after aseptic capital necrosis are extremely poor.* (In no instance was weight relieving therapy given for any length of time.)

The late functional results after the complication that WALDENSTRÖM designated necrosis of the joint cartilage are not much more favourable either (table XII).

Table XII

Late functional results after the complication described by Waldenström as necrosis of the joint cartilage

All of the 9 cases in which this complication was observed were re-examined.

Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
9	30.8±2.4	1 (1.1 %)	2 (22.2 %)	6 (66.7 %)

In one instance the epiphysis was driven away from the neck of the femur during nailing. This apparently had no effect on the late functional result, which at the re-examination was so good that the hip could be allocated to group I. In one instance the femur was fractured in the course of a closed reduction. At the re-examination this case was assigned to group II. The reason why this hip joint could not be placed in group I was only a slight restriction of motion (i. f. m. 76.5), which certainly had nothing to do with the old fracture of the femur.

The primary results obtained after closed reduction were discussed in chapter IV. As mentioned there, opinions differ widely already as to the possibility of obtaining a primary successful reduction of a slipped epiphysis by closed reduction. Still more do opinions differ as regards the advantages and disadvantages of closed reduction with respect to the late results. Some authors condemn closed reduction altogether

(WALDENSTRÖM, 1939; WATSON-JONES, 1944; WILSON, 1949, and others), others recommend this form of treatment under fairly wide indications (FRISING, 1926; BENTZON, 1939; HACKENBROCH, 1943, and others). Most authors assume an intermediate attitude. They are of the opinion that closed reduction in spite of the risk of complications, especially aseptic capital necrosis, is advisable but only to a limited extent, namely in cases with "acute displacement", "traumatic displacement", "acute traumatic displacement", or so-called "fracture separation" (PERKINS, 1932; MARTIN, 1948; PONSETI and BARTA, 1948, and others).

In table XIII a comparison is given between the late functional results observed in those cases in the present series that received only conservative treatment and in those hip joints treated mainly by closed reduction + plaster of Paris.

Among the hips with marked epiphyseal displacement during adolescence a distinct difference was found between the late

Table XIII

Late functional results after the three groups of different forms of treatment described on page 65

Treatment	Extent of epiphyseal displacement	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Conservative	slight	21	30.6 ± 1.7	16 (76.2 %)	4 (19.0 %)	1 (4.8 %)
	marked	20	33.8 ± 1.5	1 (5.0 %)	17 (85.0 %)	2 (10.0 %)
Closed reduction + plaster of Paris	slight	19	28.2 ± 1.8	14 (73.7 %)	4 (21.1 %)	1 (5.3 %)
	marked	68	34.0 ± 1.2	16 (23.5 %)	25 (36.8 %)	27 (39.7 %)
Different forms of treatment	slight	13	23.8 ± 1.9	10 (76.9 %)	2 (15.4 %)	1 (7.7 %)
	marked	37	28.6 ± 1.0	10 (27.0 %)	16 (43.2 %)	11 (29.7 %)

functional results of these two methods. The difference between the percentage of hips both in group II (85.0 per cent—36.8 per cent) and in group III (39.7—10.0 per cent) is statistically significant, in group I (23.5 per cent—5.0 per cent) statistically probable. The mean age of the group treated conservatively is 33.8 ± 1.5 years and for the hip joints treated by closed reduction + plaster of Paris 34.0 ± 1.2 years, thus no difference.

Of the 68 hips with marked epiphyseal displacement treated by closed reduction + plaster of Paris the position of the epiphysis after reduction was considerably improved or normal without any evidence of capital necrosis in 12 instances. Of these 12 cases 8 were allocated to group I, 3 to group II and 1 to group III. A considerable improvement or a normal position of the epiphysis attended by aseptic capital necrosis was observed in 8 instances. Of these 1 was placed in group II and 7 in group III. In 4 cases aseptic necrosis was diagnosed without any definite improvement in the position of the epiphysis. Of these 1 was assigned to group II and 3 to group III.

The indications for closed reduction seem to have varied somewhat from one hospital to another of those from which the cases were collected and also from one period to another in one and the same hospital. On the whole, the range of indications must be regarded as very wide. For example, closed reduction was by no means limited to acute displacements or cases with fracture-like symptoms and signs, but was also applied on hip joints with an insidious onset of symptoms of several months duration, in which the roentgenograms showed considerable callus.

As compared with conservative treatment, closed reduction + plaster of Paris of hips with marked epiphyseal displacement caused a statistically significant decrease in the number of cases with fair late functional results, a statistically significant increase in the number of cases with poor late functional results, and a statistically probable increase in the number of cases with good late functional results. A deterioration of the late functional results was more common than an

improvement (the difference in the latter respect is not statistically significant or probable).

Among the 68 cases with a marked displacement treated mainly by closed reduction + plaster of Paris 18 were subjected more than once to an attempt at closed reduction. This caused no deterioration of the late functional results (table XIV). The average age of these patients was 35.9 ± 2.0 years, hence even higher than that of all the patients with marked epiphyseal displacement in this therapeutic group (34.0 ± 1.2 years).

Table XIV

Late functional results in those cases with marked displacement in the therapeutic group 2 (page 65) that were treated by repeated closed reductions

Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
18	35.9 ± 2.0	4 (22.2 %)	8 (44.4 %)	6 (33.3 %)

In the present series there were also a few other hips with marked epiphyseal displacement that were treated by closed reduction but not included in group 2 (closed reduction + plaster of Paris). In 4 instances, osteosynthesis with a three-flanged nail was employed for fixation instead of plaster of Paris after closed reduction. Of these 4 cases 2 were assigned to group I and 2 to group III. In 9 cases the operator was immediately quite aware of the fact that the closed reduction was unsuccessful, for which reason no kind of subsequent fixation was applied. Of these 9 cases 7 were re-examined. One was placed in group I, the remaining 6 being allocated to group II. Table XV accounts for all the hip joints with a marked epiphyseal displacement treated mainly by closed reduction. When compared with the cases with marked displacement given only conservative treatment (table XIII) the difference between the percentages of hip joints in group II

and group III will be statistically significant, in group I statistically probable.

Table XV

Late functional results after closed reduction of all cases with marked displacement in which this form of treatment was the main therapeutic method applied

As will be apparent from table IV, 102 hips were treated with closed reduction + plaster of Paris: in 98 of these cases this was the main type of treatment given (page 65). Of these 98 hips 87 were re-examined. The displacement was marked in 68. These 68 have been included in this table.

Four hips were treated with closed reduction + osteosynthesis with a three-flanged nail. All of these 4 were re-examined. The displacement was marked in all of them: they were therefore all included in this table.

Eleven hips were treated with closed reduction without subsequent fixation. This constituted the main form of treatment in 9 cases. All of them were re-examined. In 7 of them the displacement was marked and they were therefore included in this table.

Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
79	33.1 ± 0.9	19 (24.1 %)	31 (39.2 %)	29 (36.7 %)

The late functional results of the hip joints with a slight epiphyseal displacement are practically the same after conservative treatment as after closed reduction + plaster of Paris, the results of the latter method being slightly inferior (table XIII). The average age of the group treated by the former method is 30.6 ± 1.7 years, for the latter 28.2 ± 1.8 years.

Among the 19 hip joints with a slight epiphyseal displacement treated by closed reduction + plaster of Paris a primary successful result could not be established in a single case. In 2 instances aseptic capital necrosis could be observed. In spite of this complication the functional results were so good that the 2 hips could be assigned to group I and group II respect-

ively. The reason for such good late functional results cannot be that the displacement in these 2 cases was only slight, but is rather simply due to chance. If the series had been larger, there would therefore surely have been a certain number of cases in which complicating aseptic capital necrosis would have impaired the late functional results to such an extent that the cases in question would have to have been placed in group III. The age distribution in the 2 therapeutic groups also causes the cases treated only conservatively to be seen against a less favourable background.

As compared with conservative treatment, closed reduction + plaster of Paris of hips with slight epiphyseal displacement had practically no effect on the late functional results.

In addition to the 19 hip joints assigned to therapeutic group 2 there were 2 other hip joints with a slight epiphyseal displacement that were treated by closed reduction but without subsequent fixation. Both were placed in group I.

Table XVI gives the hip joints that presented fracture-like symptoms and signs without any roentgenological signs of callus (which must then be regarded as most suitable for closed reduction). In all of these hips the displacement was marked. But as the average age of these patients was only 30.0 ± 1.6 years — due to a relatively large number of young patients — these hips cannot be compared directly with those treated only conservatively. Therefore all patients under 25 years of age were excluded from table XVII. After this exclusion the average age of the patients treated only conservatively is 35.1 ± 1.3 years and of those treated by closed reduction 34.6 ± 1.5 years, thus still slightly lower. The difference between the percentages of hip joints in group II is statistically significant, but not statistically significant or probable in group I and group III.

In 6 of those cases in table XVII that were treated by closed reduction the position of the epiphysis was considerably improved or normal after closed reduction and no signs of capital necrosis could be detected. Four of these were placed in group I and 2 in group II. A considerable improvement or normal

Table XVI

Late functional results after closed reduction in those cases that on admission exhibited fracture-like symptoms and signs without any roentgenologically manifest callus. In all of these cases the displacement was marked.

In the present series 32 cases presented this picture. One case, in which closed reduction was unsuccessful, was treated with open reduction and therefore cannot be included in this table. Of the remaining 31 cases 28 were re-examined. Of these 28 cases treated with closed reduction plaster of Paris was used for fixation in 26 and osteosynthesis with a three-flanged nail in 2.

Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
28	30.0 ± 1.6	11 (39.3 %)	6 (21.4 %)	11 (39.3 %)

Table XVII

Late functional results in those cases given in table XVI that were 25 years of age or more and of those likewise 25 years of age or more with a marked displacement treated solely conservatively

Treatment	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Conservative	18	35.1 ± 1.3	1 (5.6 %)	15 (83.3 %)	2 (11.1 %)
Closed reduction	18	34.6 ± 1.5	6 (33.3 %)	4 (22.2 %)	8 (44.4 %)

position of the epiphysis + aseptic capital necrosis was observed in 8 cases. One of these was placed in group II and 7 in group III. In 1 instance aseptic necrosis was seen without any definite improvement in the position of the epiphysis. This case was assigned to group II.

As compared with conservative treatment, closed reduction among those cases with fracture-like symptoms and signs with-

out roentgenological signs of callus caused a statistically significant decrease in the number of cases with fair late functional results and an increase — though not statistically significant or probable — of both the number of cases with poor late functional results and of the number of those with good late functional results. A deterioration of the late functional results was more common than an improvement (the difference in the latter respect is not statistically significant or probable).

Detailed study of the cases in table XVII¹⁶ will show that of those treated with closed reduction no symptoms at all were claimed in 7 (6),¹⁷ a slight fatigue after strenuous activity in 2 (5), mild symptoms in 7 (7) and more pronounced symptoms in 1 (0). In 7 (6) there was neither audible nor visible limp, in 1 (2) a very slight, hardly discernible limp, in 4 (8) a slight to moderate limp, and in 5 (1) severe limp. The real shortening of the leg was on the average 0.7 ± 0.5 cm. (1.4 ± 0.5 cm.), muscle atrophy of the thigh 2.0 ± 1.0 cm. (1.8 ± 0.8 cm.) and i. f. m. 53.2 ± 9.5 (60.2 ± 5.8) Trendelenburg's sign was given as uncertain in 3 cases (pos. in 5 cases). The working capacity was noted as impaired in 2 (1) cases.

Thus, also this detailed examination shows the late functional results obtained in those hips that were treated by closed reduction to be somewhat inferior in most respects to those obtained by conservative treatment only.

Table XVIII gives those cases in which closed reduction was primarily successful. In all of these cases the epiphyseal displacement was marked. The average age of these patients was 32.6 ± 2.0 years, thus lower than that of conservatively treated cases with marked displacement (33.8 ± 1.5 years). The difference between the percentages of cases in group II is statisti-

¹⁶ Case Nr. 1301 (conservative treatment) was not included as regards limp and atrophy of the thigh muscle, case Nr. 1089 (closed reduction) was not included as regards symptoms and any impairment in working capacity, and case Nr. 1002 (closed reduction) was not included as regards signs (see page 64).

¹⁷ The bracketed figures denote the corresponding values among patients treated only conservatively.

Table XVIII

Late functional results after primarily successful closed reduction. In all of these cases the displacement was marked.

Of the 24 cases in which reduction was primarily successful
22 were re-examined.

Nr. of hips	Average age in years at re-examina- tion	Group I	Group II	Group III
22	32.6 $\pm$ 2.0	8 (36.4 %)	4 (18.2 %)	10 (45.5 %)

cally significant, in group I and group III it is statistically probable.

As compared with conservative treatment, closed reduction among those cases with primarily successful results caused a statistically significant decrease in the number of cases with fair late functional results and a statistically probable increase in both the number of cases with poor late functional results and of the number of those with good late functional results. A deterioration of the late functional results was more common than an improvement (the difference in the latter respect is not statistically significant or probable).

Table XIX gives the hips with fracture-like symptoms and signs without roentgenological signs of callus (the epiphyseal

Table XIX

Late functional results in cases with fracture-like symptoms and signs on admission and in which closed reduction was primarily successful. The displacement was marked in all.

Of the 22 cases belonging to this category 20 were re-examined.

Nr. of hips	Average age in years at re-examina- tion	Group I	Group II	Group III
20	31.6 $\pm$ 2.0	8 (40.0 %)	4 (20.0 %)	8 (40.0 %)

displacement was marked in all of them) and in which closed reduction was primarily successful. As the average age of these patients was only 31.6 ± 2.0 years due to a rather rich representation of the young age groups, the late functional results obtained here cannot be compared directly with those obtained in the cases treated only conservatively. Therefore all patients that were under 24 years of age were excluded from table XX. The average age of those patients treated only conservatively was then 35.1 ± 1.3 years and for those who were treated with closed reduction 34.4 ± 1.8 years, thus still somewhat lower for the latter therapeutic group. The difference between the percentages of cases in group II is statistically significant, while in group I and group III the difference is not statistically significant or probable.

As already mentioned, of the cases treated with closed reduction, table XX includes only those in which the position of the epiphysis was considerably improved or normal after closed reduction. Aseptic capital necrosis was observed in 8 hips. Of these 1 was placed in group II and 7 in group III.

As compared with conservative treatment, closed reduction among those cases with fracture-like symptoms and signs without roentgenological signs of callus and with primarily successful results caused a statistically significant decrease in the number of cases with fair late functional results and an increase, though not statistically significant or probable, of both the number of cases with poor late functional results and the number of those with good late functional results. Even in this category of cases a deterioration of the late functional results was more common than an improvement (the difference in the latter respect is not statistically significant or probable).

A detailed study was made of the cases included in table XX.¹⁸ It was then found that of those cases treated with closed reduction 6 (6)¹⁹ had no symptoms at all, 3 (5) a slight fatigue after strenuous activity, 5 (7) mild symptoms and 1 (0) more

¹⁸ See footnote 16 page 83.

¹⁹ See footnote 17 page 83.

Table XX

Late functional results in those cases given in table XIX that were 24 years of age or more and of those likewise 24 years of age or more with marked displacement treated only conservatively

Treatment	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Conservative	18	35.1 ± 1.3	1 (5.6 %)	15 (83.3 %)	2 (11.1 %)
Closed reduction	16	34.4 ± 1.8	5 (31.3 %)	4 (25.0 %)	7 (43.8 %)

pronounced symptoms. In 7 (6) cases no limp, neither audible nor visible, could be detected, in 1 (2) case there was a very slight, hardly discernible limp, in 3 (8) a slight to moderate limp and in 4 (1) a severe limp. The real shortening of the leg was on the average 1.0 ± 0.3 cm. (1.4 ± 0.5 cm.), atrophy of the thigh muscle 1.9 ± 0.5 cm. (1.8 ± 0.8 cm.), and the i. f. m. 55.4 ± 10.3 (60.2 ± 5.8). The Trendelenburg's sign was given as uncertain in 3 cases (pos. in 5) and the working capacity was described as impaired in 2 (1) cases.

Hence, here again the late functional results after closed reduction were in many respects a little inferior to those obtained by conservative treatment only.

In the comparison of the late functional results obtained after conservative treatment and closed reduction respectively due consideration was always given to the two factors shown earlier to influence the late functional results, namely the age of the patient at the time of the re-examination and the extent of epiphyseal displacement. However, as pointed out on page 67 the extent of epiphyseal displacement could not be determined with accuracy, for which reason the series was divided in this respect into two groups only, viz., slight and marked displacement. There were, of course, great differences between the extent of displacement in the individual cases in each of these

two groups. Under unfavourable circumstances these variations might be a source of error when comparing the late functional results obtained by the various forms of treatment. But a detailed study of the series from this point of view failed to produce evidence suggesting this to be the case: on the contrary, judging by the roentgenograms, all the categories of cases compared with one another seem to have shown a comparable extent of displacement.

It cannot be excluded that aseptic necrosis would have developed in a certain percentage of cases with an acute slipping as a direct consequence of the acute displacement, even if these hips had not been subjected to closed reduction. If this be the case, it would imply that some of the poor late functional results observed after closed reduction were unjustly attributed to the treatment. As pointed out earlier, page 44, the present series will not permit any conclusions as to whether aseptic necrosis really can arise in this manner or not. However, some authors claim that this arisal mechanism is possible. But judging by a perusal of the literature, no convincing evidence for this belief is available. At any rate, even if this mode of arisal is really possible, it is probably so rare that it will have had no substantial influence on the comparisons made in this study.

Some authors are of the opinion that fixation in plaster of Paris, especially when prolonged, has an unfavourable effect in cases with a slipped epiphysis (HASS, 1930; WILSON, 1936; HOWORTH, 1941, and others).

Unfortunately, the present series includes only 8 hips treated with fixation in plaster of Paris without previous closed reduction and only 4 hips in which other fixation than plaster of Paris was used after closed reduction, namely osteosynthesis with a three-flanged nail.

Among the first mentioned 8 cases 1 was treated later with closed reduction and 1 with open reduction. Of the remaining 6 cases 3 had a slight epiphyseal displacement and in 3 the displacement was marked. The 3 cases with slight displacement were all placed in group I at the re-examination. In 1

of these cases the records contained no information as to when the plaster of Paris was removed, in the 2 other cases the hip was fixed in plaster for 12 weeks. Of the 3 cases with marked displacement 2 were allocated to group II and 1 to group III. One of these cases had been fixed in plaster for 3 weeks, but as to the other 2, the records are non-informative in this respect.

In all of the 4 cases in which closed reduction was followed by osteosynthesis with a three-flanged nail the epiphyseal displacement was marked. As to the late functional results, 2 cases were placed in group I and 2 in group III.

Judging by the few available cases, the late functional results thus show no definite tendency to be worsened by fixation in plaster of Paris.

The period of immobilisation in plaster of Paris after closed reduction varied considerably from one case to another in the present series, but the late functional results after a prolonged immobilisation in plaster of Paris did not seem to be inferior to those obtained after a relatively short fixation in plaster of Paris (table XXI and table XXII).

Neither can it be denied that the late functional results after closed reduction might possibly have been better if the reduction had been carried out very carefully. The number of primary successful reductions would, however, then certainly have been relatively small, and even among these the frequency of poor late functional results would very probably not have been substantially reduced for the following reason. In many cases the poor late functional results after closed reduction were due to an aseptic capital necrosis which, as pointed out on page 44, is much more common among cases with primarily successful results than among those where no improvement of the position of the epiphysis could be observed. This opinion is also supported by the fact that the frequency of capital necrosis was not higher nor the late functional results inferior, among those cases in which more than one attempt at closed reduction was made.

Judging by the present series, no improvement in the late

Table XXI

Relation between period of immobilisation in plaster of Paris after closed reduction and the late functional results

In some of the 87 cases in table XIII that were treated by closed reduction + plaster of Paris the period of immobilisation could not be deduced from the hospital records.

Extent of epiphyseal displacement	Immobilisation in weeks	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Slight	≥ 7	8	27.9 ± 2.3	6 (75.0%)	2 (25.0%)	
	≥ 8	11	28.4 ± 3.0	8 (72.7%)	2 (18.2%)	1 (9.1%)
Marked	≥ 7	25	34.3 ± 1.3	4 (16.0%)	12 (48.0%)	9 (36.0%)
	≥ 8	32	33.5 ± 1.5	10 (31.3%)	9 (28.1%)	13 (40.6%)

Table XXII

Relation between the period of immobilisation in plaster of Paris after closed reduction and the late functional results after exclusion of (a) those cases with primarily successful results and (b) those cases with aseptic necrosis of the epiphysis

Extent of epiphyseal displacement	Immobilisation in weeks	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Slight	≥ 7	6	27.0 ± 2.4	5 (83.3%)	1 (16.7%)	
	≥ 8	11	28.4 ± 3.0	8 (72.7%)	2 (18.2%)	1 (9.1%)
Marked	≥ 7	19	33.2 ± 1.5	4 (21.1%)	8 (42.1%)	7 (36.8%)
	≥ 8	19	35.1 ± 2.1	4 (21.1%)	9 (47.4%)	6 (31.6%)

functional results seen after closed reduction can be expected from limiting the use of the method to a fairly short period after the occurrence of the displacement, for among the cases with fracture-like acute symptoms in which closed reduction produced the desired primary result the interval between the acute displacement and the closed reduction was on the average 5.9 days, while the corresponding time for those cases in the same category in which aseptic capital necrosis could be demonstrated was only 5.2 days (see page 43 and 44).

The difference between the percentage of improved cases and the percentage of cases that became worse after closed reduction, as compared with conservative treatment, is not statistically significant or probable in any of the categories discussed in this chapter.

Nevertheless, one may surely conclude that the fairly discouraging late functional results after closed reduction as compared with those obtained by conservative treatment in the present series was not due to chance.

1. In all the categories of cases discussed in this chapter a deterioration of the late functional results was more common than an improvement.

2. This was the case even among those hips that must be regarded as most suitable for closed reduction²⁰ and in which this treatment also was primarily successful.

3. Aseptic capital necrosis, a factor followed in most cases by poor late functional results, was much more common among those cases where closed reduction was primarily successful than among those in which no improvement in the position of the epiphysis could be discerned.

Other forms of treatment are represented so sparsely in the present series that a detailed comparison of the late functional results obtained thereby would be of no practical value. Cases treated by these various forms of therapy are accounted for in tables XXIII and XXIV.

²⁰ Cases with fracture-like-symptoms and signs without roentgenological signs of callus.

Table XXIII

Late functional results after different forms of treatment in cases with slight displacement

In a few instances the hip joints were treated by more than one method. These cases have been classed according to the main form of treatment they received.

Treatment	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Conservative	21	30.6 ± 1.7	16	4	1
Traction	3	25.5 ± 5.0	3		
Plaster of Paris without previous reduction	3	22.2 ± 4.3	3		
Osteosynthesis with a three-flanged nail without previous reduction	4	18.5 ± 1.8	2	2	
Closed reduction + plaster of Paris	19	28.2 ± 1.8	14	4	1
Closed reduction without subsequent fixation	2	28.5 ± 1.4	2		
Correction of malposition under anesthesia + plaster of Paris	1	35.5			1

In many earlier publications on slipped epiphysis the late functional results are also discussed.

However, many of these earlier collections certainly include mis-diagnosed cases. The percentage of re-examined cases is not infrequently very low. In some reports the study was based entirely on questionnaires. In practically all of the collections reported upon the cases had been followed up for but a short time. Often the extent of the original displacement was not taken into consideration. As a rule the late functional results were not properly described but simply classed into such groups as "excellent, good, fair and poor results" without any detailed information as to what is to be understood by these expressions.

Table XXIV

Late functional results after different forms of treatment in cases with marked displacement

Some hips were treated by more than one method. These cases have been classed according to the main form of treatment they received.

Treatment	Nr. of hips	Average age in years at re-examination	Group I	Group II	Group III
Conservative	20	33.8 ± 1.5	1	17	2
Traction	7	26.1 ± 1.4	2	3	2
Plaster of Paris without previous reduction	3	26.8 ± 4.1		2	1
Osteosynthesis with a three-flanged nail without previous reduction	1	24.5	1		
Closed reduction + plaster of Paris	68	34.0 ± 1.2	16	25	27
Closed reduction + osteosynthesis with a three-flanged nail	4	22.0 ± 3.2	2		2
Closed reduction without subsequent fixation	7	30.6 ± 1.2	1	6	
Open reduction + plaster of Paris	2	34.0 ± 0.7			2
Open reduction + osteosynthesis with a three-flanged nail	2	19.0 ± 0.7	2		
Open reduction without subsequent fixation (explorative arthrotomy)	3	35.8 ± 1.8	1	2	
Correction of malposition under anesthesia + plaster of Paris	2	25.5 ± 4.2	1	1	
Subtrochanteric or intertrochanteric osteotomy	6	34.0 ± 3.6		2	4

In those papers in which such information is given the authors have divided or grouped their material according to the late functional results after principles of classification differing in several essential respects from those adopted in the present study. Moreover, the individual series of earlier authors were as a rule only small.

In view of the above it is not possible to make a comparison satisfying the requirements of reasonable accuracy between the

Table XXV.

Late results after various forms of treatment, collected from different authors (after Lütken)

	Total	Good	Fair	Poor	Bad
Untreated	14	1	6	7	
Treatment interrupted and insufficient	15		13		2
Rest in bed and physiotherapy	19	4	12	2	1
Supporting bandage	3	2	1		
Extension	10	4	6		
Extension + plaster	4	1	1	2	
Plaster bandage	19	10	3	6	
Impaction-fracture of the epiphysis (Jahss' method)	12	10	1	1	
Manipulation	207	68	50	53	36
Drilling	6	6			
Osteotomy of the neck	1				1
Wedge + peg	6	2	2	1	1
Realinement operation or operative correction	62	19	11	18	14 (1 died)
Arthroplasty	15		1	3	11
Sub- or transtrochanteric osteotomy	12	4	2	2	4 (1 died)
Palliative operation	2		1	1	
Total	407	131	110	96	70

late functional results in the present series and those published by earlier authors.

Nevertheless, in order to give the reader an idea of the late functional results observed by other authors after different forms of treatment, table XXV, published by LÜTKEN (1939), is given. LÜTKEN collected 659 literature cases among which the late functional results obtained in 407 hips were recorded.

Chapter IX

LATE ROENTGENOLOGICAL RESULTS

At the re-examination all of the hip joints in the present series showed pathological changes in the region of the femoral head and neck. These changes varied in severity from very slight, discernible only on direct comparison with a contralateral healthy side, to the most grotesque types.

The changed position of the epiphysis in relation to the femoral neck after a slipping of the epiphysis gives rise to secondary changes in the region of the femoral head and neck. Those parts of the metaphysis no longer covered by the epiphysis are absorbed, and new bone tissue is formed in those regions in which the epiphysis projects beyond the border of the neck.

The appearance of the roentgen picture in adult age will therefore depend essentially on the direction and extent of the epiphyseal displacement in relation to the femoral neck during adolescence.²¹ In the large majority of cases the epiphysis slips in an infero-medio-posterior direction. The roentgen picture presented by this type of displacement in uncomplicated cases will now be described.

Frontal view. Normally the epiphysis projects slightly beyond the superolateral margin of the femoral neck. This gives the superolateral contour of the femoral head and neck a concave form (Fig. 15). After displacement of the epiphysis this concavity is eliminated to a varying degree, or is replaced by a convexity (Figs. 17 and 20).

²¹ In reality it is the neck that is displaced in relation to the epiphysis and not the epiphysis in relation to the neck. The above-mentioned expression has, however, been generally accepted and will therefore be used also here.

Normally the femoral head is practically spheric. Judging by the roentgenogram, this shape is not affected by minor epiphyseal displacement. However, on major displacement the femoral head loses its spheric shape and becomes oval or almost rectangular or square (Figs. 17, 21 and 19).

Simultaneously with the sidewise shift of the epiphysis there occurs a rotation of the latter about a sagittal axis and about a frontal axis, because the proximal surface of the neck is not plane but convex and the surface of the epiphysis facing it is concave. As the inferomedial and posterior margin of the neck usually undergoes resorption, this rotation is accentuated still more. On account of this, the slight valgus normally seen between the femoral head and neck is eliminated either completely, or partially or is substituted by a varus position (Figs. 17 and 20).

If the epiphysis is displaced only slightly inferomedially, the change in position of the femoral head in relation to the neck will often be masked by new-formed bone tissue inferomedially. It therefore sometimes happens that no signs of a displacement are to be seen in this region, even though the superolateral contour of the femoral head and neck exhibit distinct changes. If, however, the distance between the femoral neck and the inferomedial pole of the epiphysis is somewhat larger, the extent of new bone formation will not be sufficient completely to mask the original change in position. This change is then seen as a persistent manifest inferomedial shift of the epiphysis in relation to the femoral neck. On account of the simultaneous rotation of the epiphysis about a sagittal axis the deformation often assumes a characteristic shape which is, however, seen not only after slipped upper femoral epiphysis but also, for example, in arthrosis deformans after subluxat. cox. (WIBERG 1939). The French call this deformation "tête coulée", the Germans "Einrollung von Kopf und Hals", and the Scandinavians "caputdroppe" (Fig. 20). On pronounced epiphyseal displacement, rotation about the sagittal axis may sometimes be so great that the distance between the medial surface of the neck and the inferomedial pole of the epiphysis will be

only very small. The space thus formed is then often filled completely by new-formed bone tissue and the femoral head and neck thereby fused to a single entity (Fig. 21).

On account of the usual externally rotated malposition of the hip joint there is often an illusory shortening of the caput-collum length. But even a real shortening may not infrequently occur on account of the epiphyseal displacement and resorption in the proximal part of the neck. In certain cases reduced growth in length may play a contributory role. The reason for this reduced growth in length is the well known fact that the epiphyseal line closes earlier after slipped epiphysis than normally. WIBERG (1941) has shown that this may, but need not always, give rise to a real shortening of the caput-collum length as compared with the healthy side.

The inferomedial displacement of the epiphysis, its rotation about a sagittal axis and consequent secondary changes give rise to a coxa vara (Fig. 21).

In a normal hip, where the longitudinal axis of the neck forms a straight line, the collo-diaphyseal angle can be measured without difficulty on the roentgenogram. However, the femoral neck as a whole is not infrequently bent after slipped epiphysis (Fig. 20). This makes it impossible to measure the collo-diaphyseal angle (at least without resorting to complicated mathematical calculations). In other cases deformation following slipped epiphysis is so pronounced that the femoral head and neck fuse to form a single entity (Fig. 21), which likewise makes it impossible to judge the collo-diaphyseal angle.

Even under normal conditions this angle varies considerably. According to VALENTIN (1922) RODET found individual variations between 121° and 144° , MICULICZ between 116° and 138° , and CHARPY between 118° and 140° , by anatomical measurements. According to VALENTIN the average angle calculated on the basis of earlier publications is 128° for Europeans, a figure which is often given in later literature as the normal value of this angle. SCHRAMM (1928) likewise measured the angle on anatomical preparations and found it to be on the left side at least 110° , and at most 124° (average 116.2°) and on the right side at least 111° , and at most 133° (average 121°). In roentgenograms of 20 normals in "normal position", i. e. with the patella facing straight upward, he found a minimum angle of 118° , a maximum of 146° , and an average of 132.8° for the left side and a minimum angle of 122° , a maximum of 153° , and an average of 135.5° for the right side. According to the table in his publication, the

difference between the left side and the right side of one and the same individual was 5° or more in no fewer than 10 of the above mentioned 20 normals and in 1 instance even 20° .

The order of the collo-diaphyseal angle as seen in the roentgenogram is also influenced to a great extent by the position in which the hip joint is placed at the roentgen examination, especially as regards the plane of rotation. On increasing external rotation from the intermediate position of the joint between internal and external rotation, i.e. with the patella facing straight upwards, the collo-diaphyseal angle will gradually increase (provided that the angle is obtuse and that the neck, as normally, inclines forwardly in relation to the frontal axis of the knee joint). On internal rotation from the intermediate position the angle gradually decreases until that phase of rotation is reached in which the longitudinal axis of the femoral neck is horizontal (with the patient lying). On further internal rotation beyond this point the collo-diaphyseal angle will again increase in size. These variations in size are admittedly slight as long as the longitudinal axis of the femoral neck deviates but slightly from the horizontal plane. Marked deviation will, however, increase the angle as seen in the roentgenogram considerably. In slipped upper femoral epiphysis, in which a permanent internal rotation deficiency is very common this exaggeration will often assume considerable proportions.

ALSBERG (1899) described a measuring method by which the position of the epiphysis is determined in direct relation to the femoral diaphysis. According to this method, the angle subtended by the longitudinal axis of the femoral diaphysis and a line passing through the base of the epiphysis is measured. A requirement for roentgenological use of this method is that the base of the epiphysis must be determinable in frontal views. After a slipped upper femoral epiphysis, when the deformation in the region of the femoral head and neck is fairly pronounced, this is, however, often impossible.

ALSBERG's so-called "Richtungswinkel", will, like the collo-diaphyseal angle, be influenced to a great extent by the position of the hip joint at the roentgen examination especially as regards the plane of rotation. Also in normals does this angle vary considerably, according to DREHMAN (1925), between 29° and 51° .

A third measuring method has been given by LANGE (1921). The longitudinal axis of the femoral diaphysis is extended superiorly. Perpendicular to this axis is drawn a line forming an upper tangent with the femoral head. Parallel to this line, after the radius of the femoral head has been determined, 4 other lines are drawn in such a manner that the distance between the 2 uppermost ones will be equal to 2 radii, while the distance between the others will be equal to 1 radius. In this manner 3 fields are obtained (Fig. 14).

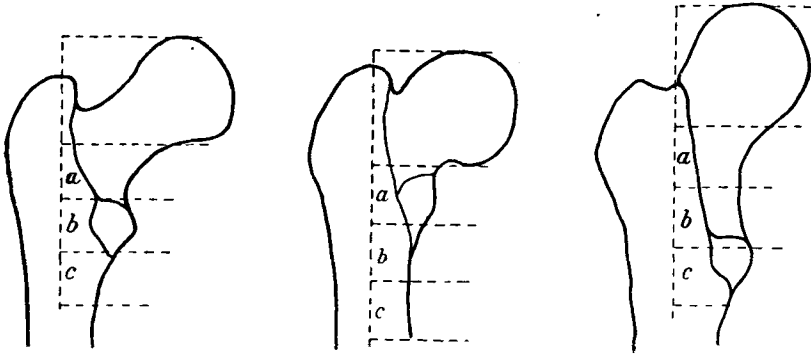


Fig. 14

Lange's measuring method (after Lange).

According to LANGE, coxa vara is present if the major part of the small trochanter lies within field a, the hip being normal if the small trochanter is in field b, and a coxa valga being present if the small trochanter is in field c. According to LANGE, the position of the hip in the plane of rotation during the roentgen examination is of no importance when using this measuring method. A requirement for the use of the method is, however, that the radius of the femoral head be determinable. This is, however, often impossible after slipped epiphysis on account of the deformity of the femoral head.

Lateral view. In normals the anterior outline of the femoral head and neck is concave (Fig. 15). After slipped epiphysis this concavity is often partly or completely eliminated or replaced by a convexity (Fig. 20).

Normally the femoral head will present a practically spheric form in this projection, too. As in frontal views, it will, depending on the extent of epiphyseal displacement, exhibit an oval, almost rectangular or almost square shape (Figs. 20, 21 and 19). As a rule, however, deviations from the spheric shape are less prominent in lateral roentgenograms than they are in frontal views.

On the above-mentioned rotation of the femoral head in association with the sidewise displacement rotation about the frontal axis is generally much greater than that about the

sagittal axis, due to the fact that the resorption of the posterior margin of the neck is usually more pronounced than is resorption of the inferomedial margin of the femoral neck. On account of this the retroversion of the epiphysis is usually much greater than its reposition, whereby the distance between the posterior surface of the neck and the posterior pole of the epiphysis will be only small. Therefore, this gap is very often filled completely with new-formed bone tissue and the original reposition thereby completely concealed (Fig. 19).

Both frontal and lateral views will show a thickening of the femoral neck in practically all cases. This is due to the secondary changes, described earlier, in the region of the femoral head and neck. If the displacement is severe this thickening will often assume considerable proportions, but in cases with only minor displacement the thickening may be so slight as to be recognized only on comparison with a healthy side. Owing to this thickening the normally gracile shape of the region of the femoral head and neck is usually lost to a varying degree.

Sometimes cystic formations (not of arthrotic nature) appear already during an early stage after the slipping of the epiphysis. These cysts are generally multiple, of varying size and located in the neighbourhood of the epiphyseal line.

A bony prominence at the border of the femoral head and neck, generally most apparent superolaterally in frontal views, is very common (Fig. 17). This bony prominence has been observed and described by a great number of authors, but only a few have attempted to explain its arisal.

SUDECK (1899) described the architecture of the femoral neck. He attaches much importance to the system of bony lamellae in the superolateral parts of the femoral neck, which he calls "der Zugbogen". According to SUDECK, the cause of a coxa vara should be sought in an insufficiency "des gesamten Zugbogensystems". The above-mentioned bony prominence is explained by him as a re-inforcement "des Zugbogensystems, die an seiner am meisten beanspruchten Stelle angebracht ist".

BÄHR (1900) is of the opinion that the capsular attachment of the hip joint is the cause of this bony prominence. NOBLE and HAUSER (1926) also think this explanation to be the most probable.

According to ELMSLIE (1907) this prominence is "doubtless the spot to which the outer extremity of the epiphysis was attached".

HACKENBROCH (1943) explains the same phenomenon as "Reaktion von seiten der Epiphysenzone, als eine Art Verkittung des gefährdeten Bereichs, in dem sich die Abgleitvorgänge abspielen". He stresses that the prominence is not an expression of secondary arthrosis but its development "gehört wesentlich zum Bilde der epiphysären Wachstumsstörung".

The present series was not followed so closely during the periods when this prominence arises that any conclusions could be drawn as to the arisal mechanism.

According to NOBEL and HAUSER (1926), this prominence appears "almost invariable", according to KÖHLER (1939), in more than half of the cases. In the present series such a prominence of varying size was observed in 100 (54.6 per cent) of the 183 re-examined hip joints.

If very slight displacements of the epiphysis in relation to the femoral neck be disregarded, it may be claimed without exaggeration that an inferomedial displacement causes a much more severe deformation of the region of the femoral head and neck than does a posterior displacement. On displacement in an essentially or only backward direction the spheric shape of the femoral head as seen in the roentgenogram will often remain practically unchanged, even if the extent of displacement is considerable.

As mentioned earlier, the slipping of the epiphysis during adolescence practically always occurs infero-medio-posteriorly. For many reasons, however, this by no means implies that the roentgenological changes in adult age will present a uniform picture.

Displacement both in inferomedial and posterior direction can vary widely in extent. As a rule the posterior displacement is greater than the inferomedial but there is no definite ratio between the extent in these two directions. Both on inferomedial and posterior displacement the degree of simultaneous rotation will vary considerably from one case to another. By certain forms of treatment (closed or open reduction) the change of

the position of the epiphysis in relation to the neck may also be modified or completely eliminated.

On account of these factors the degree of the above described roentgenological signs will vary considerably in relation to one another from one case to another. On the basis of the gross appearance of the roentgen anatomy at the re-examination it was, however, possible to distinguish a limited number of types of deformation. The types of deformation seen after the usual infero-medio-posterior displacement are described as types 1 to 4 (page 103—107).

Displacement of the epiphysis during adolescence may, though rarely, occur in lateroposterior direction (MÜLLER, 1926; SCHEUERMANN, 1930; FINCH and ROBERTS, 1946, and others). In the present series 4 such cases were seen.

A displacement of the epiphysis laterally in relation to the femoral neck may also arise as a result of over-correction during reduction of a slipped epiphysis displaced in the usual direction. In both cases the final result will be the same type of deformation, which differs in essential respects from the usual type. It is described as type 5 on page 108.

In the present series roentgen examination showed a complicating arthrosis deformans in most of the hips at the re-examination. This may cause more or less pronounced changes in the roentgenological appearance of the region of the femoral head and neck. These changes were, however, not such as to cause the original caput-collum deformation to change from one of the above-mentioned types to another. On the other hand, the changes often blurred the details of the original caput-collum deformation so extensively that it was no longer possible to decide to which type the deformation belonged. In the following description of the different types of deformation observed in the present series after slipped upper femoral epiphysis changes due to arthrosis deformans will be disregarded as far as possible.



Fig. 15 (Case Nr. 1090, left hip)

Type 1. Seventeen hip joints. Fig. 15.

Only insignificant roentgen anatomical changes are present.

In the frontal view the shape of the femoral head is thus normal. Inferomedially over the border between the femoral neck and head no medial displacement of the femoral head in relation to the neck is discernible. The concavity of the supero-lateral outline of the femoral head and neck is normal. The collo-diaphyseal angle measured was at least 125° and at most 146° .

In roentgenograms taken in Lauenstein's position the shape of the femoral head is likewise normal. In relation to the femoral neck the femoral head is in the intermediate position, in slight retroversion and/or in slight retroposition.

All of the hip joints belonging to this type nevertheless showed pathological changes of some kind in the region of the femoral head and neck. These changes were, however, always very slight, often so slight that they could be detected only on direct comparison with a healthy side. They consisted only of a slight thickening in the region of the femoral head and neck and/or a slight shortening of the caput-collum-length and/or decreased or eliminated valgus of the femoral head in relation to the neck. In some cases there was also a slight reduction of the collo-diaphyseal angle as compared with the healthy side.



Fig. 16 (Case Nr. 1077)

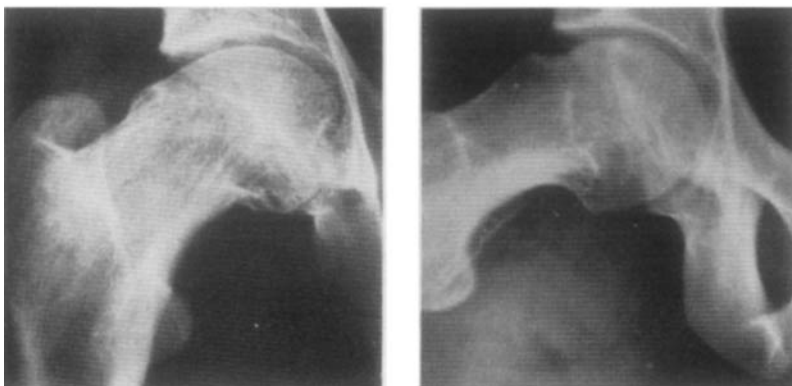


Fig. 17 (Case Nr. 3207)

Type 2. Thirty-five hip joints. Figs. 16 and 17.

In frontal views the concavity of the superolateral contour of the femoral head and neck is decreased or completely eliminated but not substituted by a convexity. The femoral neck is straight. The collo-diaphyseal angle measured was at least 118° and at most 147° . Inferomedially over the border between the femoral head and neck a medial displacement of the femoral head in relation to the neck is as a rule observable. This feature is, however, only slight, and it does not assume a so-called "Einrollungsform". The shape of the femoral head is normal or slightly oval.

In roentgenograms taken in Lauenstein's position the shape of the femoral head is likewise normal or slightly oval. In relation to the femoral neck the head is in the intermediate position or in slight retroversion and/or in slight reposition.

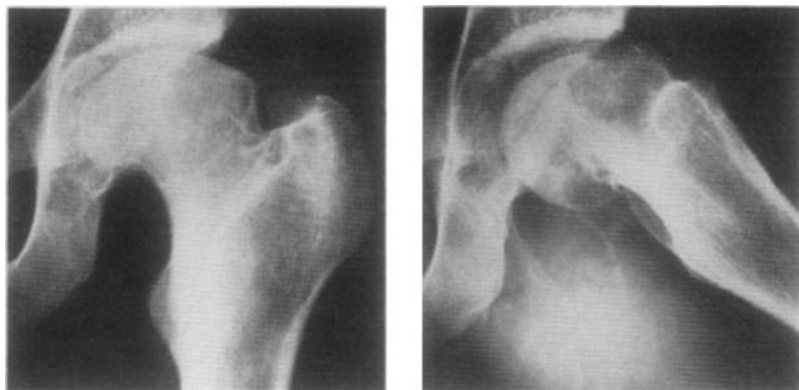


Fig. 18 (Case Nr. 3101)

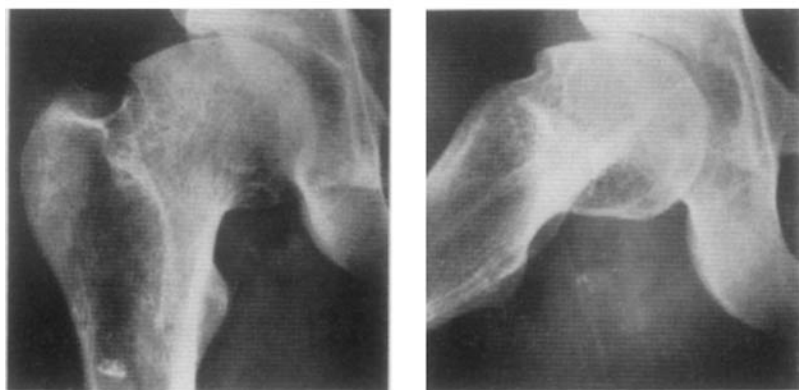


Fig. 19 (Case Nr. 3090, right hip)

Type 3. Thirty-six hip joints. Figs. 18 and 19.

In the frontal view the collum seems to extend from the femoral diaphysis at a normal or in several cases even at an abnormally large angle. The lowest value of the collo-diaphyseal angle measured was 130° . To give the maximum value of this angle was, in the opinion of the author, meaningless because a great number of hip joints belonging to this type were examined roentgenologically in a more or less externally rotated position on account of a deficiency of internal rotation. From

the neck the femoral head drops more or less abruptly in an infero-medio-posterior direction (mainly posterior). This gives a certain varus position of the femoral head in relation to the neck and an upward displacement of the trochanter, which is often fairly pronounced. In most cases, however, for reasons mentioned above these features could not be measured on the roentgenogram, neither by ALSBERG's nor LANGE's method. Inferomedially the femoral head generally projects somewhat beyond the border of the femoral neck. This medial displacement is, however, never very pronounced and only rarely does it exhibit the picture of a slight so-called "Einrollungsform". In this type the shape of the femoral head varies from oval to almost square.

In pictures taken in Lauenstein's position the shape of the femoral head is likewise oval or almost square. In relation to the femoral neck the head shows a moderate to pronounced retroversion and sometimes also slight to moderate retro-position.

Type 4. Forty-nine hip joints. Figs. 20 and 21.

In frontal views the collum is no longer straight as in normals but presents a bent shape with the convexity directed superolaterally. This gives rise to a coxa vara position, which not infrequently assumes considerable proportions. The degree of severity of the coxa vara position can, however, usually not be determined by the above described measuring methods for reasons given above. Inferomedially the femoral head projects beyond the neck. This displacement is accompanied by a marked rotation of the head about the sagittal axis with resultant typical so-called "Einrollungsform". In a few cases, in which the epiphyseal displacement and particularly the rotation of the epiphysis about the sagittal axis were very marked indeed, the gap arising between the epiphysis and the inferomedial margin of the neck was completely filled with new-formed bone tissue. On account of this, these cases did not show any "Einrollungsform" but the head and the neck

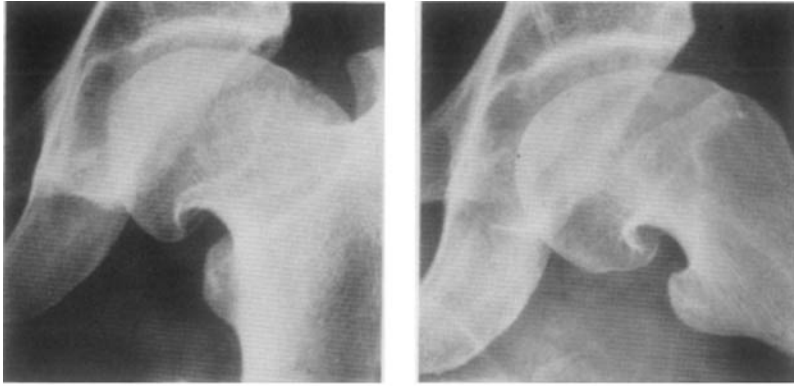


Fig. 20 (Case Nr. 3044, left hip)

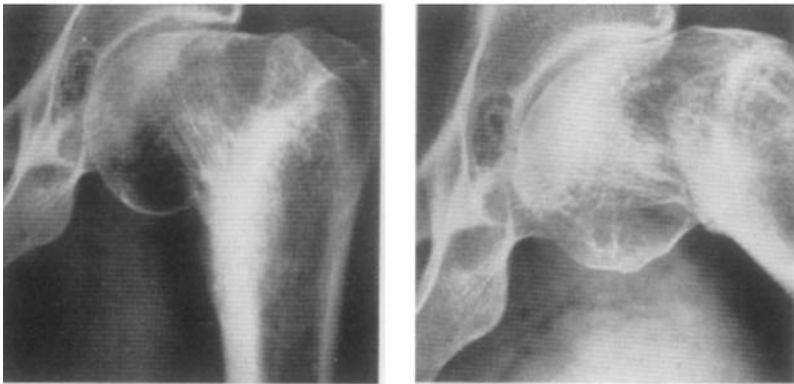


Fig. 21 (Case Nr. 1011)

had instead fused to form a single entity. In this type the femoral head (or the above mentioned single entity) is oval or sometimes even almost rectangular.

In roentgenograms taken in Lauenstein's position the shape also varies from oval to practically rectangular. In relation to the femoral neck the head (or above-mentioned single entity in relation to the femoral diaphysis) shows a moderate to pronounced retroversion and also as a rule slight to moderate retroposition.



Fig. 22 (Case Nr. 1055, left hip)

Type 5. Seven hip joints. Fig. 22.

The frontal view shows a coxa valga with a collo-diaphyseal angle varying between 155° and 165° . The valgus position of the femoral head in relation to the neck is as a rule somewhat increased. Sometimes the femoral head projects abnormally far beyond the superolateral margin of the femoral neck. The result is that the concavity of the superolateral contour of the femoral head and neck is abnormally pronounced. The femoral head is distinctly oval or slightly flattened, of the so-called "railway buffer" type.

In roentgenograms taken in Lauenstein's position the femoral head is oval. In relation to the femoral neck it shows slight to pronounced retroversion and sometimes also slight retro-position.

At the re-examination 18 hips showed such severe arthrosis deformans that it was not possible to deduce the original type of deformation of the femoral head and neck.

Two hips, one of which had been treated by intertrochanteric osteotomy, the other by subtrochanteric osteotomy, showed a deformation of the femoral head and neck of such appearance

that these two joints could not be allocated to any of the 5 types of deformation described above.

It was pointed out earlier that in the present study the hips were grouped according to the gross roentgen anatomy and not according to the degree of severity of the deformation.

For several reasons it would have been desirable to divide the series into certain groups also according to the severity of the deformation. However, the deformation as a whole comprises a number of different features. As one of these features may be less pronounced, another more pronounced, and a third extremely pronounced etc., in the individual cases, it is often impossible to decide how severe the deformity as a whole should be regarded.

The grouping principles applied here do, however, to a certain extent, although by no means exactly, also express the degree of severity of the deformity. According to the definitions of the different types of deformity it is impossible for hips with a more pronounced deformity of the region of the femoral head and neck to be classed as type 1 or type 2. On the other hand, the order of the deformity in the other types may, according to the definitions, vary from fairly slight to the most severe forms. In the great majority of the hips classed as type 3 and type 4 in the present series the deformity must however undoubtedly be regarded as more severe or even much more severe than the deformity in cases classed as type 2. To judge the degree of deformity in cases belonging to type 5 is difficult, because the deformation in these cases differs in various respects altogether from that presented by the other types. In the opinion of the author, however, the degree of deformity among those few hip joints of type 5 in the present series was comparable best with that seen in type 2.

As will be apparent from table XXVI²² the extent of the epiphyseal displacement during adolescence will to a considerable extent be responsible for the picture presented by the femoral head and neck in adult age. Of the cases in which

²² Those cases with aseptic capital necrosis, referred to in chapter V, are not included in this table.

there was a slight displacement during adolescence 70.0 per cent were allocated at the re-examination to type 1 or type 2, while only 13.8 per cent of the cases with marked displacement during adolescence were allocated at the re-examination to one of these types. The difference is statistically significant.

Table XXVI

Relation between the different types of deformation in adulthood and the extent of the epiphyseal displacement in adolescence

Extent of epiphyseal displacement	Type of deformation					
	1	2	3	4	5	?
Slight	11 (22.0%)	24 (48.0%)	4 (8.0%)	8 (16.0%)	3 (6.0%)	
Marked	6 (5.5%)	9 (8.3%)	31 (28.4%)	39 (35.8%)	4 (3.7%)	20 (18.3%)

As mentioned earlier in chapter V, on the basis of the roentgenograms taken during adolescence aseptic capital necrosis was diagnosed in 20 cases. In 19 cases the entire or the major part of the epiphysis was involved. Of these 19 cases 18 were re-examined.

In the roentgenograms taken at the re-examination 9 of these cases showed distinct signs of an earlier aseptic necrosis. In some cases this was seen as a practically total flattening of the superior outline of the femoral head (Fig. 23), in other cases as a large persistent defect in the femoral head (Fig. 24). This caused a considerable deformation of such an appearance that these hips could not be allocated to any of the types of deformity described earlier.

At the re-examination the remaining 9 hips showed such pronounced arthrosis deformans that the earlier roentgen anatomy could no longer be identified. No residual signs of aseptic necrosis could be observed. Determination of the original type was not possible either.



Fig. 23 (Case Nr. 2004)
Frontal view 30.12.1948. Almost complete flattening of upper contour of femoral head after aseptic capital necrosis (closed reduction + plaster of Paris 20.8.1936).



Fig. 24 (Case Nr. 1089)
Frontal view 16.11.1948. Large defect in the superolateral area of the femoral head after aseptic capital necrosis (closed reduction + osteosynthesis 9.2.1944).

In 1 case treated by osteosynthesis with a three-flanged nail the aseptic necrosis as seen in pictures taken during adolescence seemed to be localized to a limited area near the tip of the nail. At the re-examination there was an approximately bean-sized defect of the outline of the femoral head some distance anterior to the tip of the nail, and also a certain flattening of the entire caput-collum region. This gave a deformity of the "railway-buffer" type, which is similar in certain respects to, but different in others from, deformation of type 5.

In the last mentioned case no signs of arthrosis deformans could be seen (page 115), signs seen in all the other cases in which capital necrosis had been diagnosed.

As likewise mentioned in chapter V, in the roentgenograms taken during adolescence a so-called necrosis of the joint cartilage could be established in 9 cases. In these roentgenograms all 9 cases showed a considerable decrease in height of the articular space and 7 also a more or less marked irregularity of the articular surface of the femoral head.

At the re-examination all of them showed arthrosis de-



Fig. 25 (Case Nr. 3112, same case as illustrated in Fig. 8)

Frontal view 8.2.1949. The irregularity in the outline of the articular surface of the femoral head has decreased somewhat since previous roentgen examination on 4.11.1946 (Fig. 8 d). The height of the articular space has increased considerably but is still slightly lower than on the healthy side.

formans. In all of them there was a certain irregularity of the articular surface of the femoral head which was, however, as a rule less pronounced than before. In most cases the articular space had again increased in height, in some cases even considerably, but in none to normal proportions. In 3 cases the condition was unchanged in this respect.

With respect to the appearance of the deformation 1 case was classed as deformation of type 1, 4 as type 2, 1 as type 3 and 2 as type 4. In 1 instance arthrosis deformans was so pronounced that the case could not be typed.

In chapter V it was mentioned that in 1 of the cases discussed here there was a considerable decrease in the height of the articular space also in the contralateral hip, in spite of the fact that several roentgen examinations failed to show any signs of slipped epiphysis. At the re-examination of this case a pronounced decrease in the height of the articular space, a certain irregularity of the outline of the articular surface of the femoral head and rather advanced arthrosis deformans were observed in this hip.

The vacuum phenomenon. After slipped upper femoral epi-

physis a distant "air-streak" in the articular space is sometimes seen (without the use of contrast medium), the appearance of which agrees exactly with that seen in arthrograms with negative contrast medium in different joints. This phenomenon has been described by the present author (1948) under the name of the vacuum phenomenon in the hip joint. It has been observed in several joints by different authors (DITTMAR, 1932 and 1933; MAGNUSSON, 1937; NORDHEIM, 1938, and others) but apparently the vacuum phenomenon in the hip joint in adults had not been described earlier.

The pre-requirement for the arisal of a vacuum phenomenon is a negative pressure within the joint. The necessary order of this negative pressure is dependent upon physical laws, which is described in detail in the above mentioned earlier paper by the author.

The negative pressure was explained there as follows: After a slipped upper femoral epiphysis there often arises a bony prominence at the border of the femoral head and neck (such a prominence was also seen in all of the 6 cases in which a vacuum phenomenon was observed). When the hip is placed in Lauenstein's position this prominence is pressed against the edge of the acetabulum, where it has the effect of a hypomochlion forcing the femoral head from the acetabulum and thereby producing a negative pressure in the joint.

After the study of the large series presented here, in which no such bony prominence could be seen in the roentgen pictures of several of the cases with a distinct vacuum phenomenon, it would seem as if instead thereof the following explanation of the arisal of the negative pressure in the joint is the most probable. After slipped epiphysis the femoral head very often loses its normal, practically spheric shape. In certain positions of the hip the arc of the femoral head may therefore have a greater radius than that of the acetabulum in the same plane. On account hereof the femoral head is forced away from the bottom of the acetabulum, which surely may give rise to a negative pressure of such a degree that a vacuum phenomenon will be seen in the roentgenogram.

In the present series (as among the few cases on which the earlier publication was based) the vacuum phenomenon was seen only in pictures taken in Lauenstein's position, always localized to the superior parts of the joint, never in frontal views and never in a roentgenologically normal hip joint. Among the 183 re-examined hips the vacuum phenomenon was observed in 38 (20.8 per cent) cases.

Of these 38 cases 25 showed a bony prominence of varying degree at the border of the femoral head and neck.

Nine cases belonged to deformation of type 2, 8 to type 3, 15 to type 4, and 2 to type 5. In 4 cases the type could not be determined on account of complicating aseptic capital necrosis or arthrosis deformans.

In 14 cases the displacement during adolescence was slight, in 22 marked, and in 2 cases it was uncertain.

The lowest age of the patients at the time of the re-examination was 17.6 years, the highest 48.0 years and the average 30.0 ± 1.3 years. In no instance has the author observed a vacuum phenomenon in a stage so early that the epiphyseal line had not yet closed completely.

Nine cases belonged to the therapeutic group 1 (conservative treatment), 17 to the therapeutic group 2 (closed reduction + plaster of Paris) and 12 to the therapeutic group 3 (various forms of treatment).

In 27 cases there was roentgenological arthrosis deformans (page 115).

During the last few years the author has given special attention to the occurrence of a vacuum phenomenon in various joints. During this time no such phenomenon could be discovered in the hips of adults except in roentgenograms in Lauenstein's position of hips with a definite or very probable earlier slipped epiphysis.

Arthrosis deformans. Arthrosis deformans of the hip joint gives several characteristic roentgenological features. The features most important from a diagnostic standpoint seem to be: decrease in the height of the articular space, osteophytic

deposits in various sites, subchondral sclerosis and cystic formations both in the femoral head and in the acetabulum.

Most of the hips in the present series showed such advanced arthrosis deformans that the diagnosis presented no difficulties at all. However, a few showed such small deviations from the usual roentgen anatomy that the author was in doubt whether these deviations should be regarded as normal variations or as signs of incipient arthrosis deformans. All of these cases were judged with the kind help of Professor Olle Olsson, Chief of the Roentgen-diagnostic Clinic, Lund. When classing these roentgenograms only definite and typical changes were regarded as evidence of arthrosis deformans. Such features as a little more marked sclerosis of the acetabulum than that usually seen, a prominence, slightly more marked than ordinarily, of the upper or lower edge of the acetabulum, a slight irregularity around fovea centralis, presence of a capital drop, and a suspected decrease in the height of the articular space in cases in which there was no healthy side for comparison, were thus not considered by themselves to provide definite evidence of arthrosis deformans. Therefore such cases were regarded in this respect as normal.

When judged by the above-mentioned principles arthrosis deformans was established in 137 (74.9 per cent) of the 183 re-examined hips.

Of these 137 cases 4 belonged to deformation of type 1 (23.5 per cent of the hips belonging to this type of deformation), 13 (37.1 per cent) to type 2, 30 (83.3 per cent) to type 3, 47 (95.9 per cent) to type 4 and 5 (71.4 per cent) to type 5. The difference between the percentage of cases with arthrosis deformans in type 1 + type 2 on one hand (32.7 per cent), and type 3 + type 4, on the other (90.6 per cent), is statistically significant.

Among the 53 re-examined hips where the displacement during adolescence was slight, 17 (32.1 per cent) showed arthrosis deformans at the re-examination, while arthrosis deformans was seen in 115 (92.0 per cent) of the 125 re-

examined hips with a marked epiphyseal displacement during adolescence. The difference is statistically significant.

The average age of the 17 cases with slight displacement and showing arthrosis deformans at the re-examination was 30.9 ± 1.9 years (minimum age 19.8 years) and for the 36 cases likewise with a slight displacement but without arthrosis deformans 26.7 ± 1.2 years. The difference is not statistically significant or probable. For the 115 cases with marked displacement and with arthrosis deformans at the re-examination the average age was 32.8 ± 0.7 years (lowest age 17.6 years), for the 10 cases without arthrosis deformans it was 27.2 ± 2.1 years. The difference is statistically probable. On division of the series into different therapeutic groups a tendency to a lower average age for the cases that showed no evidence of arthrosis deformans was seen at the re-examination in all therapeutic groups (including such cases). This applies both to the category of cases in which the displacement during adolescence was slight and to that in which it was marked. In none of the therapeutic groups, however, is the difference statistically significant or probable.

Among those cases in which the displacement during adolescence was slight arthrosis deformans was seen at the re-examination in 6 (28.6 per cent) in the therapeutic group 1, conservative treatment, in 8 (42.1 per cent) in the therapeutic group 2, closed reduction + plaster of Paris, and in 3 (23.1 per cent) in the therapeutic group 3, various forms of treatment. The differences are not statistically significant or probable. Among those cases in which the displacement during adolescence was marked, arthrosis deformans was seen in 20 (100 per cent) cases in the therapeutic group 1, in 62 (91.2 per cent) in the therapeutic group 2 and in 33 (89.2 per cent) in therapeutic group 3. Neither here were the differences statistically significant or probable.²³

²³ In co-operation with Professor G. Wiberg, Chief of the Orthopaedic Clinic, Lund, the author is at present employed with an investigation intended to elucidate the roentgen appearance of arthrosis deformans after slipped epiphysis, in what manner it differs from arthrosis deformans of

Is it then possible in a given case in which the roentgen examination in adult age shows a deformation in the hip joint to decide solely on the basis of the roentgenogram whether the deformation is due to an earlier slipped epiphysis? This question cannot, of course, be answered solely on the basis of the present series. In the opinion of the author a roentgenogram taken in adult age may in many cases be so characteristic with, for example, typical deformation, bony prominence at the border of the femoral head and neck and the vacuum phenomenon that one may with certainty conclude that the roentgenological changes must be due to a slipped epiphysis. In other cases one must surely content oneself with a pronouncement that the roentgenological changes may with certainty, but need not necessarily, be due to a slipped epiphysis. In still further cases in which there is doubt as to the cause of the roentgenological changes one might, with knowledge of the roentgen picture after slipped epiphysis seen in the present fairly large series, not infrequently and with a high degree of certainty be able to exclude earlier slipped epiphysis as the cause of such changes.

other pathogenesis, the course of development etc. To deal here with these problems, both interesting and important in several respects, would, however, be to exceed too far beyond the intended scope of the present investigation.

Chapter X

RELATION BETWEEN THE LATE FUNCTIONAL AND ROENTGENOLOGICAL RESULTS

Several authors claim that there is no exact correlation between the late functional and roentgenological results after slipped upper femoral epiphysis.²⁴ BROGDEN (1935) states, for example: "The x-ray seemed to bear no relation to the functional end results" and, according to FERGUSON and HOWORTH (1931), both cases with "marked deformity with good function" and cases with "slight deformity with impaired function" are seen. FRIEDRICH (1932) points out that both symptoms and signs are often surprisingly slight in spite of marked deformation and advanced arthrosis deformans, and, according to POMERANZ and SLOANE (1935), "imperfect anatomic restitution is in no way incompatible with good function."

As will be apparent from table XXVII, at the re-examination of the present series there were placed into group I, 16 hips with a deformation of type 1 (94.1 per cent of all the hip joints belonging to this type of deformation), 24 of type 2 (68.6 per cent), 14 of type 3 (38.9 per cent), 8 of type 4 (16.3 per cent), 5 of type 5 (71.4 per cent) and 2 of the hips which could not be typed (5.1 per cent). Not a single hip showing a deformation of type 1 was assigned to group III, 6 of type 2 (17.1 per cent), 5 of type 3 (13.9 per cent), 6 of type 4 (12.2 per cent), none of type 5 (0 per cent) and 26 of the hips that could not be typed (66.7 per cent). Hence, also in the present series the agreement between the late functional results and type of deformation

²⁴ This is by no means peculiar to slipped upper femoral epiphysis only. It has been pointed out by SEVERIN (1941) with regard to the late results after luxatio cox. cong. for example.

(which, as pointed out before on page 109, is to a certain degree also an expression of the extent of the deformation) was far from exact.

Table XXVII

Relation between the late functional results and the late roentgenological results

The bracketed figures denote the number of hips with roentgenological arthrosis deformans.

Late functional results	Type of deformation						Total
	1	2	3	4	5	?	
Group I	16 (3)	24 (5)	14 (9)	8 (8)	5 (3)	2 (1)	69 (29)
Group II	1 (1)	5 (3)	17 (16)	35 (33)	2 (2)	11 (11)	71 (66)
Group III		6 (5)	5 (5)	6 (6)		26 (26)	43 (42)
Total	17 (4)	35 (13)	36 (30)	49 (47)	7 (5)	39 (38)	183 (137)

The percentage of arthrosis deformans in group I (42.0 per cent) is much lower than in group II (93.0 per cent) and group III (97.7 per cent). The difference in this respect between group I and group II and between group I and group III is statistically significant, but neither statistically significant nor probable between group II and group III.

Only a single hip without roentgenological evidence of arthrosis deformans was allocated to group III with respect to the late functional result. The reason why this case (Nr. 3082) was placed in this group was simply the severity of the symptoms claimed by the patient. If classed solely on the basis of all signs, the case would have been placed in group I. No such poor agreement between symptoms and signs (in this direction) was observed in any of the other cases in the present series. Moreover, as this patient, who was formerly a farm labourer, has now changed his occupation, as he himself claims, on account of the diseased hip, and is now undergoing training for office work, an exaggeration of the symptoms claimed might be suspected.

Thus, in the present series roentgenological arthrosis deformans was very common also among those cases with good late functional results. On the other hand, poor late functional results were not seen without co-existent arthrosis deformans (except in the above-mentioned case Nr. 3082).

As a rule the arthrosis deformans in group I was fairly slight, although in some cases it was more marked without essentially influencing the late functional results, as may be exemplified by the following case.

Case Nr. 1033 (Fig. 26). Aged 37 at the time of the re-examination. Plumber (an occupation, which, judging by patient's description of his work, must be regarded as strenuous). Between the years 1941 and 1945, military service in the artillery for altogether 420 days. During this time he was not exempted from any duties and inter alia partook in several route marches of over 20 kilometres. Not noticed any deterioration of the hip in the course of the years.

He never had any symptoms at all from the hip, not even undue fatigue after strenuous activity. He does not think his working capacity as a plumber to be in any way impaired.

Real shortening of the leg: 0.5 cm. Thigh muscle atrophy 2.5 cm. No limp. I. f. m.: 85.5. Trendelenburg's sign: negative.

Comparison only between symptoms and roentgenological arthrosis deformans shows (after exclusion of those cases with ankylosis of the hip joint) that arthrosis deformans was present in 55 of the 92 cases without any symptoms at all (59.8 per cent), in 28 of the 34 cases with slight fatigue after strenuous activity (82.4 per cent), in 29 of the 31 who claimed slight symptoms (93.5 per cent) and in 16 of the 17²⁵ that had more pronounced symptoms (94.1 per cent).

The difference between 94.1 per cent and 59.8 per cent and between 93.5 per cent and 59.8 per cent is statistically significant and the difference between 82.4 per cent and 59.8 per cent is statistically probable. Other differences are neither statistically significant nor probable.

²⁵ This figure includes case Nr. 3082. If this case be excluded, the frequency of arthrosis deformans among those cases that had more pronounced symptoms would be 100 per cent.



Fig. 26 (Case Nr. 1033)

Frontal view and roentgenogram in Lauenstein's position 30. 8. 1948. Deformation of type 3 with moderately pronounced deformation. Considerable arthrosis deformans in the form of decreased height of articular space, most marked in the superolateral part of the joint, increased sclerosis of the acetabular roof, double floor and osteophytic deposits seen most distinctly over the border of the femoral head and neck inferomedially in the frontal view.

Thus, in the present series roentgenological arthrosis deformans was very common indeed also among those cases that gave no symptoms at all. On the other hand more pronounced symptoms were not seen without co-existent arthrosis deformans (except in the above-mentioned case Nr. 3082).

In most cases the arthrosis deformans was slight among those patients who disclaimed all symptoms. In some cases they were, however, remarkably severe as, for instance, in the following case.

Case Nr. 1026 (Fig. 27). Aged 46 at the time of the re-examination. Ship's engineer. Generally only office work, but sometimes on ships for several days at a time. He often did garden work. Fond of gathering mushrooms, on one occasion in autumn 1948 he was out gathering mushrooms for four hours at a time. Nearly every Sunday he took long walks, not seldom of over 10 kilometres.

His hip had never given him any symptoms at all, not even undue fatigue after strenuous activity. He himself claims that his working capacity is in no way impaired.



Fig. 27 (Case Nr. 1026)

Frontal view and roentgenogram in Lauenstein's position 30. 10. 1948. Pronounced deformation the type of which, however, cannot be determined on account of extensive secondary arthrosis deformans in the form of very decreased height of articular space, heavy osteophytic deposits, and cystic formations both in the femoral head and acetabulum.

Real shortening of the leg: 1.5 cm. Thigh muscle atrophy: 1 cm. Slight limp. I. f. m.: 38.0. Trendelenburg's sign: positive.

In the present series taken as a whole the discrepancy between the subjective symptoms and the roentgenological arthrosis deformans was often remarkably large. With the exception of case Nr. 3082 this discrepancy was always in one and the same direction namely, that the roentgenologically manifest arthrosis deformans was more severe than was expected by the symptoms.

Case Nr. 3123 (Fig. 28). Aged 48 at the time of the re-examination. Formerly engine driver. Since 1936 employed as a labourer at the workshops of the Swedish Railways. His present occupation often includes heavy manual labour. In his spare time he often goes fishing and then sometimes walks long distances along the banks of a river. Until about a year ago he was living on the third floor of a house without a lift. He was also the caretaker of that house. Not noticed any deterioration of the hip in the course of the years.

After very hard work he sometimes feels a certain fatigue in the whole leg. He never has any aching pain or pains on movement, nor pain on



Fig. 28 (Case Nr. 3123)

Frontal view and roentgenogram in Lauenstein's position 21. 6. 1948. Pronounced deformation the type of which, however, cannot be determined on account of very extensive secondary arthrosis deformans in the form of a practically completely obliterated articular space in some parts, heavy osteophytic deposits particularly on the femoral head, and a number of cystic formations both in the femoral head and acetabulum.

weight bearing. He himself does not think his working capacity as a labourer at the workshops to be impaired.

Real shortening of the leg: 1.5 cm. Thigh muscle atrophy: 4 cm. Slight limp. I. f. m.: 48.5. Trendelenburg's sign: positive.

THE »HEALTHY« SIDE

On the basis of the roentgenograms taken during adolescence bilateral epiphyseal displacement was diagnosed in 34 (22.2 per cent) of the 153 patients re-examined.

At the re-examination during adulthood it was, however, found that no fewer than 30 of the 119 cases originally diagnosed as unilateral showed a deformation typical of a slipped epiphysis in the "healthy" hip too. In a further number of cases small deviations from the usual roentgen anatomy were observed. Also these changes were such that they might probably have been caused by an earlier epiphyseal displacement, but they were not so marked as to be classed as definitely pathological. In addition hereto 3 cases exhibited definite roentgenological changes but of such nature that they could definitely or very probably not be ascribed to an earlier epiphyseal displacement.

In 7 of the above 30 cases no roentgenograms were available of the "healthy" hip before the re-examination. In 9 cases the only roentgenograms available from the time before closure of the epiphyseal line were frontal views. In 2 of them the epiphyseal line seems to be a little wide, but the widening was not so marked as to permit its classification as definitely pathological. In most of the cases the "healthy" hip was examined roentgenologically on only a few occasions and in some cases only once. Not a single one of these 30 cases was examined regularly at close intervals up to the time of closure of the epiphyseal line. If careful roentgen examinations, including lateral views, had been made at sufficiently short intervals throughout the whole of this period, it is probable

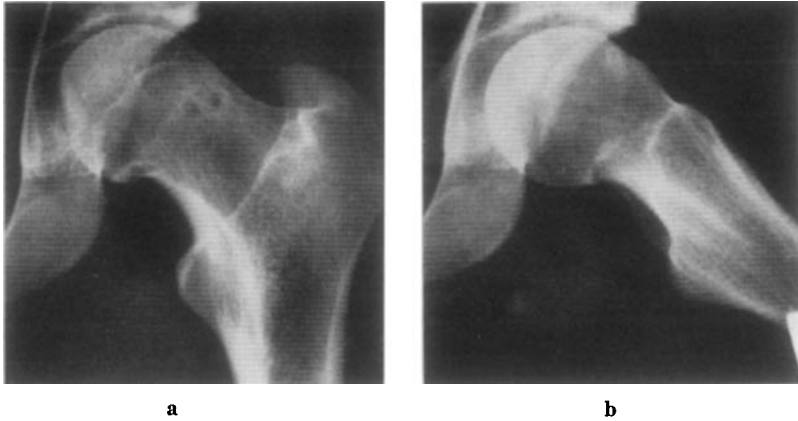


Fig. 29 (Case Nr. 3074). The "healthy" side. Deformation of type 2.
 a) Frontal view 9.12.1948. The concavity of the superolateral contour of the femoral head and neck is completely eliminated. Slight inferomedial displacement of the femoral head in relation to the neck. The femoral head is slightly oval. Small cystic formations in the proximal part of the neck.
 b) Roentgenogram in Lauenstein's position same day. Normal spheric form of the femoral head. Slight retroversion. No retroposition. Concavity of the anterior outline of the femoral head and neck is completely eliminated.

that at least most of the 30 cases now exhibiting secondary changes could have been diagnosed already during adolescence. It is, however, also possible that the pathological changes during this period were in some cases so slight that they would not have given definite roentgenological evidence during their acute stage but nevertheless to secondary roentgenological changes during a later stage.

Roentgenograms taken prior to the re-examination at a time after the epiphyseal line had closed were available in only 3 cases (14, 21 and 24 years before the re-examination). All of these roentgenograms showed the same changes as did those taken at the re-examination.

All of the 30 hips showing a deformation typical of epiphyseal displacement in the "healthy" hip at the time of the re-examination were assigned to deformation of type 2 (Figs. 29 and 30).

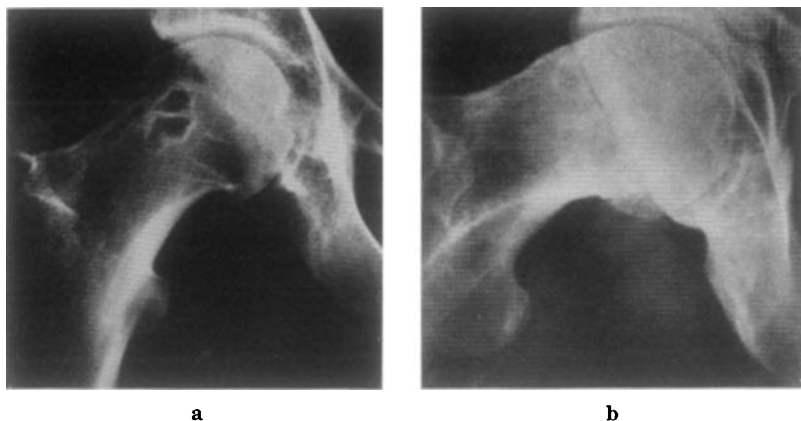


Fig. 30 (Case Nr. 1025). The "healthy" side. Deformation of type 2.
 a) Frontal view 1. 6. 1948. The concavity of the superolateral contour of the femoral head and neck is practically completely eliminated. Slight inferomedial displacement of the femoral head in relation to the neck. The femoral head is slightly oval. Superolaterally about the border of the femoral head and neck are a number of cystic formations.
 b) Roentgenogram in Lauenstein's position same day. Femoral head slightly oval. Slight retroversion and slight retroposition. Concavity of the anterior outline of the femoral head and neck is completely eliminated.

A typical bony prominence at the border of the femoral head and neck was seen in 11 (36.7 per cent) cases, a vacuum phenomenon in 4 (13.3 per cent) and arthrosis deformans in 18 (52.9 per cent). Among the 35 hips in the present series belonging to deformation of type 2 and in which a slipped epiphysis was diagnosed during adolescence 7 (20 per cent) showed a bony prominence at the border of the femoral head and neck, 9 (25.7 per cent) a vacuum phenomenon, and 13 (37.1 per cent) arthrosis deformans. In none of the above respects is the difference statistically significant or probable.

Even if the possibility cannot be excluded that also other pathological conditions in the hip can give rise to identical or similar roentgenological changes, there is hardly any doubt as to the etiology in these 30 cases, because 1) the roentgenological changes in all of the cases were typical of a slipped epiphysis,

2) in none of the cases did historical data suggest other causal factors and 3) in every instance the other hip had definitely been the site of a slipped epiphysis.

All of these 30 patients stated that they had had no symptoms from the "healthy" hip, neither during the age when a slipped epiphysis generally occurs nor during later life.

Many authors claim that cases of a slipped epiphysis without symptoms are very common. HACKENBROCH (1938) has described such cases, but in only one patient was he able to support the diagnosis by a diagnostically established slipped epiphysis in the other hip. In all of the other cases he thought he was able to establish a definite diagnosis solely on the basis of the appearance of the roentgenological changes during adulthood. He calls such cases of slipped epiphysis "abortive" or "frustrana". In his opinion many cases of arthrosis deformans in the hip are caused by such abortive slipped epiphysis. According to FRIEDRICH (1932), a slipped femoral epiphysis frequently gives no symptoms. He supports his view on the observation that many patients with a bilateral slipping have symptoms only on one side. BRAGARD (1940) claims that such symptomless cases, which he terms "formes frustes", are much more common than hitherto supposed and are perhaps just as common as the fully developed forms and are certainly the cause of a considerable percentage of the cases of apparent primary arthrosis deformans in the hip.

In the present series only 24 of the 34 re-examined cases classed as bilateral on the basis of the roentgenograms taken during adolescence exhibited the usual symptoms, in the following called manifest slipped epiphysis, in both hips, either simultaneously or consecutively. In the other 10 cases no symptoms were reported from one of the sides which will be called latent slipped epiphysis in the following.

In none of the 30 cases could the measuring methods used in the present study reveal any real shortening or thigh muscle atrophy. Functional shortening of the leg on account of adduction contracture was not seen, nor was any limp observed. Trendelenburg's sign was positive in only 1 case. The lowest

i. f. m. was 52.5, the highest 95.0, average 86.9 ± 1.5 . In no instance was the working capacity impaired by the "healthy" hip.

As to the late functional results, 27 were placed in group I and 3 in group II.

As mentioned earlier, the deformation observed in the "healthy" hip in all of these 30 cases was of type 2. This implies (as will be apparent from the definition of this type of deformation given on page 104) that the deformation must be regarded as relatively slight as compared with that generally seen after a slipped epiphysis.

Nevertheless, in no fewer than 18 cases (52.9 per cent) was arthrosis deformans seen in the roentgenograms taken at the re-examination. The average age of these 18 patients was 36.8 ± 1.7 years (lowest age 25.3 years), for the 12 cases that showed no arthrosis deformans it was 29.8 ± 2.1 years. The difference is statistically probable. The arthrosis deformans will very probably increase with increasing age and then, at least in some cases, give symptoms.

In spite of the complete absence of symptoms and in spite of the practically generally good late functional results recorded hitherto, the changes in the roentgen appearance of the "healthy" hips can by no means be regarded as negligible.

In the present series then of 153 patients with a manifest slipped epiphysis in one of the hips, 24 (15.7 per cent) also had a manifest slipped epiphysis in the other hip, 10 (6.5 per cent) a latent slipped epiphysis diagnosed during adolescence and 30 (19.6 per cent) a latent slipped epiphysis not diagnosed until adulthood. The risk for a patient with a manifest slipped epiphysis in one hip to develop the condition, manifest or latent, in the other hip is thus much greater (41.8 per cent)²⁶ than that recorded in earlier publications.

In these publications the ratio between the frequency of

²⁶ It is certainly even greater than 41.8 per cent because these figures refer only to cases in which typical evidence of an earlier epiphyseal displacement was definitely manifest. In several cases, however, suspected

unilateral and bilateral cases differs considerably, even if only the large collections are considered. MAC AUSLAND (1935), for example, gives 4.4 per cent bilateral cases of 45, MÜLLI (1938) 6.6 per cent of 61, HOWORTH (1941) 6.7 per cent of 62, HEYMAN (1949) 11.9 per cent of 42, POMERANZ and SLOANE (1935) 13.9 per cent of 101, FERGUSON and HOWORTH (1931) 21.5 per cent of 70, PONSETI and BARTA (1948) 26.0 per cent of 73, KEY (1926) 15.2 per cent of 250 literature cases, WALDENSTRÖM (1939) 15.0 per cent of 400 cases collected from the literature and LÜTKEN (1939) 9.7 per cent of 659 cases likewise collected from the literature.

It is, however, not possible to draw any conclusions from the figures in the present study as to the actual ratio between unilateral and bilateral cases. If such comparisons are to be made, it is necessary to take into account not only the latent forms among the bilateral cases but also latent unilateral cases. The frequency of such unilateral cases is, however, a completely unknown factor. To obtain an idea of the frequency of unilateral latent slipped epiphysis in the hip an examination of a probably enormous series of individuals without any symptoms from the hips would be necessary.

As in the manifest forms, small repeated displacements may surely occur at intervals also in the latent forms, and with time these small displacements may result in a considerable definitive displacement of the epiphysis, without, however, giving manifest symptoms. The establishment of a diagnosis as early as possible is therefore of great importance also in these cases, and an absolutely necessary requirement in treatment *lege artis* of a patient with a slipped epiphysis in one hip is careful roentgen examinations of the "healthy" side including, of course, lateral roentgenograms taken at fairly close intervals, in the opinion of the author, preferably once every other month, until the epiphyseal line has closed.²⁷

ever, suspected changes of similar type were seen but were not so marked that they could be regarded as definitely pathological.

²⁷ Attention should be given to protection of the genital organs against the roentgen rays.

SUMMARY

The main purposes of the present investigation were to elucidate a) the late functional and roentgenological results after slipped upper femoral epiphysis not only in early adulthood but also in relatively advanced age and b) the value of closed reduction.

In chapter I a brief history is given.

In chapter II diagnostic aspects are discussed.

Only those cases were included in the present series in which the diagnosis could be verified on the basis of available roentgenograms. In no case was the diagnosis based on the roentgen reports only. Only such cases were accepted as showed a manifest sidewise shift of the epiphysis in relation to the femoral neck in frontal or lateral roentgenograms.

In chapter III a description of the series is given. The cases were collected from the Orthopaedic Clinic, Lund, the Orthopaedic Clinic, Malmö, and the Vanförestalt, Hälsingborg. The series was based on all in- and out-patients treated at these 3 hospitals some time from the commencement of their activity until 31. 12. 1945. The series contained only cases that were at least so recent at the time of the first examination that the epiphyseal line had not completely closed.

The series consisted of 166 patients. Of these 83 per cent were males and 17 per cent females. On the basis of the roentgenograms taken during adolescence 38 (22.9 per cent) were classed as bilateral. The longest interval found in the bilateral cases between the slipping of the epiphysis in either hip was 43 months. In 73.4 per cent of the unilateral cases the slipping was on the left side. The lowest age at the time the diagnosis was first established roentgenologically was for the

males 11.5 years, the highest 23.4 years and the average 16.0 ± 0.1 years, the corresponding figures for the females being 5.6 years, 24.0 years and 13.5 ± 0.5 years.

Familial occurrence was observed in a few cases.

A re-displacement in one and the same hip was seen in 20 cases. The interval between this re-displacement and the time when the diagnosis was first confirmed roentgenologically was 2 years or more in 2 cases and over 1 year in at least 3 other cases.

In chapter IV a report is given of the primary results after closed reduction.²⁸

Roentgenological studies on skeletal preparations are briefly reported. It is claimed that the changed position of the upper femoral epiphysis in relation to the femoral neck as seen in frontal roentgenograms depends to a great extent on the position of the hip joint at the roentgen examination. In the usual form of displacement of the epiphysis, which is generally most pronounced in a backward direction, a change in the position of the hip joint from flexion towards extension and from external towards internal rotation will cause an illusory improvement of the displacement in the roentgenogram.

A considerably improved or normal position of the upper femoral epiphysis in relation to the femoral neck after closed reduction was observed in 24 of 117 cases in which this form of treatment was used, namely in 19 (73.1 per cent) of 26 hips with an acute slipped epiphysis with fracture-like symptoms and signs without roentgenological signs of callus, in 3 (50.0 per cent) of 6 cases which in spite of insidious onset nevertheless showed fracture-like symptoms and signs on admission (in none of these 6 cases were there roentgenological signs of callus formation), but only in 2 (2.4 per cent) of the 83 cases which on admission did not present fracture-like symptoms and signs.

In chapter V a description is given of the early complications.

An aseptic capital necrosis was diagnosed in 20 cases. Of

²⁸ In this study the term *closed reduction* is to be understood as attempted closed reduction under anesthesia.

these cases 15 had been treated by closed reduction + plaster of Paris, 2 by closed reduction + osteosynthesis with a three-flanged nail, 2 by open reduction and 1 by osteosynthesis with a three-flanged nail without previous reduction (in the last mentioned case the aseptic necrosis was localized only to a limited area near the tip of the nail, while in the other cases the entire epiphysis or at least the major part of it was involved).

Among the 24 hips in which closed reduction was primarily successful aseptic capital necrosis was observed in 10 (41.7 per cent) cases, but only in 7 (7.5 per cent) of the 93 hip joints in which no definite improvement of the position of the epiphysis could be observed after closed reduction. The difference is statistically significant. Closed reduction producing an improvement in the position of the epiphysis in relation to the femoral neck involves a greater risk of aseptic capital necrosis than does closed reduction producing no change in the displacement of the epiphysis.

A complication of unknown etiology and described by inter alia WALDENSTRÖM (1930) under the name "necrosis of the joint cartilage" and which expresses itself roentgenologically in the form of marked atrophy of the femoral head and the acetabulum and surrounding skeleton, considerable decrease in the height of the articular space and a more or less marked irregularity in the outline of the articular surface of the upper femoral epiphysis was observed in 9 cases.

Closed reduction caused an oblique fracture through the lower part of the femoral shaft in 1 instance.

Osteosynthesis with a three-flanged nail without previous reduction caused a driving away of the epiphysis from the femoral neck with a resultant diastasis of almost 1 cm between the epiphysis and the femoral neck. No signs of aseptic capital necrosis were seen in this case.

In chapter VI a description is given of the re-examination. Of the 166 patients (200 hip joints) included in the series 153 patients (183 hip joints) were re-examined both clinically and roentgenologically by the author. This means that 92.2 per

cent of the patients and 91.5 per cent of the hips were re-examined.

The time between the primary roentgenological diagnosis and the re-examination was 3.0 to 31.4 years with an average of 15.5 ± 0.6 years.

In chapter VII the examination technique employed at the re-examination is described.

In chapter VIII the late functional results are discussed.

The series was divided according to all symptoms and signs and any impairment of working capacity into 3 groups, namely, group I (good result), group II (fair result) and group III (poor result). Group I comprised 69 hips, group II 71 hips and group III 43 hips.

The extent of epiphyseal displacement during adolescence has a pronounced influence on the late functional results. Of the hips in which there was a slight epiphyseal displacement during adolescence 75.5 per cent were placed in group I at the re-examination and only 5.7 per cent in group III, while the corresponding figures for those hips in which the epiphyseal displacement was marked during adolescence were 21.6 per cent and 32.0 per cent respectively. The differences are statistically significant.

The late functional results became worse with increasing age. The deterioration did not seem to occur at any definite age but rather to progress gradually throughout the period of life represented in the present series.

The late functional results were very poor both after aseptic capital necrosis and after so-called necrosis of the joint cartilage.

Conservative treatment was compared with 1) closed reduction + plaster of Paris among all the cases in which this form of treatment was the main therapy given, 2) closed reduction among only those cases with fracture-like symptoms and signs without roentgenological signs of callus, 3) closed reduction among only those cases in which the treatment produced a primarily successful result, 4) closed reduction among only those cases with fracture-like symptoms and signs

without roentgenological signs of callus in which treatment led to a primarily successful result. Among all these categories of cases a deterioration of the late functional results after closed reduction was more common than an improvement of the late functional results. The difference in this respect is, however, in no instance statistically significant or probable.

In spite of this it seems justified to conclude that the demonstrated discouraging late functional results after closed reduction were not due to chance.

1. In all of the above-mentioned categories of cases the deterioration of the late functional results was more common than an improvement of the latter.

2. This holds good even if only those cases be taken into account that must be regarded as particularly suitable for closed reduction and in which this treatment also produced a primarily successful result.

3. Aseptic capital necrosis, a factor followed in most cases by poor late functional results, was much more common among those cases where closed reduction was primarily successful than among those in which no improvement in the position of the epiphysis could be discerned.

The late functional results after other forms of treatment represented in the present series are tabulated but are not discussed in detail, because the number of cases treated by each of these forms of treatment was only small.

In chapter IX the late roentgenological results are discussed.

A description of the individual roentgenological characteristics is given. The series was divided into 5 types of deformation according to the gross roentgen anatomy as seen in those roentgenograms taken at the re-examination.

The extent of epiphyseal displacement during adolescence exerts considerable influence on the deformation in the region of the femoral head and neck as seen during adulthood. Of those cases which showed a slight displacement during adolescence 70.0 per cent were classed at the re-examination as deformation of type 1 or type 2, while only 13.8 per cent of those cases which showed a marked displacement during

adolescence were allocated at the re-examination to one of these 2 types.

A vacuum phenomenon was observed in 38 (20.8 per cent) of the 183 re-examined hips.

Roentgenological arthrosis deformans was observed in 137 (74.9 per cent) of the 183 re-examined hips.

Of those hips in which the extent of epiphyseal displacement was slight during adolescence 32.1 per cent showed roentgenological arthrosis deformans at the re-examination, while such changes were seen in 92.0 per cent of those cases in which the epiphyseal displacement during adolescence was marked. The difference is statistically significant.

Arthrosis deformans was seen in 23.5 per cent of the hips assigned to deformation of type 1, in 37.1 per cent of those of type 2, in 83.3 per cent of those of type 3, in 95.9 per cent of those of type 4 and in 71.4 per cent of those of type 5.

In chapter X a comparison is made between the late functional and roentgenological results.

Roentgenological arthrosis deformans was very common also among those cases with good late functional results. Poor late functional results were not seen without accompanying arthrosis deformans (with 1 exception, case Nr. 3082, in which, however, an exaggeration of the symptoms claimed might be suspected).

The discrepancy between the symptoms and the roentgenological arthrosis deformans was often striking. With the exception of the above-mentioned case (Case Nr. 3082) this discrepancy was always in the same direction, namely that roentgenological arthrosis deformans was more advanced or even very much more advanced than had been expected from the symptoms.

In chapter XI the "healthy" side is discussed.

At the re-examination it was found that no fewer than 30 of the 119 cases diagnosed during adolescence as unilateral showed changes in the region of the femoral head and neck that were typical of a slipped epiphysis.

The risk for a patient with a slipped epiphysis in 1 hip to

develop the condition also in the other hip is thus much greater (41.8 per cent) than that recorded in earlier publications. The greater this risk is, the more important it is to observe the "healthy" hip roentgenologically at close intervals until the epiphyseal line is closed.

RÉSUMÉ

L'intention principale de cet ouvrage est 1) d'apporter une contribution à la connaissance de la façon dont se présentent, au point de vue fonctionnel et radiologique, les résultats tardifs du décollement épiphysaire de la tête fémorale, non seulement pendant la jeunesse mais aussi à un âge relativement avancé, 2) de mettre en lumière la valeur de la réduction non sanglante.

Au chap. I, nous donnons un bref historique.

Au chap. II, nous discutons certaines questions diagnostiques.

Dans la totalité des cas, il a été de rigueur que le diagnostic ait pu être vérifié sur les plaques radiographiques. Dans aucun cas il n'a donc été basé uniquement sur le rapport de l'examen radiographique. Seuls figurent parmi nos matériaux les cas présentant, soit sur des images de profil, soit sur des images frontales, un déplacement certain et directement observable de l'épiphyse par rapport au col fémoral.

Au chap. III, nous faisons une description de nos matériaux. Ceux-ci proviennent de la clinique orthopédique de Lund, de celle de Malmö et du Vanförestalt de Hålsingborg, et sont basés sur la totalité des cas hospitalisés ou traités à la polyclinique des sections spéciales ci-dessus mentionnées, depuis la création de chacune de ces sections jusqu'au 31/12 1945. Nos matériaux ne comprennent que les cas qui, lors du premier examen, étaient assez récents pour que la jointure de l'épiphyse ne soit pas complètement fermée.

Nos matériaux portent sur 166 malades, 83 % étant des hommes et 17 % des femmes. En nous basant sur des images radiographiques prises pendant l'adolescence, nous avons classé 38 cas (22,9 %) comme bilatéraux. Dans ces cas bilatéraux, le plus long intervalle de temps que l'on ait constaté entre le

décollement épiphysaire des deux côtés a été de 43 mois. Dans 73,4 % des cas unilatéraux, le décollement épiphysaire a été localisé à l'articulation gauche de la hanche. L'âge auquel le diagnostic a été vérifié radiologiquement pour la première fois a été pour le sexe masculin de 11,5 ans au moins et de 23,4 ans au plus et en moyenne de $16,0 \pm 0,1$ ans, et pour le sexe féminin de 5,6 ans au moins et de 24,0 ans au plus et en moyenne de $13,5 \pm 0,5$ ans.

Dans quelques cas on a constaté une apparition héréditaire du phénomène.

Dans 20 cas on a pu constater un renouvellement du déplacement dans la même articulation. L'intervalle de temps entre celui-ci et la date à laquelle le diagnostic a été pour la première fois vérifié radiologiquement a dans 2 cas atteint 2 ans ou plus et dans 3 autres cas au moins, dépassé 1 an.

Au chap. IV, nous donnons un compte-rendu des résultats primaires après réduction non sanglante.²⁹

Nous relatons brièvement des études radiologiques faites sur des préparations ostéologiques. La position de la hanche pendant l'examen radiographique joue un rôle important pour la façon dont se présentera le changement de position de l'épiphyse par rapport au col fémoral sur l'image frontale. Dans le déplacement ordinaire de l'épiphyse, où le déplacement en arrière est généralement le plus accentué, une amélioration illusoire du déplacement de l'épiphyse apparaît lorsque la position de la hanche est transformée de flexion en extension et de rotation externe en rotation interne.

Une amélioration certaine et considérable de la position de l'épiphyse, ou même une position exacte de cette dernière par rapport au col fémoral après réduction non sanglante, ont pu être constatées dans 24 des 117 cas où ce traitement a été employé, à savoir dans 19 des 26 cas présentant un déplacement aigu avec symptômes ressemblant à une fracture sans cal radiologiquement visible (73,1 %), dans 3 des 6 cas qui ont présenté, quoique les symptômes n'aient apparu que peu à peu, des symp-

²⁹ Dans cette étude, le terme de *réduction non sanglante* doit être compris comme tentative de réduction non sanglante à l'anesthésie générale.

tômes ressemblant à leur apparition à une fracture sans cal radiologiquement visible (50,0 %), mais seulement dans 2 des 83 cas qui à leur apparition ne présentaient pas de tels symptômes (2,4 %).

Au chap. V, nous parlons des complications précoces apparues chez nos sujets.

Une nécrose aseptique de l'épiphyse a été diagnostiquée dans 20 cas. Parmi ceux-ci 15 ont été traités par réduction non sanglante + plâtre de la hanche, 2 par réduction non sanglante + ostéosynthèse à clou, 2 par réduction sanglante et 1 par ostéosynthèse à clou sans réduction préalable (dans ce dernier cas la nécrose aseptique n'a été localisée qu'à un domaine limité dans le voisinage de la pointe du clou, dans les autres cas elle a englobé toute l'épiphyse ou au moins la plus grande partie de celle-ci).

Parmi les 24 cas mentionnés au chap. IV où une réduction non sanglante a amené le résultat désiré, une nécrose de l'épiphyse a été observée dans 10 cas (41,7 %), mais seulement dans 7 cas parmi les 97 où on n'a pu observer d'amélioration certaine du déplacement après réduction non sanglante (7,5 %). Cette différence est statistiquement garantie. Une réduction non sanglante amenant une amélioration de la position de l'épiphyse comporte un plus grand risque de nécrose aseptique qu'une telle réduction n'apportant pas de modification du déplacement de l'épiphyse.

Une complication dont la genèse n'est pas connue, décrite entre autres par Waldenström (1930) sous le nom de «nécrose du cartilage articulaire» et qui se manifeste radiologiquement par une atrophie prononcée de la tête fémorale et le l'acétabulum ainsi que des parties avoisinantes du squelette, un pincement articulaire très sensible et une irrégularité plus ou moins marquée des contours de la surface de l'articulation de l'épiphyse, a été observée dans 9 cas.

Une réduction non sanglante a dans 1 cas causé une fracture oblique à travers la partie inférieure de la diaphyse fémorale.

L'ostéosynthèse à clou sans réduction préalable a dans 1 cas causé un éclatement de la jointure de l'épiphyse avec comme

conséquence une diastase de près d'un centimètre de largeur entre la tête et le col fémoral. Aucun signe de nécrose aseptique n'apparut dans ce cas-là.

Au chap. VI, nous rendons compte des réexaminations. Sur nos 166 sujets (200 articulations de hanche) 153 (183 articulations) ont été réexaminés par nous personnellement, tant cliniquement que radiologiquement. Le pourcentage des malades ayant subi une réexamination est de 92,2 %, celui des articulations ayant subi cette réexamination est de 91,5 %.

La période d'observation a été au minimum de 3,0 ans, au maximum de 31,4 ans et en moyenne de $15,5 \pm 0,6$ ans.

Au chap. VII, nous décrivons les méthodes d'examen.

Au chap. VIII, nous traitons les résultats tardifs au point de vue fonctionnel.

A ce point de vue nos sujets ont été divisés, sur la base de tous les symptômes subjectifs et objectifs ainsi que de la diminution de la capacité de travail, en trois groupes: gr. I (bon résultat), gr. II (résultat moyen) et gr. III (mauvais résultat). Le groupe I comprend 69 articulations, le groupe II 71 et le groupe III 43.

L'ordre de grandeur du déplacement de l'épiphyse pendant l'adolescence a une grande influence sur les résultats tardifs au point de vue fonctionnel. Parmi ces cas qui, pendant l'adolescence, ont présenté un léger déplacement, 75,5 % ont été rangés après réexamination dans le groupe I et 5,7 % seulement dans le groupe III, tandis que le pourcentage correspondant des cas qui, pendant l'adolescence, ont présenté un déplacement prononcé, est respectivement de 21,6 % et de 32,0 %. Les différences sont statistiquement garanties.

Les résultats tardifs empirent avec l'âge au point de vue fonctionnel. Cette aggravation ne semble pas apparaître à un âge déterminé mais semble plutôt progresser peu à peu pendant toute la période des âges représentés dans nos matériaux.

Les résultats tardifs au point de vue fonctionnel ont été décourageants, tant après nécrose aseptique de la tête fémorale qu'après «nécrose du cartilage articulaire».

Une comparaison est faite entre d'une part le traitement con-

servatif et d'autre part 1) la réduction non sanglante + plâtre de la hanche parmi tous les cas où cette méthode de traitement a constitué la forme principale de thérapie, 2) la réduction non sanglante seulement parmi les cas présentant des symptômes ressemblant à des fractures sans cal radiologiquement visible, 3) la réduction non sanglante seulement dans les cas où le traitement a amené le résultat primaire désiré, 4) la réduction non sanglante seulement dans les cas qui ont présenté des symptômes ressemblant à des fractures sans cal radiologiquement visible et où le traitement a amené le résultat primaire désiré. Dans toutes ces catégories de cas une aggravation des résultats tardifs après réduction non sanglante a été plus fréquente qu'une amélioration. Cependant la différence à cet égard n'est dans aucun cas statistiquement garantie ou probable.

Malgré cela on peut certainement oser tirer la conclusion que ces résultats tardifs assez décourageants après ces réductions non sanglantes ne sont pas dus au hasard.

1. Dans toutes ces catégories de cas, l'aggravation des résultats tardifs l'emportent en effet sur leur amélioration.

2. Ceci vaut même si on ne tient compte que des cas qui doivent être considérés comme particulièrement propices à une réduction non sanglante et où ce traitement a aussi amené le résultat primaire désiré.

3. La nécrose aseptique de l'épiphyse, qui est suivie dans la plupart des cas de mauvais résultats tardifs, est sensiblement plus fréquente dans les cas où la réduction non sanglante avait amené un résultat primaire désiré que dans ceux où on n'a pas pu constater de changement de position de l'épiphyse.

Nous rendons compte dans des tableaux des résultats tardifs des autres méthodes de traitement représentées dans nos matériaux, mais nous ne les discutons pas davantage étant donné que le nombre de cas traités par chaque méthode particulière de thérapie est très peu élevé.

Au chap. IX, nous traitons les résultats tardifs au point de vue radiologique.

Après une description des symptômes radiologiques particuliers, nous classons nos matériaux en 5 types de déformation

en nous basant sur la façon dont l'anatomie s'est présentée en traits généraux sur les images radiographiques prises au cours de la réexamination.

L'ordre de grandeur du déplacement de l'épiphyse pendant l'adolescence joue un rôle important sur la façon dont la déformation de la région tête-col se présentera à l'âge adulte. Parmi les cas ayant présenté pendant l'adolescence un léger déplacement, 70,0 % ont été classés lors de la réexamination dans les types 1 ou 2 tandis que 13,8 % seulement des cas qui pendant l'adolescence avaient montré un déplacement prononcé ont été rattachés lors de la réexamination à l'un de ces types.

Un phénomène de vacuum a été observé dans 38 cas parmi les 183 réexaminés (20,8 %).

Des signes radiologiques d'arthrosis deformans se sont présentés dans 137 cas sur les 183 réexaminés (74,9 %).

32,1 % des cas dans lesquels le déplacement a été léger pendant l'adolescence ont présenté à la réexamination une arthrosis deformans tandis que celle-ci a existé dans 92,0 % des cas où le déplacement pendant l'adolescence a été prononcé. La différence est statistiquement garantie.

Dans le type de déformation 1, il y a eu arthrosis deformans dans 23,5 % du nombre d'articulations appartenant à ce type de déformation, dans le type 2 dans 37,1 %, dans le type 3 dans 83,3 %, dans le type 4 dans 95,9 % et dans le type 5 dans 71,4 %.

Au chap. X, nous faisons une comparaison entre les résultats tardifs aux points de vue fonctionnel et radiologique.

L'existence d'arthrosis deformans radiologiquement observable a été très fréquente même dans les cas ayant présenté un bon résultat tardif au point de vue fonctionnel. Par contre un mauvais résultat tardif au point de vue fonctionnel n'est jamais apparu sans apparition simultanée de changements dus à l'arthrosis deformans (à une exception près, dans le cas n° 3082 où on peut supposer une aggravation).

La discrédance entre les troubles subjectifs et les changements dus à l'arthrosis deformans radiologiquement observables a été dans bien des cas étonnamment grande. A l'except-

tion du cas n° 3082, cette discrétançe a toujours été orientée dans la même direction: ces changements observés radiologiquement ont été plus accentués, parfois même à un très fort degré, qu'on ne s'attendait à trouver d'après les troubles subjectifs.

Au chap. XI nous parlons du côté «sain».

Au cours de la réexamination à l'âge adulte, il s'est révélé que 30 des 119 cas classés précédemment parmi les unilatéraux ont présenté une déformation de la région tête-col typique du décollement épiphysaire.

Pour un malade chez qui un décollement épiphysaire de l'une des hanches a été diagnostiqué, le risque de décollement de l'autre hanche est donc sensiblement plus grand (41,8 %) que ce qui ressortait de matériaux précédemment publiés. Plus ce risque est grand, plus il est important que l'articulation «saine» soit également contrôlée avec soin par des examens radiographiques fréquents jusqu'à ce que la jointure de l'épiphyse soit fermée.

ZUSAMMENFASSUNG

Vorliegende Arbeit verfolgt folgende Hauptziele: 1) einen Beitrag zu liefern hinsichtlich der Spätergebnisse bei Epiphyseolysis capitis femoris vom funktionellen und röntgenologischen Gesichtspunkt nicht nur während der Jugendjahre, sondern auch in einem relativ vorgeschrittenen Alter, 2) den Wert der unblutigen Reposition zu beleuchten.

Kap. I: Kurze Historik.

Kap. II: Diskussion diagnostischer Fragen von Bedeutung für die Zusammensetzung des Materials.

In sämtlichen Fällen wurde gefordert, dass die Diagnose durch verfügbare Röntgenbilder bestätigt werden konnte. In keinem Fall basiert die Diagnose also allein auf einem Röntgengutachten. In das Material wurden nur solche Fälle einbezogen, die entweder in der Seiten- oder in der Frontalaufnahme eine sichere, direkt sichtbare Verschiebung der Caput-epiphyse im Verhältnis zum Collum aufwiesen.

Kap. III: Beschreibung des Materials. Das Material stammt aus der Orthopädischen Klinik Lund, der Orthopädischen Klinik Malmö und der Vanföreanstalt Hälsingborg. Es ist basiert auf sämtlichen Fällen, die ab Eröffnung der obigen Spezialabteilungen in diesen stationär oder poliklinisch bis zum 31. 12. 1945 zur Behandlung gelangt sind. Es enthält nur Fälle, die bei der ersten Untersuchung noch so frisch waren, dass die Epiphysenfuge nicht ganz geschlossen war.

Das Material umfasst 166 Patienten, 83 % männliche, 17 % weibliche. Nach den in der Adoleszenz gemachten Röntgenaufnahmen sind 38 Fälle als doppelseitig rubriziert worden (22.9 %). Der längste Zeitraum, der bei den doppelseitigen Fällen zwischen der Epiphysenlösung in dem einen und dem

anderen Hüftgelenk lag, betrug 43 Monate. In 73.4 % der einseitigen Fälle betraf die Epiphysenlösung das linke Hüftgelenk. Das Alter, in welchem die Diagnose erstmalig röntgenologisch bestätigt wurde, war bei den männlichen Fällen mindestens 11.5 Jahre und höchstens 23.4 Jahre, im Mittel 16.0 ± 0.1 Jahre, bei den weiblichen Fällen mindestens 5.6 Jahre, höchstens 24.0 Jahre, im Mittel 13.5 ± 0.5 Jahre.

In einigen Fällen war familiäres Vorkommen zu verzeichnen.

Eine erneute Verschiebung im gleichen Hüftgelenk hat in 20 Fällen festgestellt werden können. Das Intervall zwischen dieser und dem Zeitpunkt der ersten röntgenologischen Verifikation der Diagnose betrug in zwei Fällen 2 Jahre oder mehr, in weiteren mindestens drei Fällen über 1 Jahr.

Kap. IV: Bericht über die Primärergebnisse der unblutigen Reposition.³⁰

Kurzgefasster Bericht über röntgenologische Studien an Skelettpräparaten. Die Stellung des Hüftgelenks bei der Röntgenuntersuchung spielt eine wesentliche Rolle dafür, wie sich die Lageveränderung der Caputepiphyse im Verhältnis zum Collum in der Frontalaufnahme ausnimmt. Bei der gewöhnlichen Verschiebung der Caputepiphyse, bei der die Verschiebung rückwärts am ausgesprochensten zu sein pflegt, tritt eine scheinbare Verbesserung in der Dislokation der Caputepiphyse ein, wenn man die Stellung des Hüftgelenks von der Flexion zur Extension ändert, sowie von der Auswärtsrotation zur Einwärtsrotation.

Eine völlig sicher und höchst beträchtlich verbesserte oder exakte Lage der Caputepiphyse im Verhältnis zum Collum nach der unblutigen Reposition hat in 24 der 117 mit diesem Verfahren behandelte Fälle festgestellt werden können, und zwar in 19 der 26 Fälle, die eine akute Verschiebung mit frakturähnlichen Symptomen ohne röntgenologisch sichtbaren Callus gezeigt hatten (73.1 %), in 3 von 6 Fällen, die trotz allmählich beginnender Symptome doch bei der Einweisung ins Krankenhaus frakturähnliche Erscheinungen ohne röntgenologisch

³⁰ Unter *unblutiger Reposition* wird in dieser Arbeit unblutiger Repositionsversuch in Narkose verstanden.

sichtbaren Callus aufgewiesen hatten (50.0 %), dagegen nur in 2 von 83 Fällen, die bei der Einweisung keine frakturähnlichen Symptome gezeigt hatten (2.4 %).

Kap. V: Frühkomplikationen im Material.

Eine aseptische Caputnekrose wurde in 20 Fällen diagnostiziert. Von diesen sind 15 mit unblutiger Reposition + Hüftgipsverband behandelt worden, 2 mit unblutiger Reposition + Nagelung, 2 mit blutiger Reposition und 1 mit Nagelung ohne vorherige Reposition (im letztgenannten Fall war die aseptische Nekrose lediglich in einem begrenzten Gebiet in Nähe der Nagelspitze lokalisiert, in den übrigen Fällen umfasste dieselbe die ganze oder wenigstens den überwiegenden Teil der Caputepiphyse).

Unter den in Kap. IV geschilderten 24 Hüftgelenken, bei denen die unblutige Reposition zum gewünschten Ergebnis führte, wurde eine aseptische Caputnekrose in 10 Fällen verzeichnet (41.7 %), dagegen nur in 7 Fällen der 93 Hüftgelenke, bei denen keine sichere Lageverbesserung der Caputepiphyse nach unblutiger Reposition hatte festgestellt werden können (7.5 %). Die Differenz ist statistisch gesichert. Eine unblutige Reposition, die eine Lageverbesserung der Caputepiphyse herbeiführt, bedeutet ein grösseres Risiko für eine aseptische Caputnekrose als eine unblutige Reposition, die zu keiner Veränderung in der Dislokation der Caputepiphyse führt.

Eine Komplikation mit unbekannter Genese, die u. a. von Waldenström (1930) als »Nekrose des Gelenkknorpels« beschrieben worden ist und die sich röntgenologisch in einer ausgesprochenen Atrophie von Gelenkpfanne und Gelenkkopf nebst angrenzenden Skeletteilen, einer sehr wesentlichen Verminderung der Gelenkspaltenhöhe sowie einer mehr oder weniger markanten Unregelmässigkeit der Caputgelenkflächenkontur äussert, ist in 9 Fällen beobachtet worden.

Die unblutige Reposition bewirkte in 1 Fall eine Schrägfraktur durch den unteren Teil des Femurschaftes.

Nagelung ohne vorherige Reposition bewirkte in 1 Fall eine Sprengung der Epiphysenfuge, die eine annähernd zentimeterweite Diastase zwischen Caputepiphyse und Collum zur Folge

hatte. Anzeichen einer aseptischen Caputnekrose wurden in diesem Falle nicht festgestellt.

In Kap. VI berichtet der Verf. über die Nachuntersuchung. Von den 166 Patienten (200 Hüftgelenken) sind 153 Patienten (183 Hüftgelenke) nachuntersucht worden, und zwar sämtliche, klinisch wie röntgenologisch, vom Verfasser persönlich. Die prozentuale Anzahl der nachuntersuchten Patienten beträgt 92.2 %, die der nachuntersuchten Hüftgelenke 91.5 %.

Die Observationsdauer war mindestens 3.0 Jahre, längstens 31.4 Jahre, im Mittel 15.5 ± 0.6 Jahre.

Kap. VII: Beschreibung der Untersuchungsmethodik.

Kap. VIII: Behandlung der Spätergebnisse vom funktionellen Gesichtspunkt.

Das Material wurde funktionell an Hand sämtlicher subjektiver und objektiver Symptome sowie eventueller Einschränkung der Arbeitsfähigkeit in 3 Gruppen eingeteilt, nämlich Gruppe I (gutes Ergebnis), Gruppe II (mittelmässiges Ergebnis), Gruppe III (unbefriedigendes Ergebnis). Gruppe I umfasst 69 Hüftgelenke, Gruppe II 71 und Gruppe III 43 Hüftgelenke.

Der Umfang der Caputepiphysenverschiebung während der Adoleszenz ist von sehr grossem Einfluss auf das funktionelle Spätergebnis. Von den Hüftgelenken, die in der Adoleszenz eine leichte Verschiebung aufwiesen, konnten bei der Nachuntersuchung 75.5 % in Gruppe I eingereith werden, während nur 5.7 % in die Gruppe III fielen. Die entsprechenden Prozentzahlen bei Hüftgelenken mit hochgradiger Verschiebung in der Adoleszenz sind 21.6 % bzw. 32.0 %. Die Unterschiede sind statistisch gesichert.

Mit zunehmendem Alter verschlechtert sich das Spätergebnis vom funktionellen Gesichtspunkt. Die Verschlechterung scheint nicht bei einem bestimmten Alter einzutreten, vielmehr dürfte sie während der ganzen durch das Material des Verfassers repräsentierten Altersspanne allmählich fortschreiten.

Die funktionellen Spätergebnisse waren sehr ungünstig sowohl nach aseptischer Caputnekrose als nach sog. »Nekrose des Gelenkknorpels«.

Es wird ein Vergleich angestellt zwischen konservativer Be-

handlung einerseits, und auf der anderen Seite 1) unblutiger Reposition + Hüftgips unter sämtlichen Fällen, bei denen diese Behandlungsmethode die Haupttherapie war, 2) unblutiger Reposition nur unter den Fällen mit frakturähnlichen Erscheinungen ohne röntgenologisch nachweisbaren Callus, 3) unblutiger Reposition nur unter den Fällen, in denen die Behandlung zu einem primär gewünschten Erfolg führte, 4) unblutiger Reposition nur unter den Fällen mit frakturähnlichen Erscheinungen ohne röntgenologisch nachweisbaren Callus, bei denen die Behandlung zu einem primär gewünschten Erfolg geführt hatte. In allen diesen Kategorien von Fällen war eine Verschlechterung der Spätergebnisse nach unblutiger Reposition häufiger als eine Verbesserung derselben. Die Differenz ist diesbezüglich jedoch in keinem Falle statistisch gesichert oder wahrscheinlich.

Trotzdem dürfte man die Folgerung wagen, dass die hier mitgeteilten recht deprimierenden Dauerergebnisse der unblutigen Reposition nicht zufallsbedingt sind.

1. In sämtlichen obigen Kategorien überwiegen nämlich die Fälle mit verschlimmerten Spätergebnissen über die Fälle mit verbesserten.

2. Dasselbe gilt auch, wenn man nur diejenigen Fälle in Betracht zieht, die als für die unblutige Reposition besonders geeignet angesprochen werden konnten und bei denen diese auch primär zum gewünschten Erfolg geführt hatte.

3. Die aseptische Caputnekrose, auf die in der Regel schlechte Dauerresultate folgen, ist bedeutend häufiger unter den Fällen, bei denen die unblutige Reposition zu einem primär gewünschten Ergebnis geführt hatte als in den Fällen, in denen keine Lageveränderung der Caputepiphyse hatte festgestellt werden können.

Die Spätergebnisse der übrigen im Material des Verfassers vertretenen Behandlungsmethoden werden in Tab. vorgelegt, jedoch ohne nähere Diskussion, da die Anzahl der mit den einzelnen Therapieformen behandelten Fälle nur ganz gering ist.

Kap. IX behandelt die Dauerresultate vom röntgenologischen Gesichtspunkt.

Nach einer Schilderung der einzelnen röntgenologischen Symptome wird das Material in 5 Deformationstypen aufgeteilt je nach der Röntgenanatomie, wie diese auf den bei der Nachuntersuchung aufgenommenen Röntgenbildern in grossen Zügen in Erscheinung trat.

Der Umfang der Caputepiphysenverschiebung in der Adoleszenz spielt eine erhebliche Rolle dafür, wie sich die Deformation im Caput-Collumbezirk im Erwachsenenalter ausnimmt. Von den Fällen mit leichter Verschiebung in der Adoleszenz wurden 70.0 % bei der Nachuntersuchung als Typ 1 oder Typ 2 eingestuft, während nur 13.8 % der Fälle mit hochgradiger Verschiebung während der Adoleszenz bei der Nachuntersuchung zu einem dieser Typen gezählt werden konnten.

Ein Vakuumphänomen ist in 38 Fällen unter den 183 nachuntersuchten Hüftgelenken festgestellt worden (20.8 %).

Röntgenologische Anzeichen von Arthrosis deformans bestanden in 137 Fällen unter den 183 nachuntersuchten Hüftgelenken (74.9 %).

32.1 % der Hüftgelenke mit leichter Verschiebung während der Adoleszenz wiesen bei der Nachuntersuchung Arthrosis deformans auf, dagegen bestand eine solche in 92.0 % der Fälle mit hochgradiger Verschiebung während der Adoleszenz. Die Differenz ist statistisch gesichert.

Im Deformationstyp 1 bestand eine Arthrosis deformans bei 23.5 % der zu diesem Deformationstyp zu zählenden Hüftgelenke, im Deformationstyp 2 bei 37.1 %, im Deformationstyp 3 bei 83.3 %, im Deformationstyp 4 bei 95.9 % und im Deformationstyp 5 bei 71.4 %.

Kap. X bietet einen Vergleich zwischen den funktionellen und den röntgenologischen Dauerresultaten.

Eine röntgenologisch nachweisbare Arthrosis deformans war sehr häufig auch unter den Fällen mit funktionell gutem Spätergebnis. Dagegen kam kein funktionell unbefriedigendes Spätergebnis ohne gleichzeitige Arthrosis-deformans-Verände-

rungen vor (mit einer Ausnahme, nämlich Fall Nr. 3082, wo eine Aggravation vorliegen dürfte).

Die Diskrepanz zwischen subjektiven Beschwerden und röntgenologisch nachweisbarer Arthrosis deformans war in zahlreichen Fällen erstaunlich gross. Mit Ausnahme des vorgenannten Falles Nr. 3082 ging diese Diskrepanz stets in gleicher Richtung, und zwar so, dass die röntgenologischen Arthrosis-deformans-Veränderungen hochgradiger waren, zum Teil sogar wesentlich hochgradiger, als man nach den subjektiven Beschwerden erwartet hätte.

In Kap. XI wird die sog. gesunde Seite diskutiert.

Bei der Nachuntersuchung im Erwachsenenalter hat es sich gezeigt, dass nicht weniger als 30 der früher als einseitig rubrizierten 119 Fälle eine für Epiphyseolysis capitis femoris typische Deformation des Caput-Collumgebietes aufwiesen.

Das Risiko, dass ein Patient, bei dem Epiphyseolysis capitis femoris in dem einen Hüftgelenk diagnostiziert worden ist, eine Epiphysenlösung auch in dem anderen Hüftgelenk bekommen wird, ist also wesentlich grösser (41.8 %), als es in früher veröffentlichten Materialzusammenstellungen zum Ausdruck gekommen ist. Je grösser dieses Risiko ist, um so wichtiger ist es auch, dass das sog. gesunde Hüftgelenk durch häufige Röntgenuntersuchungen so lange sorgfältig kontrolliert wird, bis die Epiphysenfuge geschlossen ist.

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