Long-Term Results of Proximal Femoral Osteotomy in Legg-Calvé-Perthes Disease

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Background: Legg-Calvé-Perthes disease is a childhood hip disorder that may result in a deformed and poorly functioning hip. The purpose of this study was to evaluate the correlation between hip deformity at skeletal maturity and degenerative osteoarthritis and to present the long-term results of proximal femoral varus derotational osteotomy in Legg-Calvé-Perthes disease.

Methods: We analyzed the results of 40 patients (43 hips), who underwent proximal femoral varus derotational osteotomy for Legg-Calvé-Perthes disease in our institution between 1959 and1983. All available patients underwent a single long-term follow-up examination. Hips were classified with the classification system of Stulberg. Osteoarthritis was evaluated using the Tönnis classification. The long-term outcomes were evaluated after a mean follow-up period of 33 years.

Results: When examining the outcome using the Stulberg classification system, there were 8 Stulberg class I hips (19.5%), 15 Stulberg class II hips (36.6%), 8 Stulberg class III hips (19.5%), 9 Stulberg class IV hips (22%), and 1 Stulberg class V hip (2.4%). One patient, who had a bilateral Legg-Calvé-Perthes disease, underwent total hip replacement for osteoarthritis. Seven patients had poor clinical results.

Conclusions: Proximal femoral varus derotational osteotomy provides good long-term results for Legg-Calvé-Perthes disease. The Stulberg classification is a good predictor for patient outcome.

Level of Evidence: Level IV, therapeutic study.

Key Words: Legg-Calvé-Perthes disease, proximal femoral osteotomy, long-term results

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Legg-Calvé-Perthes disease (LCPD) is a childhood hip disorder. Some authors consider LCPD to be a mild disorder that requires little treatment. These authors have reported on satisfactory outcomes for most patients with nonoperative treatment such as bracing and cast immobilization.[1–8] Others believe that the disease may result in a deformed and poorly functioning hip and recommend surgery for most patients.[9,10] Good results with Salter innominate osteotomy have been reported.[11–13] Others recommend different surgical interventions including combined osteotomies,[14,15] Chiari osteotomy,[16,17] and shelf arthroplasty.[18,19] The Legg-Calvé-Perthes disease study group designed a study that examined whether any method of treatment could alter the outcome of LCPD and whether it is possible to identify specific factors that predict the outcome for patients with LCPD. However, patients were available for follow-up only until skeletal maturity.[20]

We believe that different treatment modalities for LCPD should be compared on the basis of their long-term outcomes. Many studies have evaluated the results of nonoperative treatment.[18,20–26] However, few studies have examined the long-term results of surgical management for LCPD.[18,20,27]

In our institution, patients with LCPD have undergone containment therapy by proximal femoral varus derotational osteotomy (PFVDO) since its introduction by Dr Anatol Axer[28,29] in the late 1950s. The main goal of this method was to achieve containment of the diseased part of the femoral head in an attempt to prevent future hip joint deformities.[30] Proximal femoral varus derotational osteotomy also enables containment without the need for abduction bracing for a long period.

The purpose of this study was to examine the indications for PFVDO in LCPD, to present the long-term results of 40 patients, and to evaluate the correlation between hip deformity at skeletal maturity and degenerative osteoarthritis in long-term follow-up.

METHODS

The study was approved by the institutional review board of Assaf Harofeh Medical Center, which concluded that the nature of the study was such that written patient consent was not required.

One hundred twenty-nine patients underwent PFVDO surgery in our institution during 24-year period 1959 to 1983, during which our institution was a referral center for LCPD. Ninety-nine patients underwent PFVDO for LCPD. Of these, 76 patients were located, contacted, and invited for a follow-up visit. Thirty-six patients refused to appear for the follow-up visit. We could therefore analyze the long-term results of 40 patients (43 hips) (Fig. 1).

The initial surgery included 30 (33 hips) cases of single PFVDO, and 10 cases of PFVDO were followed later on by greater trochanteric transfer with apophysiodesis to improve a Trendelenburg limp. The indication for surgery was Catterall groups 3 and 4, with "head-at-risk signs." All radiographs were classified by 2 observers who reached a consensus on their classification.

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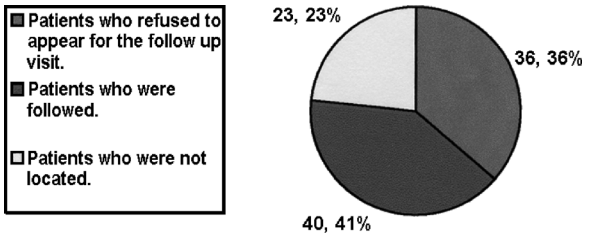

FIGURE 1. The distribution of patients who underwent PFVDO surgery for LCPD in our institution during the 24-year period from 1959 to 1983 is shown.

According to the Catterall classification, there are 4 groups of patients. In group 1, radiographic changes are restricted to the anterior part of the capital epiphysis. In group 2, there is approximately 50% involvement anterolaterally, with the medial and lateral-pillar portions of the femoral head intact, plus anterolateral metaphyseal lesions. In group 3, about 75% of the head is involved, including the lateral column, with diffuse metaphyseal reaction. In group 4, the entire epiphysis is involved. The 4 head-at-risk signs include the Gage sign—a radiolucent "v" in the lateral portion of the epiphysis, calcification lateral to the epiphysis, lateral subluxation of the femoral head, and a horizontal physis.[31] Although the Catterall system was used widely for many years in almost all studies, previous studies found that it failed to provide an acceptable level of interobserver and intraobserver agreement.[32,33] Other studies found acceptable levels of interobserver and intraobserver agreement.[34,35]

The patients in our study underwent bilateral hip arthrography before the operation. This procedure helped to evaluate the correct osteotomy angles needed for good coverage of the femoral head. The legs were positioned in various degrees of abduction and medial rotation, while the hips were monitored with the image intensifier. The measured degree of abduction and medial rotation needed to rotate the affected femoral head so that its flattened and protruding portion was covered by the acetabular roof indicated the correct osteotomy angle. In those cases in which it was seen that there was minimal or no protrusion of the anterolateral femoral head cartilage beyond the confines of the acetabulum when the legs were in the neutral position, no operative procedure was performed, and the children were not treated.[29] Trochanter transfer was performed in patients with low or negative articulotrochanteric distance and Trendelenburg gait, after femoral head bony regeneration was completed.

All available patients underwent a single long-term follow-up examination during which they were clinically evaluated. On physical examination, limb-length discrepancy was evaluated by clinically measuring the distance between the anterior superior iliac spine and the medial malleolus. The Trendelenburg test was performed. A standard anteroposterior (AP) pelvic and a lateral hip radiographs were obtained. Radiographs were rated using the Stulberg classification.[26] A class I hip was defined as "a completely normal hip joint." Class II hips were defined as spherical (same concentric circle on AP and frog-leg lateral radiographs), but with a larger-than-normal (although spherical) femoral head, a shorter femoral neck, or an abnormally steep acetabulum. Class III heads were described as nonspherical, with an ovoid, mushroom, or umbrella shape, but not flat. Class IV hips were described as having a flat femoral head with abnormalities of the femoral neck and acetabulum. Class V hips were described as those with a flat femoral head and a normal femoral neck and acetabulum.

The Tönnis classification[36] was used to grade the extent of osteoarthritis in the patients' hips (Table 1). All radiographs were evaluated by a single observer not involved in the patients' initial care.

Finally, to evaluate the functional outcome and health status of this group of patients, we administered the Short-Form 36 (SF-36)[37,38] questionnaire and the Harris Hip Score.[39] The SF-36 is a 36-question generic health outcomes measure that is useful in surveys of populations to compare the relative burdens of disease as well as the health benefits of different treatments.

The Harris Hip Score is a questionnaire that evaluates disability due to hip problems. According to the Harris Hip Score system, 90 to 100 points indicate an excellent result; 80 to 89 points, a good result; 70 to 79 points, a fair result; and less than 70 points, a poor result. For the purposes of evaluating the overall result, failure was defined as a Harris hip score of less than 70 points or a total hip arthroplasty.

Patients were also asked to self-grade their hip pain on a visual analog scale from 1 to 5 (1 = no pain at all, 5 = incapacitating pain).

The patient's current occupation was recorded and classified as either physically demanding (a job that includes carrying heavy weights or demanding physical activity, such as an automobile mechanic or a farmer), light physical (a job that requires prolonged standing and lifting small weights such as a nursery school teacher), or sedentary work (a desk job).

Statistical analysis was performed using the SPSS software (version 12.1; SPSS Inc, Chicago, Ill) with a 5% significance level. The Pearson correlation test, Spearman correlation test, Fisher exact test, and the Student *t* test were used as appropriate.

RESULTS

The long-term outcomes were evaluated after a mean follow-up period of 33 years (range, 23–47 years) and at a mean age of 40 years (range, 26–58 years). Twenty-eight patients were male (70%), and 12 were female (30%). The median age at disease onset was 6 years (mean, 6.9 years; range, 1.5–12 years), and the median age at time of surgery was 7 years (mean, 7.7 years; range, 3–13 years).

TABLE 1. Tönnis Classification of Osteoarthritis

Grade	Description
0	No signs of osteoarthritis.
1	Increased sclerosis, slight narrowing of the joint space, and slight lipping at the joint margins.
2	Small cysts, moderate narrowing of the joint space, moderate loss of head sphericity.
3	Large cysts, severe narrowing or obliteration of the joint space, severe deformity of the head.

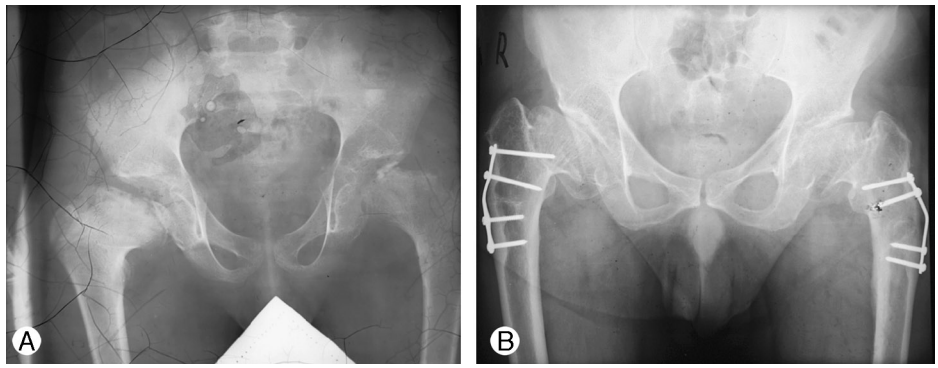

FIGURE 2. A, A preoperative AP radiograph of the pelvis of a 12-year-old boy shows bilateral LCPD with the formation of a very irregular femoral head and unsatisfactory femoral head coverage. B, A postoperative AP pelvic radiograph of the patient at age of 44 years (36 years' follow-up) demonstrates a broadened deformed head with moderate signs of osteoarthritis.

At follow-up, 22 patients (55%) graded their hip pain as 1, 8 (20%) as 2, 9 (22.5%) as 3, and 1 (2.5%) as 4. The mean Harris Hip Score was 82.18 ± 17.17, and the mean SF-36 score was 73.77 ± 21.2. To avoid potential bias, we excluded young patients (boys with disease onset at <6 years of age and girls with disease onset at <5 years of age) whose prognosis is quite good. We analyzed the results of 24 older patients (26 hips). This group of patients had a mean Harris Hip Score of 80.46 ± 18.11 and a mean SF-36 score of 72.86 ± 22.89.

According to the Harris Hip Score system, 18 patients had an excellent result, 6 patients had a good result, 8 had a fair result, and 7 patients had poor results. One patient underwent total hip replacement and was not evaluated with the Harris Hip Score system.

The Trendelenburg test was positive in 18 patients. Thirteen of these 18 patients underwent PFVDO, whereas 5 had PFVDO with trochanter transfer/apophysiodesis. The difference between the 2 groups was not statistically significant ($P > 0.05$, Fisher exact test). Limb-length discrepancy was found in 28 patients, averaging 1.4 cm (range, 0.5–3 cm). This was significantly more common in patients who underwent trochanteric transfer operation ($P = 0.004$, Student *t* test).

A correlation that did not reach statistical significance was found between age at diagnosis and the Harris Hip Score ($P = 0.065$, $R = -0.0311$, Pearson correlation test). However, when examining the older group of patients (boys with disease onset at >6 years of age and girls with disease onset at >5 years of age), a statistically significant correlation was found between age at diagnosis and the Harris Hip Score ($P = 0.049$, $R = -0.414$, Pearson correlation test). No correlation was found between age at diagnosis and the SF-36 score ($P > 0.05$, Pearson correlation test) in either group. No correlation was found between limb-length discrepancy and the Harris Hip Score and the SF-36 score ($P > 0.05$, Student *t* test) in either group. Similarly, we could not find a significant difference between PFVDO alone and PFVDO with trochanter transfer/apophysiodesis in either the Harris Hip Score or SF-36 score ($P > 0.05$, Student *t* test).

The Tönnis classification for osteoarthrosis was applied for all patients. The radiographic examination revealed mild signs of osteoarthritis (Tönnis grade 1) in 4 patients, moderate signs of osteoarthritis (Tönnis grade 2) in 4 patients, and severe osteoarthritis (Tönnis grade 3) in 1 patient (Fig. 2). One additional patient who had a bilateral LCPD underwent total hip replacement for osteoarthritis. Of the 4 patients identified with moderate osteoarthritic changes, 2 girls were diagnosed after the age of 5 years, 1 boy was diagnosed at the age of 11 years, and another boy was diagnosed at the age of 5 years. The patient with severe osteoarthritis and the patient who underwent total hip replacement were diagnosed at the ages of 11 and 5 years, respectively.

When examining the outcome using the Stulberg classification, there were 8 Stulberg class I (19.5%), 15 Stulberg class II (36.6%), 8 Stulberg class III (19.5%), 9 Stulberg class IV (22%), and 1 Stulberg class V (2.4%). The patient who had a bilateral LCPD and underwent total hip replacement was not evaluated with the Stulberg classification (Table 2).

The Stulberg classification was found to be significantly correlated with the Harris Hip Score and the SF-36 score ($P < 0.001$, $R = -0.68$; $P = 0.003$, $R = -0.463$, Pearson correlation test, respectively). It was also found to be significantly correlated with the level of osteoarthritis as measured by the Tönnis classification ($P = 0.008$, $R = 0.416$, Spearman correlation test).

Six patients worked in a physically demanding job, 9 patients worked in light physical labor, and the other 24 patients were employed in sedentary jobs. There was no correlation between job selection and the Harris Hip Score or the presence of osteoarthritis ($P = 0.523$, $R = -0.11$; $P = 0.069$, $R = -0.295$, Spearman correlation test, respectively). When asked specifically, 37 of the 40 patients chose their job regardless of their hip condition.

TABLE 2. Patient Outcome Using the Tönnis Classification for Osteoarthrosis and the Stulberg Classification

Tönnis Classification	No. Hips	Stulberg Classification	No. Hips
Grade 0	32	Class I	8 (19.5%)
Grade 1	4	Class II	15 (36.6%)
Grade 2	4	Class III	8 (19.5%)
Grade 3	1	Class IV	9 (22%)
		Class V	1 (2.4%)

DISCUSSION

The outcome of the surgical treatment for LCPD is difficult to evaluate, making the optimal treatment for these patients debatable. Many authors have described the results of different treatment methods for LCPD.[2,13,15,20–23,25,26,28,29,36,39–43] Our study has some obvious limitations, mainly the lack of complete data and the fact that there is no control group—as do most other studies that deal with surgical results for LCPD. The operative criteria 30 years ago differ from the current indications, meaning that some of the patients would have not been indicated for surgical treatment using contemporary criteria (Fig. 3). However, it is, to date, the longest follow-up on patients who have undergone PFVDO. This long follow-up enables us to investigate the correlation of shape at skeletal maturity with functional outcome and osteoarthritis in mid-adult years.

Over the mean 33-year follow-up period, favorable clinical and radiographic results were obtained in most patients. Only 1 of 43 hips had been replaced, and this was done 25 years after the index procedure. According to the Harris Hip Score, 24 patients had a very good clinical result; and 8 patients had a fair clinical result, whereas only 7 had a Harris Hip Score of less than 70. These findings are in concordance with other studies showing good clinical results even in patients with nonspherical femoral heads.[44] It is difficult to compare our results with other studies dealing with different populations, and using different indications for surgery and different evaluation methods.[20–25,44,45] The Legg-Calvé-Perthes disease study group[20] reported on similar results. They combined 68 patients who underwent innominate osteotomy and 52 patients who underwent femoral osteotomy into one surgical treatment group. In this combined surgical group, there were 61% Stulberg class I or II, 29% Stulberg class III, and 10% Stulberg class IV or V results. The outcome was similar to the outcome distribution in our study.

A study from Iowa,[24] with an average follow-up of 48 years, reported on a group of 32 patients from whom 23 patients were also examined 12 years earlier.[21] At a mean follow-up of 48 years, 40% of the patients had undergone arthroplasty, and 10% had disabling hip pain, but had not yet undergone arthroplasty. An additional 10% had a rating of less than 80 points on the Iowa scale (a rating of >80 points indicates a good level of function) but were not disabled. Still, only in a small group of patients (3 hips) had severe pain and dysfunction developed by the fourth decade of life. Other patients developed similar hip problems only in the fifth and sixth decades of life. Another study reported that most patients do well up to 30 years of age.[42] At that age, the differences in the Iowa score between spherical and aspherical congruent hips are minimal. After this age, hips with aspherical heads tend to deteriorate rapidly with increasing age.

Our results are surprisingly good. It is still a relatively short follow-up, and some of the patients might deteriorate in the next few years. Another important point is that some of the children who were operated on would not meet the current operative criteria and would have had a good clinical result even without treatment.

In many of the previous studies, evaluation of long-term results on LCPD has been at the time of follow-up, without correlating the findings with the radiographic aspects of the disease at its onset or attempting to find early prognostic indications.[21,24,44] Stulberg et al[26] described 5 reproducible radiographic classes by which hips affected by LCPD can be assessed at maturity. They showed that congruence between femoral head and acetabulum is as important as the shape of the femoral head alone and that the clinical and radiographic course of an involved hip is related to the type of congruency that exists between the femoral head and acetabulum. A statistically significant correlation between Stulberg class and Iowa score was found,[42] which seems to indicate that the Stulberg classes have a functional implication. A classification system that had a high correlation with the Stulberg classification and predicted the amount of flattening of the femoral head at skeletal maturity was developed.[46] We have found that there is a statistically significant correlation between the Stulberg classification and functional outcome (Harris Hip Score) and osteoarthritis. We believe that this uniform and easily reproducible method of assessment of the disease should help elucidate the long-term prognosis of the disease.

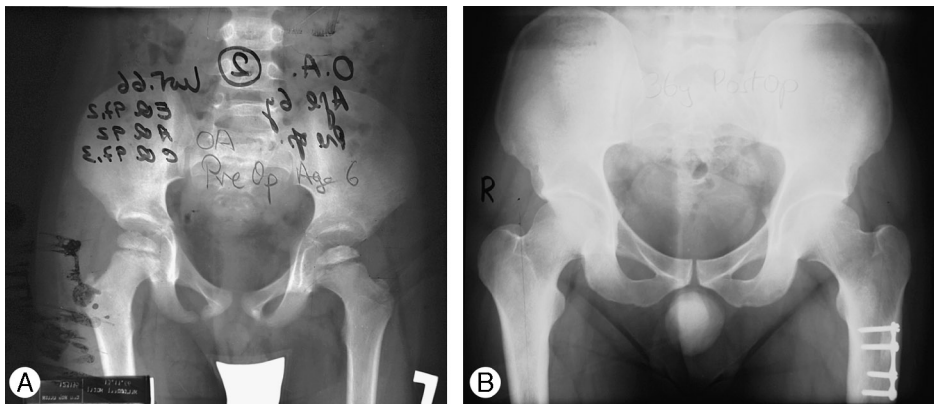

FIGURE 3. A, A preoperative AP radiograph of the pelvis of a 6-year-old boy shows LCPD of the left hip. B, At follow-up, when the patient was 42 years old, there was no pain or evidence of osteoarthritis of the affected hip. However, we believe this patient would have not undergone surgery by contemporary criteria.

Long-term studies have shown that the earlier the onset of the disease, the better the long-term prognosis.[9,24,26,30] We found a correlation that did not reach statistical significance between age at diagnosis and the Harris Hip Score. No correlation was found between age at diagnosis and the SF-36 score. Similar results were reported in a study of long-term results following PFVDO.[27] However, when examining the results only in girls and boys older than 5 and 6 years at the onset of the disease, respectively, we found a statistically significant correlation between age at diagnosis and the Harris Hip Score. We assumed that some of the young patients got worse with surgical treatment, and indeed, a clear advantage in surgical containment for patients older than 5 years was found.[40] They suggested that patients younger than 5 years fail to recover from the induced varus. Their observations imply that if "at risk" signs are found in the young child, a major growth disturbance may be present in the femoral neck, which may prejudice the result of PFVDO. The Legg-Calvé-Perthes disease study group[20] excluded children younger than 6 years at the onset of the disease and found that the age at the onset of the disease was a strong predictor of outcome.

Four patients in the current study showed radiographic signs of moderate osteoarthritis, 1 patient did not have any functional disability (Harris Hip Score, >79), another 1 patient had a fair function (Harris Hip Score, >70), and another 2 patients had a poor function (Harris Hip Score, <70). One patient had both radiographic severe osteoarthritis and poor function. Among the other 5 patients with poor function, 3 had no signs of osteoarthritis and 2 had mild signs of osteoarthritis. These findings support previous studies, stating that there is little correlation between the radiological and clinical signs of osteoarthritis, not only in LCPD, but as a general feature of osteoarthritis.[23]

A frequent problem associated with PFVDO is trochanteric prominence, resulting in an abductor weakness and Trendelenburg gait.[2,47,48] Additional operative techniques, the trochanteric arrest (apophysiodesis) and trochanteric transfer, could be performed with PFVDO to prevent trochanteric prominence at skeletal maturity. The efficacy of concomitant trochanteric arrest performed at the time of femoral PFVDO was examined.[47] This study concluded that prophylactic trochanteric arrest at the time of PFVDO preserves the articulotrochanteric distance and is associated with decreased abductor weakness, better pain scores, and superior activity levels. We found no difference in the Harris Hip Score or the SF-36 score between PFVDO alone and PFVDO with trochanter transfer/apophysiodesis. There was also no statistical difference in the incidence of a positive Trendelenburg test in these 2 groups. Our data demonstrate that trochanter transfer/apophysiodesis in patients with low or negative articulotrochanteric distance and Trendelenburg gait provides similar results to patients who underwent only PFVDO.

Femoral osteotomy is criticized because it is believed to cause unacceptable shortening.[9] In a previous study, we did not observe any difference in limb length between patients who underwent PFVDO versus other forms of containment.[49] There was not even a significant difference in limb length between patients who underwent prophylactic trochanteric arrest and those who did not.[47] Unlike other studies, we found that limb-length discrepancy was significantly more common in patients who underwent the trochanter transfer operation ($P = 0.004$, Student t test), as expected by the physeal head growth arrest caused by the disease, with consequent relative trochanteric overgrowth. However, no correlation was found between limb-length discrepancy and the Harris Hip Score and the SF-36 score.

In conclusion, PFVDO provides good long-term results for LCPD patients. A combination of PFVDO and trochanter transfer/apophysiodesis provides an efficacious means of managing patients at risk for trochanteric prominence. The Stulberg classification is a good predictor for patient outcome.

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