SWEDEN'S EXPERIENCE IN REDUCING CHILDHOOD INJURIES. A. B. Bergman and F. P. Rivara. *Pediatrics* 1991: 88:69.

Sweden has the lowest childhood injury rate in the world because of several factors, including the special characteristics of Swedish society and a 35-year campaign. Societal characteristics are a relatively homogeneous, health-conscious, law-abiding, small population that values children. Key factors in the campaign have been support of trauma surveillance systems and injury prevention research, ensuring safer environments and products through legislation and regulation, and a broad-based safety education campaign using coalitions of existing groups. Emulating the strategies used in the Swedish campaign would markedly reduce the number of U.S. children killed, injured, and disabled from trauma.

TIBIA VALGA AFTER FRACTURE: DOCUMENTATION OF MECHANISM. D. Keret, H. T. Harcke, and J. R. Bowen. *Arch Orthop Trauma Surg* 1991;110:216.

Tibia valga following fracture in the proximal metaphysis of the tibia in children was previously attributed to various mechanisms. This case report offers an additional explanation based on bone scintigraphy 10 months after injury. Decreased radionuclide uptake at the lateral proximal tibial physis without evidence of increased uptake on the medial side suggests that a Salter type V injury to the lateral growth plate can occur in conjunction with a medial metaphyseal fracture, resulting in the development of tibia valga.

TOWARD REDUCING PEDIATRIC INJURIES FROM FIREARMS: CHARTING A LEGISLATIVE AND REGULATORY COURSE. K. K. Christoffel. *Pediatrics* 1991;88:294.

Each year, 3,000 children <20 years of age die as a result of homicides, suicides, and injuries from firearms. Children are also affected by the deaths of the 30,000 adults killed violently. Increasingly, pediatricians are becoming involved in efforts to reduce injuries from firearms, as parent educators and child advocates. The advocacy goal is identified as reducing the accessibility of guns. The pros and cons of 17 possible approaches are presented.

TRANSVERSE LIGAMENT RUPTURE AND ATLANTO-AXIAL SUBLUXATION IN CHILDREN. Y. Floman, L. Kaplan, J. Elidan, et al. *J Bone Joint Surg [Br]* 1991;73:640.

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The Lateral Pillar Classification of Legg-Calvé-Perthes Disease

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Summary: To determine the predictive value of a new classification system for Legg-Perthes, 93 hips in 86 patients with radiographic follow-up to maturity were reviewed. All patients were treated by bracing at the Texas Scottish Rite Hospital from 1970 to 1980. Hips were classified during the fragmentation stage of disease into three groups based on radiolucency in the lateral pillar of the femoral head. Final radiographs were reviewed at skeletal maturity, and the outcome was determined according to the Stulberg classification. Group A had a uniformly good outcome (100% Stulberg I and II results); Group B had a good outcome in patients who were <9 years at onset (92% Stulberg I and II, 8% Stulberg III results), but a less favorable outcome in patients who were >9 years at onset (30% Stulberg II, 50% Stulberg III, and 20% Stulberg IV results). In Group C, the majority of femoral heads became aspherical in both age groups (29% Stulberg II, 52% Stulberg III, and 19% Stulberg IV results). The group C hips also had a longer duration of fragmentation and reossification stages. Members of the Legg-Perthes study group agreed 78% of the time when applying the classification to unknown radiographs. The classification group was a stronger determinant than age of onset in predicting final outcome. This classification system is easy to apply during the active stage of the disease and has a high correlation in predicting the amount of flattening of the femoral head at skeletal maturity. When combined with age at onset, it can be used to predict the natural history of the disease and evaluate various forms of treatment. **Key Words:** Lateral pillar classification—Legg-Calvé-Perthes disease—Stulberg classification.

Waldenstrom published the first classification of Legg-Perthes radiographs in 1922 (20). He described three groups, the first two being more common and having good results. His third group was relatively uncommon and had a high incidence of poor results with flattened femoral heads. Many subsequent attempts have been made to classify the disorder (2,8,14,16). Goff described three types, a spherical cap type, a mushroom type, and an irregular type (8). These were thought to occur according to the age of the patient, with the first type in children <7 years, the second in those between 7 and 11 years, and the third group in those >11 years.

The first classification to be widely used to determine treatment decisions was that of Catterall (2). He described four groups based on the amount of head involved. Groups I and II were benign, needing little treatment, while groups III and IV had more extensive head involvement and a less favorable outcome. In addition, he described four risk signs that indicated a poor prognosis. His data implied that containment treatment improved the prognosis for those "at risk" and was unnecessary for those not "at risk."

Salter and Thompson described a classification based on the extent of the subchondral fracture line, which appears early in the course of Legg-Perthes disease (16). They found that if the fracture involved less than half of the femoral head, the prognosis was good, corresponding to Catterall's groups I and II. If the fracture involved more than half of the head, the prognosis was less favorable, corresponding to Catterall's groups III and IV. They felt that the distinguishing factor between their groups A and B was the presence or absence of an intact viable lateral margin of the capital femoral epiphysis (16).

Several authors have evaluated the reproducibility of Catterall's classification and have reported poor interobserver agreement when test films were classified (3,10). The extent of femoral head involvement does appear to predict final outcome in

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certain age groups; however, a recent study has shown no correlation of head-at-risk signs with Stulberg class or clinical outcome (11).

In 1984 a multicenter study group was formed to prospectively study the therapeutic effect of four treatment modalities in Legg-Perthes. A reliable system of classification was needed to be able to compare treatment of hips of equivalent severity. Members of the study group were asked to independently perform Catterall classification on test radiographs of hips in the fragmentation phase. In this study, there was an interobserver agreement of only 0.42 for the Catterall grouping and 0.35 for the presence of risk factors (19). The same investigators were able to agree on the Stulberg classification of the final radiographs at the 0.98 level. Several intermediate patterns of femoral head involvement were noted in the course of attempting the Catterall classification. A closer study of these cases led to the concept of the lateral pillar classification.

Age at onset is a well-established prognostic factor in Legg-Perthes disease. Following Moller's report in 1926 (13), there have been many reports that confirm that the older the child is at onset of Legg-Perthes, the poorer the outcome is (1,2,5–7,9,11,12, 15,18).

The present study was designed to evaluate the relationship of age at onset and lateral pillar classification group to radiographic outcome at skeletal maturity. In addition, we studied the intraobserver and interobserver reproducibility of the lateral pillar classification system to see if it could be a better system of classification for use in the prospective Legg-Perthes study group.

CLASSIFICATION

This classification is based on the observation that fragmentation in Legg-Perthes occurs in distinct anatomic sectors of the femoral head. For the purpose of this classification the femoral head, as seen on an anteroposterior (AP) radiograph, is divided into three parts, which we term pillars: the lateral, central, and medial pillars (Fig. 1). The lateral pillar occupies the lateral 15–30% of the head width, the central pillar ~50% of the head width, and the medial pillar 20–35% of the head width. These sectors were derived by noting the location

FIG. 1. Femoral head pillars. The pillars were derived by noting the lines of demarcation between the central sequestrum and the remainder of the epiphysis on the anteroposterior radiograph.

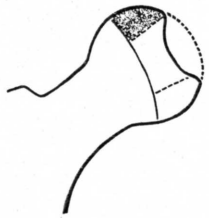

FIG. 2. Group A: Normal height of the lateral pillar maintained.

of the lines of demarcation between the central sequestrum and the remainder of the epiphysis in the stage of fragmentation. Films that are not a true AP projection should not be used for classification purposes. It is helpful to evaluate several radiographs taken about the time of early fragmentation. The radiograph showing the greatest involvement of the lateral pillar is used for classification.

Group A: No involvement of the lateral pillar

In group A, the lateral pillar is radiographically normal. There may be lucency and collapse in the central and medial pillars, but full height of the lateral pillar is maintained (Figs. 2 and 3). Fragmentation occasionally is confined to the anterior half of the head, and does not appear on the AP radiograph. In these cases, a frog lateral is necessary to document fragmentation in the anterior half of the head.

Group B: >50% of lateral pillar height maintained

In group B, the lateral pillar has some lucency, with maintainence of bone density at a height between 50 and 100% of the original height of the lateral head (Figs. 4 and 5). Comparison with the contralateral normal head is useful in documenting the relative height of the involved lateral pillar. The height of the central and medial pillars may be partially or completely decreased in this group. It is essential that the radiograph used for classification be a true AP view because an externally rotated view can show anterior fragmentation and make a group B hip appear to be a group C hip.

Group C: <50% of lateral pillar height maintained

In group C, the lateral pillar becomes more lucent than in group B, and any preserved bone is at a height <50% of the original height of the lateral pillar (Figs. 6 and 7). Again, comparison with the contralateral normal hip is useful in documenting the relative height of the involved lateral pillar. In some cases the preserved bone is displaced lateral to the metaphysis. The height of the central and medial pillars may be decreased to varying degrees in group C; however, the height of the lateral pillar is less than the height of the central pillar.

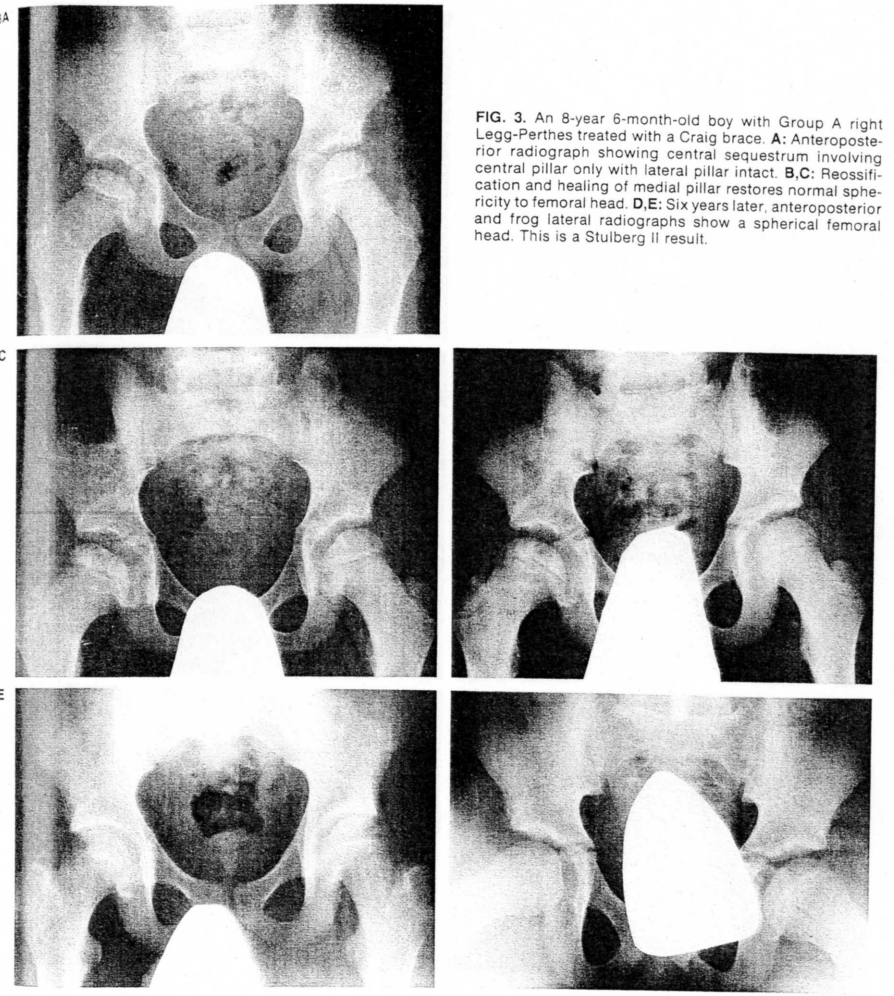

FIG. 3. An 8-year 6-month-old boy with Group A right Legg-Perthes treated with a Craig brace. **A:** Anteroposterior radiograph showing central sequestrum involving central pillar only with lateral pillar intact. **B,C:** Reossification and healing of medial pillar restores normal sphericity to femoral head. **D,E:** Six years later, anteroposterior and frog lateral radiographs show a spherical femoral head. This is a Stulberg II result.

METHODS

The charts and radiographs of 244 patients with a diagnosis of Legg-Perthes seen at the Texas Scottish Rite Hospital from 1970 to 1980 were reviewed. We included only those cases with high-quality radiographic documentation of the disorder from the fragmentation stage or earlier, with follow-up to skeletal maturity. This left 136 hips in 122 patients for further study. Ninety-three of these hips were treated in a similar manner with ambulatory bracing. The remaining patients were treated operatively or received no treatment, and therefore were excluded from the study group. Seventy-two hips were treated with the Craig brace, and 21 were treated with the Atlanta Scottish Rite brace.

All radiographs of these 93 hips were reviewed and classified by two of the authors. The lateral pillar classification was performed by reviewing only those films taken during and before the fragmentation phase, without access to healing-phase

FIG. 4. Group B: >50% of lateral pillar height maintained.

radiographs. A separate review of radiographs taken at skeletal maturity was then performed and the final results were classified by the Stulberg method (18). The duration of the Waldenstrom stages of disease was documented by noting the beginning of the fragmentation and reossification stages and completion of reossification. The presence of a subchondral fracture, which would allow the Salter-Thompson classification to be performed, was noted. An assessment of roundness of the ossified femoral head was made using the Mose template.

Sixteen members of the Legg-Perthes study group classified 32 hips by the lateral pillar classification method to determine interobserver reproducibility. Most of the members had reviewed representative slides and instruction several weeks prior to performing the classification, and all had heard a 30-minute lecture about the classification prior to classifying the radiographs. No discussion was allowed between the investigators during the classification exercise. Without the knowledge of the investigators, seven cases were duplicated to allow assessment of intraobserver reproducibility.

RESULTS

The lateral pillar classification correlated significantly with the final Stulberg result (Fig. 8). In group A there were eight Stulberg I or II results. In group B there were 35 Stulberg I and II, seven Stulberg III, and two Stulberg IV results. In group C there were 12 Stulberg II, 22 Stulberg III, and seven Stulberg IV results. There were no Stulberg V results in this study. The results in group C were significantly worse than in the other two groups ($p < 0.001$). Group C hips had a longer duration of the fragmentation (12 months) and reossification (50 months) phases than other groups (Fig. 9).

The age at onset also influenced the final result. In patients ≥9 years at onset, the outcome was significantly worse compared with patients <9 years old ($p < 0.01$). In group A the average age was 7.6 years. All of these patients were <9 years old at onset, and they all had a good outcome. In group B the average age was 7.3 years. In this group, patients <9 years at onset had a better outcome than patients ≥9 years ($p < 0.001$).

In group C the average age was 6.4 years. The difference in outcome between those older or younger than 9 years was not significant in this group ($p > 0.15$). The classification group was an overall better predictor of outcome than the age at onset (contingency coefficient 0.48 vs. 0.35).

The gender of the patient did not influence outcome or classification group. In the 14 female patients, there were three group A hips, two group B hips, and nine group C hips. The outcome was nine Stulberg II, three Stulberg III, and two Stulberg IV results.

The subchondral fracture was seen in only 15% of the hips reviewed. The infrequency of this observation was due to the fact that the first radiograph was often taken in later stages of the disease, and to the fact that many frog lateral radiographs were not in the correct position to enhance visualization of the fracture.

In the 32 hips reviewed by the Legg-Perthes study group, the interobserver agreement was 0.78 among the 16 investigators (Fig. 10). The intraobserver agreement on the radiographs that were evaluated twice was 0.79. The kappa statistic was 0.52. The probability of two randomly chosen observers giving the same classification to a randomly chosen film was 0.68.

DISCUSSION

Waldenstrom, in 1922, noted the wide range of radiologic outcomes possible in hips affected with Perthes disease, and he posed the question, "Cannot the definite type be prognosticated during the evolutionary stage, or at least cannot one say to which group it will belong?" (20). The many subsequent efforts to prognostically classify this disorder attest to the importance of predicting the outcome in the early phases of the disease. Meaningful studies of the effect of treatment can be performed only if the radiographic classification is reproducible. Otherwise, the wide variation of the natural history will outweigh and obscure all but the most obvious treatment effects.

The widely used classification of Catterall has encouraged physicians to predict which hips will likely benefit from treatment. The Catterall groups have been shown to have predictive value, and the identification of risk factors further helps with prognostication (2,4,11,16,18). This classification is difficult to use in the active stage of disease, and a number of studies have found an unacceptable reproducibility when various individuals are asked to classify films in the fragmentation stage (3,10,19). While attempting to classify a large number of hips by the Catterall method, we observed that involvement of a specific area of the head was more predictive than the percentage of head involved. This led to the concept of the lateral pillar classification system.

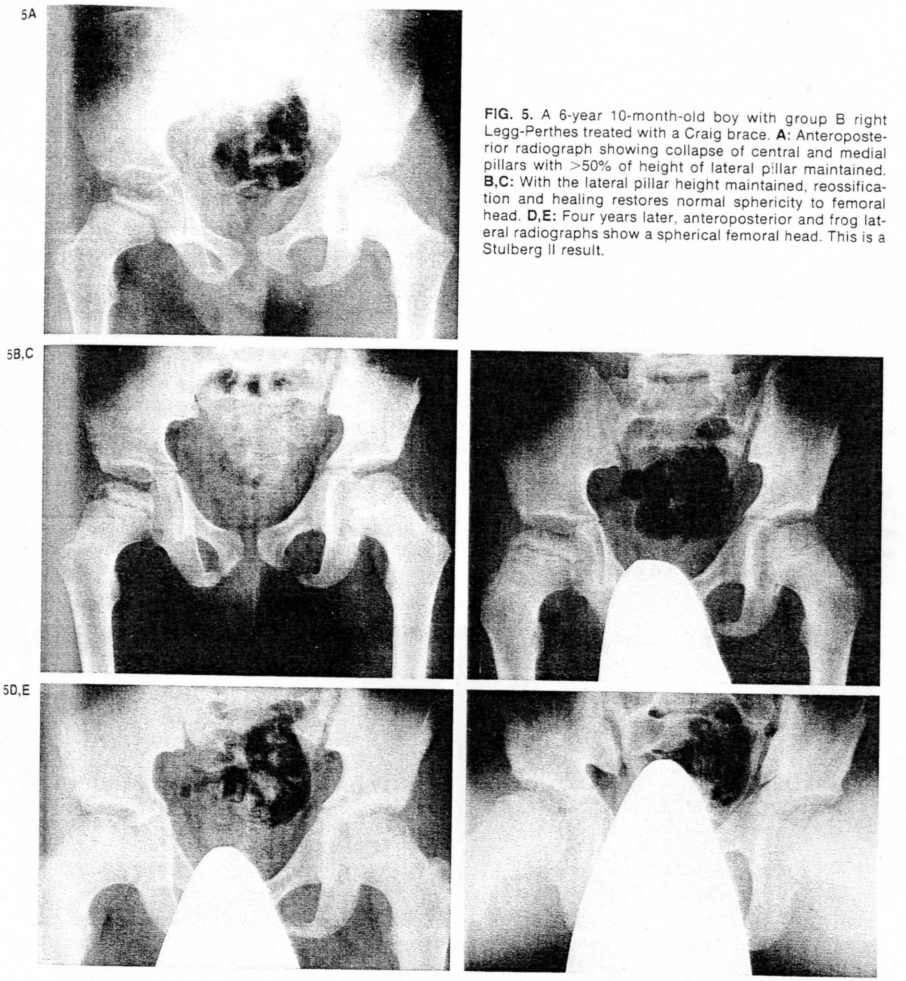

FIG. 5. A 6-year 10-month-old boy with group B right Legg-Perthes treated with a Craig brace. **A:** Anteroposterior radiograph showing collapse of central and medial pillars with >50% of height of lateral pillar maintained. **B,C:** With the lateral pillar height maintained, reossification and healing restores normal sphericity to femoral head. **D,E:** Four years later, anteroposterior and frog lateral radiographs show a spherical femoral head. This is a Stulberg II result.

The classification has many similarities to the Catterall classification, and is in part a simplification of that system. Group A hips correspond to Catterall's groups I and II. Group C includes hips classified as Catterall III and IV. Group B includes hips that would have been classified as either group II or III and represents those hips that are most difficult to classify by the Catterall method. Risk factors can be seen in both groups B and C, but do not appear to have prognostic value (Fig. 11).

The Salter-Thompson classification is appealing because it allows very early identification of the extent of head involvement. However, it is our experience that it is unusual to have the appropriate radiographs taken early enough in the course of the disease to see the subchondral fracture. In the present study, only 15% of the hips had an identifiable subchondral fracture line. In contrast, in using the lateral pillar classification, the only radiograph needed is an AP view obtained during the fragmentation stage. Thus, the classification can easily be made during the active phase of the disease.

FIG. 6. Group C: <50% of lateral pillar height maintained.

In this study of hips followed to maturity, the lateral pillar classification was clearly predictive of radiographic outcome. Group A had all Stulberg I and II results, thus no evidence of femoral head flattening. In group B, the outcome was good for all except those with an onset at >9 years of age. Group C hips developed more flattening in both age groups. We were able to observe a distinct pattern of radiographic evolution based on the degree of involvement of the lateral pillar during the fragmentation stage. With a greater degree of lateral pillar involvement, the reossification was slower and often incomplete by skeletal maturity, leading to femoral head flattening. Conversely, in younger patients with less severe involvement of the lateral pillar, healing could restore the round shape of the femoral head by skeletal maturity.

The reproducibility of the classification was satisfactory, considering that the study group had minimal prior exposure to the system. A problem for this and probably any biologic classification is classifying those cases that fall close to an arbitrary line. We identified a few borderline cases, and the outcome for those was usually intermediate between that predicted for the two adjacent groups.

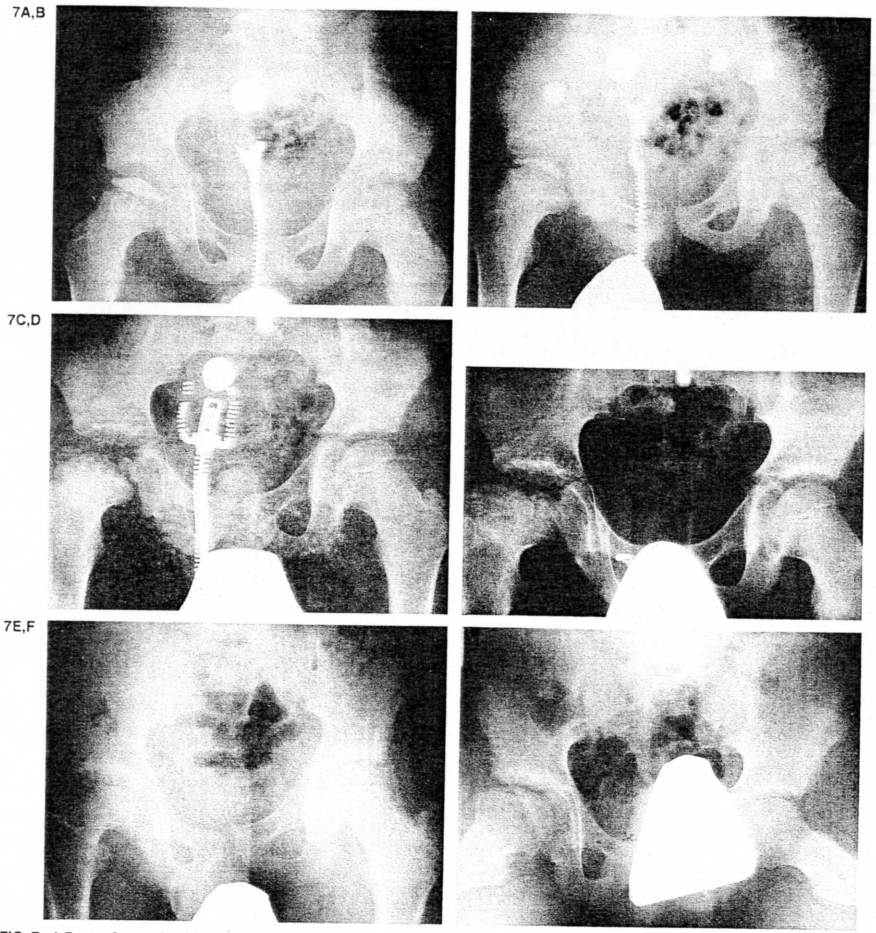

FIG. 7. A 7-year 2-month-old boy with group C right Legg-Perthes treated with the Atlanta Scottish Rite brace. **A:** Anteroposterior radiographs showing <50% of height of lateral pillar maintained. **B–D:** Flattening of femoral head persists through prolonged fragmentation and reossification stages. **E,F:** Six years later, anteroposterior and frog lateral radiographs show an aspherical femoral head with marked flattening. This is a Stulberg IV result.

Lateral pillar classification	Age	Stulberg classification				Total
		I	II	III	IV	
Group A	<9		8			8
	≥9					0
Group B	<9	1	31	2		34
	≥9		3	5	2	10
Group C	<9		12	19	5	36
	≥9			3	2	5
Totals		1	54	29	9	93

FIG. 8. Final Stulberg outcome based on lateral pillar classification and age for all hips studied.

Lateral pillar classification	Duration (months)	
	Fragmentation	Reossification
Group A	5	33
Group B	7	39
Group C	12*	50

FIG. 9. Average duration of fragmentation and reossification stages based on lateral pillar classification (*$p < 0.01$).

Classification system	Interobserver reliability
Lateral pillar	.78
Catterall classification*	.42
Head at Risk signs*	.35

FIG. 10. Interobserver reliability of lateral pillar classification, Catterall classification, and risk factors (*ref. 19).

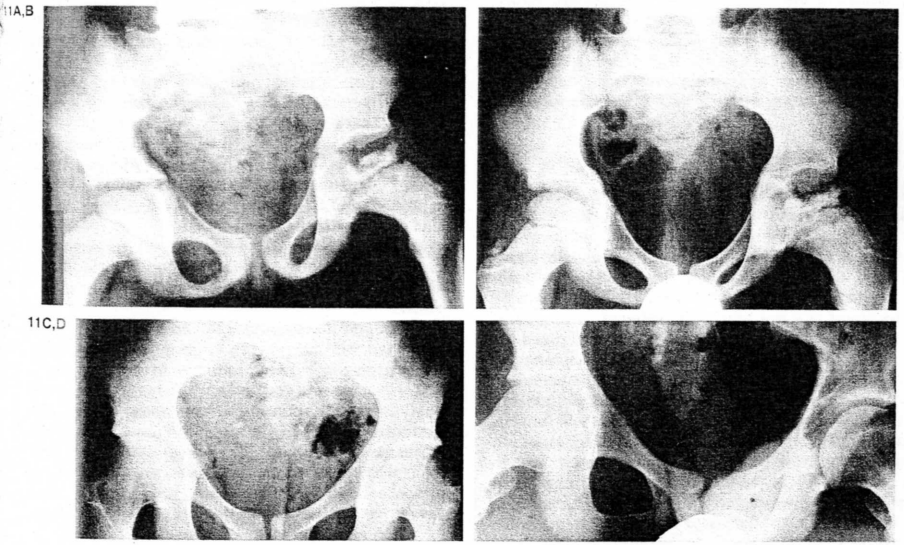

FIG. 11. An 8-year 9-month-old boy with group B left Legg-Perthes. **A:** Anteroposterior radiograph showing maintenance of >50% of height of lateral pillar along with lateral subluxation, Gage's sign, and metaphyseal cysts. **B–D:** Despite the three "at risk" signs, maintenance of the height of the lateral pillar during reossification and healing results in a good radiographic outcome at skeletal maturity.

The final purpose of this classification is to be able to evaluate treatment methods in similar groups of hips. If the outcome can be predicted by classification and age of onset, the value of treatment can be assessed as it affects the predicted outcome in each group. Using this reproducible system, meaningful comparisons of retrospective and prospective studies can be performed.

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Combined Osteotomy as a Salvage Procedure for Severe Legg–Calvé–Perthes Disease

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Summary: Combined Salter innominate and varus femoral osteotomies were performed on 14 patients with severe Legg–Calvé–Perthes disease. The mean patient age was 8 years 4 months. Nine hips were Catterall class III, five class IV, and all had three or more head-at-risk signs. The average preoperative epiphyseal index was 30%. Mean follow-up was 8 years. Eleven of 14 patients had a good clinical result, and radiographs showed progressive spherical remodeling of the femoral head. Seven hips demonstrated spherical congruency at follow-up. The epiphyseal extrusion index at follow-up was <20% in 13 of 14 hips. We conclude that combined osteotomy is a safe and effective salvage procedure in severe Legg–Calvé–Perthes disease. **Key Words:** Femoral osteotomy–Innominate osteotomy—Legg–Calvé–Perthes disease.

The modern treatment of Legg–Calvé–Perthes (LCP) disease is based on a growing understanding of its natural history. While the etiology of LCP disease remains unclear, it is widely accepted that an idiopathic avascular necrosis of the capital femoral epiphysis results in a predictable pattern of secondary hip joint pathology. Many studies have shown that the prognosis of LCP disease depends primarily on the age of onset and the extent of femoral head involvement (4,5,9,11,25). In 1971, Catterall described a classification of disease severity and five radiologic head-at-risk signs that are associated with a poor outcome (4). LCP disease in older (>6 years) patients with severe (>50% head involvement) disease and head-at-risk signs remains a difficult and controversial treatment problem.

The major goals of treatment in severe LCP disease are femoral head containment and maintenance of hip motion. The principle of femoral head containment is based on the concept that the capital femoral epiphysis is vulnerable to deformity during the healing stages of LCP disease and that a good outcome depends on maintaining femoral head sphericity by containment during the healing phase. This is most frequently accomplished by an ambulatory abduction orthosis or a Petrie-type cast; however, surgical containment methods may be used in cases where it is desirable to obtain a permanent correction and to minimize restriction of the child. Options for surgical containment include a varus or varus–derotational osteotomy of the proximal femur (3,10,13,18) or an innominate osteotomy as described by Salter (23,24) and others (2,16,26). In this study, we report on our experience using a combined Salter innominate and varus femoral osteotomy as a salvage procedure in the treatment of severe LCP disease.

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MATERIALS AND METHODS

Fourteen patients underwent combined Salter innominate and proximal femoral varus osteotomies for severe LCP disease. These operations were all performed by the same surgeon (L.T.S.) at Children's Hospital and Medical Center in Seattle, Washington, between 1974 and 1979. There were 12 males and 2 females. The right hip was involved in 10 cases and the left in 4. All patients had a poor prognosis based on the extent of femoral head involvement, head-at-risk signs, and their age at the onset of disease. Nine patients were Catterall group III and five were Catterall group IV. A preoperative radiographic review revealed that 11 patients were in the fragmentation stage and 3 were in the early reconstitution stage of the disease. There were an average of 3.7 head-at-risk signs per patient: all had some degree of lateral subluxation, lateral calcification, and metaphyseal changes (Fig. 1). The age at onset of disease averaged 7.6 years, with a range of 4.0 to 10.5 years. The time interval between the onset of symptoms and diagnosis varied between 0