# Legg-Calvé-Perthes Syndrome

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Although it has been six decades since the classical descriptions of Legg-Calvé-Perthes disease were first written, minimal progress has been made in understanding its true nature. There is a paucity of scientifically based information concerning etiology and the actual morbid anatomical process of the disease. This review discusses the present thoughts on etiology and natural history, and raises questions requiring answers before treatment can be initiated.

## ETIOLOGY

While it has long been known that the basic process in Legg-Calvé-Perthes disease is one of bone necrosis,[28-30] the actual causal mechanisms are not clear. Present research is concentrated on two planes: (1) an understanding of the morbid anatomical process, and (2) the constitutional factors that may contribute to the overall course of this disease.

### MORBID ANATOMY

It is now generally accepted that the bone necrosis in this disease is caused by interference with its blood supply either by venous[3] or arterial obstruction.[19] Simple ligation of the vessels in the femoral neck does not, however, reproduce the changes seen in Legg-Calvé-Perthes disease.[13] Deformity of the femoral head may occur in animals after a single episode of infarction if the hip is held adducted, but this does not resemble changes in Legg-Calvé-Perthes disease.[34] This suggests the concept of biologic plasticity or, alternatively, a growth disorder secondary to joint deformity. Repeated ligation of the femoral neck causing two episodes of infarction reproduces some of the changes seen in certain cases of this condition.[35] Evidence of repeated infarction is seen in human cases on biopsy specimens[16,17,20,27] and when studying the few whole femoral heads available.[23,24] None of the factors, however, explains the long duration of the disease since the avascular bone of the epiphysis (even if infarcted twice) would revascularize in a few months. Moreover, they do not explain the changes frequently seen in the metaphyseal region of the neck.

One conclusion from this is that although there is evidence of repeated bone infarction, the observed changes in animals do not exactly parallel those seen in the human disease, and there must be additional factors, other than simple repeated infarction, associated with these changes. Joint contracture may certainly play its part, as well may the untested effects of trauma and constitutional factors also.

### CONSTITUTIONAL FACTORS

The similarity between changes in Legg-Calvé-Perthes disease and those in cretinism and multiple epiphyseal dysplasia has been recognized for many years.[7] Despite considerable study and even therapeutic trials, no connection has been established with these conditions.[18] Wynne-Davies and Gormley[43]

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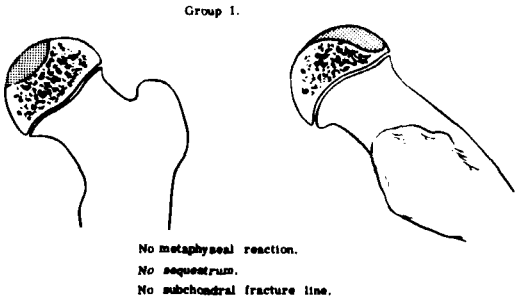



FIG. 1. Drawing of Group I.

have stated that while there are no inherited factors, they believe that both environmental and growth factors may be more important. Many of these children are of small stature.[12,31] Harrison and his associates[15] have pursued this concept, confirming these findings, and have also shown delayed bone age and in some cases "skeletal standstill" for a number of years. This has been further considered by Burwell *et al.*,[4] who demonstrated that this growth retardation does not affect the whole body but mainly the distal part of the upper and lower limbs. They concluded that the effect may be genetic, environmental, or a combination acting during embryonic life. This hypothesis does not, however, explain the delayed bone age[12,15,41] which seems to be confined to the duration of the disease. Developmental abnormalities have been shown by Catterall *et al.*[8] in relation to hernias and genitourinary tract abnormalities, and also by Hall and Harrison,[14] who observed an increased incidence of congenital abnormalities in the Legg-Calvé-Perthes syndrome.

These studies suggest that in addition to local factors within the hip, the child may have various constitutional factors predisposing him to this condition and even explaining why the condition is so long-lasting. There would seem to be a biochemical or environmental defect causing a failure of ossification, possibly affecting those epiphyses where rapid growth occurs, which might explain the delayed bone age maximal in the hands and feet as well as the unexpectedly high incidence of Köhler's disease in Legg-Calvé-Perthes disease. However, this hypothesis remains without scientific foundation at the present time.

## NATURAL HISTORY

Before considering the treatment of any disease, it is important to know its cause and natural history without treatment during the short and the long term.

Waldenstrom[39,40] established the radiologic stages of the disease but assumed it was of uniform type, the outlook varying with other factors such as age at onset, sex, and the stage of the disease at diagnosis. O'Gara[26] was the first to recognize a "half-head form" in which the posterior part of the epiphysis was normal, with a good prognosis.[21] More recently, Catterall[5-7] described four groups related to the degree of radiologic involvement of the epiphysis. The diagnosis is based on the presence or absence of seven radiologic signs (Table 1, Figs. 1–8). In order to group a case, good X-rays in both anteroposterior and Lauenstein lateral views are essential and may have to be taken after a short period of traction if there is any restriction of movement. Careful examination of the X-rays allows a diagnosis of groups to be made but not always on the first X-rays. The diagnosis can usually be established within three months. Initially, treatment will not be required unless there are "at risk" signs present (see below). It is

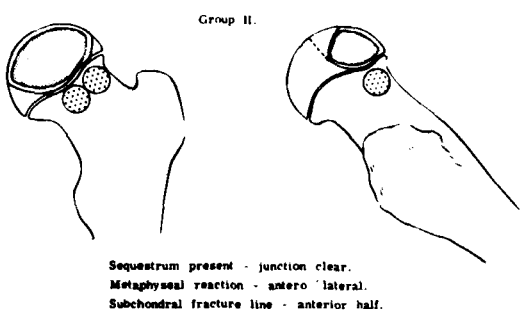



FIG. 2. Drawing of Group II.

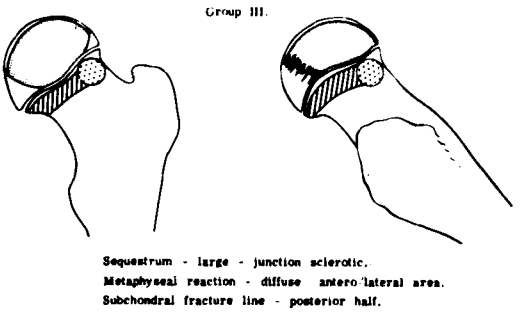



FIG. 3. Drawing of Group III.

stressed that the groups do not shift with time if sufficient care has been taken in grouping the early X-rays. There are occasional cases of "Recurrent Acute" Legg-Calvé-Perthes disease in which the process seems to reactivate when it is nearly healed and in a different form. Results of a series of untreated hips (Table 2) show that the prognosis is proportional to the degree of radiologic involvement of the epiphysis. The groups, therefore, provide a general guide to prognosis in the active phase of the disease but are not in themselves an absolute indication for treatment.

The age of disease onset does not significantly differ among the various groups, but age is important for two reasons. First, younger children are lighter weight and therefore less vulnerable to epiphyseal damage. Second, there is a longer time to remodel the epiphysis after the disease has healed (Fig. 9).

It is generally agreed that girls have a less favorable prognosis than boys. When the sex

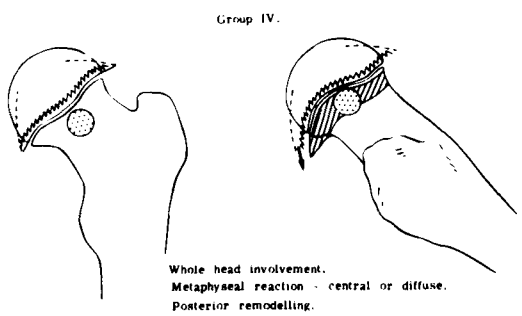
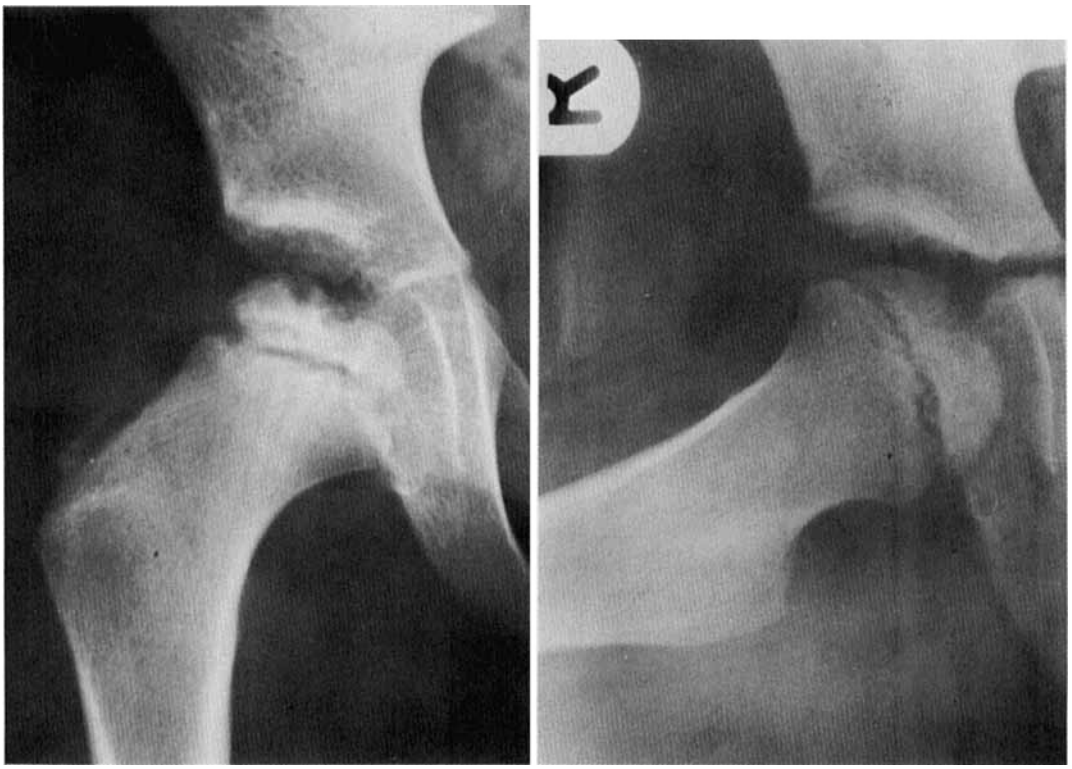



FIG. 4. Drawing of Group IV.

TABLE 1. Radiologic Signs

| | | Group | | | |
|---|---|---|---|---|---|
| | | *I* | *II* | *III* | *IV* |
| Epiphyseal changes | Sex ratio | 8.8:1 | 4.9:1 | 3.5:1 | 3:1 |
| | Sequestrum | No | Yes | Yes | Yes |
| | Subchondral fracture line | No | Anterior half | Posterior half | Posterior half |
| | Junction involved/uninvolved areas | Clear anterior/superior | Clear V or vertical | Sclerotic in posterior third | Nil |
| | Anterior extent of epiphysis along growth plate | Anterior margin | Anterior half | Posterior half | Nil |
| | Triangular appearances lateral side epiphysis | No | No | Occasionally | In the early stages |
| Metaphyseal changes | Metaphyseal reaction | No | Localized antero-laterally | Diffuse or anterior | Diffuse or central |
| | Posterior remodelling of epiphysis | No | No | No | Yes |



FIGS. 5A AND 5B. (A) Radiograph of a Group I case in a child of 5 years. (B) Lateral view.

ratio within each group is examined, the poor prognosis is explained by the fact that girls suffer more serious forms of the disease, namely Groups III and IV (Table 1).

## STAGE OF THE DISEASE AT DIAGNOSIS

There are four reasons for assessing the stage of the disease at diagnosis.[39,40] In the early stage, the femoral head is round, representing an ideal time for treatment if indicated. Second, once the bony epiphysis has flattened, the head shape may or may not change, and this can be demonstrated only by arthrography, which is thus essential in cases where treatment is being considered. Third, once healing is established, no further deterioration will occur in head shape. This concept, originally suggested by Fergusson and Howarth,[11] was recently given a sound clinical basis by Westin and Thompson.[42] Treatment advised at this time must be strictly indicated inasmuch as any deterioration must be considered etiogenic. Fourth, Lloyd-Roberts *et al.*[22] report that poor results of osteotomy commonly occur when the preoperative condition had lasted 20 months or longer.

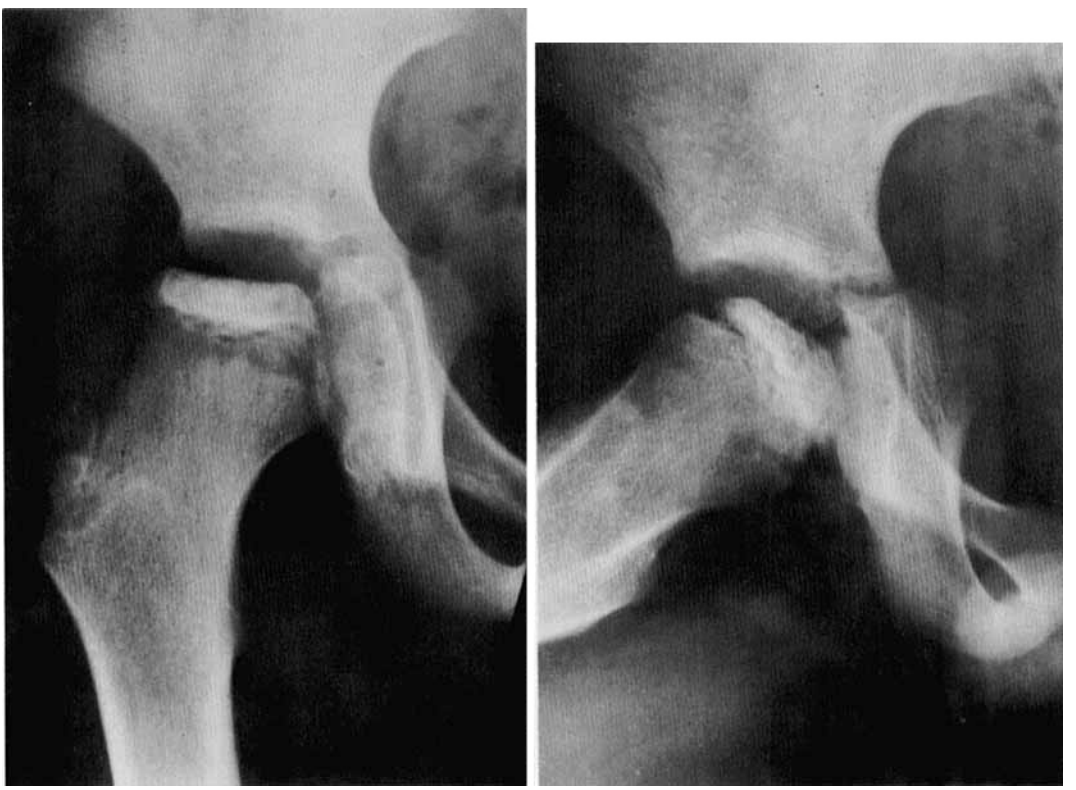
## LONG-TERM PROGNOSIS

Long-term reports in the literature are few. Mose[25] recently reported on the long-term results of the initial cases of Moller (1924), Helbo (1953), and Mose (1964). Mose presents the most comprehensive review of the incidence of osteoarthritic changes both clinicially and radiologically, as well as disturbances in function associated with these changes, confirming the original

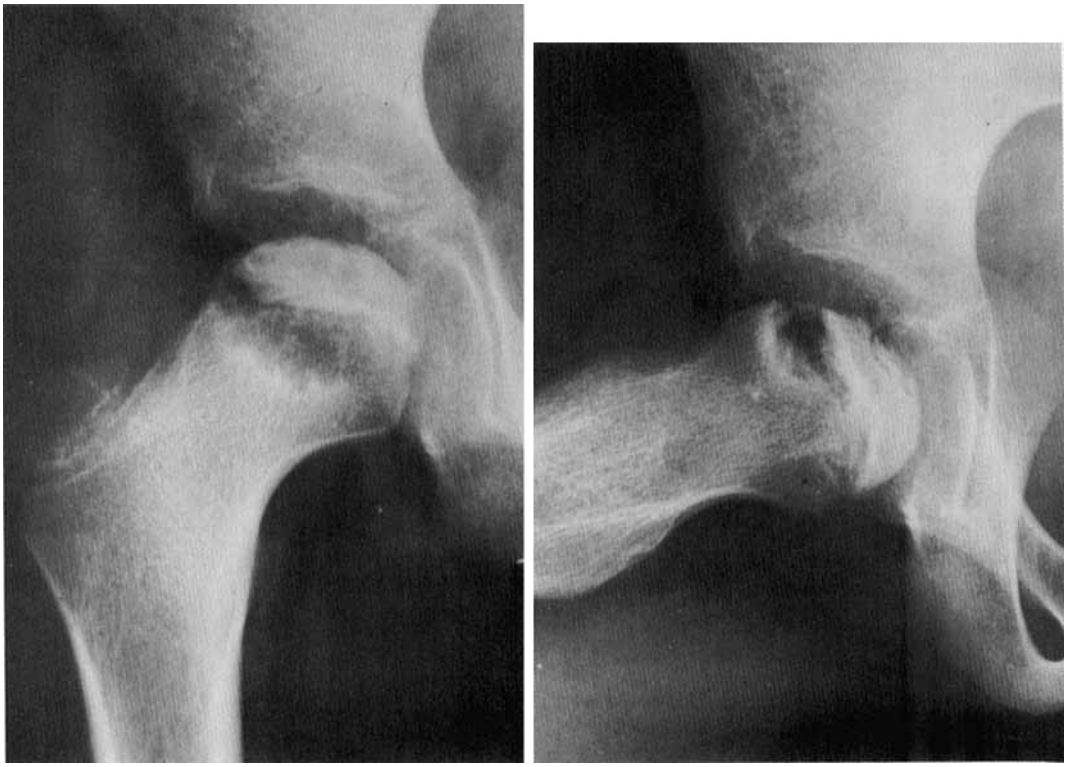
observations of Sundt[37] that in the long term, the prognosis is proportional to the sphericity of the head at the time of healing. Clinically, the minimal amount of disturbance is remarkable, although the incidence of radiologic osteoarthritis is high. Ratcliff[32,33] reported that at 30 and 40 years, in one-third of the patients the range of clinical functions is good, fair and poor.

In a series of 75 cases followed for ten years or more, 20 cases had improved by one result category and five by two result categories. The common factors in these cases were the age at the onset of healing and the congruity of the joint during the remodelling phase. More interestingly, in this series 11 cases deteriorated during follow-up; their common factor was persistent subluxation with a premature fusion of the growth plate that may be either partial or complete. This factor received little attention until recently.[38] Barnes,[1] however, has noted that this condition is most likely to occur in older children in Groups III and IV, particularly if treatment is instituted late in the disease process. This is important to consider when treatment is instituted for other reasons late in the course of the disease.

These observations conclude that there are factors in both the short and long term which influence the final prognosis. In the short term, age and sex, and the stage of the disease at diagnosis and in the groups would seem important. In the long term, age at the onset of healing, persistent lateral subluxation, and premature growth arrest would



FIGS. 6A AND 6B. (A) Radiograph of a Group II case aged 5 years showing two "at risk" signs, a horizontal growth plate and lateral subluxation. (B) Lateral radiograph showing "V" sign.



FIGS. 7A AND 7B. (A) Radiograph of a Group III case aged 6 years showing a diffuse metaphyseal change, a small medial segment and very small lateral segment. There is a subchondral fracture line. (B) Lateral radiograph showing extensive metaphyseal change. The subchondral fracture line reaches the function of the posterior one-third.

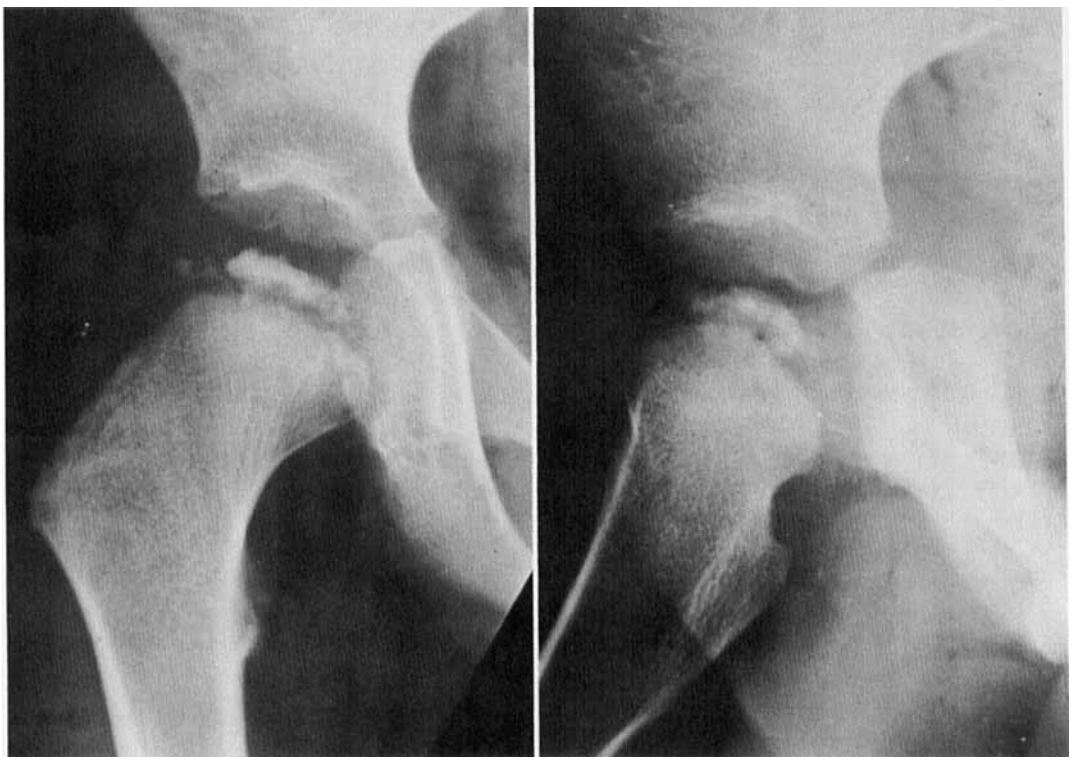
seem important. In this context, effective treatment would biologically trigger healing and reduce lateral subluxation by containing the epiphysis within the acetabulum without inducing a growth disturbance.

## THE POOR RESULT AND THE "HEAD AT RISK"

Although the results within groups follow a general trend, there are some instances where an unexpected good or poor result ensues despite other favorable prognostic factors, such as the good results in Group III and the poor results in Group II. Treatment aimed at preventing these poor results and improving the quantity of fair results over the long term would be regarded as effective, in addition to the factors already discussed.

In analyzing the poor results ensuing without treatment, it is possible to define clinical and radiologic signs or features that collectively are associated with deterioration in femoral head shape. Patients who show these signs are regarded as being "at risk" (Table 3).

The clinical signs require no real explanation and it is important to realize that a decreasing range of movement may be the earliest indication of subluxation. The heavy child is more likely to damage a softened area in the femoral head. By contrast, an increasing range of movement may be the earliest sign of healing.

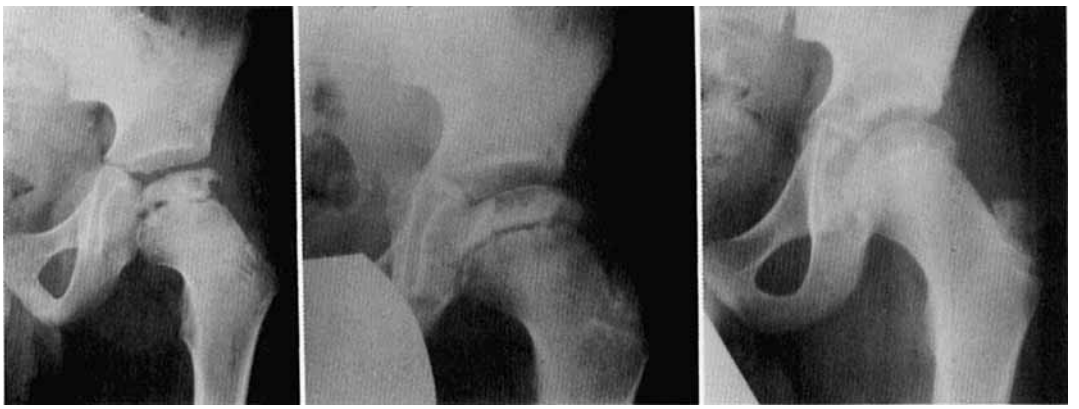


FIGS. 8A AND 8B. (A) Radiograph of Group IV case aged 4½ years showing total involvement of the epiphysis and calcification lateral to the epiphysis. (B) Lateral radiograph showing remodelling of the posterior metaphysis.

The radiologic signs were formed as a result of a study of the radiologic process of femoral head flattening. The epiphyseal changes are those of calcification lateral to the epiphysis (Fig. 8A) and a lytic area in the lateral epiphysis and/or the adjacent metaphysis (Fig. 9A). This is an area of structural weakness and is liable to deformation owing to trauma. Despite the fact that diffuse metaphyseal change has never received an adequate histologic explanation, it is suggested that this too represents an area of structural weakness liable to deformation by trauma, producing an alteration in the axis of the growth plate by infraction (Figs. 7A and 7B). Lateral subluxation (Fig. 6A), by causing loss of containment of the femoral head, alters the shape of the acetabulum cavity and produces high pressure on the softened areas of the femoral head. An adduction contracture often seen in these circumstances actively worsens the situation, further altering the stress on the hip when the child walks. A horizontal growth plate (Fig. 6A) was initially noted to be part of the "at risk" signs and was considered important because of an alteration of shear

TABLE 2. Results of 95 Untreated Cases

| *Group* | *Good* | *Fair* | *Poor* |
|---|---|---|---|
| I | 26 (>90%) | 1 | 0 |
| II | 23 (>90%) | 6 | 2 |
| III | 5 | 7 | 11 (>91%) |
| IV | 0 | 4 | 10 (>91%) |



FIGS. 9A–9C. (A) (Left) Child aged 5 with Group II appearance. There is a lytic area in the lateral epiphysis. (B) (Center) Same case at time of healing. (C) (Right) Follow-up 5 years later showing remarkable remodelling.

forces acting on a growth plate inclined to the axis of load. Moreover, it is a sign of early subluxation, being the radiologic appearance of a hip lying in slight adduction and external rotation. The difficulty in early subluxation is how to measure it. Many indices have been suggested but that of Dickens and Menalaus[9] seems the most useful.

In considering the results of untreated cases with or without the "at risk" factors, there are no poor results in cases that have not been at risk (Table 4).

## TREATMENT

The greatest controversies exist in considering the problem of treatment. We hope that the foregoing discussion on natural history and the poor result has emphasized the extreme importance of using untreated controls when assessing such cases. In light of this experience, indications for conservative and definitive treatment are listed in Tables 5 and 6. Group II and III cases are subdivided by age because with increasing age there is a greater chance that "at risk" signs will appear in the follow-up of untreated cases, predominantly occurring when the time of onset is past the age of seven. These indications would be similar for any form of treatment, but on what should treatment be based?

The long-accepted principles of treatment are containment of the femoral head[10] and relief of weight, but it is more logical now to suggest that the principles comprise mobilization of the femoral head recontained

TABLE 3. Signs of "Head at Risk"

| *Clincal* | *Radiological* |
|---|---|
| 1. The obese child | 1. Gage's sign |
| 2. A decreasing range of movement | 2. Calcification lateral to the epiphysis |
| 3. Adduction contracture | 3. A diffuse metaphyseal reaction |
| | 4. Lateral subluxation |
| | 5. Horizontal growth plate |

TABLE 4. Results of Untreated Cases With or Without "At Risk" Factors

| | *Good* | *Fair* | *Poor* |
|---|---|---|---|
| Group II | | | |
| At risk | 12 | 6 | 2 |
| Not at risk | 12 | 1 | 0 |
| Group III | | | |
| At risk | 5 | 5 | 3 |
| Not at risk | 2 | 4 | 0 |
| Group IV | | | |
| At risk | 0 | 5 | 10 |
| Not at risk | 0 | 0 | 0 |

TABLE 5. Indications for No Treatment

1. All Group I cases
2. Group II and III under 5 years not at risk
3. Group II and III over 5 years not at risk
4. Cases in which healing is established
5. Cases in which serious flattening of the femoral head is demonstrated by arthrography
6. Hinge abduction unless subluxation can be reduced

TABLE 6. Indications for Definitive Treatment

1. All "at risk" cases
2. Group II and III over the age of 7 years
3. Group IV cases in which there is no serious flattening of the femoral head shown on arthrography

within the acetabulum and prevention of femoral head deformity by reducing forces through the hip and preventing injury (Table 7).

Most of these principles represent a reversal of the signs of the "head at risk." Replacement of the femoral head within the acetabulum is traditional in the acute phases, keeping the lateral aspect of the acetabulum from deforming the femoral head. Eventually, containment will allow better long-term remodelling, a factor further encouraged by a full range of hip motion.

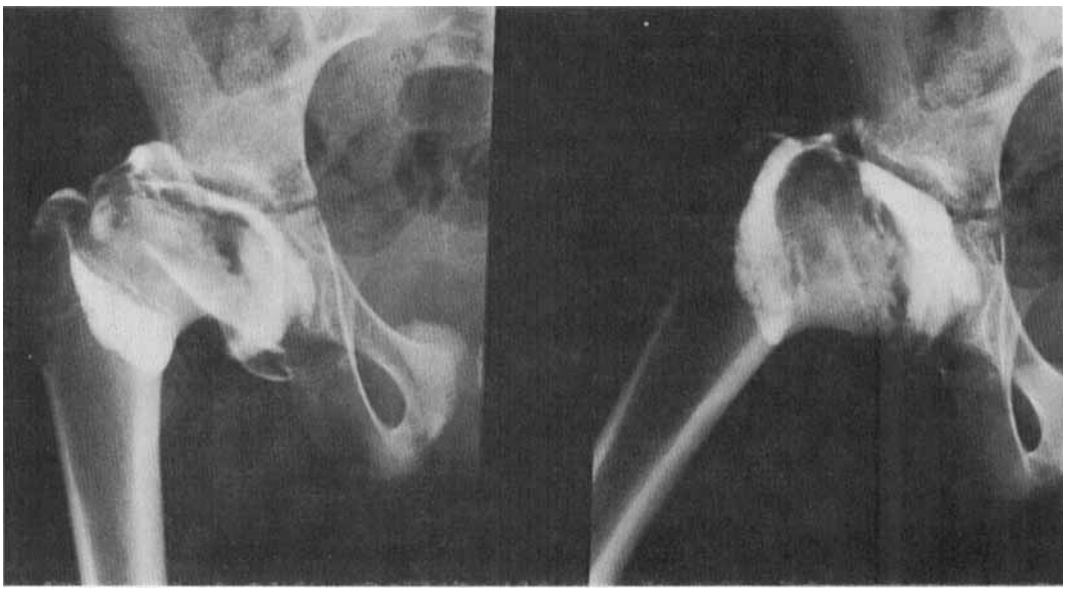
How can these principles be applied to current methods of treatment? Whether treatment is by splintage or operation, the femoral head must be congruously reduced within the acetabulum and the hip mobilized in order to restore movement (particularly abduction and internal rotation) lost because of subluxation. This can be achieved by broomstick plasters changed serially. At this point radiographs, if necessary, complemented by arthrography must establish congruity. Failure to restore congruous movement should be regarded as a contraindication to further treatment. Arthrography undertaken during the assessment phase of the disease will help to establish not only the shape of the femoral head (which may occasionally be unexpectedly large or flattened) but also the position of the leg in which the femoral head is most congruously seated. Hence, if operation is considered, the extent of the required realignment procedure will be indicated. It may also demonstrate the phenomenon of "hinge abduction" (Fig. 10) in which the outer part of the femoral head hinges on the lateral lip of the acetabulum as the leg is abducted. An examination of the hip under anesthetic at the time of arthrography enables the surgeon to assess the loss of hip movement owing to joint contracture in contrast to such loss due simply to muscle spasm.

Once containment has been achieved and the hip is mobilized, the problem of maintaining containment either by operation or further splintage must be considered and answered. Although the author has not used splints, it is important to ask the following questions of those who do: (1) when should the splint be removed; (2) does the splint shorten the duration of the disease or "biologically trigger healing"; (3) are there problems with the knees; and (4) how mobile is the child in the splint.

While surgical treatment has the immediate disadvantage of operation, it has the advantage of early mobilization as soon as the plaster has been removed. Provided that a rigid protocol is observed, femoral or innominate osteotomy will achieve containment. This must be demonstrated preoperatively; failure to do so is a contraindication to operation. By producing varus in the fem-

TABLE 7. Principles of Treatment

1. Restoration of movement
   Containment of the femoral head
   Mobilization of the hip
2. Prevention of Deformity
   Relief of stress through the hip
   Protection from injury



FIGS. 10A AND 10B. (A) Arthrogram of child of 8 years showing femoral head deformity. (B) Hinge abduction.

oral neck, osteotomy will decompress the femoral head and alter the stress on it. This effect tends to diminish as the varus corrects with growth but will persist beyond the time of full healing, thus tending to improve the remodelling process, a fact stressed by Sommerville[36] regarding the long-term results of femoral osteotomy. Containment splintage will produce this stress alteration but does not continue to do so once the splintage is removed. The effect of varus is a shortening of the leg proportional to the amount of varus. This has no serious residue inasmuch as the varus corrects and shortening is usually less than a quarter-inch at two years. The biologic effect of osteotomy is difficult to assess. In a comparison of operative and untreated cases (Table 8) operative cases achieve earlier healing and this would seem to be important, particularly in the older child. In the series of femoral osteotomies reported by Lloyd-Roberts *et al.*,[22] the actual results are improved under the strict control of age/group/"at risk"; there are still too many poor results in the Group III and IV cases "at risk". Brotherton and McKibbin[2] reviewed a retrospective series of containment splintage, demonstrating that such splintage with weight relief showed considerable improvement, particularly in Group IV cases. The factor of weight relief and the prevention of injury require further prospective trials but should possibly be included when treating cases with bad prognoses that undergo operation.

TABLE 8. Comparison of Operative and Untreated Cases

| | *Duration of Disease (months)* | | | |
|---|---|---|---|---|
| | *Group I* | *Group II* | *Group III* | *Group IV* |
| Healing | | | | |
| No treatment | 9.0 | 9.4 | 14.6 | 17.4 |
| Osteotomy | — | 8.0 | 11.6 | 14.8 |
| Healed | | | | |
| No treatment | 24.9 | 27.8 | 32.5 | 41.6 |
| Osteotomy | — | 23.8 | 32.0 | 35.8 |

When containment cannot be achieved, particularly if hinge abduction is demonstrated, the question of further treatment arises. In many, the leg is short also because of an adduction deformity. In view of the

favorable long-term results demonstrated by Ratcliff,[32,33] major operations such as cheilotomy, Chiari and acetabuloplasty would seem unjustified; cheilotomy by reducing the overall size of the femoral head may even increase the load/unit area through the femoral head. Abduction osteotomy of the femur will have the effect of improving leg length (and, therefore, gait) and also maintain load-bearing without persistent hinging effect. There remain many unanswered questions concerning management of Legg-Calvé-Perthes disease. It is hoped that a better understanding of the morbid anatomy of human cases will enable improved treatment, followed by careful evaluation based on the natural history of the disease and precise definition of the criteria for judging the results.

## SUMMARY

A review of the etiology, pathology, natural history, clinical signs, radiologic features and treatment of Legg-Calvé-Perthes disease suggests the concept of the "head at risk." This concept takes into account factors for and against operative and conservative treatment by splintage. In the older child, the objectives and principles of treatment are best achieved by operative treatment.

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