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COXA VARA INFANTUM

II. *Treatment and Results of Treatment*[1]

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THE TREATMENT OF COXA VARA INFANTUM

Only in the least serious cases can conservative treatment be considered. If we find merely an increase of the epiphyseal angle and perhaps a rather wide epiphyseal gap, we may be justified in keeping the patient under observation and radiological control at regular intervals. This was the case with one of our patients in whom the changes in the collum receded spontaneously as mentioned before in my previous article (Case 4, Fig. 2, left side).

Treatment by extension and by relief from stress and strain has been attempted by some, but seems now to have been abandoned. *Howorth,* in particular, advises against extension in a position of abduction and inward rotation as it is said to entail a risk of interference with the blood supply to the caput. Treatment by extension has not been practised in our material.

In most cases the treatment of coxa vara infantum is operative, with the object of rendering the hip:

(1) Painless
(2) Stable
(3) As mobile and functionally active as possible
(4) Free from deformity and from present or imminent shortening of the limb.

Pain.

As a rule the problem of pain has presented no great difficulties in the present material. Only in advanced cases and comparatively old

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patients did the pain problem manifest itself in its full perspective. We have tried to solve this particular problem in conformity with the special needs of each individual case.

In comparatively young patients pain is usually due to muscular insufficiency resulting from faulty weight-bearing and consequent faulty use of muscles. As a rule pain disappears spontaneously when the weight-bearing conditions improve.

Instability.

Instability of the hip is a sequel to functional shortening of muscle groups and weakening of the ligaments around the joint due to defective ossification of the collum metaphysis. The collum itself is shortened and occupies a varus position. The caput epiphysis slips downwards and the trochanter moves up. The points of origin and attachment of the muscles approach each other, and there is a catastrophic fall in their efficiency. In the later stages of the disease instability of the joint is further increased by the development of a pseudarthrosis.

In attempts to restore the static equilibrium of the collum femoris there is no end to the variety of treatments advocated, some of them being modifications of trifling importance. The object of the treatment given is to correct the varus position or to promote bony union between collum and caput or to combine both these aims simultaneously.

Subtrochanteric osteotomy with various modifications seems to be favoured by most (*Hoffa, Mesurier, Lange, Walter* and others).

It is only under exceptional conditions that arthrodesis can be considered.

Smith-Petersen nailing has been attempted with a view to preventing slipping of the caput and hastening ossification of the epiphyseal line. The results do not seem to have been very satisfactory (*Mesurier*).

Bone grafting, with a tibia graft, has been attempted by *Mesurier, Lian* and others, and pegging by *Howorth,* with seemingly excellent results. In some of the published cases, however, the observation period is rather short.

In our material subtrochanteric osteotomy was employed with a view to binding the force which acts as free shearing-stress on the weak collum area, so as to expose this threatened area only to the force of direct pressure. In this way we have sought to promote ossification of the metaphysis and at the same time to correct the varus position of the collum.

Mobility.

Limitation of the range of movements is due in part to functional disturbances and in part to mechanical factors, the latter being those just referred to. In advanced or neglected cases we encounter new problems,—arthroses and similar conditions, which we have dealt with according to their special needs. We must never forget to consider the muscle function which is not always equally obvious, and we have often been obliged to promote this function by both pre-operative and post-operative exercises.

Shortenings and malpositions.

These conditions present numerous problems in cases of coxa vara infantum. The adjustments of footwear, certain exercises in the milder forms of the disease, shortening of bones, and "stapling" of the epiphyseal line on the healthy side in the more serious cases, are among the measures to choose between. They have to some extent been employed to supplement the treatment given to our patients.

Operative technique.

Subtrochanteric osteotomy has been undertaken in the form of the so-called "peg-osteotomy" as described by *Mommsen, Lange,* and somewhat modified by *Platou. Platou's* method has been employed in most cases. It requires minute attention to technique.

Attempts have been made to render the osteotomy angle wide enough to allow of the required readjustment of the epiphyseal line. However, as the fragments were not infrequently displaced in relation to each other while the limb was being put in plaster, further attempts have been made on rare occasions to keep the fragments in place by means of a single metal suture on the lateral aspect of the osteotomy area.

It has occasionally been necessary to undertake a preliminary tenotomy of the adductor tendon.

After the operation the limb is immobilized in abduction for eight weeks.

Evaluation of the results of treatment.

The clinical evaluation of the functional activity of the hip is always very much a matter of personal opinion. Here it will be necessary to give a short account of the principles followed in our evaluation of the results as presented in Table III. In these functional-clinical results, we have attached importance to the following requirements:

1. The hip must be painless, and the patient must himself be satisfied with it.
   It may tire somewhat more easily than the healthy hip, but this should not be a prominent feature.
2. The hip must be steady and the leg strong. The Trendelenburg test should be negative or only just demonstrable.
3. The spine should present no faulty position, as a result of the hip disease, which cannot be corrected by some compensation for a possible shortening of the limb.
4. The mobility of the hip should be better than it was before the operation. We have attached less importance to this, however, than to the three requirements mentioned above.

With regard to the evaluation of the radiological-anatomical results, importance has been attached to the following points:

1. The caput epiphysis must have a firm support and have achieved bony union with the collum, at any rate, by the end of the years of growth.
2. There must be a good distance between the iliac bone and the tip of the trochanter which must not show considerable upward displacement.
3. The caput must be in place in the acetabulum, and both must be well-developed.
4. We have not attached much importance to complicating factors such as necrosis of the caput in the form of Legg–Calvé–Perthes' disease in our evaluation of the radiological-anatomical results, as the course of this disease seems to be independent of the subtrochanteric osteotomy.

Calculation of the Mobility Index of the Hip.

It is convenient to gauge the range of movements in the hip by a single figure, the so-called mobility index. This is obtained simply by addition of the range of each movement, or we may follow the principles recommended by *Ferguson & Howorth* or by *Gade*. *Gade*'s proposal shows the greatest differentiation, and it is the one we have followed, taking the normal range of movements according to this system to give an index of about 100 %.

The calculation is made thus, the sum of all the movements being regarded as the index (*Gade*):

Flexion	45°	next 45°	next 60°
	× 0.6	× 0.4	× 0.2
Abduction	15°	next 15°	further mobility
	× 0.6	× 0.4	× 0.1
Adduction	entire range of mobility		
	× 0.2		

External rotation	30° × 0.3	further range of mobility × 0.1
Internal rotation	entire range of mobility × 0.2	
Hyperextension	entire range of mobility × 0.2	

Calculation of the "epiphyseal angle".

By this term is meant the angle formed by the epiphyseal line in the colium (or the zone of rarefaction seen in the collum radiologically) with the horizontal line. Under normal conditions the epiphyseal angle should be about 0°.

The osteotomy angle.

By this term is meant the angle which the trochanter region forms with a prolongation of the shaft of the femur. Under normal conditions the trochanter region bends outwards somewhat and forms an angle of about 10–20° with the shaft of the femur.

RESULTS OF SUBTROCHANTERIC OSTEOTOMY IN GROUP I

Age under 10 years at operation.

In this group there is a total of 22 hips (16 patients–see Table I). One patient, 5 years old, died (after bilateral subtrochanteric osteo-

TABLE III

Results of subtrochanteric osteotomy in relation to the age of the patients at time of operation and to the operative readjustment of the epiphyseal angle (i.e. the angle formed by the epiphyseal line and the horizontal line).

	Hips operated on	Clinical—functional results			Radiological—anatomical results		
		excellent	good	poor	good	fair	poor
A. Age of patients at time of operation							
Group I. 3 – 9 years old ...	15	11	4	–	8	6	1
„ II. 10–15 „ „ ...	11	7	2	2	4	4	3
„ III. Over 15 „ „ ...	4	1	1	2	–	1	3
Total	30	19	7	4	12	11	7
B. After readjustment of the epiphyseal angle							
To 20–30 degrees	9	7	2	–	7	2	–
„ 40–50 „	8	6	1	1	4	3	1
„ 60–70 „	7	5	1	1	1	4	2
„ over 70 „	6	1	3	2	–	2	4
Total	30	19	7	4	12	11	7

tomy in two stages) of shock due to no known cause. Five hips are not included as the observation period is too short. The results of the treatment of the remaining 15 hips are given in Table III.

The results are clinically and functionally excellent with regard to 11 hips. Two of these hips were operated on a second time after an interval of several years, chiefly because a radiological examination had shown that the anatomical conditions had again become worse, but also because the patients had experienced a growing sense of instability of the hip.

The clinical results are less good in the case of four hips; this applies also to the anatomical-radiological results. No single hip shows a poor clinical result.

The results are good from the anatomical-radiological point of view in eight hips and six hips show fairly good results. The results are poor in one hip (see Fig. 11).

This patient underwent a new subtrochanteric osteotomy when 23 years old to increase the stability of the hip. The clinical results of this operation were excellent, both subjectively and objectively.

Aseptic bone necrosis of the caput nucleus occurred in two cases. Both patients (Cases 9 and 10) were very pleased with their hips when re-examined. In one case the lesion was situated both on the operated right side, and on the non-operated left side. The caput calotte became greatly deformed, pressed flat and cylindrical, with a corresponding remodelling and poor depth of the acetabulum on both sides (see Fig. 8).

As already pointed out in my previous paper, there was a history of severe trauma in two cases in which the course of the disease and the results of treatment were much the same as in the other cases. The results of subtrochanteric osteotomy were excellent (Case 3, Fig. 10 and Case 6).

The average post-operative observation period is eight years in this group (the shortest, one year, the longest, 20 years).

Readjustment of the epiphyseal angle.

In this group there are very great differences in the degree of success achieved by the operation, in effecting the desired change in

the mechanical factors which exert an influence on the epiphyseal line and the poorly calcified part of the collum.

Before the operation, the epiphyseal line or the zone of rarefaction in the collum presents an angle of between 70° and 100° in 16 hips. In a total of eight hips there is an angle of 90°, and only in one case is there an angle of 30°.

After the operation and removal of the plaster of paris, the angle formed ranges from 20° to 60°. It is 20° in one hip, 30° in six, 50° in another six, and 60° in four hips.

A comparison of the results obtained by the operative readjustment of the epiphyseal angle with the final results, as judged by radiological-anatomical standards, gives the following figures:

In seven hips an epiphyseal angle of 20°–30° has been achieved.

The results are good in five of these cases.

In the two other cases the results are fairly good.

POST-OPERATIVE READJUSTMENT OF THE MASS OF THE TROCHANTER

The post-operative adaptation of the mass of the trochanter, leading to a widening of the osteotomy angle, is quite considerable in this age group. The readjustment varies from 0° to 50°. It depends to a certain extent on the duration of the observation period. The readjustment is greatest during the first few years, being less marked later on.

The greatest readjustment amounted to 40° in the course of five years (Case 3). Five hips showed a readjustment of 40°–50° during an observation period of 5 to 20 years. In six hips it was between 20°–30° during an observation period of 4 to 16 years, and in six hips it was between 0° and 15° during an observation period of 0–20 years.

Mobility.

As a rule, mobility increased after the operation, but unfortunately we lack exact pre-operative records of some of our patients.

There are, however, 13 hips in this group which were thoroughly examined both before and after operation.

Six hips showed an increase of the index amounting from 11 % to 23 %.

Two hips showed a slight increase of mobility.

One hip showed no change.

Four hips showed a slightly reduced mobility index on reexamination; two of these were suffering from Perthes' disease.

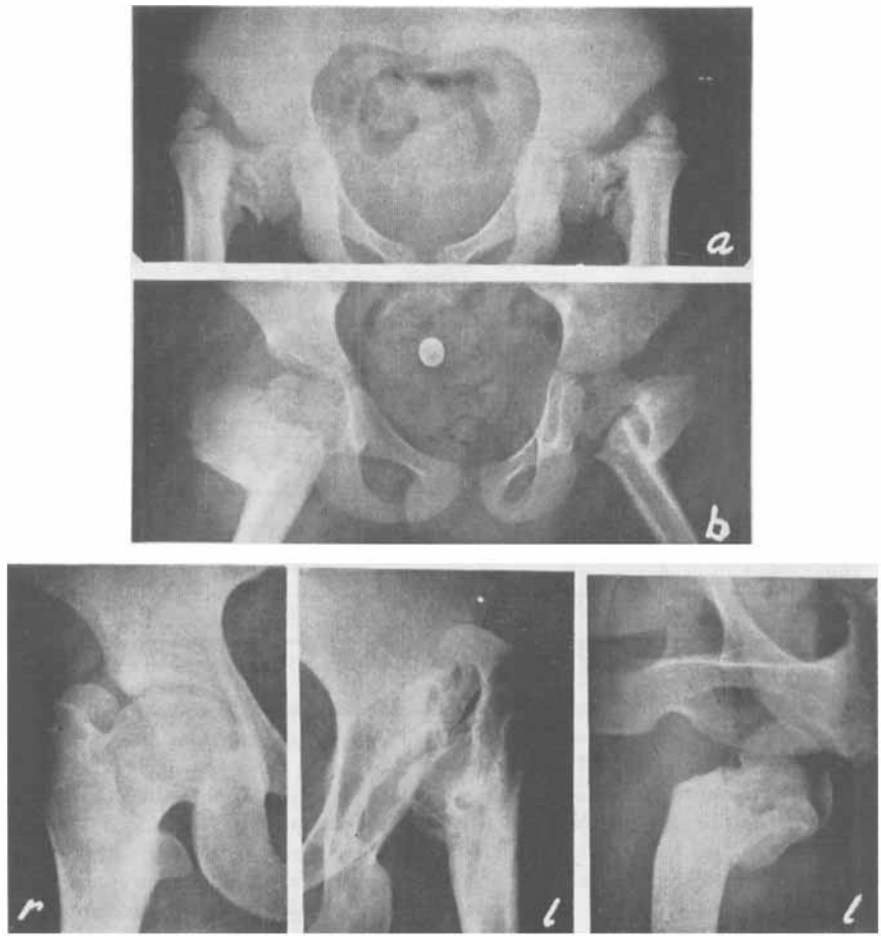

Fig. 11, Case 12. M. Age: 7 and 25 years.
Bilateral coxa vara infantum, treated with subtrochanteric osteotomy. In spite of unsatisfactory post-operative position good anatomical conditions were achieved on the right side. The result on the left side is not good. Still, a lateral view shows a comparatively well-developed caput.

The following example (Case 12, Fig. 11) shows the relative importance to the patient of the mobility of the hip compared with pain and instability:

The patient underwent subtrochanteric osteotomy on both sides for bilateral coxa vara. On the left side two operations were performed with an interval of 18 years, the last operation being undertaken two years ago.

According to the patient's own account, he is able to do ordinary farm work quite well, but when it is very hard or he has to lift very heavy weights, his left hip aches. He is particularly grateful for the second osteotomy on the left side. His left leg is 3 cm. too short, and he suffers from a slight scoliosis with convexity to the left. Trendelenburg's symptom is markedly positive on the left side, negative

on the right. He gets no benefit from a support under his heel intended to compensate the shortening of his leg.

The treatment he has received has yielded an almost perfect clinical result and a fairly good radiological result on the right side, whereas on the left side the radiological result is poor. Before the last osteotomy, the clinical result was also poor. After this osteotomy a clinically good result could be claimed. The mobility index on both sides before the osteotomy and 20 years after was as follows, according to two different methods of calculation:

TABLE IV

Mobility index for the hip calculated according to two different methods (Fig. 11, Case 12).

	Right side		Left side	
	Gade	Ferguson & Howorth	Gade	Ferguson & Howorth
Before operation	94 %	87 %	94 %	87 %
On re-examination (Observation period 20 years)	85 %	67 %	91 %	86 %
	-9 %	-20 %	-3 %	-1 %

In this case the index figures show marked difference according to the method of calculation chosen. But on the whole, the index figures run a more parallel course than in this case.

It is surprising to find that the hip which is the poorer from the clinical point of view shows the greatest mobility and the least post-operative disability whichever method of calculation is employed. However, the other, the right hip, which is better off from the clinical and radiological points of view, shows the poorest mobility and a considerably greater deterioration of the post-operative mobility index as compared with the poorer hip.

We attribute the reduction of mobility on the side which is clinically best to the instability of the poorer, left limb. This case is a textbook lesson emphasizing the wisdom of, and need for, post-operative care for several years. It also stresses the fact that, in gauging the value of post-operative results, less importance should be attached to mobility and range of movement than to pain, instability and any secondary malpositions.

THE RESULTS OF SUBTROCHANTERIC OSTEOTOMY. GROUP II

In this group there are 13 hips operated on (see Table I).

One hip was not re-examined because the patient had gone abroad.

One hip was operated on quite recently (Case 26).

Table III gives the results of treatment of the remaining 11 hips in this group.

Seven hips showed very good functional results clinically, two showed good results and two poor results.

Radiological-anatomically the results were good in four hips, in four fairly good and in three poor.

In the three showing poor results, pre-operative slipping of the caput was so marked that one could hardly expect any very good result radiologically (Case 25 right side Fig. 4, and Case 22 right and left sides). In these two patients we find the first pseudarthroses in our material in spite of operative treatment (Case 25 right side and Case 22 left side).

In one case aseptic bone necrosis developed on the operated side and gave rise to severe deformity of the caput (Case 17).

The average post-operative observation period was 12 years, the shortest being three years, the longest 23 years.

In two cases post-operative changes of position occurred, and in one of these cases (Case 25) bloody reposition was required. In the other case (Case 21, right side) wire extension was applied to improve the position.

It will thus be seen that the results of treatment in Group II were not as good as in Group I.

OPERATIVE READJUSTMENT OF THE EPIPHYSEAL ANGLE

On four occasions a post-operative epiphyseal angle of 20°–30° was achieved, and the results were very good both functionally and anatomically in all cases (Case 21, right side, Fig. 5, Case 21, left side, Case 23 and Case 17).

Case 21, Fig. 5.

The patient was 14 years old when operated on, and ossification of the epiphyseal line had not yet been completed. The stereoscopic films show that it was not only the opportunity for ossification which yielded the good results as the fact that collum and caput had found effective support in the tendon of the ilio-psoas muscle which, as it were, supported the collum and kept it in place. The trochanter minor is seen on both sides behind the collum, being well developed, especially on the right side. The tendon is covered by the quite concave outline of the collum as seen in a frontal exposure. Unfortunately these features are not so conspicuous in the radiogram taken of the right side, but the shadow (with convex outline facing upwards) of the trochanter minor is seen quite plainly behind

the collum. On the left side the outline of the collum, its concavity facing downwards, is seen clearly.

A lateral exposure shows an unusually well-formed caput. The deformity visualized in the frontal plane is situated in the collum and not in the caput calotte.

In the remaining eight hips the post-operative epiphyseal angle varied from 50°–90°.

One patient achieved a functionally fairly good result in spite of a post-operative epiphyseal angle of 90° (Case 19, right side).

Another patient with the same angle also showed a functionally fairly good result, but the result was less good anatomically.

Although eight hips in this age group show radiologically that the slipping of the caput calotte apparently has advanced too far for any good result to be expected, two of them show an excellent final result.

POST-OPERATIVE READJUSTMENT OF THE TROCHANTERIC MASS

The readjustment in this group was much more moderate in degree than in the younger age groups, and it ranged from 0° to 20°. Only in one case in this group did the final result seem to have become worse on account of this process.

The Mobility Index.

This index shows that greater improvement of mobility was achieved in Group II than in the younger age group.

Among eight hips given a thorough examination seven showed a rise of 10–37 % of index, and one with an index of 96 % was unchanged.

Seven out of eight hips showed a clinically excellent result, and one hip on re-examination showed a clinically good result only, in spite of a rise of the index by 33 %.

As special interest attaches to this age group, the mobility index for each of the hips is given below, the figures in brackets referring to the healthy side (Table V).

Group III.

The patients in this group can be classed in three categories:

A. Those for whom an attempt was made to achieve bony union between caput and collum (Cases 28–31).

B. Those for whom some palliative measure was adopted, as no bony union could be expected (Cases 32–36).

C. Those on whom no operation was performed (Cases 37–42).

TABLE V

The mobility index on re-examination of Group II.

Case no.	Index on re-examination	Clinical results
17 L	71 % (92)	Excellent
18 L	92 % (105)	„
21 R	96 % (99)	„
23 R	81 %	„
23 L	90 %	„
24 R	90 %	„
24 L	85 %	„
19 R	71 % (89)	Good
22 R	67 %	„
22 L	23 %	Poor (pseudarthrosis)
25 R	not examined	Poor (pseudarthrosis)

Group III A.

The disease was unilateral in all four cases in *A*, the age of the patients being 16 in three cases and 20 in one. The clinical, functional result was excellent in one case (Case 28), good in one case (Case 31), and poor in two cases (Cases 29 and 30).

The anatomical-radiological result was fairly good in one case and poor in three cases, in two of which a pseudarthrosis developed in the neck of the femur (Cases 29 and 30).

The post-operative observation period was on an average 15 years.

Technical mishaps befell all these patients during or directly after the operation, the osteotomy fragments becoming displaced. Yet two of these patients achieved bony union between caput and collum (Fig. 7), while two patients developed pseudarthroses as already pointed out.

In none of these cases was the readjustment of the epiphyseal line achieved to the desired extent, the post-operative angle never being less than 80°.

In none of these cases did the post-operative readjustment of the trochanteric region yield an angle of more than 20°.

On re-examination, the mobility index showed a fall of 15–25 %, and only in one case (Case 28) did it rise (by 26 %).

THE RESULTS OF TREATMENT IN RELATION TO THE EPIPHYSEAL ANGLE ALONE

If we survey the cases in Table III A, and consider the results of treatment in relation to the readjustment of the epiphyseal angle achieved by the operation, disregarding the patient's age, we arrive at the following figures (Table III B):

An angle of 20°–30° was achieved on nine occasions, none of the results being poor. Seven hips showed excellent results from both clinical and radiological points of view.

An angle of 40°–50° was achieved on eight occasions. Six hips showed a very good result clinically, and four hips a good result radiologically. One hip showed a poor clinical result, and another showed a poor radiological result.

An angle of 60°–70° was achieved in seven hips, one of which showed a poor clinical result, and two a poor radiological result.

An angle of more than 70° was achieved on six occasions, the clinical results being poor in two cases, and the radiological results poor in four cases.

The table shows that the best and most reliable results were those obtained when the post-operative epiphyseal angle was 30° or less.

When the angle is greater than 50°, not only the radiological but also the clinical results are considerably worse.

Group III B.

This group includes the patients who received palliative treatment and who belonged to the oldest age group (Case 32–36).

Six hips were operated on, and in five cases a pseudarthrosis existed before the operation. The measures adopted, therefore, had to depend largely on the needs of each case, on the patient's age, the already existing anatomical-pathological changes, and the strain to which the hip was likely to be exposed post-operatively due to the patient's work. The ages of these patients were 21, 23, 28, 29, and 47 years respectively.

In none of these cases was an attempt made to effect bony healing of the pseudarthrosis or nearthrosis. It is possible that at any rate in one of these cases (Case 34) bony healing might have been achieved if the patient had been operated on according to the principles referred to under Group III A.

In two cases the head of the femur was removed, in one of them in connexion with a subtrochanteric osteotomy with a view to giving better support to the pelvis (Fig. 6, Cases 36 and 32).

In two cases a subtrochanteric osteotomy was undertaken with a lateral wedge as shown in Fig. 12 (Cases 34 and 33, left side).

In one case (Case 35) an arthrodesis of the hip was undertaken, and in another (Case 33, right side), subtrochanteric osteotomy, to ease the strain.

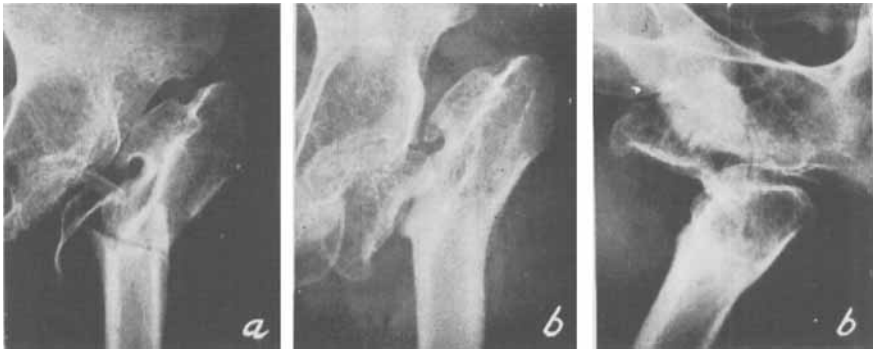

Fig. 12, Case 34. M. Age: 28 and 39 years.
Coxa vara infantum with a complete pseudarthrosis. Treated with subtrochanteric osteotomy, good result. Note the unusual site of the osteotomy and the free post-operative range of movement.

The evaluation of the results achieved in Group III B (by palliative interventions) must, of course, follow other principles than in the previous groups.

Removal of the caput alone gave the desired effect from the radiological point of view. Clinically both patients were also very satisfied and both were rid of pain.

The patient who at the same time underwent a subtrochanteric osteotomy was particularly pleased, his hip had become steady, and he could balance himself on the affected limb even though the Trendelenburg test was still positive. The strengh of his leg was satisfactory, and the mobility index was 85 %, having increased by 27 % after the operation (Case 32).

In the other case, however, the hip was still weak, Trendelenburg was positive, and there was a marked limp on walking. There was no great increase of the abdominal lordosis, however, and the post-operative mobility index was 80 % (Case 36).

The two patients operated on in the manner indicated in Fig. 12, were also well pleased. In one of these cases the mobility index was 77 % on the operated side and 93 % on the healthy side (Case 34).

The patient's own opinion of the hip is that it shows complete recovery in spite of the Trendelenburg test being markedly positive, 5 cm. measurable shortening of the limb, and slight scoliosis.

We have not personally made a follow-up examination of the other patient (Case 33 left side). Both patients are employed on full-time work, and both hips are steady.

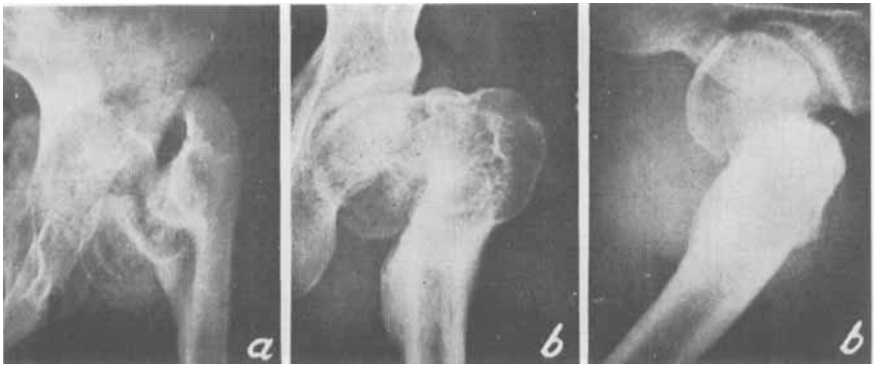

Fig. 13, Case 28. M. Age: 15 and 31 years.
Coxa vara infantum with very considerable sliding of the caput. Treatment with subtrochanteric osteotomy. In spite of the unsatisfactory post-operative position the functional result was excellent, with a firm bony support for the hip and a well-developed caput.

The patient who underwent arthrodesis of the hip is also very pleased. She finds it painless, and there is no shortening of the limb, which is in good position. Her mobility index was 84 % before the operation (Case 35).

The last patient (Case 33, right side), on whom only subtrochanteric osteotomy was performed, also expressed great satisfaction. We have not examined him personally.

The post-operative observation period in these cases ranged from 5 to 11 years.

We cannot, of course, be quite sure that none of these patients at a later date will develop arthrotic symptoms calling for renewed intervention.

Group III C.

None of the eight hips composing this last group was operated on, the reason for not operating being very different.

Fig. 7 presents the youngest patient (Case 37), who was 14 years old. The mobility index in this case was 84 and 96 % according to *Gade*, and 65 and 87 % according to *Ferguson & Howorth*.

There was considerable disability of the hip. The patient's greatest discomfort, however, was due to the instability of her ankle caused by faulty embryonic "anlage" in the latter. The correction of this instability, therefore, had to be attempted first. Later on she will surely benefit from a subtrochanteric osteotomy or, perhaps a "mold" plastic

operation. Curiously enough, this patient has no striking increase of her abdominal lordosis.

Another patient has suffered from sciatica with protruded nucleus pulposus due to scoliosis. The mobility index is 71 according to *Gade*, 57 according to *Ferguson*. The discomforts of the patient, however, are comparatively slight.

In the remaining cases operative treatment was not considered indicated at present for other reasons.

DISCUSSION

Analysis of the Results of Treatment.

Table III shows the results obtained in 30 hips, all of which were examined after a sufficiently long post-operative observation period.

In 19 cases we find an excellent clinical-functional result, while in only 12 cases the result is good radiological-anatomically. In the two other groups also there was a striking difference between the clinical evaluation on the one hand and the radiological on the other.

This discrepancy in the evaluation of the results should be interpreted merely as indicating a departure from what is taken to be the normal radiological-anatomical picture. It is an illustration of the old truth, so easily forgotten by surgeons in particular, that there are many different ways by which the same end can be attained.

Greater importance is attached to the other difference brought out by this table: the older the patient at the time of treatment, the less effecive the results. This shifting of the results which increases with the patient's age, is present both clinically and radiologically.

This difference is so constant and striking that it is of interest to investigate its causes in spite of our figures being small. Our material possesses the great merits, that the observation period is very long, that all the patients were treated by the same principle and on the whole by the same operative technique.

At the time of follow-up examination, the ossification of the epiphyseal lines was completed or so far advanced that we could be sure of solid, bony union between collum and caput developing in 26 hips.

The results of treatment may be said to be very satisfactory as far as our younger-patients are concerned. In the older age groups, however, are four patients who have developed a pseudarthrosis- i.e. no bony union between collum and caput in spite of osteotomy (Fig. 4, Cases 22, 25, 29 and 30).

In all four cases the pre-operative slipping of the caput was so advanced that more than half of the caput calotte could be seen in the radiogram to have passed the outline of the trochanter minor.

In none of these cases did an operation succeed in providing a firm support for the caput. In three cases the post-operative shift of the fragments was such that the epiphyseal angle was 90° when the plaster of paris was discarded.

The operative technique is the usual. Only in one case was another technique employed (that of *Lorenz*). Though in this case the epiphyseal angle became 50° no effective support for the caput was provided.

The cause of these four pseudarthroses appears to be the failure to create conditions giving due consideration to the basic mechanical principles of pseudarthrosis healing.

Pauwels maintains that when there is an angle of more than 30°, the shearing-stress affects the bony regenerate. Under unfavourable conditions this causes decalcification and conversion of bone tissue to connective tissue. Further, according to *Pauwels*, every step the patient takes exerts a strain on the threatened part of the femoral neck equivalent to a weight four times that of the body weight.

The second part of Table III shows how important it is to tackle these problems according to mechanical principles. A small post-operative epiphyseal angle, i.e. large osteotomy angle, gives much better final results than when a too small osteotomy angle gives a large post-operative epiphyseal angle.

It follows that comparatively satisfactory results can be achieved only when one has paid sufficient attention to these basic, static-dynamic principles.

Readjustment of the Epiphyseal Angle.

There are two different ways in which the effect of misapplied forces on the collum area can be prevented, viz.;

by swinging the upper fragment inwards, which should take place only in the frontal plane,

by subtrochanteric osteotomy ad modum *Putti*, the distal fragment is shifted on parallel lines so far inwards that it gives direct support to the caput epiphysis.

In the present material there are three main factors which are liable to impair our otherwise excellent results:

a. A too small osteotomy angle. This is the most frequent and most obvious fault.

b. The upper fragment swings round in the sagittal plane, coming into flexion. In the same way as by varus position flexion increases shearing-stress on the weak and yielding metaphysis. It should be noted that flexion and adduction have an unfavourable effect to the same extent and in the same way, but quite independently of each other when considered from a purely mechanical point of view. In practice, however, matters are a little more complicated, and it would seem that flexion is not quite as unfavourable a position as one would expect it to be in theory.
c. The femoral fragment slips past the median aspect of the upper fragment and impinges directly on the weak collum area. Such an accident leads in the most unfortunate cases to complete decalcification of the collum.

However if one succeeds in leading the femur under the caput so as to give it direct support, we usually achieve rapid calcification of the epiphyseal line or a deposit of lime in the pseudarthrosis gap.

In order to succeed in doing this, however, we must perform the osteotomy far enough down the femur.

As a rule, the distance between the caput and the end of the femur will increase later on, partly by secondary adaptation of the osteotomy angle due to the constructive readjustment of the trochanteric mass which proceeds throughout life–partly by growth in length as long as this process lasts. Our material shows no example of direct fusion of the caput with the end of the femur.

Fixation of the osteotomy ends.

With regard to the technical side of the operation, it must be admitted that in our material fixation of the osteotomy fragments does not always seem to have been adequate. Particularly in advanced cases, with marked slipping of the caput calotte, the difficulties in securing full control of the position of the upper fragment, particularly to prevent the position of flexion, appear to be very great.

In future, therefore, our hospital will employ a different technique, with more secure fixation, so as to prevent secondary displacement of the osteotomy ends (Fig. 14).

"Peg" osteotomy will be employed in slighter cases in which there seems to be no great risk of secondary displacement of the osteotomy fragments. It seems to be advisable to avoid leaving large foreign bodies of metal at the site of an osteotomy.

Bone grafting.

It would be very interesting to find out whether the readjustment of the epiphyseal angle alone has been sufficient to prevent further slipping of the caput, resulting in more normal ossification of the collum metaphysis, or whether we would have done better by making more extensive use of bone grafting in our material.

Bone grafting was not employed. It was feared that attempts to convert free shearing-stress to direct pressure would lead to complete collapse of the collum and would have pressed the caput calotte down on the mass of the trochanter.

Such a mishap never occurred as the result of our treatment. On the contrary after a successful osteotomy and satisfactory readjustment of the epiphyseal angle, we were able to see by radiological examinations how the lime content of the collum increased from month to month, and how the collum becomes constantly more normal. Moreover, the whole of the hip region, including the acetabulum and the trochanter, benefited from the changed static and functional conditions. A surprising and almost instantaneous recovery occurs of the processes of growth which hitherto had lagged behind on the affected side (See Fig. 3 our youngest patient).

If it is assumed that the collum metaphysis may be regarded as primarily hypoplastic, one might expect it to be incapable of reverting by itself to normal forms of development when exposed to increased weight-bearing. In a few instances this seems to have been the case to a certain extent. For example, in Case 1 Fig. 1, D the position after the first osteotomy is not poor. Though the epiphyseal angle is somewhat more than 30°, it increases to nearly 90° in the course of three years.

If at this stage and on account of the above-mentioned arguments we had undertaken bone grafting with a tibial graft, this probably would have led to fusion of the epiphyseal line at an early stage. We chose to undertake a second subtrochanteric osteotomy with a good angle, and the ossification of the epiphyseal line followed this operation in normal time.

On re-examination eight years later, the collum is short and plump, the epiphyseal line ossified. If we had employed a tibial graft instead of osteotomy alone, the collum would hardly have become longer, probably still shorter due to the premature closing of the epiphyseal line provoked by the graft.

On the other hand, bone grafting would probably be beneficial for those patients who come for treatment at a late stage, i.e. at the end

of puberty when the caput calotte is on its way downwards and has almost passed by the region of the trochanter minor. Our poorest results belong to this category. Even when we bear in mind the many technical difficulties which we have encountered in individual cases, and which get lost to view during the presentation of such a large material as ours, we must yet admit that in this group our results were not good.

Bone grafting can be carried out in many different ways. *Howorth's* method seems convincing. *Lian* adopted a similar method in the case recently recorded in Acta Orthopaedica. *Mesurier* has also obtained good results with his method.

However, even advanced cases show a remarkably great tendency to ossification provided the parts concerned are protected against every form of shearing-stress.

This tendency to ossification in late puberty may be so marked that only a slight modification of the existing strain and stress may be enough to assure bony union between caput and collum (Fig. 13, Case 28).

It is, however, a general rule that a steep course of the epiphyseal line will inevitably give rise to slipping of the caput.

Table III B suggests that we need not put the limit of the permissible post-operative epiphyseal angle so low as 30°, for even with an angle approaching 50° we may be fairly sure of a good result.

As a rule the poor results seem to be the consequence of our failure to satisfy the static-mechanical requirements. We may assume that in such cases bone grafting is indicated as a supplementary measure.

Readjustment of the Trochanteric Mass.

In our material the readjustment of the trochanteric mass has been a rather incalculable factor. Not only does it entail a certain limitation of the range of movement, particularly abduction, because the tip of the trochanter impinges against the ilium, but also some loss of stability of the hip, because the points of origin and attachment of the gluteal muscles have come closer to each other.

It seems that after puberty the tendency of the trochanteric mass to readjustment diminishes, and it continues at a considerably slower rate than during the years of active growth.

Fig. 1 (Case 1) shows one of the most characteristic readjustments of the trochanter. It will be seen that the fragments have been fixed by wire laterally on the femur by osteotomy, undertaken for the second time at the age of 8 years.

The readjustment of the trochanteric mass has become so great in the course of a few years that this metal wire can now be seen medially on the femur. The roentgenogram also shows how the tip of the trochanter is drawn inwards towards the ilium, and how the caput with the collum has been pressed downwards partly owing to static forces, and partly owing to the dynamic forces acting on the upper end of the trochanter.

In spite of the fact that the osteotomy was technically very successful and that the post-operative epiphyseal angle was good, the neck of the femur reverted to its former faulty position in the course of a few years. Although all the already-mentioned theoretic mechanical factors, calculated to arrest the pathological process, were present, this continued almost unabated, and the faulty position recurred. Yet the metaphysis and epiphysis finally ossified almost surprisingly at the end of puberty.

Earlier in this study an attempt was made to draw up the guiding principles on which to act. The post-operative course of our cases shows how obstinately the organism tries to counteract our therapeutic essays. Attention has already been drawn to the curious part which the tendon of the psoas muscle seems to play by apparently providing a support for the metaphysis.

For this reason we may ask if, by changing our technique, we can help our youngest patients more than hitherto. It might well be an advantage if we did not adhere too strictly to static-mechanical principles, but rather repeated osteotomy several times while the patient is still growing. This is a point of view which is particularly applicable to those cases in which we encounter technical difficulties in our attempts to achieve a theoretically ideal position.

On the other hand, we should be stricter in our standards and requirements when we have to deal with advanced cases presenting pseudarthroses and advanced slipping of the caput.

In Groups III B and C the character of the treatment has varied so greatly that no general conclusion with regard to the results of treatment can be drawn. Here we encounter several new problems: secondary arthroses, nearthroses, pseudarthroses etc. each presenting special features. These hips, therefore, must be regarded only as isolated observations.

One patient may be well served by the removal of the caput (Fig. 6), another by a subtrochanteric osteotomy below the caput, and a third by an osteotomy the apex of which impinges on the centre of the caput (Fig. 12).

As a result of our palliative treatment, all our patients feel much better subjectively and, after having been practically totally disabled, they are all again fully fit for work.

The mobility in the hips is partly increased, partly reduced. It is

more important, however, that possible faulty positions have been corrected or prevented from developing, thanks to the intervention.

Post-operative control.

In the great majority of cases the slipping of the caput calotte goes on through many years. It is therefore justifiable, in the mildest forms of the disease, merely to keep the patient under observation. Spontaneous recovery may occur, although it is most exceptional as we have seen in our material.

When in doubt we should always operate! As a rule, one osteotomy too many is better than one too few.

Patients who have been operated on should be kept under systematic supervision, in some cases for many years, till definite bony union between caput and collum has been achieved.

Clinical or radiological evidence of aggravation is an indication for operation; a single subtrochanteric osteotomy does the patient no harm. The patient should always be examined at the time of puberty, and we should always be aware of the possibility that the patient may benefit from renewed osteotomy both with a view to the ossification of the metaphysis and epiphysis and the maintenance of a proper distance between the tip of the trochanter and the ilium.

As already pointed out, stabilization of the collum region is necessary, not only for the healing of the local morbid process, but also for the normal development of the whole of the hip, and indeed of the whole of the lower limb.

CONCLUSION

The following conclusions may be drawn from our investigations:

1. Coxa vara infantum should be treated by subtrochanteric osteotomy as early as possible. Quite young patients may be kept under observation for a time as long as slipping of the caput does not occur. Treatment should be completed before school age.
2. The osteotomy angle should be made so wide that the threatened part of the collum is freed from shearing-stress. In other words, the angle formed by the radiologically visible gap with the horizontal line should not be wider than 50°, preferably not wider than 30°.
3. Care must be taken to provide adequate fixation at the site of the osteotomy, special attention being paid to the upper fragment so that it does not come into a position of flexion

(radiological control on the operation table in two vertical planes).

4. In advanced cases, at puberty or later, with extensive slipping of the caput, it is advisable to combine osteotomy with bone grafting at the site of the pseudarthrosis.
5. Patients should be kept under uninterrupted supervision till definite bony union between the collum metaphysis and the epiphysis has been achieved. On signs of fresh slipping, or when the readjustment of the trochanteric mass has gone too far, reoperation is indicated.

SUMMARY

A brief survey is given of the principles guiding the treatment of coxa vara infantum, and of the criteria, clinical-functional and radiological, by which the results of treatment have been evaluated in this investigation. Causal treatment with subtrochanteric "peg" osteotomy has been employed on 30 hips. Six hips have been subjected to various forms of palliative treatment, and for different reasons eight hips were not operated on. There was one death from post-operative shock.

All the 30 causally treated hips had been kept under postoperative observation for several years, in some cases for more than 20 years. Excellent clinical-functional results were achieved in 19 cases, and in four cases the results were poor. After detailed analysis of the causes of the poor and less satisfactory results, the author demonstrates that purely mechanical and dynamic factors have a crucial influence on the results of treatment. The conclusions drawn have been compiled in five points (see p. 121).

The radiological results are less satisfactory than the clinical findings, a difference which, in the author's opinion, is of no material importance.

The surprisingly good results of palliative measures are discussed. It is pointed out that *Putti's* technique for subtrochanteric osteotomy seems to be the most rational procedure in such cases.

The non-operative patients present a series of other problems which have not been closely discussed, however, as they are of partly coordinate, partly secondary character.

ZUSAMMENFASSUNG

Der Verfasser giebt eine kurze Übersicht über die Grundsätze nach denen die Behandlung der coxa vara infantum geleitet ist, sowie der

klinisch-funktionellen und röntgenologischen Gesichtspunkte, nach welchen die Behandlungsergebnisse in dieser Untersuchung gewertet sind. Causale Behandlung mit subtrochantärer „Zapfen" osteotomie wurde in 30 Fällen angewendet. Sechs Hüften wurden in verschiedener Weise palliativ behandelt, und 8 Hüften wurden aus verschiedenen Gründen nicht operiert. Ein Patient starb an postoperativem Schock.

Alle 30 causal behandelten Hüften sind mehrere Jahre hindurch nach der Operation unter Beobachtung gehalten worden. In einigen Fällen betrug die Beobachtungsdauer mehr als 20 Jahre. Ausgezeichnete klinisch-funktionelle Resultate wurden in 19 Fällen erzielt. In vier Fällen war das Resultat schlecht. Nach einer eingehenden Analyse der Ursachen für die schlechten und weniger zufriedenstellenden Ergebnisse, zeigt der Verfasser, dass rein mechanische und dynamische Faktoren einen wesentlichen Einfluss auf die Behandlungsergebnisse haben. Die erhobenen Schlussfolgerungen sind in fünf Punkten zusammengefasst (S. 121).

Die röntgenologischen Befunde sind weniger zufriedenstellend als die klinischen, ein Unterschied, dem, nach der Meinung des Verfassers, keine wesentliche Bedeutung beizumessen ist.

Die überraschend guten Ergebnisse palliativer Massnahmen werden besprochen. Es wird hervorgehoben, dass Puttis Methode der subtrochantären Osteotomie das günstigste Vorgehen in solchen Fällen zu sein scheint. Die nicht operierten Patienten stellen eine Reihe anderer teils gleichgeordneter, teils sekundärer Probleme dar.

RÉSUMÉ

Un compte rendu sommaire est donné des principes qui guident le traitement du coxa vara infantum et des critères (cliniques, fonctionnels et radiologiques) d'après lesquels a été considéré le traitement dans la présente enquête. Un traitement causal avec ostéotomie « enchevillée » subtrochantérienne a été appliqué dans 30 cas. Six hanches avaient été soumises à diverses formes de traitement palliatif, et pour différentes raisons huit hanches n'avaient pas été opérées. Il s'était produit un décès à la suite d'un choc post-opératoire.

Toutes les 30 hanches causalement traitées ont été maintenues en observation post-opératoire pendant plusieurs années, dans certains cas pendant plus de 20 ans. D'excellents résultats cliniques et fonctionnels avaient été obtenus dans 19 cas, mais dans 4 cas les résultats étaient médiocres. Après une analyse détaillée des causes de ces résultats médiocres et peu satisfaisants, l'auteur démontre que des

facteurs purement mécaniques et dynamiques ont une influence cruciale sur les résultats du traitement. Les conclusions tirées ont été établies en 5 points (voir p. 121).

Les résultats radiologiques sont moins satisfaisants que les trouvailles cliniques, différence qui, de l'avis de l'auteur, ne présente aucune importance matérielle.

Les résultats étonnamment bons des mesures palliatives sont discutés. Il est souligné que la technique de Putti pour l'ostéotomie subtrochantérienne semble être le procédé le plus rationnel dans ces cas.

Les malades qui n'ont pas été opérés présentent une série d'autres problèmes qui ne sont pas discutés à fond, étant donné qu'ils sont soit de caractère coordonné, soit de caractère secondaire.

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