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Original Article

Mid-Term Results and Predictors of Patient-Reported Outcomes of Birmingham Hip Resurfacing

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ABSTRACT

Background: Birmingham hip resurfacing (BHR) is the only Food and Drug Administration approved resurfacing option currently available in the United States. While adequate BHR outcomes are established, there is a paucity of US-based literature demonstrating factors critical to improve patient reported outcomes (PROs). This study answers: (1) What is the implant survivorship in a large US cohort? (2) Which preoperative factors result in higher PRO scores over 5 years postoperatively?
Methods: A retrospective 541 hip single-surgeon cohort with mean of 6.2 years follow-up (range 5-8.1) was collected. Preoperative patient/implant variables, including postoperative radiographic acetabular inclination and femoral component position, clinical outcomes, and follow-up PRO questionnaire information were collected. Validated PROs included the Hip Disability and Osteoarthritis Outcome Score (HOOS), Veterans Rand-12, and University of California Los Angeles (UCLA) activity. PROs were modeled with ordinary least squares then used to create nomograms.
Results: Average patient age was 53 years with 391 (72%) males. Seven hips were revised, resulting in an overall survival of 98.8% at 5 years. Predictive modeling identified preoperative variables (sex, body mass index, smoking, and comorbidity) that had statistically significant associations with HOOS pain ($P = .049$), HOOS activities of daily living ($P = .017$), UCLA activity ($P < .001$), and Veterans Rand-12 physical ($P < .001$) PROs at latest follow-up. Nomograms predicted follow-up PROs using preoperative patient-specific variables.
Conclusion: This study documents excellent survival of the largest reported single-center cohort of BHRs in the United States with a mean 6.2 years follow-up. Multivariate modeling shows male nonsmokers with low body mass index, and no comorbidities will have less hip pain, better function in daily life, higher activity, and better general physical health after BHR arthroplasty.

Hip resurfacing arthroplasty is an alternative to total hip arthroplasty (THA) for end-stage hip osteoarthritis (OA) in younger patients. Multiple hip resurfacing systems are available outside the United States, all sharing the characteristics of a metal-on-metal articulation and large-diameter femoral head. The Birmingham Hip Resurfacing (BHR) system was approved by the US Food and Drug Administration (FDA) in 2006 and is currently the only FDA-approved hip resurfacing option available in the United States [1]. Prior to its 2006 US release, years of outcomes data exist since its initial use in 1997 in other countries. Multiple studies investigating the BHR system have shown robust outcomes with failure rates ranging from 0.86%-8.5% with a 1.3-10.9 year median follow-up period [2,3]. Excellent long-term 10-15 year survivorship has been shown in the United Kingdom and Australia [4,5]. Results show a greater risk of hip resurfacing revisions in female patients and those with smaller component sizes [4,6,7].

While it is well established which factors lead to a higher risk of revisions and failures, there is a paucity of literature demonstrating factors leading to the most improvement in patient-reported outcomes (PROs). PROs show the effectiveness of the procedure in

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improving patients' function, pain, symptoms, and quality of life (QOL). A mechanism to preoperatively identify the patients for whom a BHR would be most effective at improving PROs would be immensely helpful in patient selection, but no predictive algorithm currently exists. If such mechanism were available, it would help maximize the benefits of this procedure. Additionally, there are few studies documenting outcomes for this procedure in the US population. It is important to establish BHR outcomes in the current health care environment.

With a large cohort that underwent BHR hip arthroplasty with consistent follow-up in a single US hospital, we attempted to answer the following questions: (1) What are the revision rates, complication rates, and implant survivorship in this cohort? (2) Which preoperative patient-specific factors result in higher PRO scores at more than 5 years after surgery? Based on previous literature, we hypothesize that gender and component size will predict PROs in patients that underwent BHR arthroplasty.

Materials and Methods

Patient Cohort

A retrospective cohort of 541 hips was assembled from consecutive patients who underwent a primary BHR hip arthroplasty more than 5 years ago between 2006 and 2009. All surgeries were performed by a single surgeon. Indications for surgery were end-stage hip arthritis that failed conservative therapy. Primary OA was classified as OA without any secondary etiology established. Secondary OA included cam-type femoroacetabular impingement (FAI), slipped capital femoral epiphysis, dysplasia, avascular necrosis, posttraumatic, Perthes' disease, postseptic, and multiple epiphyseal dysplasia. Contraindications for surgery included patients with active infection and women with childbearing intentions. This study was approved by the hospital's institutional review board.

Operative Technique and Postoperative Care

All procedures were performed using an anterolateral transgluteal approach using traditional instrumentation. Component sizes were estimated preoperatively using digital templating. A “mushroom” template was used intraoperatively to assist in sizing and orientation of the femoral component [8]. Postoperatively, deep vein thrombosis prophylaxis included 12-14 days of enoxaparin then aspirin up to one month. Ultrasound deep vein thrombosis screening was performed 2 and 14 days postoperatively. All patients followed a weight-bearing protocol of 75% partial weight bearing for 6 weeks postoperatively, avoidance of strenuous exertion (no running, jumping, and heavy lifting) for 1 year postoperatively, and unrestricted activity thereafter. All patients had physical therapy evaluation. Follow-up visits were at 6 weeks, 1 year, 2 years, and 5 years postoperatively.

Data Collection

An electronic medical record (EMR) chart review was performed to collect the following variables: patients' age, gender, ethnicity, body mass index (BMI), comorbidities as part of the Charlson Comorbidity Index (CCI), nickel allergy status, smoking status, surgery index diagnosis, prior hip arthroscopy, prior hip surgery (non-arthroscopy), arthroplasty status of the contralateral hip, and component sizes. Nickel allergy status was specifically asked to patients, and lymphocyte transformation testing or skin patch testing was not routine. CCI was used to assign a numeric score to patient comorbidity [9]. Diagnoses were split into primary OA, secondary OA, and other arthritis. Patients who only had the diagnosis of OA in the EMR were categorized into the primary or secondary OA groups based on measurements of preoperative X-rays.

Patients were contacted via telephone and asked to follow-up with a PRO questionnaire via mail or email. Patients received a $20 gift card for survey completion. Revision and complication information was obtained through telephone interview and confirmation in the EMR. Study data were managed using Research Electronic Data Capture tools [10].

Radiographic Parameters

Preoperative and postoperative anterior-posterior (AP) pelvis X-rays were obtained on all patients. Patients were positioned supine with legs internally rotated 15°-20°. Measurements were made using Aquarius Imaging Software (TeraRecon, Foster City, CA) and were averaged between 2 independent readers. On preoperative X-rays, alpha angle and lateral center edge angle were measured using previously published definitions [11,12]. An AP pelvis, alpha angle of >50° [13-15] was categorized as OA secondary to CAM-type FAI. An AP pelvis lateral center edge angle of <22° [16] was categorized as OA secondary to dysplasia. If patients with an EMR diagnosis of only OA did not fit radiographic criteria for secondary OA, they were categorized as primary OA. Patients with the EMR diagnoses of CAM-type FAI or dysplasia were verified using the cutoff angles, and the majority matched this applied criteria. In postoperative AP pelvis X-rays, BHR cup inclination and femoral component position were measured using previously published definitions [17,18]. Varus/valgus femoral component alignment was defined relative to the anatomic neck axis (calculated as postoperative component stem-shaft angle minus preoperative femoral neck-shaft angle). Positive alignment measurements correlate with valgus femoral component position, and negative alignment measurements correlate with varus femoral component position. Heterotopic ossification (HO) was classified in the most recent postoperative AP pelvis X-ray using the Brooker classification [19].

Patient-Reported Outcomes

The validated PROs included in the follow-up questionnaire included the Hip Disability and Osteoarthritis Outcome Score (HOOS), the Veterans Rand-12 (VR-12), and the UCLA activity. The HOOS consists of 5 subscales and has proven psychometric properties in patients with hip arthroplasty and hip OA [20-22]. HOOS scoring ranges from 0-100 with 0 indicating extreme problems and 100 indicating no problems. The VR-12, made up of physical component scores (PCS) and mental component scores, assesses health-related QOL [23]. VR-12 scoring has a population standardized mean of 50 and standard deviation of 10. The UCLA activity has shown high reliability and validity in patients with hip OA and hip arthroplasty [24,25]. The UCLA activity scoring ranges from 1 to 10 with 1 meaning “wholly inactive” and 10 meaning “regularly participates in impact sports.”

Statistical Analysis

Failure rate was calculated by dividing the total number of revision cases by the total number of hip cases. A Kaplan-Meier survival curve for the entire 541 hip cohort was created with revision for any reason as the end point. Hips not revised at the time of latest follow-up were censored at this time point. Postoperative PROs were modeled using ordinary least squares models with preoperative variables (age, gender, ethnicity, BMI, CCI, nickel allergy status, smoking status, surgery index diagnosis, prior hip