Thirty-five-Year Results After Charnley Total Hip Arthroplasty in Patients Less Than Fifty Years Old

A Concise Follow-up of Previous Reports*

Lucian C. Warth, MD, John J. Callaghan, MD, Steve S. Liu, MD, Alison L. Klaassen, MA, Devon D. Goetz, MD, and Richard C. Johnston, MD

Investigation performed at the Department of Orthopaedic Surgery, University of Iowa Hospitals and Clinics, Iowa City, and Des Moines Orthopaedic Surgeons, West Des Moines, Iowa

Abstract: We report the updated results for a previously described cohort of patients who were less than fifty years old at the time of the index Charnley total hip arthroplasty with cement. The original cohort consisted of ninety-three consecutive hips in sixty-nine patients. The patients were followed for a minimum of thirty-five years after surgery or until death. At the latest follow-up evaluation, there were forty-one total hip replacements (44%) in thirty-two living patients. Thirty-four (37%) of the ninety-three total hip replacements in the original cohort had been revised or removed. Twenty acetabular (22%) and seven femoral (8%) components had been revised for aseptic loosening. Since the twenty-five-year follow-up, the average six-minute-walk distance decreased from 395 m to 171 m, and this decrease correlated with increasing comorbidity. This study demonstrates the durability of cemented total hip replacements in a young patient population. Although 63% (fifty-nine) of the ninety-three original hip replacements were functioning at the latest follow-up or at the time of death, a significant decrease in activity level was seen over time ($p < 0.001$). Of the forty-one original implants in the patients who were alive at the time of the thirty-five-year follow-up, only 46% (nineteen) were retained.

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

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Background

The purpose of the present study was to evaluate the results thirty-five years after Charnley total hip arthroplasty in a previously reported group of patients less than fifty years old at the time of index arthroplasty[1-3]. We include data on patient function and radiographic follow-up. This series of patients represents a consecutive, nonselected cohort with all arthroplasties performed by a single surgeon (R.C.J.).

In the original cohort, Charnley total hip arthroplasty was performed in ninety-three hips in sixty-nine patients. The

**Original Publications*

Sullivan PM, MacKenzie JR, Callaghan JJ, Johnston RC. Total hip arthroplasty with cement in patients who are less than fifty years old. A sixteen to twenty-two-year follow-up study. J Bone Joint Surg Am. 1994 Jun;76(6):863-9.

Callaghan JJ, Forest EE, Olejniczak JP, Goetz DD, Johnston RC. Charnley total hip arthroplasty in patients less than fifty years old. A twenty to twenty-five-year follow-up note. J Bone Joint Surg Am. 1998 May;80(5):704-14.

Keener JD, Callaghan JJ, Goetz DD, Pederson DR, Sullivan PM, Johnston RC. Twenty-five-year results after Charnley total hip arthroplasty in patients less than fifty years old: a concise follow-up of a previous report. J Bone Joint Surg Am. 2003 Jun;85(6):1066-72.

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TABLE I Number of Revisions at Time of Final Follow-up

Outcome	All Hips* (N = 93)	Hips of Patients Alive at ≥35 Years Following Index Surgery* (N = 41)
Original prosthesis retained	59 (63%)	19 (46%)
Revision		
One	24 (3, 10, 0, 0)	16 (5, 11, 0, 0)
Two	7 (2, 2, 1, 2)	5 (0, 2, 1, 2)
Three	1 (0, 1, 0, 0)	1 (0, 1, 0, 0)
Resection arthroplasty	2 (2, 0, 0, 0)	2 (2, 0, 0, 0)

*The numbers of hips according to the different reasons for revision (infection, aseptic loosening, dislocation, and femoral fracture) are given in parentheses.

average age at the time of the index procedure was forty-two years (range, eighteen to forty-nine years). Thirty five patients were women, and thirty-four patients were men. A Charnley hip prosthesis (Thackray, Leeds, England, or Zimmer, Warsaw, Indiana) was used in all patients. A stainless-steel polished flat-back or narrow femoral stem (modified to a thinner diameter in four hips) with a 22-mm-diameter head and an ultra-high molecular weight polyethylene acetabular component were inserted with cement. The cement was hand-packed, with surgery performed through the transtrochanteric approach. No antibiotics were used perioperatively (Fig. 1).

Methods

Radiographs were made at a minimum of thirty-five years (range, 35.1 to 40.8 years; average, 36.9 years) postoperatively for thirty-one of thirty-nine hips in living patients (excluding two previously explanted hips). Observations and serial measurements were based on anteroposterior pelvic radiographs made early in the postoperative period and usually at five-year intervals thereafter until the latest follow-up visit. Radiographic analysis of heterotopic ossification, femoral

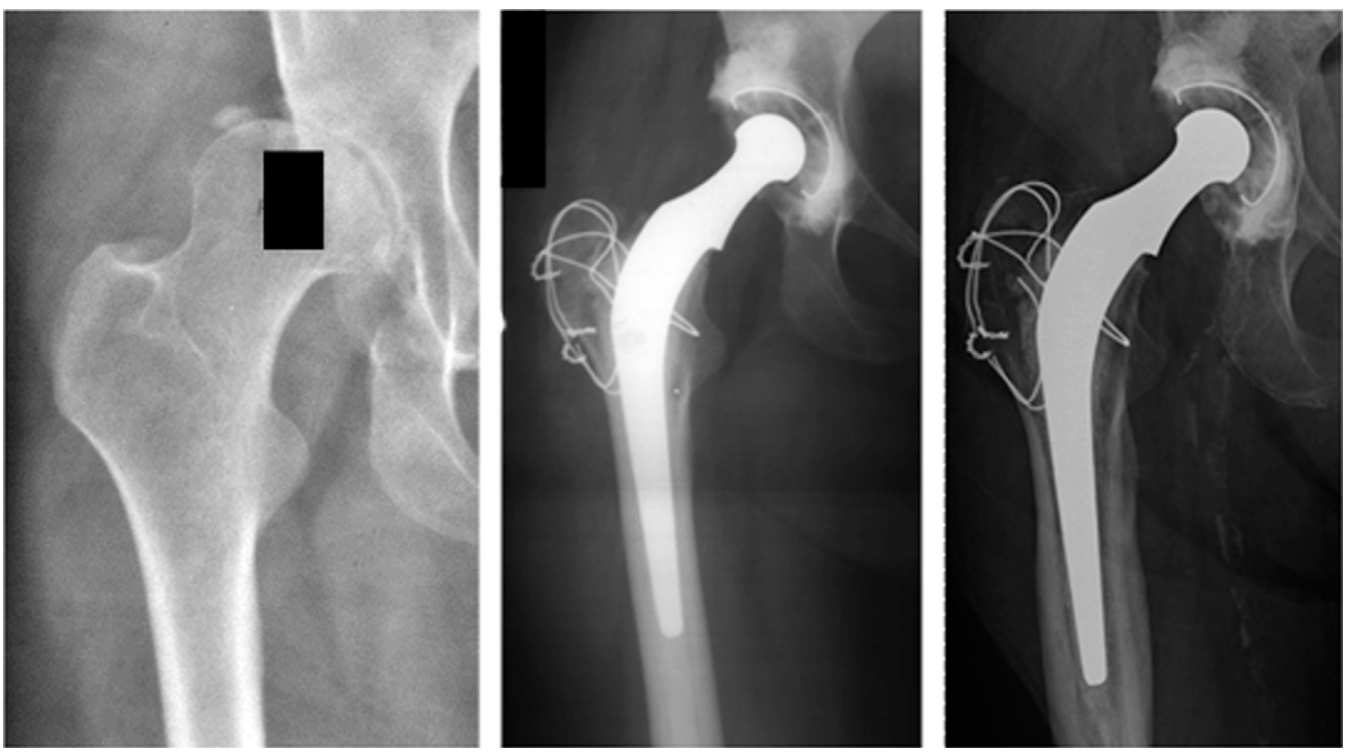

Fig. 1

Preoperative (left), postoperative (center), and thirty-five-year follow-up radiographs (right) of a female patient who underwent Charnley total hip arthroplasty at the age of forty-five years for end-stage arthritis secondary to developmental dysplasia of the hip. Although there is a broken trochanteric fixation wire, the trochanter remains united and there are no substantial radiolucencies around the acetabular or femoral components. The Harris hip score was 86 points at both the twenty-five and thirty-five-year follow-up evaluations.

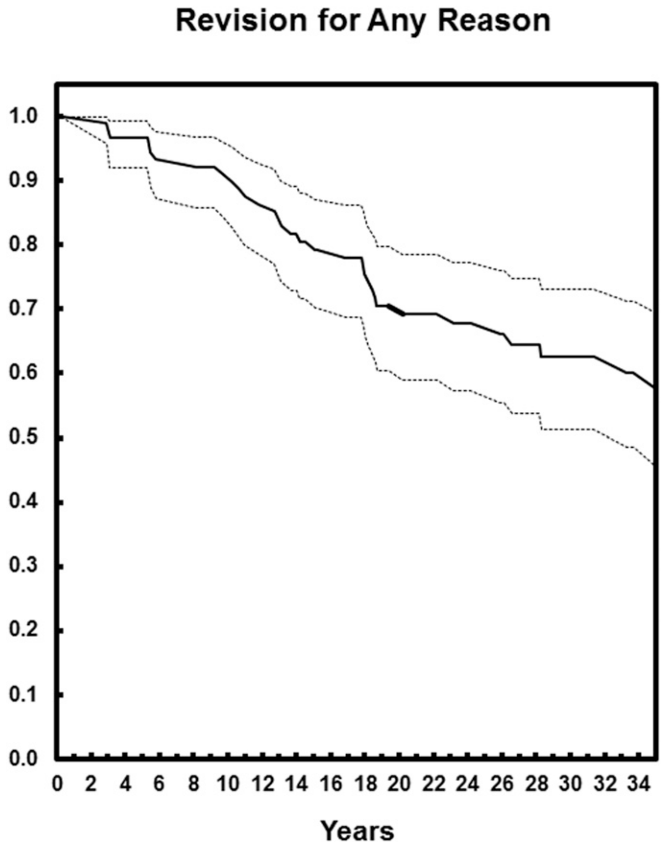

Fig. 2
Kaplan-Meier survivorship curve with revision for any reason as the end point. The calculated Kaplan-Meier implant survivorship at the thirty-five-year follow-up with revision for any reason as the end point was 57.6% (95% confidence interval, 45.7% to 69.5%).

cement grade, osteolysis, and loosening of the acetabular and femoral components were performed with the same methods reported in earlier follow-up studies of the same patient cohort[4-10]. Any radiolucency between the prosthesis and the cement in zone 1 of Gruen et al.[5], regardless of width, was recorded as debonding. We quantified debonding according to the system described by Berry et al.[11]. All patients completed a self-administered Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) test[12] (paper questionnaire form), and Harris hip scores[13] were calculated for each patient at his or her current level of function. All available patients had a supervised six-minute walk test that was compared with previously reported data for this cohort[14], as well as predicted distance using reference formulas generated from a group of selected, healthy, age-matched subjects as reported by Enright and Sherrill[15]. Activity was further assessed using a StepWatch Activity Monitor (StepWatch; Orthocare Innovations, Mountlake Terrace, Washington)[16,17].

Statistical Analysis

The Kaplan-Meier method was used to evaluate the survival of the implant with regard to revision, radiographic loosening, or both[18-20]. Survivorship curves, with corresponding confidence intervals, were generated, with failure defined according to six commonly cited end points (Fig. 2; see Appendix). The Student t test was used to analyze normally distributed functional scores.

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The Bierbaum Research Fund (institutional funds) was the source of funding for this study.

Results

At the time of clinical follow-up at a minimum of thirty-five years after the index arthroplasty, thirty-two patients (forty-one hips; 44%) were alive and thirty-seven patients (fifty-two hips) had died. The average age of the thirty-two living patients was seventy-eight years and six months. One patient (one hip) was lost to follow-up, leaving thirty-one patients (forty hips) available for study inclusion. The patient lost to follow-up previously had a resection arthroplasty for deep infection (Fig. 3). Twenty (65%) of thirty-one patients wore a pedometer. Twenty patients (65%) completed a six-minute walk. Twenty-two (71%) of thirty-one patients completed the Short Form (SF)-36, WOMAC, and Harris hip score questionnaires. Radiographs were made at a minimum of thirty-five years (average, 36.9 years) postoperatively for thirty-one (79%) of thirty-nine hips in living patients (two hips were excluded secondary to resection arthroplasty for infection).

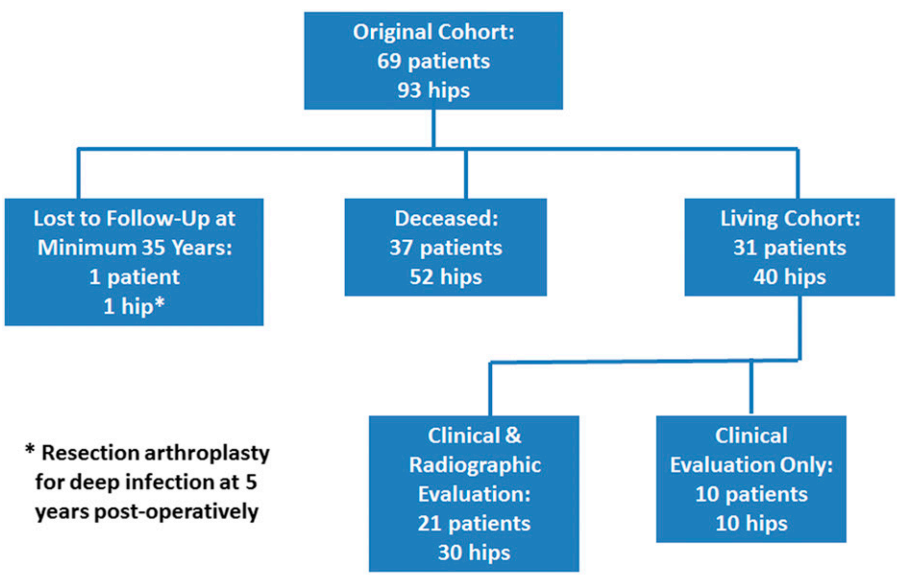

Fig. 3
Radiographic and clinical follow-up flowchart.

Revision of the Original Prosthesis

Of the ninety-three original hips, thirty-four (37%) had undergone either a revision or resection arthroplasty at the latest clinical follow-up. The revision (thirty-two hips) or resection (two hips) was performed because of aseptic loosening in twenty-four hips (26%); infection in seven (8%), including the two that had resection; periprosthetic fracture in two (2%); and recurrent dislocation in one hip (1%).

Of the forty-one hips in thirty-two patients living thirty-five years after the index operation, twenty-two hips (54%) had had a revision or resection arthroplasty. The reason for revision or resection was aseptic loosening in fourteen hips (34%); infection in five hips (12%), including the two that had resection; fracture of the femur in two (5%); and recurrent dislocation in one hip (2%). A single patient required more than two revisions (Table I).

Since the minimum twenty-five-year follow-up[3], eight additional revisions were performed, with three being re-revisions. Two hips were revised for infection; one was revised for aseptic acetabular loosening; one, for aseptic femoral loosening; and one, for both femoral and acetabular aseptic loosening (see Appendix).

Function

Functional evaluations were completed for twenty-two patients with at least thirty-five years of follow-up since the index arthroplasty. The SF-36 physical component summary scores of the study group decreased significantly over the twenty-five-year to thirty-five-year follow-up interval from 43.3 to 33.9 ($p = 0.0035$). The SF-36 mental component summary score did not demonstrate an appreciable decline (53.1 and 53.6 at the twenty-five and thirty-five-year follow-up, respectively). The Harris hip scores of the study group were significantly decreased over the twenty-five to thirty-five-year follow-up interval from 86.9 to 61.9 points ($p < 0.001$). The WOMAC subscales for pain and stiffness did not demonstrate any significant change between the follow-up time points ($p = 0.62$ and $p = 0.17$, respectively), while the WOMAC subscale for function demonstrated a decline from 13.6 to 22.7 over the interval ($p = 0.03$) (see Appendix).

Activity

A six-minute-walk performance test was obtained for twenty (65%) of thirty-one available patients. Average walking distance for all patients was 171 m. This compares with the results of the same cohort at the twenty-five-year follow-up time point of 395 m, suggesting that function had decreased significantly, by approximately 57% ($p < 0.001$). In patients with two or more comorbidities, walking distance was less than half of that of the healthier subgroup (112 m versus 242 m; $p = 0.002$) (see Appendix). This corroborates the significant difference in six-minute-walk distance based on increasing medical and musculoskeletal comorbidity in these patients demonstrated at the twenty-five-year follow-up.

StepWatch Activity Monitor data were collected for twenty (65%) of thirty-one patients. The average calculated yearly step count for all patients was 705,000 steps. Increasing comorbidity was significantly correlated with decreasing pedometer performance. The subgroup with two or more comorbidities had an average calculated yearly step count of 469,000 steps (range, 17,000 to 1,205,000 steps), while the healthier subgroup had a step count of 942,000 steps (range, 195,000 to 1,494,000 steps) ($p = 0.003$).

Radiographic Results

Of the original ninety-three hips (excluding the ten that had been revised because of infection, periprosthetic fracture, or dislocation), thirty-five had loosening of the acetabular component, and twenty of those had been revised. Seventeen hips had radiographic loosening of the femoral components, and seven of them had been revised. Since the time of the twenty-five-year follow-up, in addition to the three hips that were revised for aseptic loosening, there were two hips with acetabular loosening and two with femoral loosening. The combined prevalence of definite or probable radiographic loosening of the femoral component and aseptic loosening of the femoral component that required revision was 18% (seventeen hips) overall and 24% (ten hips) in patients with a minimum follow-up of thirty-five years. The combined prevalence of definite or probable radiographic loosening of the acetabular component and aseptic loosening of the acetabular component that necessitated revision was 38% (thirty-five hips) overall and 49% (twenty hips) in patients with a minimum follow-up of thirty-five years.

Component Survivorship Analysis

Of the original ninety-three prosthetic hips, fifty-nine (63%) were functioning at the latest follow-up evaluation or at the time of death of the patient. Of the forty-one hips in living patients, nineteen (46%) were functioning with the index prosthesis in place at least thirty-five years after implantation. We were unable to demonstrate a significant relationship between the decade of life at the time of index surgery and the prevalence of aseptic loosening or revision of either component ($p > 0.05$). The changes in revision and radiographic survivorship since the twenty-five-year follow-up evaluation are summarized in a table (see Appendix).

Conclusions

Compared with the findings in our previous reports on this cohort of young patients who underwent Charnley total hip arthroplasty[1-3,14], acetabular component loosening continues to progress with time. Two additional hips (2%) required revision because of acetabular component loosening, and an additional two hips (2%) had radiographic signs of acetabular component loosening. Femoral sided failure was demonstrated in two patients (2%) requiring revision. At a minimum thirty-five-year follow-up, overall component failure for aseptic loosening was twice as high on the acetabular side as on the femoral side (38% versus 18%).

Compared with the twenty-five-year follow-up report, patient function at the thirty-five-year follow-up, as demonstrated by the six-minute walk, had decreased by >50% (see Appendix). Decreased six-minute-walk time was again associated with increasing patient comorbidity, suggesting that decreased six-minute-walk times can be attributed both to increased age and to increased comorbidity. We were unable to correlate increased walk times or pedometer findings with loosening or need for revision. Additionally, SF-36 physical component summary scores, WOMAC functional scores, and Harris hip scores all declined significantly. The decrease in the average Harris hip score from 86.9 to 61.9 points between the twenty-five and thirty-five-year follow-up time points is especially impressive, even in this aging population. The majority of this decrease appeared to be in the functional subscale of the Harris hip score.

In our cohort, the average age at the time of surgery was forty-one years, and 44% (forty-one) of the ninety-three prostheses were in patients who were still alive and able to be evaluated thirty-five years after the index procedure. This compares favorably with the only other thirty-five-year follow-up study of total hip replacements[21], to our knowledge, in which the average age at the time of surgery was sixty-five years, and only 4.5% (fifteen) of the 330 hips were in patients who were still alive at the time of the thirty-five-year follow-up (see Appendix). This represents a nearly tenfold difference in the percentage (44% versus 4.5%) of total hip replacements available to be evaluated at thirty-five years of follow-up. Additionally, survivorship analysis at the thirty-five-year follow-up in this young cohort (fifty years old and under) compared with that in an older population (an average of sixty-five years at the time of index arthroplasty), previously reported by Callaghan et al.[21], demonstrated significantly increased rates of failure on the acetabular side, with excellent results for both cohorts on the femoral side. With nearly universal excellence of reported short and mid-term outcomes after total hip arthroplasty between different implants, we believe that the present study demonstrated that a younger patient cohort is important to follow to definitively evaluate long-term differences in component function and survival.

The present study demonstrated that total hip replacements in this relatively young patient group have satisfactory long-term function and durability. Nearly two-thirds (63%) of the original implants were retained at the time of death or thirty-five-year follow-up. For the patients living at the time of the thirty-five-year follow-up, the results were less durable, as approximately half (46%) of the patients retained their original prosthesis. These results should be considered a standard for comparison with the outcomes of newer designs used in this younger age-group.

The functional results in the study group, as measured by the SF-36, WOMAC, and especially the Harris hip scores, were significantly poorer than the reported values from the same study group at the twenty-five-year follow-up. There was minimal deterioration between twenty-five and thirty-five years in terms of fixation. This study demonstrates that total hip replacement can be safely performed in younger patients and that durable function and fixation can be maintained in many of these patients.

Appendix

eA Figures demonstrating Kaplan-Meier survivorship curves, with revision for aseptic loosening, revision for aseptic loosening of the acetabular component, revision for aseptic loosening of the femoral component, radiographic loosening of the acetabular component, and radiographic loosening of the femoral component as the end points, and tables showing a comparison of radiographic and survivorship data at twenty-five and thirty-five years, a comparison of functional data at twenty-five and thirty-five years, a functional comparison according to the results of the six-minute walk test, and a comparison of patient and implant survivorship are available with the online version of this article as a data supplement at jbjs.org. ■

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Lucian C. Warth, MD
John J. Callaghan, MD
Steve S. Liu, MD
Alison L. Klaassen, MA
Richard C. Johnston, MD
Department of Orthopaedic Surgery,
University of Iowa Hospitals and Clinics,
200 Hawkins Drive,
UIHC, 01029 JPP,
Iowa City, IA 52242.
E-mail address for J.J. Callaghan: john-callaghan@uiowa.edu

Devon D. Goetz, MD
Des Moines Orthopaedic Surgeons,
6001 Westown Parkway,
West Des Moines, IA 50266

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