Risk Factors for Dislocation After Revision Total Hip Arthroplasty

Nathan G. Wetters BS, Trevor G. Murray MD,
Mario Moric MS, Scott M. Sporer MD,
Wayne G. Paprosky MD, Craig J. Della Valle MD

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Abstract

Background Despite dislocation being the most frequent complication after revision THA, risk factors for its occurrence are not completely understood.

Questions/purposes We therefore (1) determined the overall risk of dislocation after revision THA in a large series of revision THAs using contemporary revision techniques, (2) identified patient-related risk factors predicting dislocation, and (3) identified surgical variables predicting dislocation.

Methods We performed 1211 revision THAs between June 2004 and October 2010 in 576 women and 415 men who had a mean age of 64.7 years (range, 25–95 years) at

time of surgery. Forty-six (4%) were lost to followup and 13 died (1%), leaving 1152 hips followed for a minimum of 90 days (mean, 2 years; range, 90 days to 7.1 years). Multivariate logistic regression was performed to identify risk factors for dislocation. The model was also tested on patients followed for a minimum 1 year to assess any difference in longer followup.

Results One hundred thirteen patients dislocated over the followup period (9.8%). Factors that were different between patients who dislocated and those who remained stable included a history of at least one previous dislocation (odds ratio [OR] = 2.673), abductor deficiency (OR = 2.672), and Paprosky acetabulum class (OR = 1.522).

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N. G. Wetters (✉), M. Moric, S. M. Sporer,
W. G. Paprosky, C. J. Della Valle
Department of Orthopaedic Surgery, Rush University
Medical Center, 1611 West Harrison Street,
Suite 300, Chicago, IL 60612, USA
e-mail: nwetters@gmail.com

T. G. Murray
Department of Orthopaedics, Cleveland Clinic,
Cleveland, OH, USA

Use of a constrained liner (OR = 0.503) and increased femoral head size (OR = 0.942) were protective against dislocation, while with longer followup a constrained liner was no longer significant.

Conclusions Dislocation remains a common problem after revision THA. Identifying these risk factors can assist in patient education and surgical planning. Recognition of these risk factors in both patient type and surgical strategy is important for the surgeon performing revision THA and for minimizing these risks.

Level of Evidence Level IV, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Dislocation is one of the leading causes of failure and need for rerevision after revision THA [21]. As the rate of primary THA is increasing and the population ages, the number of revision surgeries is predicted to increase in the future [14]. Identifying risk factors for this complication is important, as the identification of patients at risk can assist with preoperative patient education and management at the time of revision surgery.

Several patient- and surgery-specific risk factors have been described previously, including femoral head size, deficient abductors, nonunion of the greater trochanter, surgical approach, malposition of components, use of a liner with an elevated rim, and number of previous hip surgeries [1, 7, 10, 11, 16]. In the largest such study, Alberton et al. [1] reviewed 1548 revision THAs and reported an overall dislocation rate of 7.4%. This study was performed, however, before the routine use of femoral head diameters larger than 32 mm and the authors excluded revisions for instability, tumor, and infection in their analysis. In 2011, Cogan et al. [5] evaluated 447 hips for risk factors for dislocation through an anterior approach. They found BMI was the only risk factor in their patient population. Several studies have been performed in the population of patients requiring revision for recurrent dislocation [2, 3, 19, 22]. Carter et al. [3] found previous revision surgery and smaller head sizes put these patients at risk. They also noted the use of a constrained liner is relegated to the most high-risk patients, specifically those with deficient abductors. Another study evaluating patients in the Kaiser Permanente Total Joint Registry looked at possible risk factors for dislocation for patients after both primary and revision THA [12]. Their conclusion through multivariate analysis was that previous revision surgery, higher American Society of Anesthesiologists (ASA) score, and rheumatoid arthritis were risk factors after revision THA.

The patient cohort evaluated in this article has been published previously as part of a study aimed at the question of how abduction bracing affects dislocation within 90 days after revision THA [17]. The current study reports a more in-depth evaluation of the risk factors associated with dislocation after revision THA. We are now assessing all dislocations in addition to those previously published and taking the analysis one step further by looking at multiple risk factors as opposed to a single variable as in our previous study.

We therefore (1) determined the overall risk of dislocation after revision THA in a large series of revision THAs using contemporary revision techniques, (2) identified patient-related risk factors predictive of dislocation, and (3) identified surgical variables predictive of dislocation.

Patients and Methods

Three surgeons performed 1211 revision THAs using a posterior approach (215 had concomitant extended trochanteric osteotomy) in 1050 patients between June 1, 2004, and October 31, 2010. Of the 1211 revision THAs, 13 patients (1.1%) were deceased and 46 (3.8%) were lost to followup before minimum 90 days' followup. The remaining 1152 hips in 991 patients (576 women, 415 men) had a mean age at time of surgery of 64.7 years (range, 25–95 years). These patients were followed a minimum of 90 days (mean, 2 years; range, 90 days to 7.1 years). This patient cohort of 1211 revision THAs has been reported on in a previous publication evaluating the utility of abduction bracing after revision THA [17]. No patients were recalled specifically for this study; all data were obtained from medical records.

Revision THA was defined as a surgical procedure involving exchange of the acetabular component and/or liner, femoral stem and/or modular head, or any combination thereof. Of the 1152 procedures reviewed in our cohort, the indication for revision THA was aseptic loosening in 420 (36.5%), polyethylene wear with or without osteolysis in 223 (19.3%), instability in 204 (17.7%), periprosthetic joint infection in 176 (15.3%), periprosthetic fracture in 55 (4.8%), and other miscellaneous etiologies in the remaining 74 (4.8%). Our standard practice includes the routine use of larger femoral head sizes (> 32 mm), modular femoral components for patients with Paprosky Femoral Classification Type III or greater [6], and acetabular augments for instances of substantial bone loss.

Each patient was evaluated preoperatively, at 3 weeks, 6 weeks, and 3 months postoperatively, and annually thereafter for examination and radiographic followup. At each visit, standard evaluation measures, including Harris

hip score, and plain radiographs, including AP pelvis and AP/lateral views of the affected hip, were collected [9].

Possible risk factors for dislocation were stratified as either patient or surgery specific for ease of interpretation and description. Patient-specific factors included age, sex, BMI, Paprosky femoral and acetabular classifications [6, 18] (determined from the preoperative radiographs in 1139 of 1152 hips [98.9%]), history of at least one episode of instability before revision, number of previous hip surgeries, Charlson Comorbidity Index [4], and abductor status (classified as either intact or deficient as seen at the time of revision; deficient abductor status included nonunion of the greater trochanter or gross detachment or absence of the abductor musculature). Procedure-specific factors reviewed were acetabular cup diameter, femoral head diameter, femoral neck length, head-to-cup ratio, procedure type, use of a constrained liner, or use of an elevated rim liner. The type of procedure was separated into five categories, including isolated acetabular component revision (316, 27.4%), isolated femoral component revision (175, 15.2%), concurrent revision of both components (215, 18.7%), modular femoral head and liner exchange (321, 27.9%), and reimplantation THA (125, 10.8%) after treatment for periprosthetic joint infection.

Descriptive statistics for continuous and categorical variables are reported as means and SDs or counts and frequencies, respectively. We compared between stable and unstable hips normally distributed continuous variables using Student's t-test and categorical variables using a chi-square test of independence or if dichotomous using a Fisher's exact test. Identification of risk factors followed a two-step process. The first step was to identify variables that in isolation were predictive (univariate analysis), after which all variables found to be important were included in an iterative progression and evaluation of multivariate logistic regression models until the optimal, most parsimonious model was determined. Any variables missing greater than 5% of their possible data points were excluded from any analysis. Variables found to be important ($p < 0.10$) in the unadjusted univariate analysis were included in a multivariate stepwise logistic regression (inclusion criteria = 0.20, retention criteria = 0.10) and reevaluated using backward elimination (retention criteria = 0.10) logistic regression. Both methods (stepwise and backward elimination) provided an identical set of risk factors.

Patient factors, using univariate analysis, identified possible risk factors, including age, sex, percentage of patients undergoing at least three previous revisions, a history of instability, and deficient abductors. The same analysis identified surgical factors of cup size, head size, head-to-cup ratio, procedure type, and constrained liners as possible risk factors. Possible risk factors showing no significance were excluded.

Several important interactions were additionally evaluated, as well as different combinations of the head, cup, and head-to-cup ratio variables. Before analysis, we decided the factors of sex, age, and BMI were to be included as covariates to control for these effects and were subsequently forced into the final model. Logistic regression model assumptions and fit, as well as distributional assumptions, were evaluated for suitability. The combined set of both patient and surgical factors found to be important in the univariate analysis were used as the starting point for the stepwise and backward elimination logistic regression algorithm. We found no tested bivariate interactions to be significant and both stepwise and backward elimination methods resulted in the same final set of variables/factors. The final model fit well with a nonsignificant Hosmer and Lemeshow goodness-of-fit test (chi-square = 7.4, $p = 0.499$). To evaluate the sensitivity and stability of the risk factors to our choice of followup period length, we reevaluated the final model on the subset with a minimum 1-year followup.

Results

At most recent followup, 113 of 1152 (9.8%) hips in 113 patients had dislocated. First dislocation after revision THA occurred at a median 77 days (range, 0 days [same day as procedure] to 4.9 years) postoperatively. Our experience with extended trochanteric osteotomy showed an identical dislocation rate compared to the overall cohort, 21 of 215 (9.8%). Of the 113 patients with at least one episode of instability after revision THA, 45 (40%) were rerevised for recurrent instability. Patients undergoing revision for instability after a primary procedure dislocated at a rate of 12 of 95 (13%) while patients undergoing revision for instability after a previous revision THA dislocated at a rate of 25 of 129 (19%). Overall, 45 of 1152 (4%) hips were rerevised for recurrent instability after revision THA.

After our univariate analysis, the stepwise logistic regression analysis identified sex, age, history of previous dislocation, abductor deficiency, and higher acetabular complexity as patient-specific risk factors (Table 1) and use of a constrained liner and head size as surgery-specific factors (Table 2). In addition to the risk factors identified, the unmodifiable patient demographic factor, BMI (sex and age included by default as they were identified as risk factors), was forced into the model, producing the final model (Table 3). The final model showed adequate accuracy with an area under the curve of 69% (Fig. 1). We reevaluated the final model on the subset with a minimum 1-year followup (Table 4) and found similar results, even with this reduced power (Fig. 2).

Table 1. Patient-specific variables and univariate analysis of stable and unstable groups

Variable	Unstable (n = 113 hips)	Stable (n = 1039 hips)	p value
Age (years)*	62 (12)	65 (13)	0.061
Female (n = 991 patients)	50/72 (69.4%)	526/919 (57.2%)	0.047
BMI*	28.3 (6.2)	29.1 (6.8)	0.235
Charlson Comorbidity Index ≥ 3	18 (15.9%)	137 (13.2%)	0.387
Number of prior revisions ≥ 3	28 (24.8%)	147 (14.2%)	0.005
History of instability	52 (46.0%)	251 (24.2%)	0.001
Abductor deficiency	19 (16.8%)	61 (5.9%)	0.001
Followup (years)*	2.2 (1.6)	2.0 (1.6)	0.220
Paprosky femoral classification score (1–4)*	2.4 (0.5)	2.3 (0.5)	0.098
Paprosky Femur Type 3A/3B/4	58 (51.8%)	501 (48.8%)	0.552
Paprosky Acetabulum Type 3A/3B	19 (17.0%)	149 (14.5%)	0.484

* Values are expressed as mean, with SD in parentheses; the remaining values are expressed as count (number of hips), with frequency in parentheses.

Table 2. Surgery-specific variables and univariate analysis of stable and unstable groups

Variable	Unstable (n = 113 hips)	Stable (n = 1039 hips)	p value
Cup size (mm)*	58.0 (8)	59.4 (7)	0.050
Head size (mm)*	34.2 (5)	36.0 (5)	0.001
Head-to-cup ratio*	0.60 (0.08)	0.62 (0.07)	0.008
Cup revised	53 (46.9%)	604 (58.1%)	0.027
Stem revised	40 (35.4%)	475 (45.7%)	0.037
Constrained liners	33 (29.2%)	231 (22.3%)	0.100
Elevated rim	17 (15.9%)	172 (16.6%)	0.789
Modular head exchange	111 (98.2%)	1032 (99.3%)	0.218
Procedure type			0.074
Head/liner exchange	41 (36.3%)	280 (27.0%)	
Revision of both components	13 (11.5%)	202 (19.4%)	
Isolated acetabular revision	32 (28.3%)	284 (27.3%)	
Isolated femoral revision	19 (16.8%)	156 (15.0%)	
Reimplantation after revision for periprosthetic jointinfection	8 (7.1%)	117 (11.3%)	

* Values are expressed as mean, with SD in parentheses; the remaining values are expressed as count (number of hips), with frequency in parentheses.

Discussion

Dislocation after revision THA remains a common problem. Despite dislocation being the most frequent complication after revision THA, risk factors for its occurrence are not completely understood. Our purposes were to determine the risk of dislocation using contemporary revision techniques (including the routine use of larger

Table 3. Risk factors in multivariate analysis for dislocation after revision THA at minimum 90 days' followup

Variable	Odds ratio	95% CI	p value
Sex (female versus male)	1.471	0.940 2.303	0.091
Age	0.987	0.971 1.002	0.092
BMI	0.989	0.958 1.021	0.485
History of instability	2.673	1.637 4.365	0.001
Abductor deficiency	2.672	1.379 5.176	0.004
Constrained liner	0.503	0.273 0.925	0.027
Paprosky acetabulum classification	1.522	1.000 2.318	0.050
Head size	0.942	0.902 0.983	0.007

femoral heads [> 32 mm]) and to identify surgical and patient factors that could be considered to minimize the risk of dislocation after revision THA.

Our study has several limitations. First, this was a retrospective review, and although we made an effort to identify all data points, in some cases, certain data points were missing, such as the preoperative radiographs that precluded determination of the Paprosky classification in 13 of 1152 (1%). Some variables that may be interesting to evaluate, including cup version and inclination and stem offset and/or length, did not meet our criteria of less than 5% missing data points and were omitted from analysis. Second, with greater length of followup, more dislocations may occur and thus we may have underestimated the prevalence of this problem. Similarly, although we carefully reviewed each chart, some dislocations may not have been identified in our review. Finally, all procedures described were performed via a posterior approach and this may in itself be a risk factor for dislocation and may not be applicable if an alternative approach is utilized. However, most surgeons performing revisions prefer this approach

Fig. 1 In our final multivariate regression model, a receiver operating characteristic (ROC) curve demonstrates good discrimination for the interaction of risk factors for dislocation (area under the curve, 0.69).

Table 4. Risk factors in multivariate analysis for dislocation after revision THA at minimum 1-year followup

Variable	Odds ratio	95% CI	p value
Sex (female versus male)	1.268	0.756 2.126	0.368
Age	0.990	0.972 1.009	0.320
BMI	0.993	0.972 1.009	0.320
History of instability	1.896	1.048 3.430	0.034
Abductor deficiency	3.215	1.497 6.908	0.003
Constrained liner	0.578	0.283 1.181	0.133
Paprosky acetabulum classification	1.503	0.922 2.449	0.102
Head size	0.923	0.877 0.971	0.002

given the greater access afforded to the posterior column of the pelvis, and thus we believe our findings are applicable to most clinical practices.

After controlling each variable using regression analysis, a history of dislocation in the operative hip and abductor deficiency were the strongest predictors of dislocation, with ORs of 2.673 and 2.672, respectively. In our practice, we have routinely used constrained liners in patients with abductor deficiency based on prior data showing large heads may not be effective for this patient subset [3, 13]. This may in part explain our paradoxical finding whereby, although a higher percentage of patients

Fig. 2A–B Graphs show ORs with 95% profile-likelihood confidence limits for patient followup at (A) minimum 90 days and (B) minimum 1 year. F = female; M = male.

in the unstable group had a constrained liner, the multivariate analysis found them to be protective against a dislocation; that is, patients in whom a constrained liner was used often had abductor deficiency and were thus at high risk and the constrained liners protected them against failure ($p = 0.027$, $OR = 0.503$). When testing our model for sensitivity and stability, we lost power in our analysis, and the utility of a constrained liner was no longer significant at a followup of more than 1 year. More work is required in this area to treat this difficult patient subset.

Our dislocation rate of 9.8% is consistent with that of other studies in the literature. Currently, the dislocation rate after revision THA is between 6.6% and 21.2% [1, 3, 5, 12, 15, 23]. Alberton et al. [1] evaluated 1548 revision THAs and reported risk factors of small femoral head size, trochanteric nonunion, and elevated rim liners. Khatod et al. [12], evaluating the Kaiser Permanente database, found high ASA score, rheumatoid arthritis, and previous revision surgery were risk factors for dislocation. These are the only other studies we have found previously reporting on a

Table 5. Literature comparison of comparable studies including risk factors for dislocation after revision THA

Study	Number of hips	Followup range (years)	Dislocation rate (%)	Trochanter nonunion/ Abductor deficiency	Head size	Elevated rim liner	Previous revision surgery	ASA score	BMI	Rheumatoid arthritis	Paprosky acetabulum classification	History of instability	Constrained liner	Miscellaneous
Alberton et al. [1]	1548	24–197	7.4	+	+	+	–	–	–	–	–	–	–	Excluded revisions for instability/infection/tumor
Cogan et al. [5]	447	12–84	6.6	–	–	–	–	–	+	–	–	–	–	Anterior approach
Carter et al. [3]	156	24–119	21.2	+	+	–	+	–	–	–	–	–	–	All patients revised for recurrent instability
Khatod et al. [12]	277	> 12	5.1	–	–	–	+	+	–	+	–	–	–	Data from Kaiser Permanente Total Joint Registry database, univariate analysis
Sah et al. [20]	115	24–132	10	–	+	–	–	–	–	–	–	–	–	Univariate analysis
Current study	1153	3–85	9.8	+	+	–	–	–	–	–	+	+	+*	Posterior approach

* In evaluating our subset of patients with minimum 1-year followup, while the trend remained, a constrained liner was shown to no longer be significant in protecting against dislocation; ASA = American Society of Anesthesiologists.

large-scale multivariate analysis. Other studies have also shown femoral head size to be a factor in the stability of the revision THA [1, 3, 8, 20]. Cogan et al. [5] evaluated patients undergoing revision THA through an anterior approach and found BMI was the only risk factor for dislocation in their patient population. Our study evaluated as many of these risk factors as possible through our stepwise logistic regression of 1211 hips and found trends in many of these same variables. We also confirmed significant risk factors from other studies, including abductor deficiency/trochanter nonunion and small head size (Table 5).

As has been shown, using a larger femoral head diameter was also protective in our patients. Upsizing the femoral head to at least 36 mm during revision THA may be warranted based on this evidence and work done by Garbuz et al. [8]. They showed, in a randomized controlled trial, patients with 32-mm heads had a dislocation rate of 8.7%, while using 36- and 40-mm diameter heads lowered that rate to 1.1% at a minimum followup of 2 years.

Increasing acetabular defect complexity was also a risk factor. Special attention should be paid to reproducing proper tension of the abductors and appropriately restoring the center of rotation to minimize failure by dislocation. Proper cup position may also be more difficult in these patients given the distorted anatomy.

In conclusion, our retrospective review of 1211 revision THAs showed dislocation is still a major problem despite the routine use of larger heads and other contemporary revision techniques. Patients in general should be counseled regarding the risk of this complication, and patients at higher risk (including females, younger patients, those with abductor deficiency, a history of instability, and a complex acetabular defect) should be educated regarding the presence of risk factors that make them particularly high risk for this complication. Further, the surgeon performing the revision must identify these patients and consider all options to minimize the risk of this complication. Further work is required in this area and alternative solutions, particularly for the patient with abductor deficiency, are needed.

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