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Redefining the Acetabular Component Safe Zone for Posterior Approach Total Hip Arthroplasty

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ABSTRACT

Background: Acetabular component orientation influences joint stability in total hip arthroplasty (THA). The purpose of this study was to evaluate the effect of cup orientation and other variables on hip dislocation risk and to define a posterior approach specific safe zone.

Methods: A cohort of 1289 posterior approach primary THA cases was prospectively followed and component position measured radiographically.

Results: Cup malposition, with respect to the Lewinnek safe zone, was an independent risk factor for dislocation (OR1.88). Modifying the anteversion safe zone limits to 10-25° strongly predicted increased dislocation risk (OR2.69). No dislocations occurred within a zone defined by a circle centered at 41.4° abduction and 17.1° anteversion, radius 4.3°.

Conclusion: Utilizing a posterior approach specific safe zone of 10-25° anteversion and 30-50° abduction may minimize THA dislocations.

Level of Evidence: Level III

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Hip dislocation continues to be a concern to patients undergoing total hip arthroplasty (THA) and a leading complication in the postoperative period, occurring in 2% to 3% of all primary cases and accounting for 22.5% of revision surgery [1-8]. Proper component position is crucial for achieving implant longevity and stability. Lewinnek et al [4] initially proposed the ideal position for acetabular component orientation in 1978. This publication cited a 4× higher dislocation rate in cups positioned outside a safe zone of 30° to 50° of abduction and 5° to 25° of anteversion; this range was designated as the ideal cup position. Although this study had flaws including low patient number, confounding variables, and unclear radiological measurement techniques, the Lewinnek safe zone remains widely used today.

Most surgeons use free-hand technique to position the acetabular component within this range, sometimes using an external alignment guide for assistance. However, as noted by Callanan et al [9], they fail at a rate of 30% to 75% [9-11]. Posterior approach surgeons only achieve the safe zone in 60% of cases [9]. This has led to the advent of anatomic landmarks [12-15], intraoperative fluoroscopy [16], and surgical navigation technologies to optimize acetabular component position [17-20]. These new techniques may become increasingly important as a recent publication by Elkins et al [21] has challenged the traditional Lewinnek safe zone and proposed limiting it to 37.5° to 47.5° abduction and 12° to 22° anteversion, a range that few surgeons will be able to reproducibly accomplish.

Even if positioning of the acetabular component within the Lewinnek safe zone is achieved, dislocations are still seen within this zone, and some have questioned its utility [3,4,14,22-24]. However, these studies did not control for surgical approach, grouping all approaches into the same cohort or articulation type (metal-on-polyethylene, ceramic-on-polyethylene, metal-on-metal), and many were small in patient number. Excessive anteversion correlates with an increased prevalence of anterior dislocation, and similarly, lack of anteversion correlates with an increased prevalence of posterior dislocation [4]. It is known that posterior capsulotomies are associated with increased risk of posterior hip dislocations, which can be mitigated by increasing anteversion and the performance of a robust soft tissue repair. Thus, we believe that using a single safe zone for all THA regardless of the surgical approach is inappropriate and the location of the capsulotomy should be a significant determinant of the safe zone to minimize this risk.

The purpose of this study was to (1) determine the accuracy of conventional free-hand acetabular cup positioning within the traditional Lewinnek safe zone in a large population of patients undergoing posterior approach THA; (2) evaluate the effect of acetabular component orientation and other variables on the risk of hip dislocation; and (3) define a posterior approach THA specific safe zone.

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Methods and Methods

Using our center's institutional review board–approved joint registry, we identified 1532 primary THA procedures over a 13-year period (between January 1999 and December 2013). All surgical procedures were performed by orthopedic surgeons who completed an arthroplasty fellowship, at 2 hospitals that were part of the same institution. These patients were followed throughout the duration of their initial hospital course and at postoperative outpatient visits at 1 month, 3 months, 1 year, and every 2 to 3 years thereafter as needed; they were also followed through any additional outpatient visits or inpatient admissions related to orthopedic concerns. At each encounter, patients were queried about hip instability including subluxations or dislocation events confirmed radiographically and requiring formal reduction in the operating room or emergency department. Multiple subluxations requiring revision surgery or at least 1 dislocation event were used as the primary outcome. Any patient who failed to follow up beyond 1 year was contacted by a member of the research team to ask about dislocation events and revision surgeries.

Patients included in this study's cohort included only posterior approach THA with a minimum of 6-month follow-up and a digital anteroposterior (AP) pelvis radiograph. Patients were required to have a minimum of 6 months of follow-up based on prior studies suggesting that 80% of all dislocations after THA occur within the first 3 months postoperatively and multiple other studies that required a minimum of 6-month follow-up from surgery [3,8,25]. We excluded patients with anterior or lateral surgical approaches (59 hips), articulation including metal-on-metal (44 hips), ceramic-on-ceramic (25 hips), ceramic-on-metal (5), constrained liner or tripolar articulation (48 hips), and those who had a noninstability complication necessitating revision within the follow-up period (18 periprosthetic joint infections, 12 periprosthetic fractures, 13 femoral loosening/subsidence, 8 acetabular loosening, and 11 additional revisions for nondislocation etiologies).

Thus, our analysis included 1289 primary THAs performed using a posterior approach and a metal-on-polyethylene or ceramic-on-polyethylene articulation. The Food and Drug Administration approved all implants used in these patients. From this database, we collected patient information for each THA including laterality of operated hip, age, sex, preoperative diagnosis, history of prior hip surgery, height, weight, body mass index (BMI), surgical approach, performing surgeon, femoral head size, acetabular cup outer diameter, and femoral head type. The demographics of this cohort are described in Table 1. A power analysis based on a logistic regression model was performed and suggested that 609 cases were required to achieve 80% power at a 0.05 significance level to detect a change in dislocation rate between 6.1% and 1.5% (as in the Lewinnek study); our inclusion of 1289 THAs provided 98.2% power at a 0.05 significance level to detect the same difference [4,26].

Patients were required to have a digital postoperative AP pelvic radiograph, as cup inclination and version angles were calculated from the AP film using Martell Hip Analysis Suite Version 8.0.4.1 (Martell HAS, Chicago, IL), a validated computer-assisted technique [9,27]. Two unbiased measurers, blinded to patient outcome, performed all measurements with an interobserver reliability of 0.962 for anteversion and 0.977 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 if the cup was anteverted or retroverted.

For the statistical analysis, we defined acceptable angle ranges as 30° to 50° for abduction and 5° to 25° for version based on surgeon consensus and the safe zone defined by Lewinnek et al [4]. We then analyzed acetabular component position relative to the Lewinnek safe zone, in addition to 9 other variables listed in Table 1, to assess their effect on dislocation rate. Age at surgery was divided into 3 groups: younger than 50 years, 50 to 70 years, and older than 70 years [4]. Sex was divided into male or female. Diagnosis was divided into 5 groups: osteoarthritis, avascular necrosis, inflammatory arthritis, femoral neck fracture, and prior failed open reduction internal fixation or hemiarthroplasty. Conversion cases were defined as hips that had prior surgery and significant capsular violation on the ipsilateral side. Body mass index was divided into 3 groups based on classifications from the World Health Organization, with BMI greater than or equal to 30 considered obese and BMI less than or equal to 20 considered underweight (BMI 20-30 considered normal). Height was divided into 3 groups: less than or equal to 5 ft, between 5 and 6 ft, and greater than or equal to 6 ft. Femoral head size was divided into less than 32 mm, 32 mm, or greater than 32 mm. Acetabular cup outer diameter was divided into 3 groups: less than or equal to 50, 50 to 60, and greater than or equal to 60. Femoral head type was divided into metal or ceramic.

Acetabular cup orientation within the Lewinnek safe zone and patient and surgical factors were correlated to dislocation rates. Patient demographics, surgical influences, and cup position was analyzed using univariate logistic regression analysis for dislocation rates. Then, all factors were re-examined using multivariate logistic regression analysis to determine whether there was an impact on dislocation rate. Odds ratios (ORs) for the increased chance of dislocation were calculated for all factors included in the univariate and multivariate analyses. Odds ratios were considered significant when the *P* value was less than .05, and all statistical analyses were performed in SPSS (SPSS, Inc, Chicago, IL).

Table 1
Patient Demographics.

	All Patients (n = 1289)	No Dislocation (n = 1247, 96.7%)	Dislocation (n = 42, 3.3%)	*P*
Age group (y)				.187
<50	188 (14.6%)	185 (14.8%)	3 (7.1%)	
50-70	612 (47.5%)	594 (47.6%)	18 (42.9%)	
>70	489 (37.9%)	468 (37.5%)	21 (50.0%)	
Sex				.325
Female	733 (56.9%)	706 (56.6%)	27 (64.3%)	
Male	556 (43.1%)	541 (43.4%)	15 (35.7%)	
Diagnosis				.177
Osteoarthritis	1034 (80.2%)	1004 (80.5%)	30 (71.4%)	
Avascular necrosis	162 (12.6%)	157 (12.6%)	5 (11.9%)	
Inflammatory arthritis	24 (1.9%)	22 (1.8%)	2 (4.8%)	
Femoral neck fracture	45 (3.5%)	41 (3.3%)	4 (9.5%)	
Failed ORIF/ hemiarthroplasty	24 (1.9%)	23 (1.8%)	1 (2.4%)	
Conversion status				.674
Conversion	73 (5.7%)	70 (5.6%)	3 (7.1%)	
Not conversion	1216 (94.3%)	1177 (94.4%)	39 (92.9%)	
BMI (n = 1111)				.256
<20	57 (5.1%)	55 (5.1%)	2 (5.9%)	
20-30	712 (64.1%)	686 (63.7%)	26 (76.5%)	
>30	342 (30.8%)	336 (31.2%)	6 (17.6%)	
Height (n = 1169)				.303
<5′	46 (3.9%)	44 (3.9%)	2 (5.6%)	
5′-6′	932 (79.7%)	907 (80.0%)	25 (69.4%)	
>6′	191 (16.4%)	182 (16.1%)	9 (25.0%)	
Femoral head size				.346
<32	425 (33.0%)	408 (32.7%)	17 (40.5%)	
32	506 (39.3%)	494 (39.6%)	12 (28.6%)	
>32	358 (27.7%)	345 (27.7%)	13 (30.9%)	
Acetabular cup outer diameter				.096
≤50	241 (18.7%)	239 (19.2%)	2 (4.8%)	
50-60	859 (66.6%)	827 (66.3%)	32 (76.2%)	
≥60	189 (14.7%)	181 (14.5%)	8 (19.0%)	
Femoral head type (n = 881)				.353
Metal	681 (77.3%)	662 (77.5%)	19 (70.4%)	
Ceramic	200 (22.7%)	192 (22.5%)	8 (29.6%)	

Data were incomplete for BMI (178 hips), height (120 hips), head type (408 hips).