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Total Hip Arthroplasty Functional Outcomes Are Independent of Acetabular Component Orientation When a Polyethylene Liner Is Used

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ABSTRACT

Background: This study evaluated patient-reported outcomes in patients undergoing primary total hip arthroplasty with a polyethylene liner to determine the influence of cup orientation and other variables on patient-reported outcomes.

Methods: A total of 477 cases were prospectively monitored through average 4.7 years follow-up. Cup position was measured on pelvis radiographs. Patients completed the Western Ontario and McMaster Universities Osteoarthritis Index and Short Form 12 Health Survey questionnaires.

Results: Average cup abduction was 43.1° ± 7.5° and anteversion was 13.3° ± 7.5°. Three hundred cups were within the target zone. All outcomes' improvement from baseline and cup position was not an independent risk factor for the Western Ontario and McMaster Universities Osteoarthritis Index or Short Form 12 Health Survey improvement.

Conclusion: Accurate cup orientation may not be critical to maximizing patient-perceived outcomes if the combined anteversion is within a normal range, the hip joint is properly balanced, and a polyethylene liner is coupled with a metal or ceramic femoral head.

Primary total hip arthroplasty (THA) is a cost-effective procedure with excellent functional outcomes [1-3]. Nevertheless, the number of revision THAs performed in the United States is rapidly increasing, having increased 23% from 2005 to 2010 [1]. Failed primary THA and subsequent revision THA can impair a patient's health and increase morbidity and mortality, in addition to burdening the health care system with increased cost relative to uncomplicated primary THA [1-3]. A renewed emphasis on achieving improved quality of life and patient-reported functional outcomes is necessary to combat the rising number of revision THAs.

Proper acetabular component positioning during THA is critical for minimizing complications while maximizing implant longevity and stability [4-6]. Dislocation alone occurs in 2%-3% of all primary THA and is the most common cause of revision surgery, accounting for 22.5% of all revisions [4,7]. To that end, surgeons typically aim to place the acetabular component in a safe zone in which such complications are diminished, most commonly that proposed by Lewinnek et al [5] in 1978 (30°-50° of inclination and 5°-25° of anteversion). Several studies have suggested that malpositioning outside of the Lewinnek safe zone increases the risk of prosthesis dislocation, liner fracture, and component wear leading to osteolysis and aseptic loosening [5,6,8-12]. Other publications have

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This research study has been performed in accordance with the ethical standards in the 1964 Declaration of Helsinki and carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act. Our institution's institutional review board has reviewed and approved this study, and a copy of the approval letter is included in the submission.

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demonstrated that how in metal-on-metal and ceramic-on-ceramic bearing couples, articulating at the extreme ranges of this safe zone (edge loading) or outside the zone results in increased wear rates, elevated serum metal ion levels, an audible squeaking noise, and adverse local tissue reactions [13]. The metal-on-polyethyelene bearing couple can compensate for cup malposition, as this articulation is durable at the extremes of range of motion and is resilient to the negative outcomes in the hard-on-hard bearing couples [14].

To prevent these complications, much research has been devoted to optimizing the positioning of the acetabular component within the safe zone through anatomic landmarks [15-18], intraoperative fluoroscopy [19], and surgical navigation technologies [20-23]. Such technologies appear necessary, as the commonly used free-hand technique for cup positioning affords only 25%-70% successful placement in the safe zone [24-26]. However, many studies have questioned whether cup positioning in the Lewinnek safe zone truly decreases complication rates [5,7,10,17,27,28]. Further adding to the confusion, cup malposition does not necessary impart a negative prognosis and poor quality of life for a patient while a properly oriented cup may not guarantee success. No prior study has examined the influence of acetabular component orientation on patient-reported outcomes.

The purpose of this study was to (1) evaluate patient-reported outcomes in a large cohort of patients undergoing THA with a polyethylene liner and (2) determine the effect of acetabular component orientation and other variables on patient-reported outcomes after THA.

Methods

We prospectively followed 898 patients who underwent 1046 primary THA procedures over an 11-year period (between January 2002 and January 2013) using our center's institutional review board approved joint registry. Two fellowship-trained orthopedic surgeons performed all surgical procedures. These patients were followed through their preoperative visit, throughout the duration of their initial hospital course, and at postoperative outpatient visits at 1 month, 3 months, 1 year, and every 2-3 years thereafter as needed. At each encounter, patients were asked to complete the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire and Short Form 12 Health Survey (SF-12) in order to assess their disease-specific and generic health status respectively. Patients who did not attend a scheduled encounter were mailed WOMAC and SF-12 questionnaires. All patients must have completed WOMAC and SF-12 questionnaires at their preoperative visits and at a postoperative visit of minimum 1-year follow-up to be included in the study population. Furthermore, all patients were required to be >18 years and to have had no prior hip surgery, fracture or other capsular violation of the ipsilateral hip, or history of primary or metastatic cancer. All procedures were performed with a metal-on-polyethylene or ceramic-on-polyethylene nonconstrained articulation, and all patients were required to have a digital postoperative anteroposterior pelvis radiograph.

Our analysis included 477 primary THAs performed using a metal-on-polyethylene or ceramic-on-polyethylene articulation, with mean age 65.3 years and mean follow-up 4.74 years. The Food and Drug Administration approved all implants used in these patients. From the previously mentioned database, we collected patient information for each THA including laterality of operated hip, age, gender, preoperative diagnosis, height, weight, body mass index (BMI), surgical approach, performing surgeon, femoral head size, acetabular cup outer diameter, and femoral head type, in addition to all WOMAC and SF-12 data. The demographics of this cohort are described in Table 1. A power analysis based on a logistic regression model was performed, and suggested 350 cases were required to achieve 80% power at a 0.05 significance level to detect an effect size of 15% (assuming 50% of patients overall will have malpositioned acetabular components, based on Callanan et al) [25,29].

Table 1
Patient Demographics.

Demographics	All Patients (n = 477)	In Lewinnek Safe Zone (n = 300, 62.9%)	Outside Safe Zone (n = 177, 37.1%)	*P* Value
Age group				.471
<50 y	57 (11.9%)	32 (10.7%)	25 (14.1%)	
50-70 y	230 (48.2%)	141 (47.0%)	89 (50.3%)	
>70 y	190 (39.8%)	127 (42.3%)	63 (35.6%)	
Gender				.916
Female	279 (58.5%)	176 (58.7%)	103 (58.2%)	
Male	198 (41.5%)	124 (41.3%)	74 (41.8%)	
Laterality				.228
Left	204 (42.8%)	122 (40.7%)	82 (46.3%)	
Right	273 (57.2%)	178 (59.3%)	95 (53.7%)	
Diagnosis				.489
Osteoarthritis	419 (87.8%)	261 (87.0%)	158 (89.3%)	
Avascular necrosis	53 (11.1%)	35 (11.7%)	18 (10.2%)	
Inflammatory arthritis	5 (0.1%)	4 (1.3%)	1 (0.5%)	
Approach				.049
Posterior	463 (97.1%)	295 (98.3%)	168 (94.9%)	
Anterolateral	14 (2.9%)	5 (1.7%)	9 (5.1%)	
BMI[a] (n = 416)				.882
<20	18 (4.3%)	11 (4.3%)	7 (4.4%)	
20-30	276 (66.4%)	172 (66.9%)	104 (65.4%)	
>30	122 (29.3%)	74 (28.8%)	48 (30.2%)	
Femoral head size				.245
<32	137 (28.7%)	92 (30.7%)	45 (25.4%)	
32	223 (46.8%)	136 (45.3%)	87 (49.2%)	
>32	117 (24.5%)	72 (24.0%)	45 (25.4%)	
Acetabular cup outer diameter				.961
≤50	68 (16.3%)	44 (14.7%)	24 (13.6%)	
50-60	313 (65.6%)	203 (67.7%)	110 (62.1%)	
≥60	96 (20.1%)	53 (17.6%)	43 (24.3%)	
Femoral head type[a] (n = 266)				.452
Metal	231 (86.8%)	142 (85.5%)	89 (89.0%)	
Ceramic	35 (13.2%)	24 (14.5%)	11 (11.0%)	
WOMAC				
Pain	45.0 ± 23.0	43.8 ± 23.2	47.1 ± 22.7	.131
Function	47.1 ± 20.0	45.8 ± 19.8	49.3 ± 20.2	.065
Stiffness	45.5 ± 24.3	44.9 ± 24.6	46.5 ± 24.0	.489
Total	45.9 ± 19.5	44.8 ± 19.7	47.8 ± 19.1	.105
SF-12				
MCS	50.0 ± 11.4	49.9 ± 11.2	50.0 ± 11.8	.927
PCS	30.3 ± 8.0	30.1 ± 8.5	30.3 ± 7.1	.797

BMI, body mass index; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; SF-12, Short Form 12 Health Survey; MCS, Mental Component Score; PCS, Physical Component Score.
[a] Data were incomplete for BMI (61 hips) and head type (211 hips).

Cup inclination and version angles were calculated from the anteroposterior pelvis film using Martell Hip Analysis Suite (HAS), version 8.0.4.1 (Martell HAS; Chicago, IL), a validated computer-assisted technique.[25,30] Two unbiased measurers, blinded to patient outcome, performed all measurements with an interobserver reliability of 0.973 for anteversion and 0.984 for abduction by intraclass correlation coefficient. Because HAS is unable to determine the sign of the version angle, cross-table lateral radiographs were used to determine cup version.

For the statistical analysis, we defined acceptable angle ranges as 30°-50° for abduction and 5°-25° for version based on surgeon consensus and the safe zone defined by Lewinnek et al. We then analyzed acetabular component position relative to the Lewinnek safe zone to assess its effects on deltaWOMAC subscores (pain, stiffness, function) and total and on deltaSF-12 subscores (Mental and Physical), in addition to age, gender, laterality, diagnosis,