Bipolar Hemiarthroplasty in Juvenile Rheumatoid Arthritis

Long-Term Survivorship and Outcomes

Andrew G. Yun, MD,* Scott Martin, MD,† David Zurakowski, PhD,‡ and Richard Scott, MD†

Abstract: Because controversy surrounds the management of end-stage hip disease in juvenile rheumatoid arthritis (JRA), this study evaluated the long-term outcome of bipolar hemiarthroplasty as an alternative to conventional joint arthroplasty. A total of 24 JRA patients underwent 39 hemiarthroplasties; follow-up averaged 12 years (range, 3 to 15 years). There were 14 hips (36%) revised, and 25 hips (64%) maintained the original components. Mean Harris hip scores in surviving hips improved from 29 to 69 points ($P<.001$). Radiographs showed progressive bipolar superomedial migration ($P<.01$) despite attempted augmentation. Failure defined as revision to total hip arthroplasty or definite radiographic loosening occurred in 15 hips (38%). Ten-year Kaplan-Meier survivorship for all prostheses was 78%. Independent multivariate risk factors for failure included acetabular grafting ($P = .006$), prosthesis type ($P<.001$), and unilateral replacement ($P<.001$). **Key words:** bipolar hemiarthroplasty, juvenile rheumatoid arthritis (JRA), total hip arthroplasty (THA), complications, revision, survivorship.

Juvenile rheumatoid arthritis (JRA) can exert a devastating and widespread effect on hips at risk. Numerous long-term reviews show the high incidence of progressive degeneration that ultimately affects most of these patients [1]. A retrospective analysis of 386 JRA hips by Jacobsen, Crawford, and Broste [2] showed these destructive changes lead to poor overall outcomes. Chronic pain and loss of function ensue, and the consequent morbidity is magnified further in a population vulnerable to altered or delayed psychosocial development.

The treatment dilemma surrounds the peculiarities of the JRA population—young age, abnormal pelvic and femoral anatomy, contractures, and polyarticular involvement. The youth of these patients warrants a cautious approach and an emphasis on efforts maximizing joint preservation. Nonarthroplasty alternatives, such as synovectomy or osteotomy, have yielded historically inconsistent results, however, and no longer are indicated in end-stage hip disease. Despite the implicit risk of future revisions, prosthetic reconstruction has emerged as the most predictable form of treatment.

Total hip arthroplasty (THA) provides reliable functional improvement [3–7]. Questions surround the long-term durability of these components, however, especially on the acetabular side. Rates of failure or loosening of cemented cups are 25% to

*From the *Arthritis Institute, Inglewood, California; †Brigham and Women's Hospital; and ‡Departments of Orthopaedic Surgery and Biostatistics, Children's Hospital, Boston, Massachusetts.*
Submitted November 29, 2001; accepted June 13, 2002.
No benefits or funds were received in support of this study.
Reprint requests: Andrew Yun, MD, 535 East 70th Street, Department of Orthopaedic Surgery, The Hospital for Special Surgery, New York, NY 10021. E-mail: yuna@hss.edu

0883-5403/02/1708-0014$35.00/0
doi:10.1054/arth.2002.35799

60% in long-term follow-up [7–12]. Long-term results of cementless sockets are not yet available. Bone-sparing strategies not involving a fixed acetabular component may represent a reasonable reconstructive alternative. Early reports of endoprostheses described early short-term success but raised secondary issues of potential migration with bone deficiencies, osteolysis, and unreliable pain relief [13,14]. In response to the uncertainties regarding the lasting effects of hemiarthroplasty in JRA, we report the long-term results and complications of patients after bipolar reconstruction.

Materials and Methods

From 1983 to 1990, 24 consecutive patients with JRA underwent a total of 39 hip primary bipolar hemiarthroplasties at the Brigham and Women's Hospital. Data were collected by an independent Total Joint Registry and surgeons not directly involved in the index procedure. The charts and radiographs of these patients were retrospectively reviewed. All patients were available for follow-up and included in analysis until the time of revision or death. Follow-up averaged 12.2 ± 3.8 years (range, 3 to 15 years).

Patients included 6 males and 18 females with a mean age of 22 ± 9 years (range, 11 to 51 years), mean height of 61 cm (range, 49 to 70 cm), and mean weight of 106 lb. (range, 91 to 143 lb.). All patients complained of symptoms refractory to medical management, and 3 patients (4 hips) already had failed prior hip surgery, including synovectomy or osteotomy. Nearly all patients were handicapped with severe polyarticular disease. Of 24 patients, 22 (92%) were classified as Charnley class C, and most had undergone or soon underwent additional prosthetic reconstructions in other large joints.

Clinical outcomes were measured using the Harris hip score. Only the subset of patients with retained components were able to be included in clinical and radiographic follow-up; hips that were revised were defined as failures. Preoperative radiographs were studied for the extent of degenerative changes and protrusio. Serial standard anteroposterior pelvis and hip films were used for comparative evaluation of migration, graft incorporation and resorption, and loosening using Mueller templates. Determination of loosening and migration were per methods previously well described by Wilson and Nikpoor et al [15], O'Neill and Harris [16], and Engh, Bobyn, and Glassman [17]. Estimated survival was calculated using a Kaplan-Meier survivorship model at 10 and 12 years and defined as freedom from failure by either revision surgery or definite loosening.

Procedure

Surgery was done on 21 right and 18 left hips. Nine patients underwent unilateral hemiarthroplasty, and 15 patients had either same-day or staged bilateral surgery spaced 10 to 14 days apart. A standard posterolateral approach was used in all cases, with 11 exposures augmented with trochanteric osteotomy. Complete capsulectomy was done in all cases, and 4 hips had additional iliopsoas release.

Notable portions of acetabular preparation include removal of remaining arthritic cartilage with gentle reaming and preservation of subchondral bone. Morcellized femoral head autograft was used in 26 hips, with additional morcellized allograft needed in 7 hips. No bulk allograft was used, and 13 hips did not require acetabular grafting. A Stryker Howmedica Osteonics (Allendale, NJ) Bipolar Cap was chosen to achieve either press fit or line-to-line fit, and intraoperative radiographs often were used to verify maximal filling of the acetabulum. Femoral stem fixation involved 35 uncemented and 4 cemented components. Custom components were necessary in 8 hips. Cementing techniques were second generation.

Statistical Analysis

Estimated survivorship rates at 5, 10, and 12 years were determined using the Kaplan-Meier method with 95% confidence intervals based on Greenwood's formula, and subgroups were compared by the log-rank test [18]. Time-related univariate and multivariate analysis was done using the Cox proportional hazards regression model with failure as the outcome variable [19]. A forward stepwise procedure was used to identify the independent predictors of bipolar arthroplasty failure by examining 12 variables simultaneously: age at surgery, gender, side, unilateral versus bilateral arthroplasty, Charnley class, follow-up mobility, acetabular grafting, preoperative protrusio, integrity of the subchondral plate, inner bearing head diameter, femoral stem type, and cemented versus uncemented fixation. The risk ratio and 95% confidence intervals were calculated to assess the annual risk of failure for each significant multivariate predictor.

Preoperative and postoperative outcomes, including pain and function scores and Harris hip scores, were evaluated by paired *t*-tests. Radio-

Table 1. Clinical Outcomes for Surviving Hips (n = 24)

Outcome	Preoperative	Follow-Up	Improvement	*P* Value*
Pain score	14 ± 11	42 ± 6	28 ± 12	<.001
Function score	5 ± 4	5 ± 4	0 ± 4	.43
Harris hip score	29 ± 18	69 ± 17	40 ± 22	<.001

NOTE. Values represent the mean and SD.
**P* values are based on paired *t*-tests.

graphic outcomes including superior and medial position and acetabular wall thickness were evaluated using repeated-measures analysis of variance followed by Bonferroni-adjusted paired *t*-tests for evaluating changes between preoperative, postoperative, and follow-up values. Because all clinical and radiographic outcome variables followed a normal distribution as assessed by the Kolmogorov-Smirnov goodness-of-fit test [20], values are presented in terms of the mean and SD. Two-tailed *P* values <.05 were considered statistically significant for all comparisons. Statistical analysis was conducted using the SAS (version 6.12; SAS Institute, Cary, NC). A power analysis indicated that a sample size of 30 hips would provide 90% power ($\beta = 0.10$, $\alpha = 0.05$) for detecting a difference of 1 SD (effect size of 1.0) between preoperative and postoperative values for each of the clinical and radiographic outcome variables using multiple paired *t*-tests with a Bonferroni correction (version 4.0, nQuery Advisor; Statistical Solutions, Boston, MA).

Results

Bipolar hemiarthroplasty led to a statistically significant improvement in clinical outcomes in surviving hips ($P<.001$). Outcomes related to pain and function improved by a mean of 28 and 4 points (Table 1). Overall Harris hip scores improved by a mean ± SD of 40 ± 22 points.

Preoperatively, nearly all patients complained of significant pain. Four patients were totally disabled, and 20 had marked-to-moderate symptoms. Long-term follow-up of 25 surviving hips in 14 patients revealed statistically significant relief of pain ($P< .001$), with 13 of 14 patients (93%) having mild or no pain. The 1 patient (1 hip) with moderate pain persisting in follow-up had improved 20 points from her preoperative condition (from 0 to 20).

Mobility in patients with surviving hips, defined by ambulatory distance and the need for assistive devices, showed limited gains. Preoperatively, 5 patients were unable to walk, 4 patients were limited to the home, 11 were limited community ambulators, and 4 patients considered their walking unlimited. For assistance, 15 required either a wheelchair or 2 crutches, and 8 patients used either a cane or no device at all. In follow-up of surviving hips, 2 patients remained unable to walk and required wheelchairs. Of these, 1 patient was mentally retarded and completely dependent in all activities of daily living, and the other had bilateral hip and bilateral knee arthroplasties with a severe spinal scoliosis. Two patients were unlimited community ambulators, and the remaining 10 patients were able to walk 2 to 6 blocks. Only 1 patient reported deterioration in mobility from 6 blocks down 2 blocks. Of ambulatory patients, 4 used 2 crutches, and 8 patients needed either a cane or no aid at all.

Radiographic Results

Preoperative radiographs of 1 patient (2 hips) had been destroyed and were unavailable for review. Preoperative radiographic findings in 37 hips showed 23 hips (62%) with an intact subchondral plate, 24 hips (65%) with femoral head changes consistent with osteonecrosis, and 14 hips (38%) with protrusio deformity.

All acetabula that had been grafted showed radiographic evidence of incorporation. Postoperative analysis of all hips revealed an initial statistically significant improvement in the center of rotation to a more anatomic inferolateral position ($P<.01$) (Table 2). Only 1 patient had an early worsening of acetabular position. This worsening was noted in a radiograph taken 2 years after surgery in a patient with rapid osteolysis, femoral stem loosening, and recurrent protrusio. Long-term comparisons in surviving hips were remarkable, however, for a loss of correction and medial wall thickness ($P<.01$). The bipolar heads shifted over time toward the original preoperative position; Table 2 details the extent of recurrent superior and medial migration in these hips as measured with Mueller templates (Fig. 1). Follow-up of 25 surviving hips revealed recurrent protrusio in 7 hips (28%). All of these occurred in patients who had preoperative protrusio deformity. In contrast, of the 14 hips that underwent revision, there was significant erosion of the acetabulum with central bone loss. Although protrusio in this subset was as extensive as preoperative deficiencies,

Table 2. Radiographic Outcomes for Surviving Hips (n = 24)

Parameter	Preoperative	Postoperative	Follow-Up	Overall *P* Value*
Superior position	26 ± 5	22 ± 4	26 ± 6	<.01
Medial position	26 ± 5	25 ± 6	24 ± 7	<.01
Acetabular wall thickness	5 ± 4	7 ± 3	5 ± 5	<.01

NOTE. Values are mean and SD in millimeters.
*Based on repeated-measures analysis of variance with post-hoc Bonferroni-corrected time-point comparisons.
Significant reduction in superior and medial bipolar cup position and an increase in acetabular wall thickness after surgery ($P<.01$ in each case).
Significant recurrent bipolar cup superior migration and decrease in acetabular wall thickness at follow-up ($P<.01$ in each case).
No significant differences were found for preoperative versus follow-up for any of the radiographic parameters.

there were no cases of major column defects or pelvic discontinuities.

Bead shedding was notably prevalent in 1 specific type of stem, the Stryker Howmedica Osteonics HS2P stem. Of 13 components, 11 (85%) showed shedding of the proximally porous-coated surface. Serial radiographs in these particular hips were remarkable for progressive loosening of femoral components and associated with significant acetabular osteolysis (Fig. 2). This small subset of components also accounted for 10 of the 14 failures (71%) ending in revision. Of the remaining 3 HS2P stems not revised, 1 showed bead shedding with femoral loosening at the time of the patient's death, and the remaining 2 stems were stable in 1 patient who died at 7 years. No other surviving femoral components showed radiographic signs of failure.

Survivorship and Risk Factors

Survivorship estimates were based on Kaplan-Meier product-limit models using as endpoints revision (14 hips) and radiographic loosening (1 hip). Predicted survivorship rates at 10 and 12 years for all hips were 78% and 72% (Table 3). Stratification according to prosthesis showed a significantly higher rate of failure for HS2P patch porous-coated stems compared with all other stems (log-rank test = 24.46; $P<.001$). Notably, predicted 10- and 12-year survivorship rates for HS2P stems were 47% and 28% compared with 95% and 90% for all other stems (Figs. 3 and 4).

Presumed risk factors for clinical and radiographic failure included 11 different variables (Table 4). Univariate analysis indicated that type of stem, older age, and unilateral joint arthroplasty were significantly associated with failure. The mean age of the 15 failures was 26 years compared with 18 years for surviving hips. Multivariate analysis of these 11 variables using the Cox proportional-hazards model revealed 3 statistically significant independent risk factors for failure. The annual estimated risk of failure was 30 times higher for

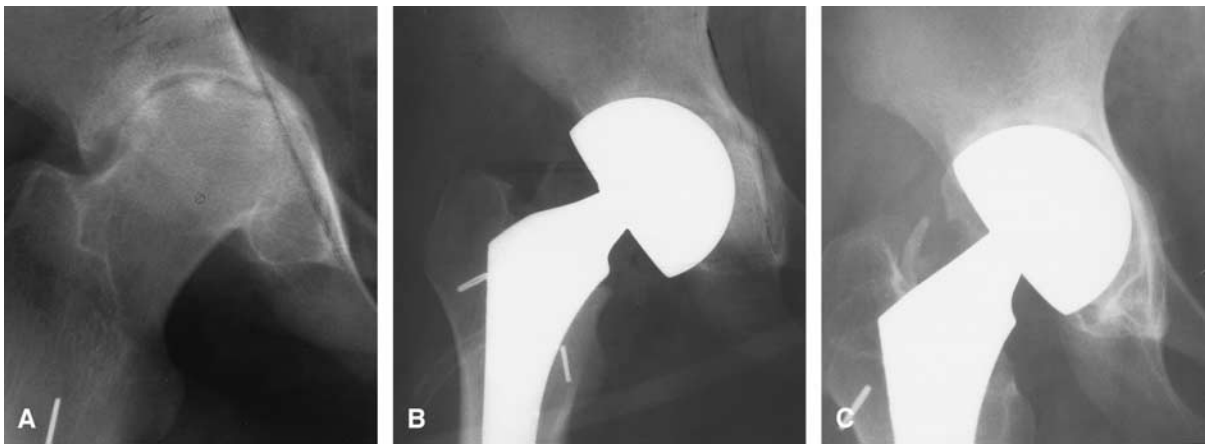

Fig. 1. (A) Preoperative radiograph shows degenerative changes with protrusio. (B) Early postoperative acetabular reconstruction with bone–graft. Note graft incorporation and correction of hip center. (C) Follow-up radiograph shows recurrent superomedial migration.

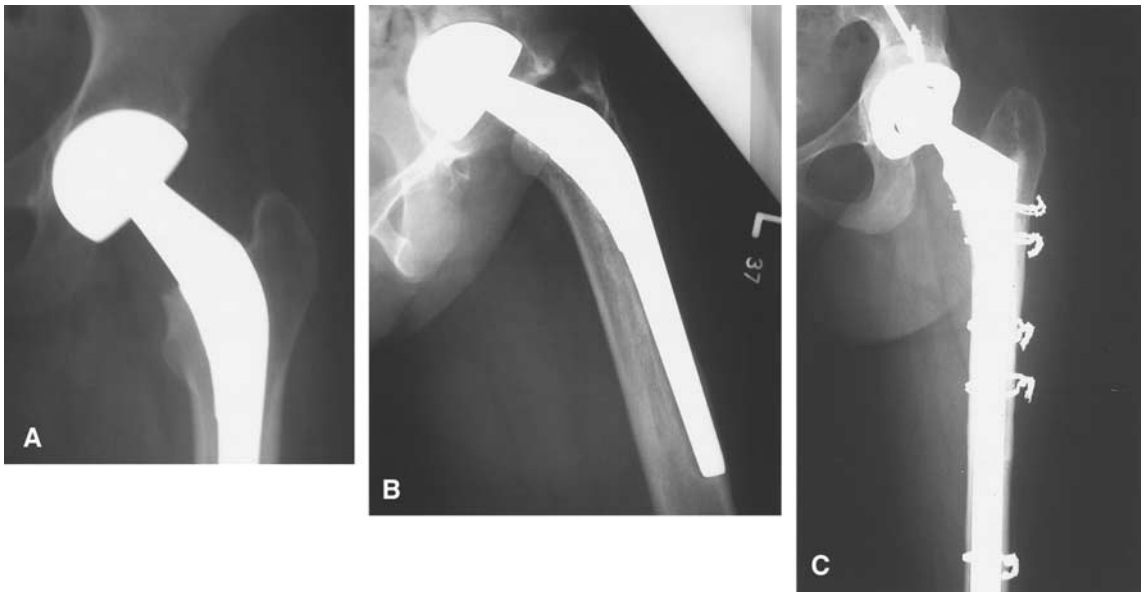

Fig. 2. Aseptic femoral loosening and acetabular osteolysis associated with patch porous-coated stems. (A) Early postoperative radiograph shows a well-fixed component in acceptable alignment. (B) Prosthetic failure with stem migration and cortical perforation and extensive acetabular lysis. (C) Conversion THA with bulk allograft acetabular reconstruction and long-stem revision with strut allograft.

unilateral hemiarthroplasties, 25 times higher for the HS2P stem, and 10 times higher for hips in need of grafting. Even based on the lower limits of the 95% confidence intervals, an estimated annual risk of failure of 3- to 12-fold higher was found for these predictors (Table 4). Age was not found to be a predictor of failure in multivariate analysis.

Of the 11 patients who underwent a total of 14 revisions to THA, the indication for surgery was progressive migration with acetabular lysis and femoral loosening in 12 hips (86%) and acetabular osteolysis in 2 hips (14%). Revision to a fixed acetabular component was mostly straightforward. Cementless hemispherical components with screw fixation were used in all cases, with 12 hips (86%) augmented with morcellized allograft (Fig. 5). One bulk allograft was used in a case with a central cavitary defect, and 1 hip did not require grafting. The sizes of the sockets ranged from 46 to 54 mm. On the femoral side, 13 components (93%) were exchanged, and 1 (7%) was left *in situ*. Revised femoral components included 8 extensively porous-coated stems, 3 long-stem modular proximally porous-coated stems, and 2 cemented stems. Two cases required additional onlay grafting for femoral defects related to osteolysis and cortical thinning.

There were few overall complications. One patient suffered an acute perioperative dislocation that was successfully reduced. There were no further dislocations or any other cases of instability overall. Another patient developed a superficial wound infection that resolved with wound care and antibiotics alone. There were no cases of deep infection. One nondisplaced femoral fracture was identified intraoperatively and treated with cerclage wiring, which resulted in no lasting sequelae. Late complications included 1 case of recalcitrant trochanteric bursitis in a patient who had undergone

Table 3. Kaplan-Meier Freedom From Failure Rates for All Hips and According to Stem Type*

	5-Year	10-Year	12-Year	15-Year
All hips	95% (90–100%)	78% (66–90%)	72% (57–87%)	30% (10–50%)
HS2P stem type	92% (84–100%)	47% (27–67%)	28% (8–48%)	0% (0–10%)
Other types	100% (95–100%)	95% (90–100%)	90% (80–100%)	56% (32–80%)

*95% confidence intervals based on Greenwood's formula are shown in parentheses.

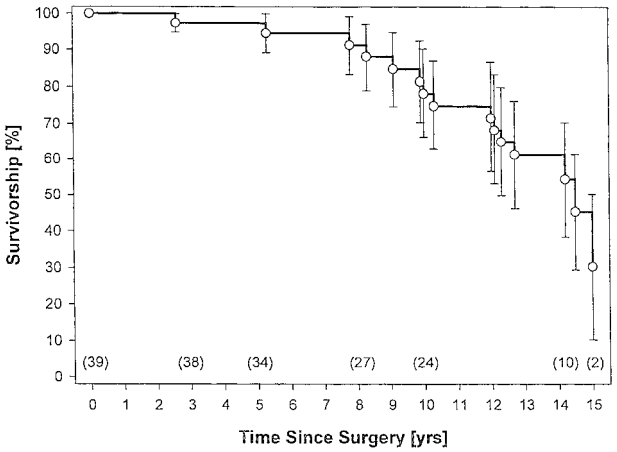

Fig. 3. Kaplan-Meier estimated 15-year survivorship for all 39 bipolar hips. Error bars denote 95% confidence intervals derived by Greenwood's formula. The numbers of hips remaining in the follow-up period on which the estimates are based are shown in parentheses.

wiring of a trochanteric osteotomy. This patient underwent removal of hardware several years later. All trochanteric osteotomies healed. Three patients (5 hips) died during the follow-up period at 7, 8, and 11 years after the original surgery. Causes of death included suicide in 1 patient and sepsis unrelated to the index procedure in 2 patients.

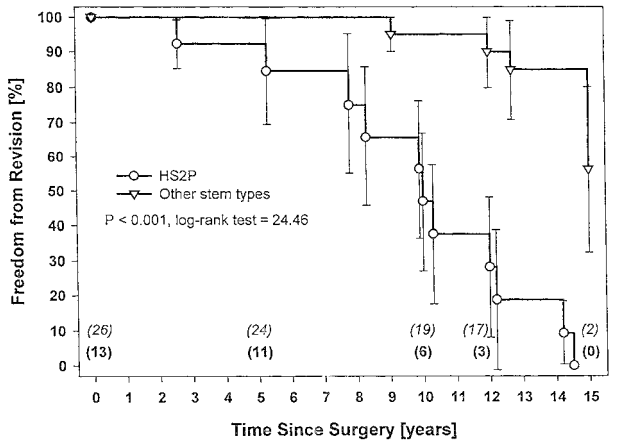

Fig. 4. Kaplan-Meier estimated 15-year survivorship for bipolar hips according to femoral stem type. Error bars denote 95% confidence intervals derived by Greenwood's formula. The numbers of hips remaining in the follow-up period on which the estimates are based are shown in parentheses. The HS2P stem type showed a significantly higher rate of failure compared with all other stem types ($P<.001$).

Table 4. Predictors of Failure of Bipolar Arthroplasty of the Hip (39 Hips, 24 Patients)

Variable	Univariate		Multivariate*	
	P Value	Risk Ratio	95% CI	*P* Value
Age at surgery (y)	.03			.35
Gender	.17			.94
Unilateral vs bilateral	<.001	30.3	12.3–74.5	<.001
Left vs right side	.45			.47
Charnley class	.37			.28
Head diameter (mm)	.16			.10
HS2P stem vs other type	<.001	25.4	9.5–67.7	<.001
Cement vs no cement fixation	.64			.78
Grafted vs not grafted	.08	10.2	3.1–27.0	.006
Protrusio	.69			.21
Subchondral plate	.46			.68
Follow-up mobility	.07			.08

Abbreviation: CI, confidence interval.
*Based on Cox proportional hazard regression model.

Discussion

Despite the risks inherent in primary prosthetic replacement in young patients, THA nevertheless has become the gold standard for treating end-stage disease [21]. Unremitting pain is the most significant and debilitating complaint and carries far-reaching consequences in terms of social adjustment and emotional development. As the primary indication for reconstruction, THA offers a proven, reliable relief of symptoms in these patients. Numerous studies report successful clinical outcomes in cemented and cementless components. In a long-term follow-up of cemented components, Chmell, Scott et al [8] reported 35 of 55 hips (76%) to be pain-free and no patients having pain severe enough to restrict activity at a minimum of 11 years. Maric and Haynes [22] noted slight to no pain in all 17 hips (100%) at a mean of 9.3 years. In more limited follow-up of cementless components, Haber and Goodman [23] found that 27 of 29 patients (93%) had no pain at a mean of 53 months, and Witt, Swann, and Ansell [9] and Lachiewicz [6] reported dramatic improvements in overall hip pain scores with the Hospital for Special Surgery scoring system.

The clinical efficacy of bipolar hemiarthroplasty in relieving symptoms has raised concerns, however. Studies of more active patients with osteoarthritis, osteonecrosis, or femoral neck fracture treated with hemiarthroplasty reveal a high incidence of postoperative hip pain [24,25]. Our findings suggest, however, that patients suffering from

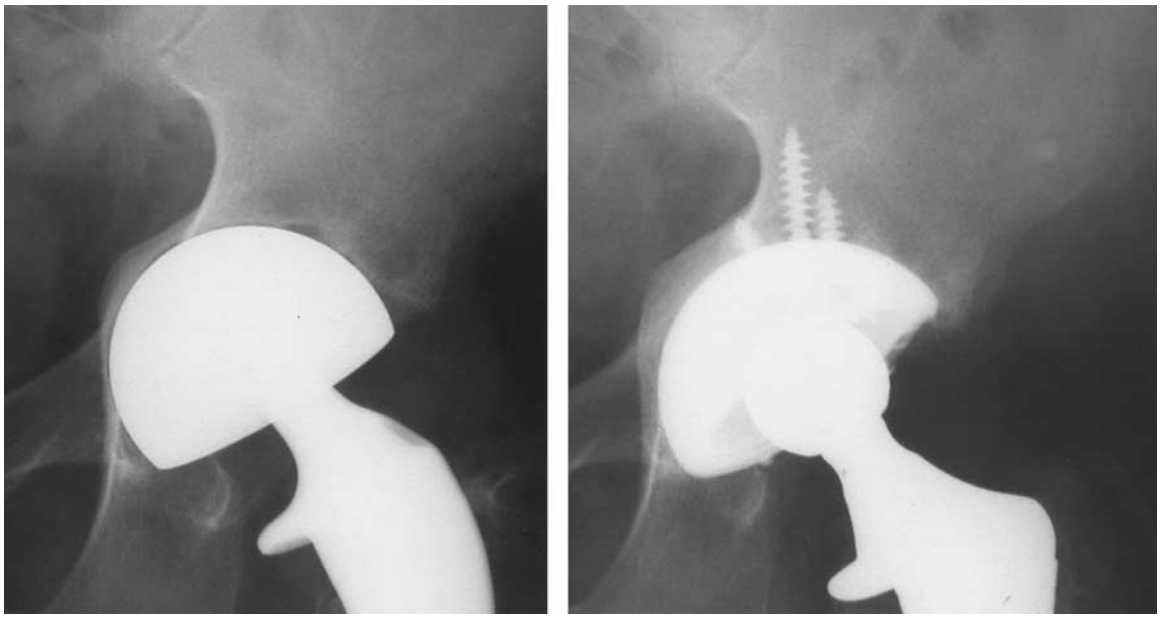

Fig. 5. (A) Prerevision radiograph shows characteristic acetabular osteolysis. (B) Conversion to THA with standard cementless hemispherical sockets.

JRA may be a unique population. In our long-term follow-up of surviving hips, 93% of patients reported having mild to no pain at all. Four patients (29%) continued to have significant symptoms but reported a comparatively lasting benefit. Pain relief after hemiarthroplasty also is recorded in other populations limited by inflammatory arthropathy. In other series examining the results of acetabulum-preserving surgery, early short-term reports by Mogenson and Ekelund et al [26] revealed that 16 of 17 hips in JRA patients treated with surface arthroplasty were pain-free at 2 years, and Willems, Rozing, and Macfarlane [27] presented similar findings in 11 patients after double-cup arthroplasty. Vazquez-Vela [28] reported that 100 of 114 cases (88%) with rheumatoid arthritis had good-to-excellent results, and Bhan and Malhotra [29] found good results in all 19 cases of ankylosing spondylitis treated with bipolar procedures, stating that bipolar hip arthroplasties are "ideally suited for young patients" with ankylosing spondylitis.

Despite the relative gains after hemiarthroplasty seen in surviving hips, the overall Harris hip scores in our patients fall short of those in JRA patients treated with THA. Although it is difficult to compare patient populations, numerous authors have reported mean Harris hip scores ranging from 78 to 91 after total joint arthroplasty in these patients [6,23] versus a mean of 68 in our group. We noted that gains in function and mobility were limited. The 2 patients unable to walk before surgery were still unable to walk in follow-up, and 4 additional patients (29%) still required 2 crutches. Preoperative expectations regarding mobility and independence in paitents with JRA need to be modified in light of disease severity.

Total joint arthroplasty has proved to be clinically reliable, but long-term studies of cemented designs raise concerns over acetabular loosening and failure. In a follow-up study of 186 cases after 22 years, Lehtimaki and Lehto et al [21] reported survival to be approximately 92% at 10 years and 83% at 15 years in cemented THA. Several groups report acetabular loosening and osteolysis ranging from 26% to 60% [7,9]. Of 55 hips followed for at least 11 years, Chmell and Scott et al [8] reported survival rates at 15 years to be 85% on the femoral side but 61% on the acetabular side in cemented cups. Stable acetabular fixation with cementless designs is promising but is available only in short-term and intermediate-term follow-up [6,22,23,30].

More conservative approaches were used in the hope of preserving pelvic bone stock and facilitating potential future revisions. Our findings reveal that gains in acetabular bone restoration are initially feasible but ultimately transient. Early postoperative radiographs show reconstitution of medial wall thickness ($P<.001$). Long-term analysis revealed progressive resorption and loss of position over time, however. These later findings are less optimistic than those reported earlier by Wilson and Scott [13] in a subset of our patients after only 2 to

6 years of follow-up. Similarly, Rogalski and Huebner et al [31] reported in his series of 24 hips resorption of bone–graft over time, and Nakata and Ohzono et al [32] in a study of 65 patients with dysplasia found a 77% rate of migration with bipolar arthroplasties. Brien and Bruce et al [33] noted 11 failures in 18 patients who had undergone a similar procedure in the revision setting and recommended it only as a salvage procedure.

Despite the problem of migration related to medial bone loss and recurrent protrusio, acetabular revisions were mostly straightforward except in the 1 case that required bulk allograft. Acetabular defects were predominantly central and managed readily with morcellized femoral head allograft. The peripheral structure of the native acetabulum often remained intact with an adequate hemisphere for cementless components. Bone stock in the posterior column and superolateral rim was sufficient for a rim fit, and we did not see the more global pelvic osteolysis often associated with loosening of cemented sockets. No cases required revision to a reconstruction cage or other advanced techniques.

Another striking finding in our follow-up study involved the statistically significant association between bead shedding, osteolysis, and failure in the Osteonics HS2P stems ($P<.001$). The stem is a first-generation monoblock Osteonics design of chromium-cobalt that has a noncircumferential proximal porous coating. A retrospective review by Cabanela [34] of 20 HS2P stems at 47 months revealed 2 early revisions and 6 other cases with either bead shedding or stem subsidence. In our series, all 10 stems in living patients required eventual revision, and 1 stem was loose at the time of death in another patient, for an overall failure rate of 85%. If these stems are excluded from analysis, predicted Kaplan-Meier survivorship for all hemiarthroplasties at 10 years approaches 95% and is maintained at 90% at 12 years (95% confidence interval 80% to 100%). Our findings also show that the presence of loose beads represents a significant predictor of failure in bipolar arthroplasty in these components and suggests the need for continued vigilance and early intervention in similar patients at risk.

End-stage hip disease in JRA encompasses all the reconstructive challenges of restoring lasting function in young patients. Bipolar hemiarthroplasty can provide clinical improvement in a subset of surviving hips, and in cases of failure, conversion to fixed sockets has proved amenable to more straightforward reconstruction with cementless components. Concerns continue to surround issues of durability and acetabular lysis, however. Attempts to restore acetabular bone stock rarely are maintained over the long-term even in surviving prostheses. Kaplan-Meier survivorship analysis predicted overall 10- and 12-year survival rates (78% and 72%) to fall short of those reported in THA. The effect of femoral stem design has a significant influence on hemiarthroplasty durability because flaws associated with patch porous-coated stems lead to nearly predictable failure. Bipolar hemiarthroplasty in JRA represents an historic alternative used during an era when solutions to the problem of cemented sockets were evolving. It should not alter the current enthusiasm, however, for cementless THA in patients with JRA.

References

1. Harris CM, Baum J: Involvement of the hip in juvenile rheumatoid arthritis: a longitudinal study. J Bone Joint Surg Am 70:821, 1988
2. Jacobsen FS, Crawford AH, Broste S: Hip involvement in juvenile rheumatoid arthritis. J Pediatr Orthop 12:45, 1992
3. Colville J, Raunio P: Total hip replacement in juvenile rheumatoid arthritis: analysis of 59 hips. Acta Orthop Scand 50:197, 1979
4. Cage DJ, Granberry WM, Tullos HS: Long-term results of total arthroplasty in adolescents with debilitating polyarthropathy. Clin Orthop 283:156, 1992
5. Ruddlesdin C, Ansell BM, Arden GP, Swann M: Total hip replacement in children with juvenile chronic arthritis. J Bone Joint Surg Br 68:218, 1986
6. Lachiewicz PF: Porous-coated total hip arthroplasty in rheumatoid arthritis. J Arthroplasty 9:9, 1994
7. Bsila RS, Inglis AE, Ranawat CS: Joint replacement surgery in patients under thirty. J Bone Joint Surg Am 58:1098, 1976
8. Chmell MJ, Scott RD, Thomas WH, Sledge CB: Total hip arthroplasty with cement for juvenile rheumatoid arthritis: results at a minimum of ten years in patients less than thirty years old. J Bone Joint Surg Am 79:44, 1997
9. Witt JD, Swann M, Ansell BM: Total hip replacement for juvenile chronic arthritis. J Bone Joint Surg Br 73:770, 1991
10. Severt R, Wood R, Cracchiolo A 3rd, Amstutz HC: Long-term follow-up of cemented total hip arthroplasty in rheumatoid arthritis. Clin Orthop 265:137, 1991
11. Lachiewicz PF, McCaskill B, Inglis A, et al: Total hip arthroplasty in juvenile rheumatoid arthritis: two to eleven-year results. J Bone Joint Surg Am 68:502, 1986
12. Learmonth ID, Heywood AW, Kaye J, Dall D: Radiological loosening after cemented hip replacement for juvenile chronic arthritis. J Bone Joint Surg Br 71: 209, 1989
13. Wilson MG, Scott RD: The bipolar socket in juvenile

rheumatoid arthritis: a two- to five-year follow-up study. J Orthop Rheumatol 2:133, 1989
14. Kim WC, Grogan T, Amstutz HC, Dorey F: Survivorship comparison of THARIES and conventional hip arthroplasty in patients younger than 40 years old. Clin Orthop 214:269, 1987
15. Wilson MG, Nikpoor N, Aliabadi P, et al: The fate of acetabular allografts after bipolar revision arthroplasty of the hip: a radiographic review. J Bone Joint Surg Am 71:1469, 1989
16. O'Neill DA, Harris WH: Failed total hip replacement: assessment by plain radiographs, arthrograms, and aspiration of the hip joint. J Bone Joint Surg Am 66:540, 1984
17. Engh CA, Bobyn JD, Glassman AH: Porous-coated hip replacement: the factors governing bone ingrowth, stress shielding, and clinical results. J Bone Joint Surg Br 69:45, 1987
18. Kaplan EL, Meier P: Nonparametric estimation from incomplete observations. J Am Stat Assoc 53:457, 1958
19. Cox DR: Regression models and life tables. J R Stat Soc Series B 34:187, 1972
20. Sokal RR, Rohlf FJ: Biometry: the principles and practice of statistics in biological research. W.H. Freeman, New York, 1995
21. Lehtimaki MY, Lehto MU, Kautiainen H, et al: Survivorship of the Charnley total hip arthroplasty in juvenile chronic arthritis: a follow-up of 186 cases for 22 years. J Bone Joint Surg Br 79:792, 1997
22. Maric Z, Haynes RJ: Total hip arthroplasty in juvenile rheumatoid arthritis. Clin Orthop 290:197, 1993
23. Haber D, Goodman SB: Total hip arthroplasty in juvenile chronic arthritis: a consecutive series. J Arthroplasty 13:259, 1998
24. Prieskorn D, Burton P, Page BJ 2nd, Swienckowski J: Bipolar hemiarthroplasty for primary osteoarthritis of the hip. Orthopedics 17:1105, 1994
25. Pandit R: Bipolar femoral head arthroplasty in osteoarthritis: a prospective study with a minimum 5-year follow-up period. J Arthroplasty 11:560, 1996
26. Mogensen B, Ekelund L, Hansson LI, et al: Surface replacement of the hip in chronic arthritis: a clinical, radiographic and roentgen stereophotogrammetric evaluation. Acta Orthop Scand 53:929, 1982
27. Willems WJ, Rozing PM, Macfarlane JD: Gerard cup arthroplasty in inflammatory arthropathy of the hip. Clin Orthop 210:179, 1986
28. Vazquez-Vela G, Vazquez-Vela E, Garcia-Dobarganes F: The Bateman bipolar prosthesis in osteoarthritis and rheumatoid arthritis. A review of 400 cases. Clin Orthop 251:82, 1990
29. Bhan S, Malhotra R: Bipolar hip arthroplasty in ankylosing spondylitis. Arch Orthop Trauma Surg 115: 94, 1996
30. Kumar MN, Swann M: Uncemented total hip arthroplasty in young patients with juvenile chronic arthritis. Ann R Coll Surg Engl 80:203, 1998
31. Rogalski R, Huebner J, Goulet J, Kaufer H: Two-year follow up of bipolar hemiarthroplasty. Orthopedics 16:759, 1993
32. Nakata K, Ohzono K, Masuhara K, et al: Acetabular osteolysis and migration in bipolar arthroplasty of the hip: five- to 13-year follow-up study. J Bone Joint Surg Br 79:258, 1997
33. Brien WW, Bruce WJ, Salvati EA, et al: Acetabular reconstruction with a bipolar prosthesis and morseled bone grafts. J Bone Joint Surg Am 72:1230, 1990
34. Cabanela ME: Result of Osteonics Uncemented Microstructure Total Hip Arthroplasty. p. 658. In Morrey B (ed): Joint replacement arthroplasty. Churchill Livingstone, New York, 2000