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SUBTROCHANTERIC OSTEOTOMY IN THE TREATMENT OF LEGG-CALVÉ-PERTHES' SYNDROME (L. C. P. S.)

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The Legg-Calvé-Perthes' Syndrome starts apparently with ischaemia and avascular necrosis of the proximal femoral epiphysis. Already in its initial stage the syndrome produces harmful side effects such as hypertrophy of the osteochondral caput (Axer & Schiller 1972) and lateral subluxation (Axer & Schiller 1972, Caffey 1968, Katz 1957, Kemp & Boldero 1966, Korvin 1947, Strange 1965). This combination of biological and mechanical factors disrupts the functional capacity of the hip joint and leads to excessive pressure being exerted by the antero-lateral part of the acetabular roof on the corresponding segment of the necrotic femoral head which becomes flattened and "squeezed out" laterally and anteriorly. This has been observed on plain roentgenograms (Waldenstrom 1934), and on arthrography (Axer & Schiller 1972) in the initial stage of L. C. P. S.

Consequently, treatment should be directed towards early correction of this mechanical derangement of the hip joint by placing the diseased femoral head deeply into the acetabulum. To thereby reduce the femoral head, internal rotation combined with abduction is necessary. This will accomplish a more even redistribution of the intra-articular pressure over the articular surface of the femoral head. Many methods of conservative treatment, with and without weight-bearing, have been devised to obtain this goal (Goff 1954, Katz 1967, Harrison & Menon 1966, Harrison et al. 1969, Tachdijian & Jouett 1968, Petrie &

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Bitenc 1971). All these methods of conservative treatment impose prolonged physical restriction on the child.

Innominate osteotomy (Salter 1966) has been used to provide acetabular coverage, but its application has been limited to patients with a poor prognosis (Bobechko et al. 1968).

We prefer varus derotation subtrochanteric osteotomy (Axer 1965) to the above methods for the following reasons:

1. Following the operation the treatment can usually be completed in six to eight weeks in a double hip spica, after which the child is free to bear weight without restriction while healing takes place. This greatly relieves the physical restriction which awkward devices place on the child and the psychological burden on the parents and the child.

2. The proper amount of internal rotation and abduction of the proximal fragment can be determined by preoperative radiography in different positions of the hip and by arthrography; the operative technique is simple.

3. The osteotomy produces hyperaemia in the hip joint area such as that seen after fractures (Laurnen & Kelly 1969, Mindell & Sherman 1951, Wray 1964). This biological effect, together with the normal pumping action of the unrestricted pelvi femoral muscles, may accelerate revascularisation of the epiphysis and in this way decrease the time of the disease process (Axer & Rzetelny 1971). It may also stimulate the growth in length of the extremity (Siffert 1966, Sofield 1959) to compensate for its shortening, which is the natural sequela of L. C. P. S. (Carpenter & Powell 1960, Edgren 1965). Furthermore, the normal range of motion will permit the reciprocal moulding of the plastic femoral head and of the acetabulum.

4. Finally, and not least of all, after postoperative treatment is completed the surgeon need not rely on the fortitude and intelligence of the parents to continue with adequate and consistent care of the unruly youngsters. All that is required are regular x-ray checks of their hips.

MATERIAL AND METHODS

Between 1958 and 1971 subtrochanteric varus and/or derotation osteotomy was carried out in 51 hips (47 patients with L.C.P.S.) in our department. This study is based on osteotomies performed between the years 1958–1970 in 34 patients with unilateral L. C. P. S., whose

average age at the onset of the disease was six years. The latter was estimated from the earliest available radiograph of each patient according to Ståhl's (1944) method. We have been inclined, however, to antedate the commencement of the disease in patients whose earliest radiographs revealed a stage of advanced condensation of the femoral epiphysis, for longer periods of time than Ståhl estimated (up to one year).

In 23 patients a varus-derotation was performed, in 9 derotation, and in 2 patients varus osteotomy. Five patients were reoperated. Thus a total of 39 osteotomies were done. 26 patients were males and 8 females.

Prior to the operation, most patients had some form of consistent conservative treatment which lasted from one to twelve months.

The Operation

There has been little change in the technique since 1965 (Axer 1965) and this will not be repeated. Anteversion views (Dunlap et al. 1953) are made pre-operatively to prevent excessive derotation and hence retroversion, especially in the early stages of the disease when the incidence of increased anteversion is low (Axer et al. 1972). Arthrography of both hips is routinely performed under anaesthesia with the hips in different positions, including that of internal rotation and abduction in order to estimate the degree of flattening of the osteochondral caput and to select more accurately the degree of derotation and varus angulation required to effect satisfactory coverage. The bone plate is pre-bent to the desired angle and fixed to the femoral shaft with four screws after excision of a suitable wedge of bone with the base pointing medially.

Method of Evaluation of Results

In studying the results of treatment we have utilized the method of Mose (1964) employing the transparent device described by Edgren (1965). Good results comprised spherical heads whose radii were equal on antero-posterior and lateral radiographs. (All lateral views of the hips were made in Lauenstein's position.) Fair results had heads which deviated from a circle by up to 2 mm. Poor results had heads which were irregular, with outlines differing by more than 2 mm. Although this system does not take into account the relationship between the head and the acetabulum, it gives a very critical analysis of the anatomical outcome of the disease and is of considerable prog-

nostic value, since sphericity of the femoral head appears to be of paramount importance for the functional durability of the hip joint (Edgren 1965, Heyman & Herndon 1950, Katz 1967, Meyer 1966, Mose 1964, Sundt 1949).

In the preliminary report (Axer 1965) the results were assessed on the basis of the comprehensive quotient of Heyman & Herndon (1950). It has been shown that it is difficult to measure accurately the head-neck quotient and that it can vary significantly with hip rotation (Schiller & Axer 1972). Thus the comprehensive quotient even in the early period of healing has been said to be unduly flattering (Harrison et al. 1969). Aside from the head-neck quotient the other individual quotients are quite reproducible and stable (Schiller & Axen 1972) and very useful for describing various important facets of the disease, i. e. epiphyseal flattening (epiphyseal quotient), acetabular capacity (acetabular quotient) and the degree of lateral protrusion of the head (acetabular-head quotient).

We have calculated the comprehensive quotients in the previously reported 11 cases for comparison.

RESULTS

The final results in all 34 patients based on the method of Mose are presented in Table 1 after an average follow-up of 6 years and 8 months (from a minimum of two years to a maximum of 13 years and ten months[1]). At the last roentgenological examination all involved hips were either completely healed (18 hips), or they were in the late stages of regeneration (16 hips). The shape of the head at the advanced stage of healing is usually preserved until adulthood (Jonsäter 1953, Trueta & Trias 1961). We have observed improvement of the shape of the femoral head in a considerable number of patients after the second post-operative year (Axer & Rzetelny 1971, Figure 7A, B, C, D.).

Table 1. Final Results in 34 Unilateral Cases According to Mose.

Result	No. of cases	Percent
Good	18	53
Fair	13	38
Poor	3	9

[1] Of the 29 patients reported previously (Schiller & Axer 1972) 2 cases with poor results improved during the last year and became fair.

Table 2. Comprehensive Quotient in the 11 Cases of the Earlier Report

Year	Very good	Good	Fair	Poor	Average duration of postoperative follow-up (in years)
1965	5	4	1	1	2 5/12
1971	7	2	1	1	8 3/12

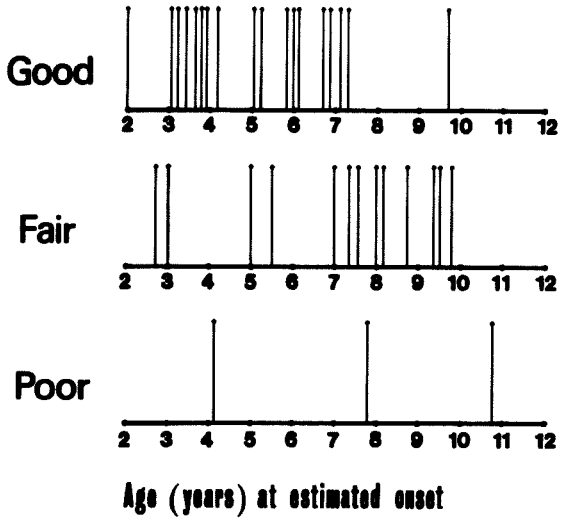


Figure 1. Graph showing relation between age at estimated onset of the disease and the anatomical end results (Mose) (see text).

Results in the initial 11 patients with reported comprehensive quotients are presented in Table 2. After an average additional period of 5 years of observation (average follow-up 8 years and 3 months), they have remained either unchanged, or became upgraded from good to very good (3 cases). One case dropped from very good to good.

Table 3. Results According to the Stage of the Disease at the Operation (Mose).

Result	"Necrosis"	"Fragmentation"	"Regeneration"
Good	9	9	0
Fair	4	3	6
Poor	1	0	2
Total	14	12	8

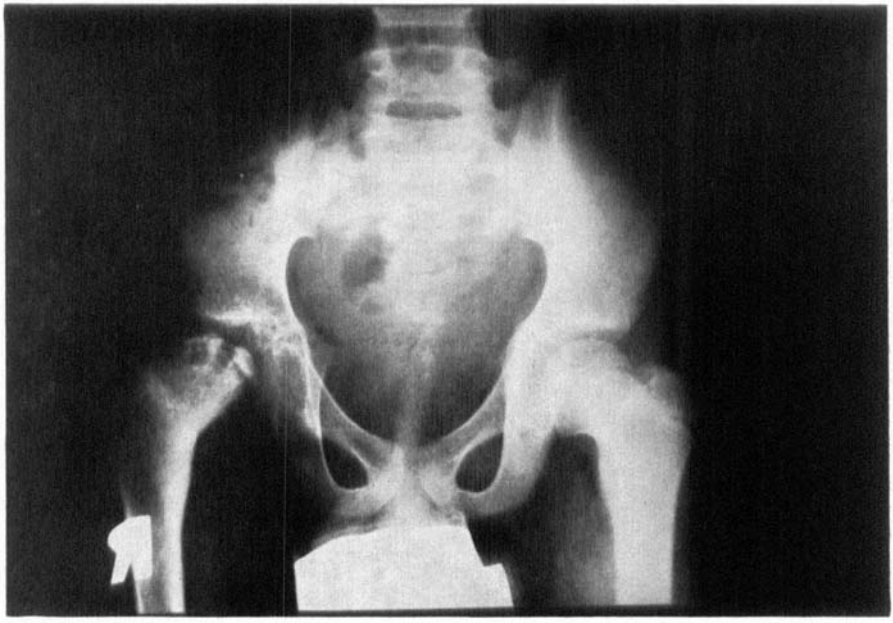


Figure 2. Patient N. E., male, aged 9 years and 9 months at estimated onset of the disease.

Figure 2 A. Antero-posterior preoperative roentgenogram at the age of 11 years and 8 months showing the regeneration stage with marked lateral protrusion of the head, 11 mm increase in the medial joint space, marked epiphyseal flattening and metaphyseal cystic changes.

The Results in Relation to the Age at Onset (Figure 1)

Good results were concentrated among children with onset of the disease between the third and the seventh year of life. Most of the fair results were encountered in patients who became affected between the seventh and tenth year of life.

The average age at onset in patients with good results was 5 years, with fair results it was 7 years and with poor results it was 7 years and 6 months. In 19 of the 31 patients with good and fair results, the disease began before they reached the age of 7.

Results According to the Stage of the Disease at Operation (Table 3)

Best results were obtained in the 24 hips operated in the stage of necrosis or fragmentation. None of the 8 children operated in the stage of regeneration ended up with a good result: 6 of them became "fair" and two "poor".

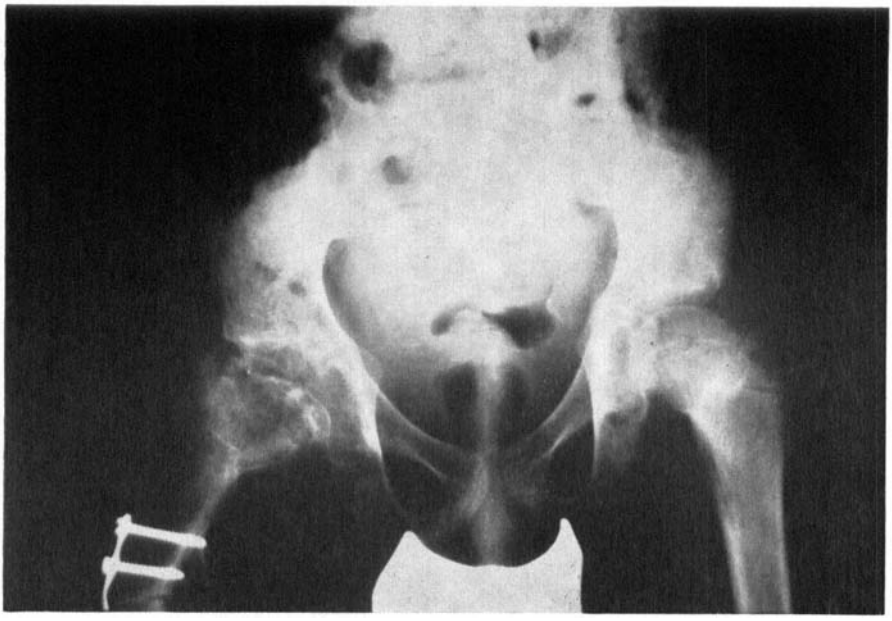


Figure 2 B. Antero-posterior roentgenogram 7 months after a varus derotation subtrochanteric osteotomy shows enlarged head well reduced within the acetabulum. The greater trochanter is very high. This patient later had a transfer of greater trochanter. Articulo-trochanteric distance: 2 mm.

Results according to the Type of Osteotomy

1. Twenty-three patients had derotation varus osteotomy initially; 12 became good, 10 fair and one became a poor result. The latter was a boy aged 9 years and 9 months at the estimated onset of the disease who had no treatment until he was 11 years and 8 months old, when surgery was performed on a subluxated hip with a hypertrophied caput and in the stage of regeneration (Figure 2A, B, C).

An example of a good result is illustrated in Figure 3A, B, C and D[2] with a follow-up of 10 years and 9 months and of a fair result in Figure 4A, B, C with a follow-up of 4 years and 7 months.

Three of the 23 patients had the varus derotation osteotomy repeated (Table 4). In one of them (case no. 1) the plate broke after the first operation, subluxation recurred and the acetabulum-head quotient became very low (65 per cent). One year later, when the hip was

[2] The patient's radiographs were presented in the preliminary report (Axer 1965) p. 497, case 3 with a follow-up of 3 years and 7 months.

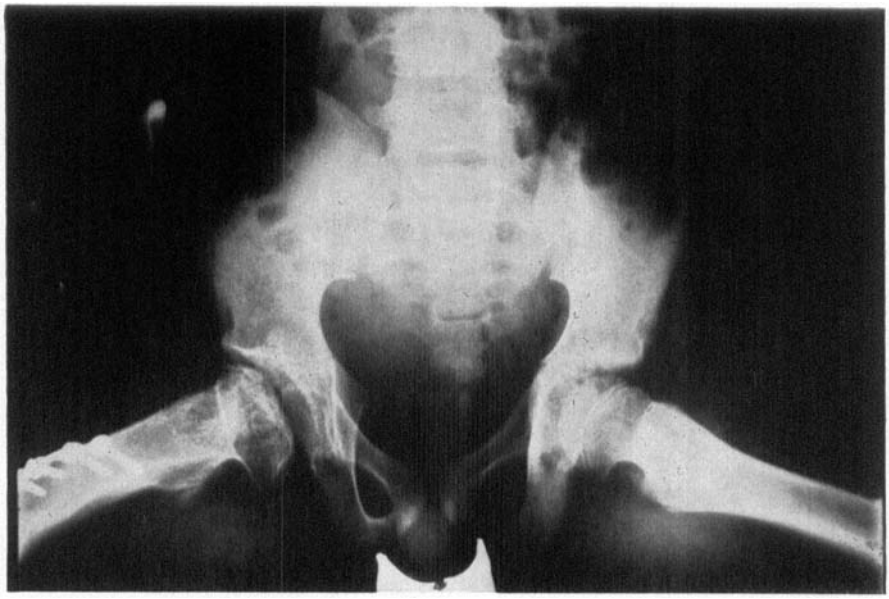


Figure 2 C. Lateral roentgenogram 2 years after surgery at age of 13 years and 7 months. A "poor" result (Mose), with enlarged head.

Table 4.

No.	Kind of operation		Age at operation			
	First	Reoperation	First Y	First M	Reoperation Y	Reoperation M
1.	Varus/ Derotation	Varus/ Derotation	5	7	6	7
2.	Varus/ Derotation	Varus/ Derotation	4	10	6	3
3.	Varus/ Derotation	Varus/ Derotation	9	9	11	2
4.	Varus	Derotation	6	1	8	6
5.	Derotation	Varus	9	4	10	8

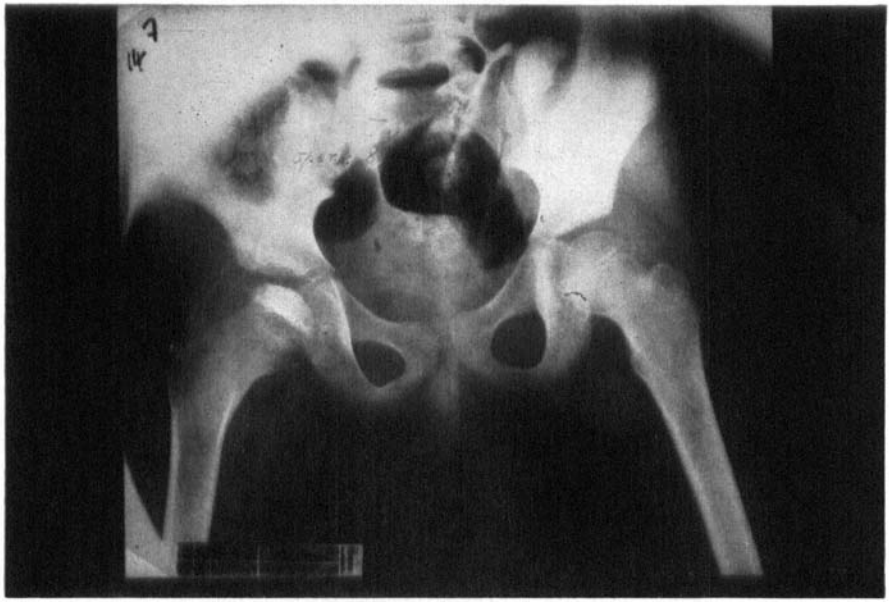


Figure 3. Patient S. M., male aged 6 years and 8 months at estimated onset of the disease and treated conservatively for 8 months prior to surgery.

Figure 3 A. Antero-posterior preoperative roentgenogram at the age of 7 years and 9 months showing the "necrotic" stage with some epiphyseal flattening and enlarged medial joint space. Cystic damage beneath the somewhat irregular growth plate is present.

Reoperation

Stage at operation		Indications for reoperation	Results	
First	Reoperation		First	Reoperation
Necrosis	Regeneration	Recurrence of subluxation due to broken plate	Fair	Good
Fragmentation	Regeneration	Recurrent subluxation	Fair	Fair
Necrosis	Regeneration	Recurrent subluxation	Poor	Poor
Regeneration	Regeneration	Insufficient coverage of femoral head	Poor	Poor
Necrosis	Fragmentation	Recurrent subluxation	Poor	Fair

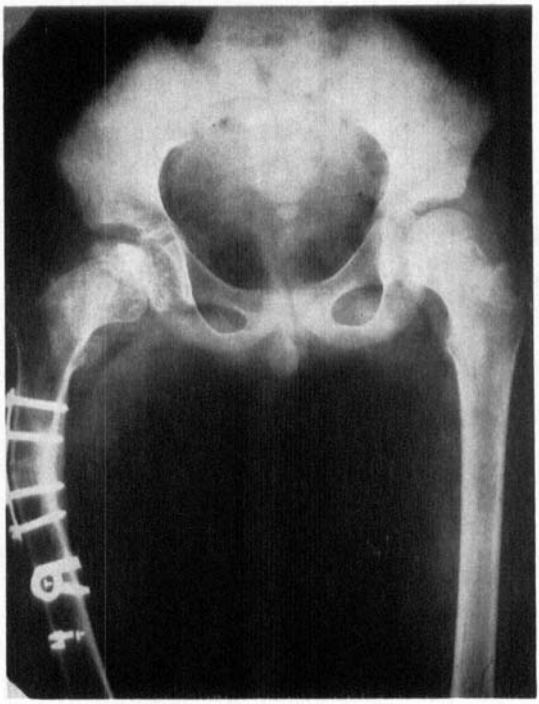


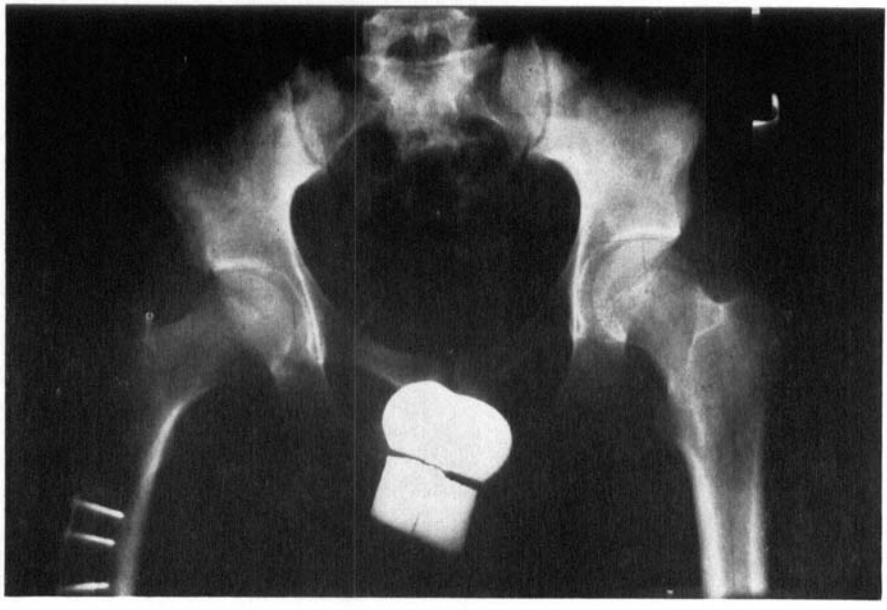
Figure 3 B. Antero-posterior roentgenogram 4 months after a rather low varus derotation subtrochanteric osteotomy shows a well-centered caput with the epiphysis already in the regeneration stage. The osteotomy angle was 29°.

in the early regeneration stage, the second osteotomy was done. This hip eventually became a good result.

In another child (case no. 2) following the osteotomy inadequate coverage of the femoral head was obtained (acetabulum-head quotient 75 per cent). The second derotation varus osteotomy was carried out in the regeneration stage and a satisfactory coverage (acetabulum-head quotient 94 per cent) with a fair result was achieved.

The third patient (case no. 3) had a recurrence of subluxation with a poor result, which did not improve after reoperation carried out in the stage of regeneration.

2. Two patients had varus osteotomy alone. Both became poor results. The first patient was a girl with an estimated onset of the disease at the age of 4. She was treated in another hospital with a weight-relieving calliper for over a year. At the time of surgery she was 6 years old and the head of femur was already in the regeneration



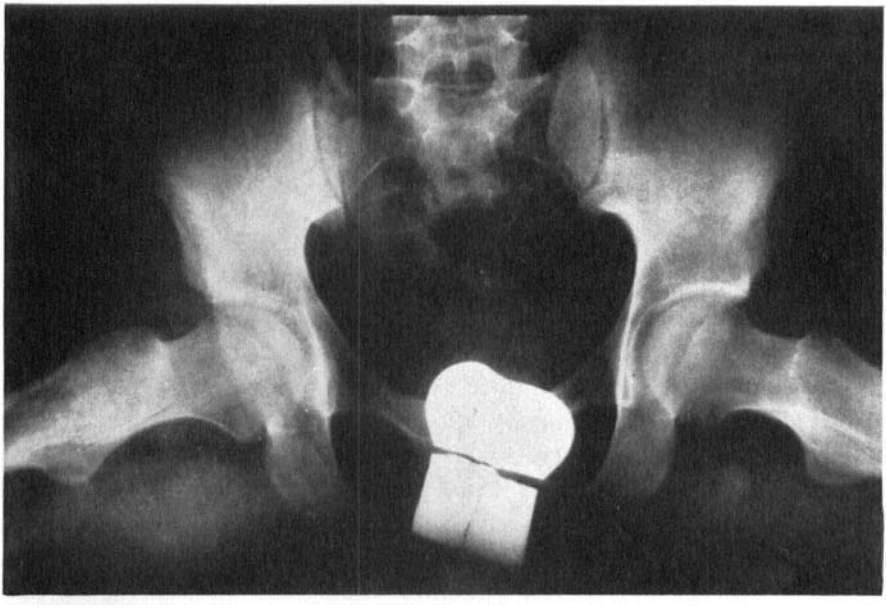


Figure 3 C and 3 D. Antero-posterior and lateral roentgenograms 10 years and 9 months after surgery showing "good" result (Mose). The post-osteotomy angle is now 8°. Note head sizes are equal.

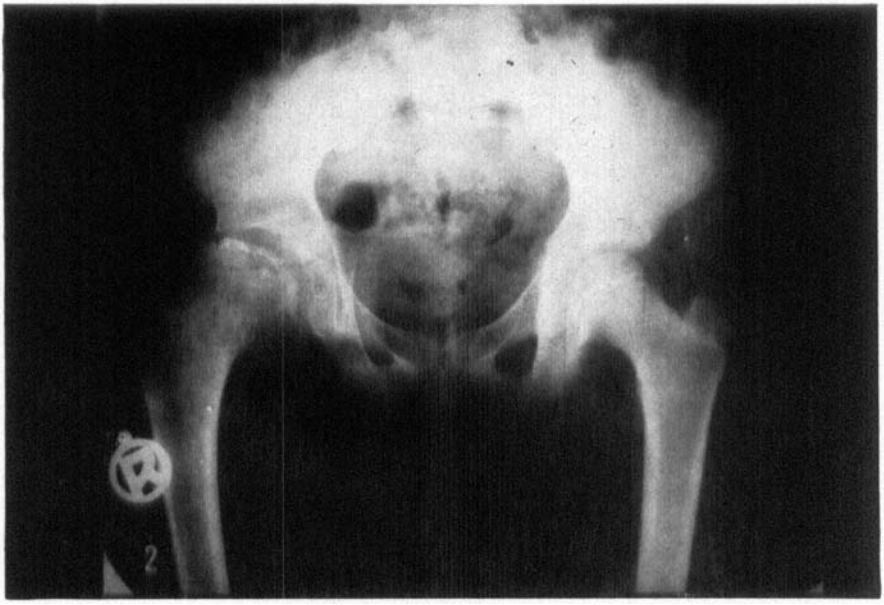


Figure 4. Patient O. L., female aged 7 at time of estimated onset, who was treated conservatively for 14 months.

Figure 4 A. Antero-posterior preoperative roentgenogram at age 8 years and 7 months showing the regeneration stage with marked lateral protrusion of the head, 8 mm increase in the medial joint space, marked head hypertrophy (8 mm in radius greater) and marked flattening of the epiphysis.

stage with considerable flattening and subluxation. No internal rotation could be achieved and in spite of varus angulation of 30° inadequate coverage was obtained (acetabulum-head quotient 79 per cent). Therefore the second osteotomy (derotation) was carried out in the late stage of regeneration (Table 4, case no. 4). Although the head was finally well seated (acetablum-head quotient 100 per cent) the result remained poor (Figure 5).

The other patient was a boy aged 11 at the estimated onset of the disease. After an uncooperative 6 months in a spica he was lost to treatment for 8 months. At the operation he was 12 years and 2 months old and with a markedly deformed and subluxated hip in the stage of regeneration. He had a limp with severe pain and limitation of motion in the hip. Varus osteotomy was done as a salvage procedure; it resulted in relief from pain, but it was the worst result in the series.

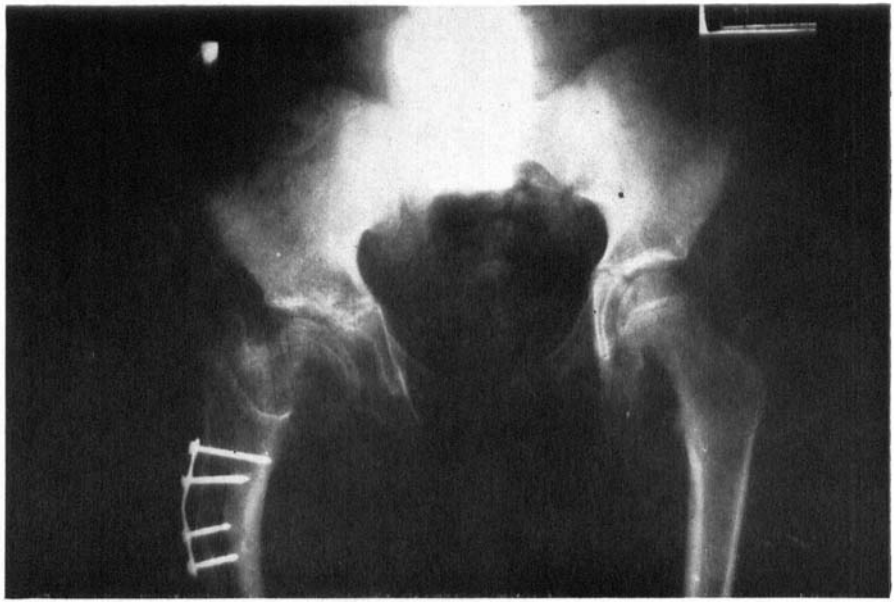


Figure 4 B. Antero-posterior roentgenogram 2 years and 7 months after surgery showing good coverage, but an A. T. D. of minus 7 mm and premature closure of the epiphyseal plate.

3. Nine patients had derotation osteotomy alone, 6 of them achieved a good and 3 a fair result. One of them improved from poor to fair following reoperation (varus osteotomy) which was performed 1 year and 4 months following the first operation in the stage of fragmentation (Table 4, case no. 5).

An example of a good result can be seen in Figure 6A, B[3], C after 13 years and 10 months of observation at the age of 21 years.

Reoperations

Four patients were in the regeneration stage at the time of the second operation and one in the stage of fragmentation. The indication for reoperation was insufficient containment of the femoral head caused either by recurrence of subluxation or by inadequate initial coverage of the head at the first operation. In 3 patients the result did not change. In 2 they improved, in one from fair to good and in the other one from poor to fair.

[3] Radiographs of this patient were presented in the preliminary report (Axer 1965) case 1, p. 495, with a follow-up of 5 years and 4 months.

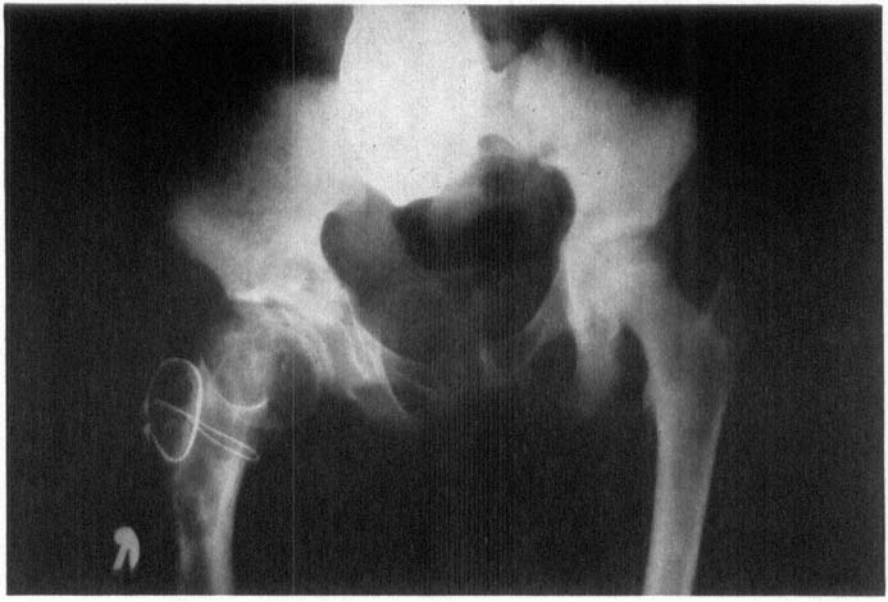


Figure 4 C. Antero-posterior roentgenogram 9 months after distal transfer of the greater trochanter. Trendelenburg sign disappeared. Note the marked head hypertrophy (10 mm in radius greater than the contralateral side). The head is spherical. This is a "fair" result (Mose).

Ancillary Surgery

One patient with a fair result had adductor tenotomy; 3 patients had trochanteric epiphysiodesis with distal transfer of the hip abductors, 3 patients had transfer of the greater trochanter distally (Figure 4C), and curettage of its epiphyseal plate. Thus 6 of the 34 patients had surgery to their abductor mechanism.

The indications for this ancillary surgery have been Trendelenburg limp with the tip of the greater trochanter approaching, or crossing the level of the apex of the femoral head (negative articulo-trochanteric distance of Edgren (1965)).

It was found that muscle strength improved, the limp and the Trendelenburg sign disappeared after these operations, but in the 3 patients with trochanteric epiphysiodesis the greater trochanter continued to grow significantly.

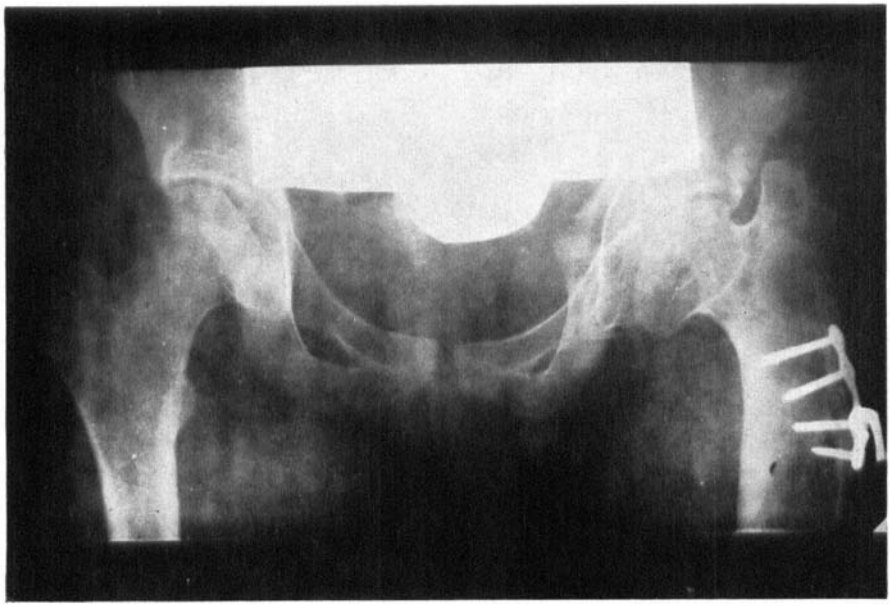


Figure 5. Patient Z. M., a female aged 4 years and 2 months at time of estimated onset of disease. At the age 6½ years, in the regeneration stage of the disease, she had a varus osteotomy after 15 months of conservative treatment. No internal rotation was possible at the time of surgery. Derotation osteotomy was done at the age of 8 years and 4 months to decrease the still present anteversion and to correct the persistent poor coverage of the head. This antero-posterior roentgenogram shows the very high trochanter (articulo-trochanteric distance: 22 mm) and the irregular head. A "poor" result.

Complications

In one patient the plate broke during the early postoperative period. This resulted in a loss of containment of the femoral head (see above). There were no other postoperative complications.

Post-Osteotomy Angle

This angle was measured by constructing intersecting lines through the middle of the proximal and distal fragments of the osteotomised shaft of the femur. This is a labile measurement easily affected by rotation of the femur, but the appearance of the metallic plate has been a useful guide to the estimation of the actual position of the extremity from one examination to another.

The average post-osteotomy angle in the 23 cases with varus angulation seen immediately after surgery was 16° with a range of 7° to 35°

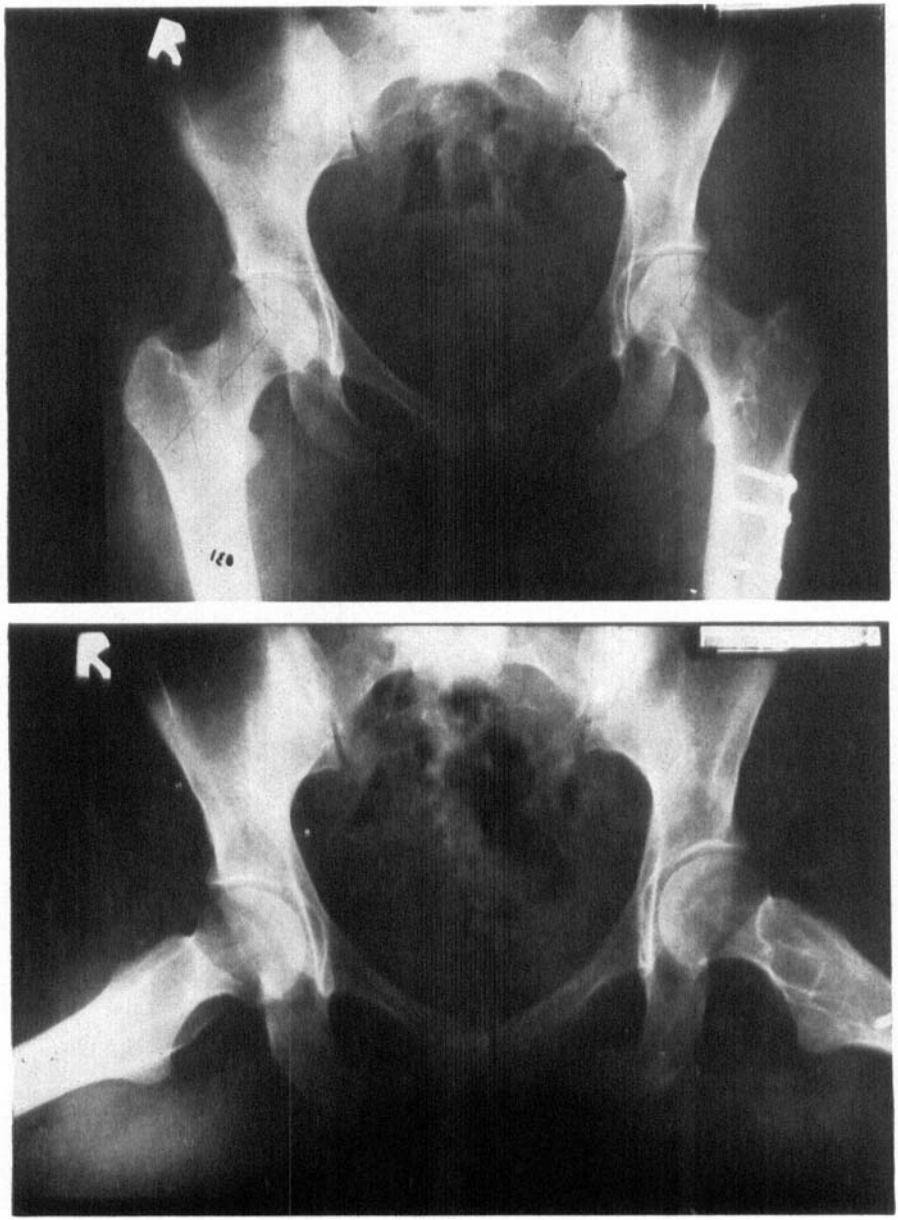


Figure 6. A. D., a female 5½ years at estimated onset. After one month of bed rest she had a derotation subtrochanteric osteotomy at the age of 7 years and 6 months.

Figure 6 A and 6 B. Antero-postero and lateral roentgenogram 13 years and 10 months later, showing a round, well-contained head equal in size in comparison with the normal side.

Figure 7 A.

Figure 7. S. S., a female aged 8 years and 2 months at estimated onset. At the age of 9 years and 3 months, following one month of bed rest, derotation subtrochanteric osteotomy was done when the head was in the "necrotic" stage.

Figure 7 A and 7 B. Antero-posterior and lateral roentgenograms 2 years after surgery showing late regeneration stage in a head well contained within the acetabulum. However, on the lateral view, it is not round and more than 2 mm of irregularity exists. Thus it is an early "poor" result.

and at final analysis of 21 cases it decreased to an average of 11.5° with a range of 0° to 25°.

Clinical Assessment

Several patients complained of mild sporadic hip and thigh pain. 8 patients limped and 10 had a positive Trendelenburg sign. 18 patients had shortening of the affected extremity by an average of 1.4 cm (ranging from 0.5 to 4.5 cm). The patient with a length discrepancy of 4.5 cm had a poor result and a fixed hip contracture in flexion and external rotation. In 4 patients the operated extremity became longer by 1 to 2 cm. Most of the patients exhibited some limitation of internal rotation, abduction or external rotation.

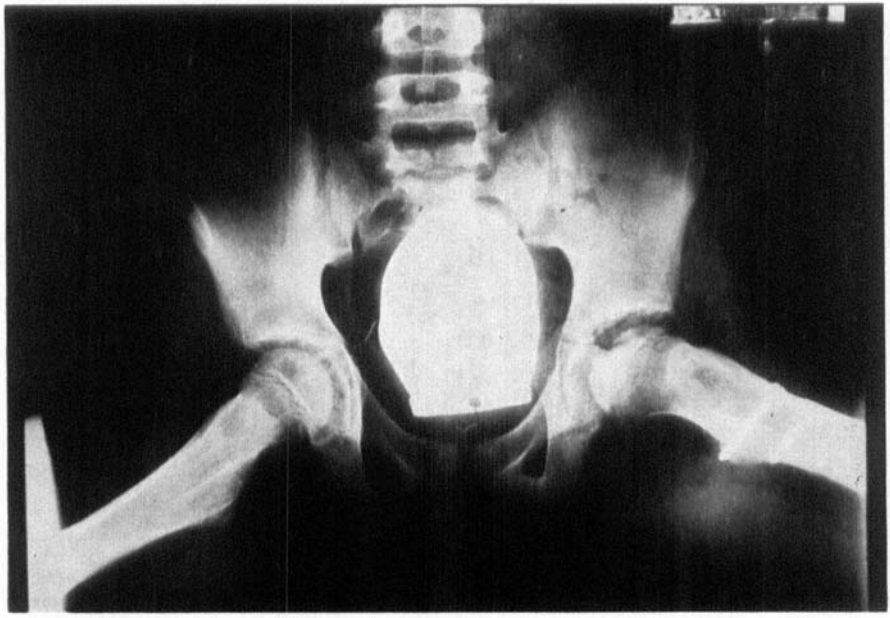


Figure 7 B.

DISCUSSION

It has been observed in the past that the clinical assessment of results for up to 10 and 15 years after healing of L. C. P. S. shows little correlation with the roentgenographic appearance of the diseased hip joint (Broder 1958, Evans 1958, Eyre-Brook 1936, Meyer 1966, Mindell et al. 1951). Twenty-five years or more after healing the spherical hips present little roentgenographic or clinical evidence of degenerative arthritis, but the latter begins to occur with increasing frequency and severity in hips which healed with deformity (Branciforti & Montina 1964, Danielsson & Hernborg 1965, Eaton 1967, Gower & Johnston 1971, Helbo 1966, Ratliff 1956, Sundt 1949). It seems reasonable to assume that the hips which are not as close to normal as the "good" or "fair" groups of Mose are potential candidates for this disease. In this series of 34 patients 53 per cent had good, 38 per cent fair and 9 per cent had poor results (Table 1). Hence 91 per cent were satisfactory and 9 per cent unsatisfactory.

When compared with larger series of conservatively treated patients exposed to prolonged physical restriction (Katz 1967, Mose 1964, Petrie & Bitenc 1971), and assessed according to the method of Mose, the

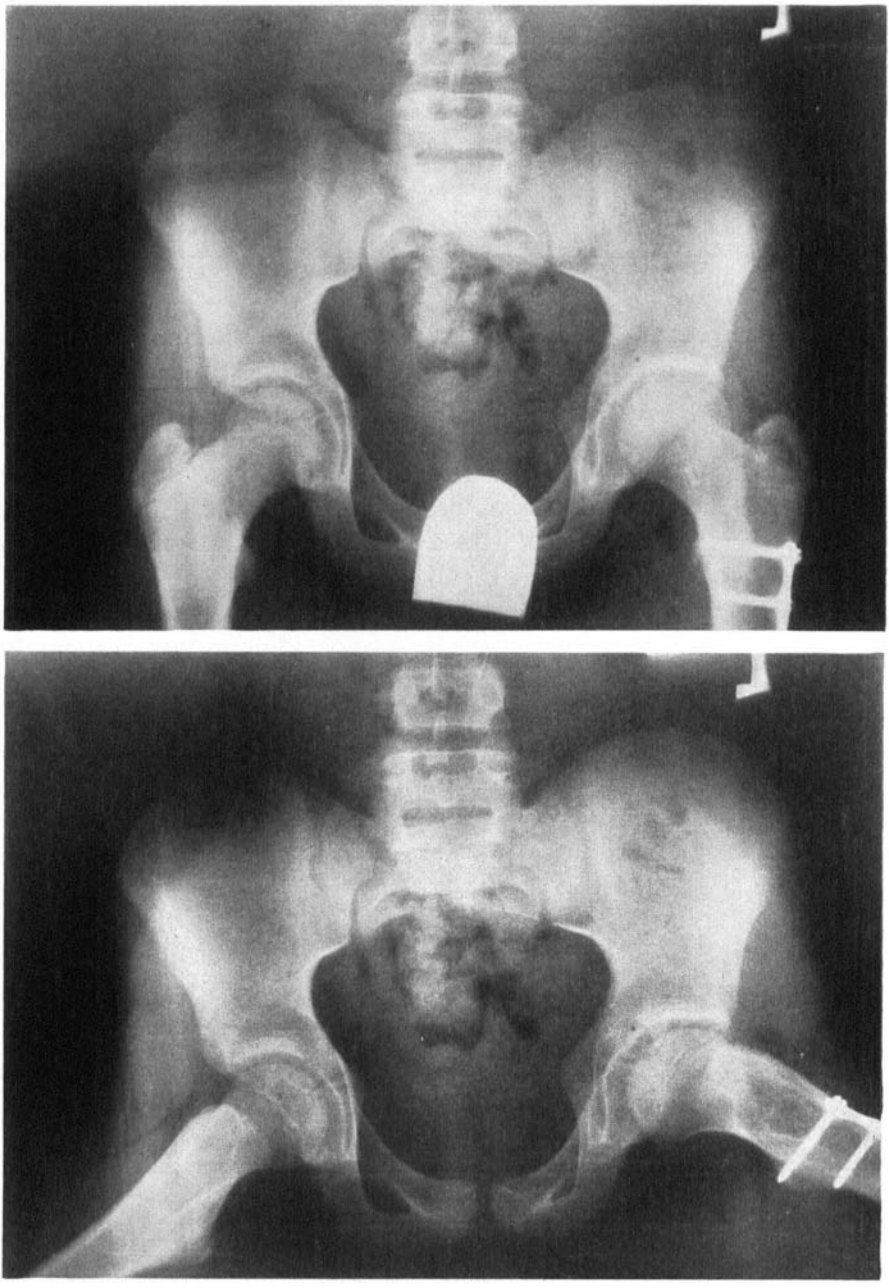


Figure 7 C and 7 D. Antero-posterior and lateral roentgenograms 3 years and 1 month after surgery. Late regeneration stage. The head is now more circular. The result improved from poor to fair during the third postoperative year.

Figure 5. Comparison of Results by Mose's Method.

Author	No. of patients	Good %	Fair %	Total satisf.	Poor %
Mose	209	55	18	73	27
Katz	284			80	20
Petrie & Bitenc	60	60.3	30.9	91.2	8.8
Present study	34	53	38	91	9

results following the osteotomy are found to be better than those of Mose and Katz and compare favourably with those of Petrie & Bitenc (1971) (Table 5). If, however, the 8 patients who were already in regeneration stage at the time of the initial surgery are deleted (in one of them the osteotomy was carried out as a salvage procedure), 25 patients are left who were operated in the initial stages of the disease (necrotic or fragmentation) with 24 satisfactory and only one poor result (Table 6).

When Petrie & Bitenc's series of 60 patients is divided into 20 in whom the treatment was started between the 12th and the 27th months following the onset of the disease and 38 in whom it was initiated within the first year after the onset, the incidence of poor results in the first group increase to nearly 25 per cent (5 of 22 patients). It is worthwhile to note that also in our material 2 of the 8 late operations ended up with poor results. Thus it is obviously better to operate in the initial stages of the disease, as it is more likely to achieve suprerior results when the treatment in abduction is started within the first year following the onset of the disease.

It has been reported and generally recognized that a close correlation exists between the age at the onset of the disease and the final results (Broder 1958), Edgren 1965, Mose 1964). However, Ralston (1961) and

Table 6. Results (Mose) in Hips Operated in the Stage of Necrosis and Fragmentation Only.

Result	No. of cases
Good	17
Fair	7
Poor	1
Total	25

Chung & Moe (1965) did not find a statistically significant correlation between these two factors. In this study differences within the groups do exist: we found that 15 out of 18 children with good results contracted the disease before the age of 7, whereas of the 13 children with fair results only 4 were less than 7 years old at the time of its estimated onset (Figure 1).

Varus angulation osteotomy alone may not be adequate. Two patients who had this procedure ended up with poor results.

With derotation osteotomy alone good anatomical results were achieved in 6 out of 9 patients, 3 had a fair result. Although the incidence of good results following varus-derotation osteotomy was lower (12 out of 23), we prefer this operation to derotation osteotomy because it seems to be more efficient in achievement of optimal containment of the head.

Not included in this study are 17 additional osteotomies with a postoperative follow-up of less than two years. With few exceptions their progress has been very gratifying.

It has been generally recognised that hips with so-called partial involvement of the capital epiphysis carry a better prognosis, especially those who became affected with L. C. P. S. very early in life. Some of them may heal with spherical femoral heads even without treatment. However, the establishment of the degree of the involvement of the femoral epiphysis is possible only in the later stages of fragmentation. We realise that some of our patients operated on in the initial stage of the disease may have had a partial involvement, but we feel that an undue delay of this simple operation would be hardly justified in children over four years of age with an established diagnosis of L. C. P. S., because an opportunity of achieving a spherical head with minimum physical restriction of the child may be missed.

If following the osteotomy the subluxation recurs, the operation should be repeated as soon as possible. In 2 out of the 5 reoperated patients improvement of the shape of the femoral head was observed.

Transfer of the greater trochanter in the presence of a negative articulo-trochanteric-distance accompanied by abductor limp is a useful ancillary procedure. Curettage of the trochanteric growth plate may not be sufficient for correction of this deformity, as the greater trochanter continues to grow. The experimental findings of Salenius & Videman (1970) provide an explanation for this phenomenon.

In spite of the varus osteotomy, the shortening of the operated extremity was found in only 18 patients, and it amounted to an average

of 1.4 cm. This amount of shortening can be expected to develop as a natural sequela of L. C. P. S. independently of the method of treatment. The improvement of the initial postoperative leg-length discrepancy was due, most probably, to the stimulation of enchondral ossification caused by hyperaemia following the osteotomy and to the progressive increase of the post-osteotomy angle.

SUMMARY AND CONCLUSIONS

1. This study is based on an analysis of results of subtrochanteric osteotomy carried out in 34 patients affected with unilateral L. C. P. S. between 1958 and 1970. Five reoperations were performed. The average postoperative follow-up was 6 years and 8 months, ranging from a minimum of 2 to a maximum of 13 years and 10 months.
2. The principles underlying this procedure are described. Its main advantage is the marked shortening of the time of physical restriction imposed upon the child compared with different methods of conservative treatment.
3. There were 18 (53 per cent) good, 13 (38 per cent) fair and 3 (9 per cent) bad results according to Mose's method of evaluation of anatomical results. When the 8 patients operated in the late stage of the disease are eliminated, the results are good and fair in 25 patients and poor in one. Best results were obtained when the operation was carried out at the early stages of the disease and in children who became affected before the seventh year of life. These results compare very favourably with larger series of patients treated conservatively for prolonged periods of time.
4. The 11 patients of the first communication (Axer 1965) have been found to maintain, and in three instances to improve, their previously reported comprehensive quotient after a further period of observation averaging 5 years. In one of them a very good result became good.
5. Average shortening of the operated extremity amounted to only 1.4 cm.

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