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Preoperative Joint Space Width Predicts Patient-Reported Outcomes After Total Hip Arthroplasty in Young Patients

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A B S T R A C T

Background: In a new health care economy, there is an emerging need to understand and quantify predictors of total hip arthroplasty (THA) outcomes. We investigated the association between preoperative radiographic disease (as measured quantitatively by joint space width [JSW]) and patient-reported function, activity, pain, and quality of life after THA.

Methods: We retrospectively analyzed 146 patients (146 hips) 55 years or younger with a diagnosis of osteoarthritis who underwent cementless THA between January 2009 and December 2010. Preoperative pelvic radiographs were measured by 1 author blinded to clinical outcomes to establish JSW, defined as the shortest distance between the femoral head margin and the superolateral weight-bearing portion of the acetabulum. The JSW value was treated as a continuous variable when applied to statistical modeling. The relationship between the JSW and the improvement of clinical outcome was examined via a general linear modeling approach with adjustments for patients' age, body mass index, and sex.

Results: We identified an inverse relationship between preoperative JSW and improvements in functional, activity, pain, and quality of life. We found that, as JSW decreased by 1 mm, the outcome measure improvements were modified Harris Hip Score of 6.3 ($p<0.001$); SF-12 physical: 2.1 ($p=0.027$); WOMAC-pain: 4.8 ($p=0.01$); and UCLA Activity: 0.44 ($p=0.02$).

Conclusions: Our results demonstrate that patients with greater preoperative joint space have less predictable improvement in terms of function, pain relief, and activity. These findings suggest that THA in young patients with a JSW less than 1.5 to 2 mm provides more predictable improvements in pain and functional outcomes.

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Joint arthroplasty utilization trends continue to rise in the United States [1]. Government reforms, such as Accountable Care Organizations and bundled payment structures, are currently being implemented to scrutinize health care spending and penalize hospitals with poor outcomes [2]. Elective surgeries, such as total hip arthroplasty (THA), are at the forefront of such legislation. Thus, there is an urgent need to study those factors predictive of clinical outcomes to optimize patient satisfaction and uphold value-based care principles in this emerging sector of young patients.

The long-term success of modern, cementless THA is well documented [3,4]. Previous studies have established that patient satisfaction after hip arthroplasty is strongly correlated to postoperative pain, function and activity levels, and success in meeting patient expectations [5,6]. Furthermore, it has been shown that a decrease in joint space width (JSW) on radiograph is associated with an increase in the number of clinical signs and symptoms with which patients present to a general practitioner for a chief concern of hip pain, as well as the subsequent likelihood to pursue arthroplasty surgery [7–10]. In regard to the knee, Polkowski et al [11] found that 25% (19/76) of patients with relatively preserved joint spaces (Kellgren-Lawrence grade I or II arthritis) had significant ongoing pain after knee arthroplasty. For the hip, however,

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the association of JSW and symptom progression is less well defined. Nilsdotter et al and others have demonstrated that qualitative osteoarthritis (OA) grading alone does not accurately predict outcomes after THA [12–14].

The purpose of our study was to investigate the association between preoperative radiographic disease, as measured quantitatively by JSW treated as a continuous variable, and postoperative patient-reported functional, activity, pain, and quality-of-life score improvements. We hypothesize that young individuals with more advanced radiographic hip OA, as determined by a narrowing joint space, experience consistent and greater magnitudes of improvement in functional outcomes after THA compared with those with similar clinical symptoms but less radiographic narrowing of the hip joint.

Materials and Methods

After ethical approval by the institutional review board at our academic institution, we reviewed prospectively collected data available from our joint arthroplasty repository. All elective primary THAs in patients ≤55 years of age performed by the senior surgeon during a 2-year period (January 2009 through December 2010) were reviewed for consideration. Two hundred fourteen primary THAs were identified. We excluded 57 bilateral THAs done during this period, as differentiating causes of pain and functional improvements were likely to be influenced by the timing between surgeries. Eleven patients with an underlying diagnosis of hip dysplasia were excluded because of inconsistencies in pelvic tilt, rotation, and femoral-acetabular profile on anteroposterior (AP) pelvic radiograph. We were left with 146 hips (146 patients) that met inclusion criteria of having a THA performed during the aforementioned period for a primary diagnosis of degenerative OA, consented for inclusion in research, had the requisite preoperative AP digitized pelvic radiographs, and were younger than 55 years at the time of surgery.

The majority of patients had their total hip approached through a posterior incision (144/147, 98%), whereas 3 subjects (2%) underwent an anterolateral approach. All components used were Zimmer (Warsaw, IN) products, except for 5 subjects (3.4%) who had a Depuy Pinnacle Bantam (Warsaw, IN) stems chosen because of their young age and small stature. Eight-two subjects (56%) had Zimmer M/L Taper stems, 44 others (30%) were Zimmer VerSys Fiber Metal or Beaded MidCoat stems, and the remaining 21 stems (14%) were Zimmer VerSys Epoch FullCoat. As for acetabulum, 138 patients (94%) had Zimmer Trilogy components, whereas the remaining 9 subjects (6%) were given Zimmer Trabecular Metal Cluster shells. Finally, all patients received Biolox delta (CeramTec Inc, Plochingen, Germany) components. Ninety-one percent of patients (133 subjects) received 32-mm heads, whereas 6 subjects had 28-mm heads (4%) and 8 others (5%) had 36-mm heads.

All radiographic measurements were made using the digital radiograph measurement tool provided by our hospital's imaging system (Clinical Desktop, Inc, St Louis, MO). This system has not been validated in the literature but allows for scaling, manipulating, and performing measurements through use of a standard picture archiving and communication system. Radiographs were measured by a research fellow with more than 10 years of orthopedic adult reconstructive surgery experience who was trained by the senior author and had no role in clinical care. Joint space width was measured as the minimal joint space (ie, the shortest distance between the femoral head margin and the acetabulum) in the weight-bearing zone, as defined by the medial and lateral aspects of the acetabular sourcil. The medial joint space was not assessed because of less distinct landmarks [15]. Measurements on the same patient were made greater than 2 weeks apart and then averaged to determine an average measurement and remove bias. This value was then corrected by a factor of 1.2 to account for original image magnification of 120% at time of acquisition (Fig. 1). The JSW value, recorded in millimeters, was treated as a continuous variable when applied to statistical modeling. Although our radiology technicians do not use a calibration marker, they do follow a detailed technique in which patients lie supine on the x-ray table with both lower extremities oriented in 15° of internal rotation and the tube-to-film distance is set at 120 cm with the tube oriented perpendicular to the table [16]. The radiographic beam is then centered directly on a point midway between the superior aspect of the pubic symphysis and a point on a line bisecting the anterior superior iliac spines.

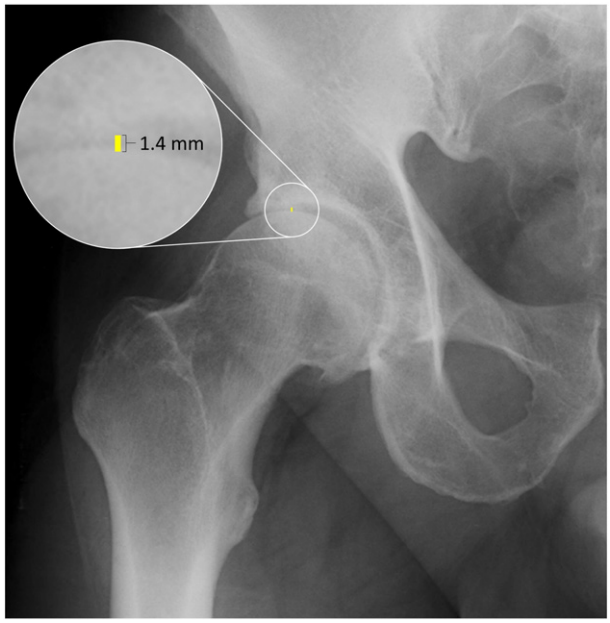

Fig. 1. Joint space width measured from AP pelvis radiograph with neutral tilt and rotation with coned-in view to focus on superolateral weight-bearing region of the joint.

Preoperative evaluation of joint symptoms included self-reported outcome measures of the modified Harris Hip Score (mHHS) [17], San Francisco Health Survey (SF-12) mental and physical components [18], Western Ontario and McMasters Osteoarthritis Index (WOMAC) [19], and University of California Los Angeles (UCLA) activity score [20]. We chose to use the mHHS over the HHS because it has been shown to have acceptable construct validity in young patients with a variety of hip pathology [21]. All patients had minimum 2-year follow-up with repeated functional assessment. A total of 79 women (54%) and 68 men (46%) who underwent THA performed by a single surgeon for symptomatic hip arthritis were included for analysis during the study period. The group consisted of 54% women (n = 79) and 46% (n = 67) men, with a median age of 47 years and a median body mass index (BMI) of 27.5 kg/m^2 (Table 1). The average prearthroplasty JSW for the cohort was 1.14 mm (SD, 1.1 mm). Eighty-three percent (121 subjects) of participants identified as Caucasian, 15% (22 subjects) as African American, and 2% (n = 3) as other. All subjects had appropriate preoperative radiographs, and between 90.4% and 93.8% of the cohort had completed the requisite patient outcome questionnaires (Table 2).

A pretest power analysis was performed, and with 146 subjects enrolled, we found that we would be able to reject the null hypothesis with a probability of 0.996 if the mHHS change was greater than 7 points. The type I error associated with this test of the null hypothesis is 0.05. The minimal clinically important difference for the WOMAC inventory has previously been determined as a 16% to 18% improvement from baseline or an aggregate 9 to 12 score change [22,23], whereas the UCLA, mHHS, and SF-12 lack such designations specifically regarding hip arthritis.

Demographic and clinical characteristics of all the enrolled patients are summarized using descriptive statistics. The relationship between the width of joint space and the improvement of clinical outcome is examined via a general linear modeling approach with the adjustment for patients' age, BMI, and gender. The *improvement of clinical outcome* is defined as the difference between the assessment scores measured