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Original article

Restoring femoral offset is the most important technical factor in preventing total hip arthroplasty dislocation

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ABSTRACT

Purpose: Our aim was to determine if acetabular component position, femoral offset restoration, or leg-length equality is most important for total hip arthroplasty (THA) stability.
Methods: A matched case (n = 67)-control (n = 247) design and conditional logistic regression model were used to examine risk factors for dislocation in primary THA.
Results: When femoral offset was at least 3 mm greater than that of the contralateral hip, risk of dislocation was lower (p = 0.0192). Neither leg-length difference nor acetabular component abduction or version angle was associated with dislocation.
Conclusions: Our data suggest restoring femoral offset is the most important technical factor in preventing THA dislocation.

1. Introduction

Total hip arthroplasty (THA) is widely performed and its frequency is expected to increase substantially over the next two decades.[1–4] One of the primary goals of THA is to provide a stable hip by restoring joint biomechanics. Failure to achieve this goal results in dislocation, and occurs regardless of surgical approach.[5] THA dislocation requires closed reduction, adherence to hip precautions, and at times cumbersome bracing. Recurrent dislocation refractory to conservative management necessitates revision surgery, which has a significant risk of infection, hospital readmission, and in-hospital mortality.[6–8] Thus, efforts to minimize the risk of THA dislocation are essential.

Proper component position and restoration of soft tissue tension are widely accepted technical goals during THA, but the extent to which each of these factors contributes to THA stability is unclear.[9–15] Elucidating the relative impact of acetabular component position, femoral offset restoration, and leg-length equality on THA stability may help guide intraoperative decision-making to minimize the risk of postoperative dislocation.

The aims of this study were to determine: (1) if acetabular component position, femoral offset restoration, or leg-length equality is most important for THA stability; and (2) if patient characteristics or surgical factors predict THA dislocation.

2. Materials and methods

2.1. Study design

We examined the risk factors for THA dislocation using a retrospective matched case-control design. Institutional Review Board at our hospital approved this study. This retrospective study did not require formal consent.

The source population was all patients who underwent primary THA via the posterior approach by fellowship-trained adult reconstruction surgeons at our orthopaedic tertiary referral center from 2002 to 2012 (n = 17,329). Cases were defined as patients who required subsequent THA closed reduction performed at our institution (n = 67). Controls, THA patients who did not require closed reduction, were matched at a ratio of 4 controls per case by surgeon and year of surgery (n = 247).

2.2. Outcomes and statistical analysis

Risk factors of interest were acetabular component abduction angle and version, femoral offset difference, and leg-length difference. Each

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Table 1
Patient Distribution Across Matched Variables Among Cases (Dislocation) and Controls (No Dislocation).

Matched Variables	No Dislocation		Dislocation		p-value
	N	%	N	%	
Surgeon					0.7487
1	9	3.5	3	4.9	
2	29	11.7	8	11.9	
3	5	2.0	0	0	
4	6	2.4	1	1.5	
5	15	6.1	5	7.5	
6	61	24.7	16	23.9	
7	4	1.6	1	1.5	
8	8	3.2	2	3.0	
9	11	4.5	3	4.5	
10	4	1.6	1	1.5	
11	2	0.8	1	1.5	
12	15	5.9	4	6.0	
13	11	4.5	3	4.5	
14	3	1.2	1	1.5	
15	7	2.8	3	4.5	
16	4	1.6	1	1.5	
17	2	0.8	0	0	
18	35	14.2	10	14.9	
19	16	6.5	4	6.0	
Year of surgery					0.4014
2002	13	5.3	5	7.5	
2003	52	21.1	15	22.4	
2004	23	9.3	6	9.0	
2005	22	8.9	7	10.4	
2006	27	10.9	9	13.4	
2007	13	5.3	1	1.5	
2008	32	13.0	8	11.9	
2009	23	9.3	5	7.5	
2010	26	10.5	6	9.0	
2011	12	4.9	3	4.5	
2012	4	1.6	1	1.5	

Table 2a
Patient Distribution Across Adjusted Covariates Among Cases (Dislocation) and Controls (No Dislocation) With Univariate Analysis of Risk of Dislocation.

	No Dislocation		Dislocation		p-value
	N	Mean (SD)	N	Mean (SD)	
Age	247	67.0 (11.8)	67	63.6 (12.2)	0.0968
BMI	240	27.8 (5.4)	63	28.2 (5.2)	0.2564
Gender					0.4109
Female	136	55.1	42	62.7	
Male	111	44.9	24	35.8	
Head size					0.0111
< 36	128	51.8	48	71.6	
> = 36	119	48.2	19	28.4	

Table 2b
Multivariate Analysis of Risk of Dislocation Across Adjusted Covariates.

Logistic Regression Analysis for Dislocation			
	OR	95%CI	p-value
Age	0.97	0.94–1.00	0.0453
BMI	1.04	0.97–1.11	0.3007
Gender (F vs. M)	1.58	0.77–3.27	0.2164
Head size (> = 36 vs. < 36)	0.43	0.19–0.95	0.0367

of these was measured on the first postoperative standing AP pelvis radiograph taken at our institution per standard protocol. Acetabular component version was measured with digital edge-detection method software (TraumaCad, Voyant Health, Petach-Tikva, Israel). This software calculates version by analyzing the elliptical radiographic profile

Table 3a
Description of Factors on AP Pelvis Radiographs Among Cases (Dislocation) and Controls (No Dislocation) With Univariate Analysis of Risk of Dislocation.

	No Dislocation		Dislocation		p-value
	N	Mean (SD)	N	Mean (SD)	
Acetabular component abduction angle	244	42.71 (6.67)	65	44.52 (8.33)	0.0675
Femoral offset difference (operative-nonoperative)	245	3.08 (5.46)	67	1.71 (9.09)	0.1240
Leg-length difference (operative-nonoperative)	234	3.04 (6.58)	63	0.87 (8.5)	0.0301

Table 3b
Multivariate Analysis of Risk of Dislocation Across Factors on AP Pelvis Radiographs.

Logistic Regression Analysis for Dislocation			
	OR	95%CI	p-value
Acetabular component abduction angle	1.04	0.99–1.09	0.1381
Femoral offset difference (operative-nonoperative)	0.94	0.89–0.99	0.0192
Leg-length difference (operative-nonoperative)	0.97	0.92–1.01	0.1435

*Adjusted for age, gender, BMI, and head size.

of a hemispherical acetabular component relative to a line along the inferior aspect of the ischial tuberosities. Anteversion or retroversion was determined using a cross-table lateral radiograph. The remainder of the measurements were made digitally using a medical software package (AGFA IMPAX Orthopaedic Tools, Greenville, SC) integrated into our institution's Picture Archiving and Communication System (PACS). Acetabular component abduction angle was determined by the angle between a line along the face of the acetabular component and a line along the inferior aspect of the ischial tuberosities. Femoral offset was determined by measuring the distance from the center of the femoral head to the tip of the greater trochanter along a line perpendicular to the long axis of the femur. Femoral offset difference was calculated by measuring femoral offset of the replaced hip and subtracting from it femoral offset of the contralateral hip. Leg-length was determined by extending a line along the inferior aspect of the ischial tuberosities and measuring the perpendicular distance to this line from the superior aspect of the lesser trochanter. To obtain leg-length difference, the above value of the contralateral hip was subtracted from that of the replaced hip.

The risk of dislocation was assessed utilizing a conditional logistic regression model, where outcome was case versus control status. The model was adjusted for age, gender, body mass index (BMI), and prosthetic head size. With type I error set at 5%, 67 matched sets of cases and controls (1 case matched to 4 controls), and an odds ratio of 2.6 for dislocation, we anticipated statistical power > 0.80 to detect this difference.

3. Results

After matching controls to cases, there were no differences between groups with regard to operating surgeon or year of surgery (Table 1). The distribution of case and control patients across the adjusted covariates of age, BMI, gender, and prosthetic head size is given in Table 2a. Younger age (OR 0.97, 95%CI 0.94–1.00, p = 0.0453) and smaller head size (OR 0.43, 95%CI 0.19–0.95, p = 0.0367) were associated with an increased risk of dislocation, while BMI and gender did not have an effect on dislocation risk (Table 2b).

The mean acetabular component abduction angle, femoral offset difference, and leg-length difference among cases and controls is given in Table 3a. The results of the logistic regression model adjusted for age, BMI, gender, and head size with acetabular component abduction angle, femoral offset difference, and leg-length difference as risk factors are provided in Table 3b. When femoral offset was at least 3 mm greater than that of the contralateral hip, the risk of dislocation was lower (OR 0.94, 95%CI 0.89–0.99, p = 0.0192). Leg-length difference and acetabular component abduction angle were not associated with dislocation risk.

Acetabular component version was measured for 40 patients (13 cases and 27 controls) for whom cross-table lateral radiographs were available. All acetabular components were anteverted in patients with dislocations. Among patients without dislocations, one acetabular component was retroverted while all others were anteverted. Acetabular component version angle was not associated with dislocation risk (OR = 1.09, 95%CI 0.96–1.22, p = 0.1821).

4. Discussion

Appropriate component position and soft tissue tension must be achieved during THA to minimize the risk of dislocation. The relative contribution of these factors to THA stability, however, is unknown. Our primary study aim was to determine which of acetabular component position, femoral offset restoration, or leg-length equality is most important to THA stability. Secondarily, we assessed if patient characteristics or surgical factors were predictors of THA dislocation.

While this study may provide technical guidance helpful to performing THA, we understand our work has limitations. First, this is a retrospective study limited by the quality of available records. We did not have access to outside hospital records, so all dislocations may not have been captured. Second, we did not measure femoral component version, as a validated method for measurement on AP pelvis radiographs has not been established. Finally, we may not have adequately assessed the effect of significant component malposition on stability, as all study patients were those of high-volume, fellowship-trained surgeons.

To our knowledge, we are the first to report that restoring femoral offset is more important to THA stability than leg-length equality or acetabular component position. Our data do not suggest an association between leg-length and risk of THA dislocation, which is concordant with multiple prior studies.[12,13,15] Our finding that acetabular component position was not associated with THA dislocation risk is also in agreement with previously published work.[14,16,17]

We found that THA dislocation risk was increased with younger age and smaller prosthetic head size. Others have reported older age to be associated with dislocation, but these studies were case series with heterogeneous populations.[18,19] The observed increased dislocation risk in younger patients may be due to higher activity levels and increased demands at the extremes of hip motion.

Based on our study findings, intraoperative instability during THA should first be addressed by confirming restoration of femoral offset. Leg-length equality and acetabular component position remain important considerations in THA due to patient satisfaction and bearing surface wear/psoas tendon impingement, respectively. Efforts to prevent THA dislocation are particularly important in younger patients, who are at high risk. Future work may assess the role of femoral component version on THA stability and interaction with the factors investigated herein.

Conflict of interest

None.

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Kurtz S, Mowat F, Ong K, Chan N, Lau E, Halpern M. Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002. *J Bone Joint Surg Am.* 2005;87:1487–1497.
2. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am.* 2007;89:780–785.
3. Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. *Clin Orthop Relat Res.* 2010;467:2606–2612.
4. Kurtz SM, Ong KL, Schmier J, Zhao K, Mowat F, Lau E. Primary and revision arthroplasty surgery caseloads in the United States from 1990 to 2004. *J Arthroplast.* 2009;24:195–203.
5. Kwon MS, Kuskowski M, Mulhall KJ, Macaulay W, Brown TE, Saleh KJ. Does surgical approach affect total hip arthroplasty dislocation rates? *Clin Orthop Relat Res.* 2006;447:34–38.
6. Zhan C, Kaczmarek R, Loyo-Berrios N, Sangl J, Bright RA. Incidence and short-term outcomes of primary and revision hip replacement in the United States. *J Bone Joint Surg Am.* 2007;89:526–533.
7. Mahomed NN, Barrett J, Katz JN, Baron JA, Wright J, Losina E. Epidemiology of total knee replacement in the United States medicare population. *J Bone Joint Surg Am.* 2005;87:1222–1228.
8. Cram P, Lu X, Kates SL, Singh JA, Li Y, Wolf BR. Total knee arthroplasty volume, utilization, and outcomes among medicare beneficiaries, 1991–2010. *JAMA.* 2012;308:1227–1236.
9. Nevelos J, Johnson A, Heffernan C, Macintyre J, Markel DC, Mont MA. What factors affect posterior dislocation distance in THA? *Clin Orthop Relat Res.* 2013;471:519–526.
10. Barsoum WK, Patterson RW, Higuera C, Klika AK, Krebs VE, Molloy R. A computer model of the position of the combined component in the prevention of impingement in total hip replacement. *J Bone Joint Surg Br.* 2007;89:839–845.
11. Scifert CF, Brown TD, Pedersen DR, Callaghan JJ. A finite element analysis of factors influencing total hip dislocation. *Clin Orthop Relat Res.* 1998;355:152–162.
12. Jolles BM, Zangger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty. *J Arthroplast.* 2002;17:282–288.
13. Woolson ST, Rahimtoola ZO. Risk factors for dislocation during the first 3 months after primary total hip replacement. *J Arthroplast.* 1999;14:662–668.
14. Paterno SA, Lachiewicz PF, Kelley SS. The influence of patient-related factors and the position of the acetabular component on the rate of dislocation after total hip replacement. *J Bone Joint Surg Am.* 1997;79:1202–1210.
15. Fackler CD, Poss R. Dislocation in total hip arthroplastites. *Clin Orthop Relat Res.* 1980;151:169–178.
16. Esposito CI, Gladnick BP, Lee YY, et al. Cup position alone does not predict dislocation after hip arthroplasty. *J Arthroplast.* 2015;30(1):109–113.
17. Abdel MP, von Roth P, Jennings MT, Hanssen AD, Pagnano MW. What safe zone? The vast majority of dislocated THAs are within the lewinnek safe zone for acetabular component position. *Clin Orthop Relat Res.* 2016;474(2):386–391.
18. Ekelund A, Rydell N, Nilsson OS. Total hip arthroplasty in patients 80 years of age and older. *Clin Orthop Relat Res.* 1992;281:101–106.
19. Levy RN, Levy CM, Snyder J, Digiovanni J. Outcome and long-term results following total hip replacement in elderly patiens. *Clin Orthop Relat Res.* 1995;316:25–30.