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Long-Term Results of Total Hip Arthroplasty with 28-Millimeter Cobalt-Chromium Femoral Heads on Highly Cross-Linked Polyethylene in Patients 50 Years and Less

Jeffrey B. Stambough, MD [a], Gail Pashos, BS, MT [a], Frank C. Bohnenkamp, MD [b], William J. Maloney, MD [c], John M. Martell, MD [d], John C. Clohisy, MD [a]

[a] Washington University School of Medicine, Department of Orthopaedic Surgery, St. Louis, Missouri
[b] Crystal Lake Orthopedics, Crystal Lake, Illinois
[c] Stanford Medicine Outpatient Center, Department of Orthopedic Surgery, Redwood City, California
[d] Orthopaedic Biomedical Institute, Department of Orthopaedic Surgery and Rehabilitation Medicine, University of Chicago Medicine & Biological Sciences, Chicago, Illinois

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ABSTRACT

Highly cross-linked polyethylene (HXLPE) is the most commonly used bearing surface in total hip arthroplasty (THA) because of its superior wear properties, but long-term results in young patients are limited. We report on the clinical outcome, radiographic wear patterns and survivorship of 72 patients ≤50 years old who had a 28-millimeter cobalt-chromium femoral head on HXLPE acetabular liner. Mean and median true linear wear rates at average ten-year follow-up were 0.0104 and 0.016 mm per year ± 0.07 mm. Mean and median two-dimensional volumetric wear rates were 12.79 mm^3 and 5.834 mm^3 per year ± 26.1 mm^3 as determined by Martell analysis. As a result of the minimal wear profile, there was no evidence of radiographic osteolysis and no wear-related revisions.

Polyethylene wear is a well-defined mechanism that can directly lead to osteolysis and subsequent total hip arthroplasty (THA) failure [1]. Furthermore, previous research has established that linear polyethylene wear exceeding 0.2 mm per year or volumetric wear surpassing 150 mm^3 per year predisposes the hip to periprosthetic osteolysis [2]. Highly cross-linked polyethylene (HXLPE) after electron-beam radiation and re-melting is a specific type of alternative bearing that has been championed over the past 15 years because of laboratory findings of reduced wear rates and particle formation [3–5]. Mid and long-term *in vivo* results have corroborated simulated findings of decreased wear rates [6–8], but concerns still exist regarding the longevity of the bearing surface due to fatigue fracture risk [9] and potentially increased biologic activity of wear particles [10].

Young patients present a unique dilemma for bearing survivorship in that they not only live longer, but commonly pursue more physically demanding activities that place significantly more stresses across the articulation surfaces [11,12]. Currently, few reports in the literature focus on long-term results of HXLPLE in younger cohorts [13], which is an important issue to clarify due to recent problems with hip resurfacing, metal-on-metal, and primary modular implants. The purpose of this study is to evaluate the linear and volumetric wear patterns, survivorship and functional activity scores at average ten-year follow-up of a specific cohort of patients under the age of 50 years at the time they underwent THA utilizing 28-mm cobalt-chromium femoral heads on modern HXLPE liners.

Materials and Methods

After the ethical review committee granted approval, we performed a retrospective review of our institutional database for all patients 50 years of age or less who underwent THA with the bearing combination of a 28-millimeter cobalt-chromium (CoCr) femoral head on HXPLE acetabular liner. All surgeries were performed by one of two senior authors. All patients received the combination of cementless acetabular shell augmented with screw fixation (Trilogy®, Zimmer, Warsaw, IN) and a CoCr femoral head (VerSys™, Zimmer, Warsaw, IN). The HXLPE acetabular liner (Longevity ®: Zimmer) was fabricated by a process that included electron-beam irradiation to 9 mRad and gas plasma-sterilized, remelting, and annealing. Ninety-six percent (n = 96) of patients had cementless femoral stem fixation. All patients had a posterolateral approach. Only those patients with greater than eight-year

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Reprint requests: Jeffrey B. Stambough, M.D., Washington University School of Medicine, Department of Orthopaedic Surgery, 660 S. Euclid Ave, Campus Box 8233, St. Louis, MO 63110.

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follow-up were included. Patients were excluded if they had undergone previous THA or received any combination of components other than listed above. We did not discriminate based on preoperative diagnosis. The primary study end-point was defined as all-cause revision, with secondary outcomes including reoperation or death.

We identified 99 consecutive hips (95 patients) that had received a HXLPE acetabular bearing from July 2001–February 2004. Eight patients (nine hips, 9%) were lost to follow-up despite extensive efforts to contact them to return for clinical evaluation. Fifteen patients (16 hips, 16%) had an average follow-up of 5.25 years (SD 2.1 years) and were excluded due to insufficient long-term follow-up duration. It is important to state, however, that none of these 16 patients required a revision for any reason at the time of their most recent follow-up. After these exclusions, 75 hips (72 patients, 75%) with an average 10-year follow-up (range 98–143 months, SD 10.8 months) who received the 28-mm CoCr head on HXLPLE liner combination remained. No other alternative bearing surfaces were utilized by the surgeons at our institution during the time period of this study.

Prospective institutional joint registry data entry has been accomplished for all patients undergoing total hip arthroplasty at our institution, including preoperative evaluations and postoperative assessments at recommended six-week, one-year, two-year, five-year, and ten-years, unless otherwise specified by the treating surgeon. Retrospective data review was performed by two individuals who were neither directly involved in surgical treatment or patient management.

The study group was comprised of 43 females (59%) and 29 males (41%). The mean patient age was 41.2 years (SD 8.5, range 17–50 years) and mean BMI was 28.8 kg/m^2 (SD 5.6, range 17.7–46.2 kg/m^2). Eighty percent of cohort members self-identified as Caucasian (n = 58), while the remainder of subjects identified themselves as either African-American (15%, n = 11) or Asian (1%, n = 1). The two most common preoperative diagnoses included osteoarthritis (53%, n = 38) and osteonecrosis (39%, n = 28), while post-traumatic arthritis and other causes comprised 4% each (n = 3). Comorbidities included inflammatory arthritis, hypertension and smoking (each 16%, n = 12), gastrointestinal (14% n = 10), respiratory (8%, n = 6), and alcohol, neuropathy, obesity (each 7% n = 5), and others (12%, n = 14).

Preoperative and postoperative patient-reported outcome measures included the modified Harris hip score (mHHS) [14], the Western Ontario and McMasters Universities (WOMAC) Index [15] and the UCLA activity scale. The HHS and WOMAC have been validated as a reliable measures of overall function after hip replacement [16]. The UCLA scoring system is a patient reported self-assessment scale, with '1' indicating inactivity and '10' representing participation in high impact sports [17].

A standard radiographic series including low anteroposterior (AP) pelvis and cross-table lateral views of the affected hip were obtained and digitally assessed for all patients. Acetabular component inclination and version were determined using techniques previously described [18]. Osteolysis surrounding the acetabular and femoral components were determined using the DeLee and Charnley and Gruen methods, respectively [19,20]. Definite acetabular component loosening was defined by either component migration >4 mm from initial component placement or complete, contiguous radiolucency ≥2 mm wide present in all three DeLee and Charnley zones. Criteria described by Engh et al. were utilized to determine femoral implant stability [21]. Postoperative heterotopic ossification was quantified according to the Brooker classification system [22].

Table 1
Summary of Preoperative and >10 year Follow-Up Patient Reported Outcomes (PROs).

PRO	Pre-operative (SD)	Post-operative (SD)	*P*-value
mHHS	46.3 (14.7)	81.9 (19)	$P < 0.001$
UCLA Activity	4.1 (2)	6.3 (2)	$P < 0.001$
WOMAC Pain	38.7 (18.9)	82.6 (23.7)	$P < 0.001$
WOMAC Stiffness	40.2 (23.6)	78.3 (26.8)	$P < 0.001$
WOMAC Function	41.8 (17.1)	81.8 (22.3)	$P < 0.001$

PRO = patient-reported outcome, mHHS = modified Harris Hip score, WOMAC = Western Ontario and McMasters Universities Index, SD = standard deviation.

Table 2
Subgroup Analysis Comparing Linear and Volumetric Wear Rates Based on Low (UCLA score 1–7) versus High (UCLA score 8–10) Postoperative Activity Levels.

UCLA 1–7 vs. 8–10			*P*-values	
Linear (mm)	Low	High	t-Test	Mann–Whitney
Mean linear rate	0.010	0.002	0.360	0.266
Median linear rate	0.015	0.016		
Stnd. dev. Linear	0.043	0.056		
Volumetric (mm^3)	Low	High	0.879	0.694
Mean vol. rate	9.453	9.991		
Median vol. rate	4.700	5.921		
Stnd, dev. Vol.	10.785	15.118		

The Martell computerized, semi-automated, edge-detection method was used to determine the two-dimensional vector wear by one author who was trained and validated in the use and function of the program (Martell Hip Analysis Suite, version 8.0.4.3; University of Chicago, Chicago IL). Calculation of linear wear was performed with this validated computer algorithm for all AP radiographs taken at two, five and ten years postoperatively against a baseline radiograph taken at the first postoperative visit and a subsequent radiograph taken one year after THA [23]. A radiograph taken between 12–18 months after surgery was used as a baseline for the measurement of steady-wear rate to account for bedding-in of the liner within the acetabular shell [24]. The resultant data was processed using the two measurements approach as described by Shia et al [25]. Volumetric wear is calculated from the magnitude of the wear vector on the two-dimensional projection on AP radiograph and the direction of the wear with respect to the cup face and the femoral head size [23,26].

Statistical analysis included the use of the Wilcoxon signed rank sum test, which does not require a normality assumption, to examine the difference between the pre and post-operative clinical assessment measures as a non-parametric alternative of a paired t-test. Revision free survival probability was estimated by the Kaplan-Meier survival curve. Pearson correlation coefficients were calculated among cup angles and wear data.

Results

The modified Harris Hip score improved from mean of 46.3–81.9 ($P < 0.001$) at final follow-up (Table 1). The mean postoperative

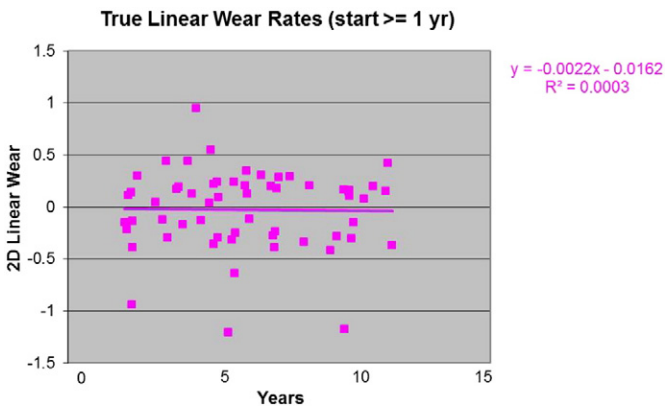

Fig. 1. The true linear wear rate for HXLPE liners calculated from the 1-year AP pelvis compared with the longest available follow-up film available for each subject yielded a mean wear rate of 0.0003 mm (SD 0.04) per year excluding the first year bedding-in period.