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Periacetabular Osteotomy for the Treatment of Acetabular Dysplasia Associated with Major Aspherical Femoral Head Deformities

By John C. Clohisy, MD, Ryan M. Nunley, MD, Madelyn C. Curry, RN, and Perry L. Schoenecker, MD

Investigation performed at the St. Louis Shriners Hospital for Children, Barnes-Jewish Hospital at Washington University Medical School, and St. Louis Children's Hospital, St. Louis, Missouri

Background: Acetabular dysplasia associated with deformity of the proximal part of the femur can result in hip dysfunction and degenerative arthritis in young adults. The optimal method of surgical correction for these challenging combined deformities remains controversial.

Methods: We retrospectively analyzed twenty-four hips in twenty patients who underwent a Bernese periacetabular osteotomy, which was done with a proximal femoral valgus-producing osteotomy in thirteen hips, for the treatment of acetabular dysplasia associated with proximal femoral structural abnormalities. The average age of the patients at the time of surgery was 22.7 years, and the average duration of clinical follow-up was 4.5 years. The Harris hip score and overall patient satisfaction with surgery were used to assess hip function and clinical results. Plain radiographs were used to assess the correction of the deformity, healing of the osteotomy, and progression of degenerative arthritis.


Results: The mean Harris hip score increased from 68.8 points preoperatively to 91.3 points at the time of the most recent follow-up ($p < 0.0001$). Sixteen patients (nineteen hips) had an excellent clinical result, and one patient (one hip) had a good result. Two patients (two hips) had a fair result, and one patient (two hips) had a poor result. Twenty-two of the twenty-four hips improved clinically. There was an average improvement of 27.6° in the lateral center-edge angle of Wiberg ($p < 0.0001$), an average improvement of 33.1° in the anterior center-edge angle of Lequesne and de Seze ($p < 0.0001$), and an average improvement of 16.5° in the acetabular roof obliquity ($p < 0.0001$). The hip center was translated medially an average of 6.3 mm ($p = 0.0003$). The Tönnis osteoarthritis grade was unchanged in twenty hips, progressed one grade in three hips, and progressed two grades in one hip. There were three major technical complications. At the time of the most recent follow-up, none of the hips had required total hip arthroplasty.

Conclusions: The combination of acetabular dysplasia and proximal femoral deformities presents a complex reconstructive problem. The range of motion and radiographic assessment of the hip are major factors in the selection of patients for surgery. In selected patients, the periacetabular osteotomy combined with concurrent femoral procedures, when indicated, can provide comprehensive deformity correction and improved hip function.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Proximal femoral abnormalities that are characterized by a large aspherical femoral head, a short femoral neck, and so-called trochanteric overgrowth are termed *Perthes-like* deformities¹⁻³ and may be associated with acetabular dysplasia¹⁻⁵. These combined deformities can result in instability of the hip, femoroacetabular impingement, joint incongruity, abductor in-

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sufficiency, and limb-length inequality. Perthes-like deformities have been associated with the development of degenerative hip disease in several studies⁶⁻¹¹, and it is reasonable that joint preservation surgery should be considered for the treatment of symptomatic patients. This combination of acetabular and proximal femoral deformities presents a challenge to the surgeon because correction must achieve a tenuous balance between hip stability achieved by acetabular correction, while avoiding secondary acetabular impingement by the abnormal aspherical femoral head and short femoral neck.

Given the efficacy of the Bernese periacetabular osteotomy in the treatment of symptomatic acetabular dysplasia¹²⁻¹⁶, we hypothesized that this acetabular reorientation technique would also be effective in the management of selected hips with combined acetabular and proximal femoral deformities. Therefore, over several years, we managed acetabular dysplasia associated with Perthes-like femoral deformities with a reconstructive periacetabular osteotomy. On occasion, the acetabular osteotomy was combined with a proximal femoral osteotomy to achieve congruency, optimize hip range of motion, and minimize femoroacetabular impingement. In this study, we present the early results and complications associated with this type of hip reconstruction.

Materials and Methods

This retrospective study received institutional review board approval. Between 1994 and 2003, the senior authors (J.C.C. and P.L.S.) performed 111 consecutive periacetabular osteotomies for the treatment of acetabular dysplasia. We performed a retrospective radiographic review of all 111 procedures and found that twenty-four hips in twenty patients had features characteristic of a Perthes-like femoral deformity associated with a dysplastic acetabulum (see Appendix). All twenty-four hips had proximal femoral deformities that included an aspherical femoral head, short femoral neck, and a relatively high greater trochanter (Figs. 1-A through 1-D), consistent with class III of the Stulberg classification system³. Hips with major incongruity (Stulberg class IV), advanced secondary osteoarthritis, or marked restriction of flexion ($<95^\circ$) were not considered candidates for joint preservation surgery.

Nine patients (nine hips) had a history consistent with Legg-Calvé-Perthes disease; six patients (seven hips) had a Perthes-like deformity considered to be secondary to acetabular dysplasia. One patient (two hips) had dysplasia of both the acetabulum and the proximal part of the femur due to metaphyseal chondroplasia (McKusick type of cartilage-hair hypoplasia). One patient (two hips) presented with acetabular dysplasia and femoral deformity associated with pseudoachondroplasia. One patient (two hips) had atypical dysplasia of the acetabulum (including bilateral retroversion) and proximal femoral deformity associated with static encephalitis. One patient (one hip) had a residual deformity associated with childhood infection, and one patient (one hip) had severe acetabular and femoral deformity associated with a congenitally short femur.

There were nine male and eleven female patients. The average age at the time of surgery was 22.7 years (range, thirteen to



Fig. 1-A

Figs. 1-A through 1-D An eighteen-year-old female patient with severe acetabular dysplasia and varus malalignment of the proximal part of the femur who presented with pain in the right hip and a limp. The preoperative hip flexion was 105° . **Fig. 1-A** The patient had a history of Legg-Calvé-Perthes disease and a previous varus-producing proximal femoral osteotomy. She had an elliptical femoral head, a short femoral neck, and a relatively high greater trochanter. There was marked acetabular dysplasia.

forty-four years), and all patients were skeletally mature. The average height of the patients at the time of surgery was 163.7 cm (range, 137 to 183 cm), and the average weight was 65.8 kg (range, 42.5 to 99.9 kg). The average body-mass index was 24.1 (range, 18.4 to 31.6). Twelve hips (50%) had not undergone a previous surgical procedure, and the remaining twelve hips had had a total of thirty-three surgical procedures prior to the index periacetabular osteotomy. Two of these hips had one previous procedure, three hips had two, three hips had three, and four hips had four previous procedures. Open reduction of the hip had been performed eleven times in six hips, a varus-producing proximal femoral osteotomy had been performed in seven hips, and an adductor tenotomy had been performed in five hips. Also, a Salter osteotomy, a trochanteric transfer, and incision and drainage for infection had been performed separately in three hips, and seven hips had previously had hardware removed.

All patients had progressive hip pain and hip flexion of $\geq 95^\circ$. None had advanced degenerative joint disease (Tönnis grade-3 osteoarthritis¹⁷), and all had adequate congruency, which we defined as a concentric relationship between the acetabular sourcil and the superior portion of the femoral head on an anteroposterior plain radiograph with the hip in flexion



Fig. 1-B

A periacetabular osteotomy was performed, and the intraoperative acetabular correction is demonstrated.

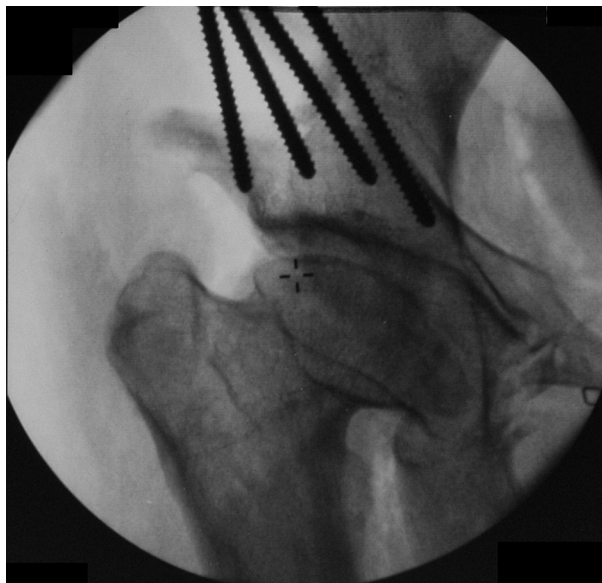


Fig. 1-C

After completion of the periacetabular osteotomy, an intraoperative adduction radiograph demonstrated maintenance of congruency. A proximal femoral valgus-producing osteotomy, a trochanteric advancement, and an osteochondroplasty of the femoral head-neck junction were then performed.

and abduction. The flexion-abduction radiograph simulates the congruency obtained with the periacetabular osteotomy.

The decision to perform an adjunctive femoral procedure was based on an intraoperative assessment of the hip. Because the preoperative abduction range of motion was limited

by the Perthes-like deformities, after completion of the periacetabular osteotomy, we assessed the hip with an anteroposterior flexion-adduction functional radiograph to simulate the correction and congruency that might be obtained with a proximal femoral valgus-producing osteotomy. If there was $<20^\circ$ of hip abduction after acetabular reorientation and if the intraoperative adduction functional radiograph showed maintenance of or improvement in the congruency of the joint, we performed a proximal femoral valgus-producing osteotomy. The goals of performing the femoral osteotomy were to enhance joint congruity, improve clinical abduction, minimize anterolateral femoroacetabular impingement, advance the greater trochanter distally and laterally, and lengthen the extremity (Figs. 1-A through 1-D).

All twenty-four hips were treated with a periacetabular osteotomy^{13,18,19} to correct the acetabular deformity. Twenty-



Fig. 1-D

Twenty-four months postoperatively, the radiograph shows osteotomy healing and correction of the deformities. The patient had no pain in the hip and an excellent clinical result.

one concurrent femoral osseous or soft-tissue procedures were performed in fifteen hips (63%). These included thirteen proximal femoral valgus-producing osteotomies, one trochanteric advancement, and one isolated osteochondroplasty of the femoral head-neck junction²⁰. An osteochondroplasty was also performed in conjunction with one of the proximal femoral osteotomies. Three hips had an adductor tenotomy, and two of these hips also had a fractional lengthening of the psoas tendon. Three proximal femoral valgus-producing osteotomies were performed as a second stage at six weeks after a technically demanding periacetabular osteotomy.

Surgical Technique

The acetabular osteotomy was performed as previously described by Ganz et al.^{13,18,19}. Electromyographic peripheral nerve monitoring was used in all acetabular procedures²¹. A Cell Saver (Haemonetics, Braintree, Massachusetts) was utilized for blood collection and reinfusion. A modified anterior²² or modified Smith-Peterson¹³ approach was used. Periacetabular cuts, acetabular reduction, and screw fixation were monitored intraoperatively with fluoroscopy. The correction of the acetabulum (anterior coverage, lateral coverage, and acetabular inclination) was assessed intraoperatively with anteroposterior and false-profile fluoroscopic images. The acetabular fragment was fixed with three, four, or five 4.5-mm cortical screws. An arthrotomy was not routinely performed in the first twenty-one procedures, but it was performed in three hips later in the series. Two of these three hips demonstrated anterior femoroacetabular impingement, for which a head-neck-junction osteoplasty was performed. At the time of the arthrotomy, impingement was assessed by inspection of the femoral head for an impingement trough that demarcated asphericity and by testing for abutment of the femoral head-neck junction on the acetabular rim with the hip in flexion and internal rotation.

Clinical Evaluation

Clinical hip function was assessed with the Harris hip score preoperatively and at the time of the follow-up visits⁷. A score of 91 to 100 points indicated excellent function; 81 to 90 points, good function; 71 to 80 points, fair function; and ≤ 70 points, poor function. All patients returned for a follow-up clinic visit and radiographic examination at a minimum of two years, and the average duration of clinical follow-up was 3.9 years (range, 2.0 to 9.3 years). Telephone interviews²³ of all patients who had not been seen in the clinic in the past twelve months were conducted to assess the subjective functional outcome (modified Harris hip score) and to ensure that they had not undergone a total hip arthroplasty or any other surgical procedure on the involved hip(s). The average duration of clinical follow-up, including telephone interviews, was 4.5 years. Patient-reported overall satisfaction with the surgical procedure was also ascertained at the most recent follow-up visit or telephone interview. The patients were asked whether they were satisfied with the result of their surgical treatment. A yes-or-no response was recorded. This information was collected by one of the treating surgeons at the time of the clinical follow-up visits or by an in-

dividual who was not a treating surgeon during the telephone interview. No patient was lost to follow-up. All other clinical and operative data were obtained from a retrospective chart review by one of the authors (R.M.N.), who was not involved in the clinical care of the patients.

Radiographic Evaluation

Preoperative and periodic postoperative radiographic analysis was performed in an unblinded fashion for all patients by one senior-level orthopaedic resident (R.M.N.) in conjunction with one attending surgeon (J.C.C.). Standing anteroposterior and false-profile radiographs were made at each clinic visit. The lateral center-edge angle of Wiberg²⁴, anterior center-edge angle of Lequesne and de Seze²⁵, acetabular roof obliquity^{26,27}, and hip center position^{26,28} were measured, and the preoperative and postoperative values were compared to assess deformity correction. Osseous healing was determined by the presence or absence of consolidation across the osteotomy sites on both the anteroposterior and false-profile radiographs. The ischial, superior pubic ramus, iliac, and posterior column osteotomies were all evaluated for radiographic evidence of healing. Grading of the osteoarthritis was performed with the Tönnis classification system^{27,29}.

Statistical Analysis

Preoperative and follow-up clinical hip scores and radiographic parameters of acetabular position were compared with a paired *t* test. Significance was determined at a *p* value of < 0.05 .

Results

At an average of 4.5 years (range, 2.0 to 9.3 years) postoperatively, nineteen patients (twenty-two hips; 92%) were satisfied with the clinical result of surgery. The Harris hip score had improved in nineteen patients (twenty-two hips; 92%). The average Harris hip score for all patients was 68.8 (range, 44 to 93 points) preoperatively, and it had improved to 91.3 (range, 69 to 100 points) at the most recent clinical evaluation ($p < 0.0001$). Sixteen patients (nineteen hips) had an excellent clinical result, and one patient (one hip) had a good clinical result. Two patients (two hips) had a fair result, and one patient (two hips) had a poor clinical result. No hip had been converted to a total joint arthroplasty. The pain component of the Harris hip score improved for nineteen patients (twenty-two hips) from a mean score of 21.8 points (range, 10 to 44 points) preoperatively to 38.2 points (range, 20 to 44 points) at the latest follow-up visit ($p < 0.0001$). At that evaluation, thirteen patients (fifteen hips) had no associated pain, four patients (five hips) had slight occasional pain, one patient (two hips) had mild pain, and two patients (two hips) had moderate pain. No patient reported severe pain. Seventeen patients (twenty hips) had no limp (as reported by the patient), two patients (two hips) had a slight occasional limp, and one patient (two hips) had a moderate limp. Seventeen patients (twenty hips) were able to walk an unlimited distance, while three patients (four hips) were able to walk a limited distance of six blocks or less. Eighteen patients (twenty-one hips) required no assistive device for walking, one patient

TABLE I Summary of Radiographic Correction and Osteoarthritis Progression

	Radiographic Findings*		P Value
	Preop.	Postop.	
Lateral center-edge angle (<i>deg</i>)	2.9 (–28 to 19)	30.5 (15 to 51)	<0.0001
Anterior center-edge angle (<i>deg</i>)	–3.96 (–32 to 19)	29.2 (–25 to 52)	<0.0001
Acetabular roof obliquity (<i>deg</i>)	25.2 (15 to 45)	8.7 (–5 to 21)	<0.0001
Hip joint medialization (<i>mm</i>)	16.1 (9 to 24)	9.8 (0 to 23)	0.0003
Tönnis grade (<i>no. of hips</i>)			
0	19	15	
1	4	7	
2	1	2	
3	0	0	

*The values are given as the mean, with the range in parentheses.

(two hips) required use of a cane for long distances, and one patient (one hip) used a cane at all times.

One patient (two hips) was not satisfied. This patient had atypical dysplasia associated with static encephalitis. The patient was limited by the underlying neuromuscular disorder, and symptoms recurred in the hip after isolated periacetabular osteotomies. Two patients (two hips) had a fair clinical result, yet they were satisfied with the improvement from surgery. One patient with a fair result after treatment with a periacetabular osteotomy and trochanteric advancement reported intermittent pain on the lateral aspect of the hip at the time of the most recent follow-up at four years postoperatively. The second patient with a fair result had had severe acetabular and femoral deformities associated with a congenitally short femur, had multiple previous surgeries on the extremity, and had a major limb-length discrepancy. Although hip congruency and femoral head coverage were improved with the surgery, the patient continued to have activity-related hip pain.

Radiographic analysis demonstrated consistent deformity correction and significant improvements in the lateral center-edge angle (mean, 27.6°; $p < 0.0001$), the anterior center-edge angle (mean, 33.1°; $p < 0.0001$), the acetabular roof obliquity (mean, 16.5°; $p < 0.0001$), and hip joint medialization (mean, 6.3 mm; $p = 0.0003$) (Table I). The Tönnis osteoarthritis grade was unchanged in twenty hips, it progressed one grade in three hips, and it progressed two grades in one hip. None of the hips had advanced degenerative changes (Tönnis grade-3 osteoarthritis) at the most recent follow-up evaluation. All of the major osteotomies healed, although two patients (two hips) had nonunion of an osteotomy of the superior pubic ramus. One of those patients was asymptomatic, and one was treated surgically (see below).

Additional Procedures and Complications

Despite the overall good clinical results, additional procedures (with the exclusion of elective hardware removal) were performed in three patients to optimize the hip reconstruction. Two of the three additional procedures were performed for

persistent hip symptoms related to secondary anterior femoroacetabular impingement. One patient underwent open reduction and internal fixation with iliac crest bone-grafting for nonunion at the site of a superior pubic ramus osteotomy and had no relief of symptoms. Subsequently, this hip was treated with combined arthroscopic labral débridement and a limited open femoral head-neck junction osteoplasty for anterior impingement³⁰. The patient did well after that procedure. He was satisfied with the overall result and had a Harris hip score of 92 points at the time of the four-year follow-up. The second patient had hip symptoms recur five years postoperatively because of residual anterior femoroacetabular impingement. The symptoms worsened over time, and seven years after the index procedure, the patient underwent open labral débridement, osteoplasty of the acetabular rim, osteoplasty of the femoral head-neck junction, and trochanteric advancement. Five months after this second procedure, the patient was asymptomatic except for a slight limp and she had a Harris hip score of 96 points. The third patient underwent screw exchange one month following periacetabular osteotomy because of a concern for intra-articular penetration.

Major complications occurred in three patients, with two requiring surgery. All three complications occurred in the first eleven procedures that we performed; all three patients had previous procedures on the hip. One patient who had a previous proximal femoral varus-producing osteotomy and adductor release had excessive limb-lengthening, which was associated with the combined periacetabular osteotomy and proximal femoral valgus-producing osteotomy, and she had a transient peroneal nerve palsy. Five days postoperatively, the patient underwent femoral shortening through the osteotomy. At forty-four months postoperatively, she had an excellent clinical result with a Harris hip score of 93 points. The patient had a full recovery of motor function with slightly decreased sensation over the distal lateral aspect of the calf that was not a problem. Another patient had a transient femoral nerve palsy develop following an isolated periacetabular osteotomy. Electromyographic monitoring had not detected femoral nerve

stimulation during the surgical procedure. This patient had a history of two open hip reductions in childhood and a previous proximal femoral varus-producing osteotomy for the treatment of developmental dysplasia of the hip. The patient had full motor recovery with slightly decreased sensation over the anteromedial aspect of the thigh that was not a problem. At sixty-seven months, the patient had an excellent clinical result with a Harris hip score of 93 points. One patient (who had two previous open reductions, an adductor release, and a proximal femoral osteotomy) reported continued pain in the groin and the lateral aspect of the hip for several months following the combined periacetabular osteotomy and proximal femoral valgus-producing osteotomy. On the basis of the radiographs, we suspected a delayed union of the intertrochanteric osteotomy at eleven months. The patient underwent exploration and was found to have a partial union that was treated with iliac crest bone-grafting. The osteotomy went on to heal by six months, and she had a hip score of 97 points at the time of the last visit (sixty-three months postoperatively).

One additional complication included the development of heterotopic ossification (Brooker class II) in one hip that was associated with an excellent clinical result and a Harris hip score of 92 points at the two-year evaluation. No patient had a major, persistent neurovascular injury, an intra-articular fracture, or a thromboembolic complication, and no hip had a total hip arthroplasty.

Discussion

Perthes-like hip deformities in skeletally mature patients are known to be associated with a substantial risk for subsequent degenerative osteoarthritis in the fifth and sixth decades of life⁶⁻¹¹. To date, the optimal method(s) and timing of surgical intervention in these patients remain controversial. Perhaps the most challenging clinical scenario occurs when a Perthes-like deformity of the proximal part of the femur is associated with substantial acetabular dysplasia. In this circumstance, we have used the periacetabular osteotomy¹³ for deformity correction on the acetabular side combined, in selected patients, with a valgus-producing proximal femoral osteotomy. Our results demonstrate substantial improvements in clinical hip function and a high rate of patient satisfaction at a mean follow-up of 4.5 years. Similarly, one of the innovators of the periacetabular osteotomy¹ reported good to excellent results in 88% of twenty-seven Perthes-like hips followed for thirty-six months. Our radiographic analysis revealed significant improvement in the radiographic parameters of acetabular dysplasia and reliable healing of the acetabular osteotomy.

We also observed a relatively high risk for perioperative complications and reoperations. This is likely due to several factors that increase the complexity of these procedures. First and most importantly, many of these procedures were performed early in our experience¹⁷ with the periacetabular osteotomy. Secondly, many of these patients had severe deformities and had previous surgical procedures on the involved hip, both of which may have contributed to a higher risk of perioperative complications.


Our surgical strategy for Perthes-like hip deformities has evolved over time. Careful preoperative assessment is necessary to determine whether the hip symptoms are primarily caused by instability, impingement, or a combination of these two problems. Surgical treatment is then tailored to correct the specific deformities in each hip and may employ a combination of techniques, including periacetabular osteotomy, proximal femoral osteotomy, osteochondroplasty of the head-neck junction, trochanteric advancement, and/or labral débridement or repair. Currently, when acetabular dysplasia is present and clinical evaluation suggests that the acetabular deformity is symptomatic (lateral abductor fatigue pain and joint overload pain, i.e., discomfort in the groin with upright activities), we correct the acetabular deformity to optimize hip biomechanics and relieve localized articular overload associated with joint instability. However, it must be emphasized that acetabular reorientation alone to improve anterolateral coverage of the femoral head and normalize the acetabular inclination reduces hip flexion and abduction motion. This is of specific concern because of the potential for anterolateral impingement with a large aspherical femoral head. For this reason, we remain reluctant to perform an acetabular reorientation unless the patient has $\geq 95^\circ$ of hip flexion preoperatively. Thus, acetabular reorientation may result in secondary femoroacetabular impingement, which should be corrected with adjunctive procedures on the femoral side^{20,31-33}. Two of our patients treated early in the series with only a periacetabular osteotomy had symptomatic, secondary femoroacetabular impingement develop, and they required an additional procedure to decompress the joint anterolaterally. Both of these hips had an anterior labral tear and demonstrated impingement of the femoral head-neck junction on the acetabular rim. Labral débridement and anterior decompression was associated with excellent relief of symptoms. These two instances heightened our awareness of this problem and prompted us to be more aggressive in performing an arthrotomy and adjunctive femoral procedures with the goal of optimizing the impingement-free range of motion after acetabular reorientation. Currently, we always perform an arthrotomy to inspect the labrum and to treat (débride or repair) unstable labral tears. The anterior femoral head-neck junction is then evaluated, and the hip is assessed for anterior impingement during flexion and internal rotation. If impingement is observed from a large aspherical femoral head, we perform an osteochondroplasty of the head-neck junction to optimize impingement-free hip flexion. If additional femoral correction is required, we perform a proximal femoral valgus-producing osteotomy and/or a trochanteric advancement to optimize hip congruency and range of motion, abductor function, and limb length.

There are certain limitations of this study. This is a retrospective review that analyzes procedures performed over our learning experience with the periacetabular osteotomy. It is likely that our clinical results, complication rate, and reoperation rate may be more favorable in the future as our experience broadens. While all patients received a periacetabular osteotomy, the adjunctive proximal femoral reconstructive techniques we utilized varied as we became more experienced in treating

these patients with unique combinations of deformities. Finally, identifying an appropriate control group for this patient cohort is difficult. Even historical cohorts followed in natural history studies⁶⁻¹¹ are of limited value because of the substantial heterogeneity of Perthes-like deformities in terms of the pathoanatomy, associated acetabular abnormalities, and clinical manifestation of the structural disease. The cohort we analyzed is unique in that it represents a consecutive series of patients who all had a symptomatic hip, Perthes-like disease of the proximal part of the femur, and associated acetabular dysplasia.

In summary, we emphasize that surgical treatment of acetabular dysplasia associated with Perthes-like femoral deformities is complex, and the entire pathoanatomy of the hip must be taken into account. Our results suggest that periacetabular osteotomy combined with appropriate femoral correction, when indicated, is associated with good clinical results at short-term to mid-term follow-up. Continued clinical and radiographic evaluation at longer-term follow-up is essential to assess the efficacy of this surgical strategy.

Appendix

 A table showing details on all patients in the study is available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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References

- Beck M, Mast JW. The periacetabular osteotomy in Legg-Perthes-like deformities. *Semin Arthroplasty*. 1997;8:102-7.
- Heyman CH, Herndon CH. Legg-Perthes disease; a method for the measurement of the roentgenographic result. *J Bone Joint Surg Am*. 1950;32:767-78.
- Stulberg SD, Cooperman DR, Wallensten R. The natural history of Legg-Calvé-Perthes disease. *J Bone Joint Surg Am*. 1981;63:1095-108.
- Joseph B. Morphological changes in the acetabulum in Perthes' disease. *J Bone Joint Surg Br*. 1989;71:756-63.
- Kamegaya M, Shinada Y, Moriya H, Tsuchiya K, Akita T, Someya M. Acetabular remodelling in Perthes' disease after primary healing. *J Pediatr Orthop*. 1992;12:308-14.
- Aronson J. Osteoarthritis of the young adult hip: etiology and treatment. *Instr Course Lect*. 1986;35:119-28.
- Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am*. 1969;51:737-55.
- McAndrew MP, Weinstein SL. A long-term follow-up of Legg-Calvé-Perthes disease. *J Bone Joint Surg Am*. 1984;66:860-9.
- Mose K. Methods of measuring in Legg-Calvé-Perthes disease with special regard to the prognosis. *Clin Orthop Relat Res*. 1980;150:103-9.
- Mose K, Hjorth L, Ulfeldt M, Christensen ER, Jensen A. Legg Calvé Perthes disease. The late occurrence of coxarthrosis. *Acta Orthop Scand Suppl*. 1977;169:1-39.
- Yrjonen T. Long-term prognosis of Legg-Calvé-Perthes disease: a meta-analysis. *J Pediatr Orthop B*. 1999;8:169-72.
- Clohisy JC, Barrett SE, Gordon JE, Delgado ED, Schoenecker PL. Periacetabular osteotomy for the treatment of severe acetabular dysplasia. *J Bone Joint Surg Am*. 2005;87:254-9.
- Ganz R, Klaue K, Vinh TS, Mast JW. A new periacetabular osteotomy for the treatment of hip dysplasias. Technique and preliminary results. *Clin Orthop Relat Res*. 1988;232:26-36.
- Matta JM, Stover MD, Siebenrock K. Periacetabular osteotomy through the Smith-Petersen approach. *Clin Orthop Relat Res*. 1999;363:21-32.
- Siebenrock KA, Scholl E, Lottenbach M, Ganz R. Bernese periacetabular osteotomy. *Clin Orthop Relat Res*. 1999;363:9-20.
- Trousdale RT, Ekkernkamp A, Ganz R, Wallrichs SL. Periacetabular and intertrochanteric osteotomy for the treatment of osteoarthritis in dysplastic hips. *J Bone Joint Surg Am*. 1995;77:73-85.
- Davey JP, Santore RF. Complications of periacetabular osteotomy. *Clin Orthop Relat Res*. 1999;363:33-7.
- Clohisy JC, Barrett SE, Gordon JE, Delgado ED, Schoenecker PL. Periacetabular osteotomy in the treatment of severe acetabular dysplasia. Surgical technique. *J Bone Joint Surg Am*. 2006;88(1 Suppl 1):65-83.
- Leunig M, Siebenrock KA, Ganz R. Instructional course lecture. Rationale of periacetabular osteotomy and background work. *J Bone Joint Surg Am*. 2001;83:438-48.
- Myers SR, Eijer H, Ganz R. Anterior femoroacetabular impingement after periacetabular osteotomy. *Clin Orthop Relat Res*. 1999;363:93-9.
- Trousdale RT, Cabanela ME, Berry DJ, Wenger DE. Magnetic resonance imaging pelvimetry before and after a periacetabular osteotomy. *J Bone Joint Surg Am*. 2002;84:552-6.
- Murphy SB, Millis MB. Periacetabular osteotomy without abductor dissection using direct anterior exposure. *Clin Orthop Relat Res*. 1999;364:92-8.
- McGrory BJ, Shinar AA, Freiberg AA, Harris WH. Enhancement of the value of hip questionnaires by telephone follow-up evaluation. *J Arthroplasty*. 1997;12:340-3.
- Wiberg G. The anatomy and roentgenographic appearance of a normal hip joint. *Acta Chir Scand*. 1939;83 Suppl 58:7-38.
- Lequesne M, de Seze. [False profile of the pelvis. A new radiographic incidence for the study of the hip. Its use in dysplasias and different coxopathies]. *Rev Rhum Mal Osteoartic*. 1961;28:643-52. French.
- Matsui M, Masuhara K, Nakata K, Nishii T, Sugano N, Ochi T. Early deterioration after modified rotational acetabular osteotomy for the dysplastic hip. *J Bone Joint Surg Br*. 1997;79:220-4.
- Tönnis D. Congenital dysplasia and dislocation of the hip in children and adults. New York: Springer; 1987.
- Clohisy JC, Barrett SE, Gordon JE, Delgado ED, Schoenecker PL. Medial translation of the hip joint center associated with the Bernese periacetabular osteotomy. *Iowa Orthop J*. 2004;24:43-8.
- Mayo KA, Trumble SJ, Mast JW. Results of periacetabular osteotomy in patients with previous surgery for hip dysplasia. *Clin Orthop Relat Res*. 1999;363:73-80.
- Clohisy JC, McClure JT. Treatment of anterior femoroacetabular impingement with combined hip arthroscopy and limited anterior decompression. *Iowa Orthop J*. 2005;25:164-71.
- Beck M, Leunig M, Parvizi J, Boutier V, Wyss D, Ganz R. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. *Clin Orthop Relat Res*. 2004;418:67-73.
- Ganz R, Gill TJ, Gautier E, Ganz K, Krugel N, Berlemann U. Surgical dislocation of the adult hip: a technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. *J Bone Joint Surg Br*. 2001;83:1119-24.
- Lavigne M, Parvizi J, Beck M, Siebenrock KA, Ganz R, Leunig M. Anterior femoroacetabular impingement: part I. Techniques of joint preserving surgery. *Clin Orthop Relat Res*. 2004;418:61-6.