

## Anterior and Anterolateral Approaches for THA Are Associated With Lower Dislocation Risk Without Higher Revision Risk

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### Abstract

**Background** Lack of consensus continues regarding the benefit of anteriorly based surgical approaches for primary total hip arthroplasty (THA). The purpose of this study was to evaluate the risk of aseptic revision, septic revision, and dislocations for various approaches used in primary THAs from a community-based healthcare organization.

**Questions/purposes** (1) What is the incidence of aseptic revision, septic revision, and dislocation for primary THA in a large community-based healthcare organization? (2)

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Does the risk of aseptic revision, septic revision, and dislocation vary by THA surgical approach?

**Methods** The Kaiser Permanente Total Joint Replacement Registry was used to identify primary THAs performed between April 1, 2001 and December 31, 2011. Endpoints were septic revisions, aseptic revisions, and dislocations. The exposure of interest was surgical approach (posterior, anterolateral, direct lateral, direct anterior). Patient, implant, surgeon, and hospital factors were evaluated as possible confounders. Survival analysis was performed with marginal multivariate Cox models. Hazard ratios (HRs) and 95% confidence intervals (CIs) are reported. A total of 42,438 primary THAs were available for analysis of revision outcomes and 22,237 for dislocation. Median followup was 3 years (interquartile range, 1–5 years). The registry's voluntary participation is 95%. The most commonly used approach was posterior (75%, N = 31,747) followed by anterolateral (10%, N = 4226), direct anterior (4%, N = 1851), and direct lateral (2%, N = 667).

**Results** During the study period 785 hips (2%) were revised for aseptic reasons, 213 (0.5%) for septic reasons, and 276 (1%) experienced a dislocation. The revision rate per 100 years of observation was 0.54 for aseptic revisions, 0.15 for septic revisions, and 0.58 for dislocations. There were no differences in adjusted risk of revision (either septic or aseptic) across the different THA approaches. However, the anterolateral approach (adjusted HR, 0.29; 95% CI, 0.13–0.63, p = 0.002) and direct anterior approach (adjusted HR, 0.44; 95% CI, 0.22–0.87, p = 0.017) had a lower risk of dislocation relative to the posterior approach. There were no differences in any of the outcomes when comparing the direct anterior approach with the anterolateral approach.

**Conclusions** Anterior and anterolateral surgical approaches had the advantage of a lower risk of dislocation without increasing the risk of early revision.

**Level of Evidence** Level III, therapeutic study.

## Introduction

Modifications of traditional anteriorly based surgical approaches were introduced in the early 2000s to reduce dislocations and facilitate early rehabilitation after surgery [5, 23, 25, 35]. A number of recent studies have compared the newer approaches with traditional lateral and posterior approaches [1, 12, 15, 18, 34, 49] but there is lack of consensus on whether there is any demonstrable difference in reducing muscle damage, improving postoperative gait, or facilitating earlier rehabilitation [21, 29, 38, 41, 42, 46].

The main advantage of anteriorly based approaches has been reduction in the incidence of hip dislocation [14, 43, 45, 51]. However, some studies have expressed concern regarding implant malposition that could compromise long-term survival of the implant [3, 33]. There are other complications of concern, not seen with traditional approaches, such as greater trochanter fracture, canal perforation, and remote site fractures [3, 11, 34, 37, 38]. The learning curve associated with newer approaches may also have negative implications on the results [10, 28, 50]. Only a few studies have specifically evaluated the impact of surgical approach on surgical outcomes including complications and short- and medium-term survivorship [2, 34, 39]. Finally, because most reported studies have been conducted either by single surgeons at a single center or performed in a controlled fashion [1–4, 6, 7], the generalizability of these results to the greater orthopaedic community and patients is limited.

The purpose of our study is to evaluate the risk of aseptic revision, septic revision, and dislocations in the various surgical approaches used for primary THAs performed in the setting of a community-based integrated healthcare system. Specifically, we asked: (1) What is the incidence of aseptic revision, septic revision, and dislocation in primary THA in a large community-based healthcare organization? (2) Does the risk of aseptic revision, septic revision, and dislocation vary by THA surgical approach?

## Materials and Methods

A retrospective analysis of a prospectively followed cohort was conducted. A total joint replacement registry (Kaiser Permanente Total Joint Replacement Registry) was used to identify primary THAs performed for any elective diagnosis between April 1, 2001 and December 31, 2011, in a large integrated US healthcare system. The study sample included cases from 50 medical centers with 336 surgeons in seven US geographical regions (southern and northern California, Colorado, Georgia, Hawaii, Northwest, mid-Atlantic). During the course of the study, the membership population in these regions was more

than nine million people. When dislocation was the outcome, the sample was limited to operative dates from January 1, 2007 to December 31, 2011, for southern California, northern California, and Hawaii, which are the time periods and regions for which complete information regarding dislocations was available.

The Total Joint Replacement Registry uses standardized electronic and paper data collection forms. The forms are completed by the surgeons and staff in the operating room. The participation is voluntary and was 95% for the THAs in 2011 [40]. The forms capture information on patient demographics, surgical technique, implant characteristics, and patient outcome. Registry data are validated using the hospital utilization database and independent chart review.

All patients undergoing primary elective THA with any diagnosis were included in the study (N = 42,438). Revision procedures and same-day bilateral procedures were not included.

The exposure of interest in this study was surgical approach (posterior, anterolateral, direct lateral, direct anterior). Other variables were regarded as potential confounders of the relationship between surgical approach and the outcomes of interest. These potential confounders included patient, implant, surgeon, and hospital factors. Patient covariates evaluated were: age, sex, race (white, black, Hispanic, Asian, Native American, other/multi), body mass index, and American Society of Anesthesiologists score (1, 2,  $\geq 3$ ). Implant attributes evaluated included: fixation type (cemented, uncemented, hybrid), bearing surface (ceramic-on-ceramic, ceramic-on-constrained, ceramic-on-conventional polyethylene, ceramic-on-highly crosslinked polyethylene, ceramic-on-metal, metal-on-constrained polyethylene, metal-on-conventional polyethylene, metal-on-highly crosslinked polyethylene, and metal-on-metal), femoral head size ( $\leq 28$  mm, 32 mm, 36 mm,  $> 36$  mm), and whether a DePuy's ASR Hip System (DePuy Orthopaedics, Inc, Warsaw, IN, USA) was used for the procedure. The DePuy ASR Hip System components were separated in the analysis to attempt to control for the unique increase in risk of revision of this component as a result of its August 2010 recall and implantation cessation in this organization in June 2010 [17].

The endpoints of this study were septic revisions, aseptic revisions, and dislocations. Revision was defined as any operation after the index THA where a component was replaced. Aseptic revisions were performed for any reason other than infection-related causes. Reasons for revision were recorded by the surgeons on the Total Joint Replacement Registry operative forms and confirmed by chart review by a trained clinical research associate (see Acknowledgments). Dislocations were identified based on International Classifications of Disease, 9th Revision, Clinical Modification (ICD-9-CM) codes 718.35, 835\*, or

996.42. Dislocations were considered related to the index hip if they occurred within 1 year of the operation date.

Frequencies, proportions, mean, SDs, medians, and interquartile ranges (IQRs) were used to describe the study sample. Crude revision rates and revision rate per 100 years of observation were calculated. Survival analysis was performed with marginal multivariate Cox models using a robust standard error (SE) approach to account for surgeon clustering effects [30]. Adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) for the risk of revision/dislocation for surgical approach are reported. All covariates were included in adjusted models. To account for missing values of some variables, multiple imputations were performed to create 50 versions of the analytic data set and then used Rubin's rules to calculate the final parameter estimates and SEs from the output sets [44]. The imputation model included all covariates as well as the event indicator and the Nelson-Aalen estimator of the cumulative baseline hazard at the time of event or censoring for each case [48]. Significance tests for proportional hazards were based on plots of the standardized score process against time for each covariate and comparing the observed curve with 1000 simulated curves under the assumption of proportional hazards using the listwise deleted data [31]. A similar approach using cumulative sums of martingale residuals was adopted for tests of functional form. In the presence of a significant test, the form of the relationship was based on plots of the data (eg, omitted variable plots of martingale residuals to determine the functional form). We have sufficient power ( $1 - \beta \geq 0.80$ ) to detect a minimum difference (which we believe to be a clinically important effect size) of  $HR = 1.5$  for the anterolateral and direct anterior approaches for aseptic revisions and anterolateral for septic revisions (all in comparison to the posterior approach). Data were analyzed using SAS (Version 9.2; SAS Institute, Cary, NC, USA) and  $\alpha = 0.05$  was used as the threshold for statistical significance.

A total of 42,438 primary THAs were available for analysis of revision outcomes and 22,237 for the dislocation outcome. The cohort mean age was 66 years old (SD = 12) and was mostly female (58%) and white (75%). The most commonly used approach was posterior (75%,  $N = 31,747$ ) followed by anterolateral (10%,  $N = 4,226$ ), direct anterior (4%,  $N = 1,851$ ), and direct lateral (2%,  $N = 667$ ). The most common bearing surface was metal on highly crosslinked polyethylene (58%;  $N = 24,685$ ). Uncemented implants were used in 83% ( $N = 35,024$ ) of the cases and femoral head sizes  $\geq 36$  mm were used in 46% ( $N = 19,323$ ) of the cases (Table 1).

During the 3 years (IQR, 1–5 years) median followup of the cohort, 2767 (7%) patients died and 4282 (10%) terminated their health plan membership.

## Results

During the study period, 785 hips (2%) were revised for aseptic reasons, 213 (1%) for infection, and 276 (1%) experienced a dislocation (Table 2). The revision rate per 100 years of observation is 0.54 (95% CI, 0.5–0.57) for aseptic revisions, 0.15 (95% CI, 0.13–0.17) for septic revisions, and 0.58 (95% CI, 0.52–0.65) for dislocations.

There were no differences in adjusted risk of revision (either septic or aseptic) and THA approaches (Table 3). However, the anterolateral approach (HR, 0.29; 95% CI, 0.13–0.63,  $p = 0.002$ ) and direct anterior approach (HR, 0.44; 95% CI, 0.22–0.87,  $p = 0.017$ ) had a lower adjusted risk of dislocation relative to the posterior approach.

We compared anterolateral and direct anterior approaches as well and found that there were no significant differences in the risk of septic revision (HR, 0.78; 95% CI, 0.34–1.77,  $p = 0.558$ ), aseptic revision (HR, 0.79; 95% CI, 0.46–1.35,  $p = 0.393$ ), and dislocation (HR, 0.69; 95% CI, 0.24–1.97,  $p = 0.491$ ), but the point estimates do favor the anterolateral approach.

## Discussion

Anteriorly based surgical approaches (those approaches characterized by opening the joint capsule from the front of the joint) are being used increasingly in the community setting. However, we do not know whether these approaches reduce the risk of dislocation without increasing risk of early failure. In our large community-based sample, a lower risk of dislocation, with no evidence of difference in the risk of revision (either septic or aseptic), was observed in THAs performed with anterolateral and direct anterior approaches compared with a posterior approach.

Our study is limited to the three outcomes evaluated. We were not able to evaluate other postoperative outcomes potentially different between the approaches evaluated such as acetabular cup inclination, implant positioning, intraoperative complication (eg, limp, never injuries, intraoperative fractures), functional outcomes, patient-reported outcomes, or postoperative recovery. How dislocations were ascertained also is a potential limitation of our study. Dislocations were identified using a hospital utilization database using ICD-9-CM discharge diagnosis codes but as a result of the lack of laterality, specificity, and sometimes inaccuracies of ICD-9-CM codes, these events could potentially be inaccurate. However, we used the same algorithms used by large studies [7, 24] using administrative data in an attempt to use a comparable way to ascertain the outcome so our estimations could be compared with others. Additionally, missing data was a limitation of our study. This was handled by using multiple

**Table 1.** Patient and implant characteristics of overall sample and by surgical approach, 2001–2011

Variables	Total	Anterolateral	Direct lateral	Posterior	Direct anterior	Missing
Total number (%)	42,438	4226 (10)	667 (2)	31,747 (75)	1851 (4)	3947 (9)
Mean age (years; SD)	66 (12)	67 (11)	65 (11)	66 (12)	65 (11)	65 (12)
Mean BMI (kg/m <sup>2</sup> ; SD)	29 (6)	29 (6)	30 (6)	290 (6)	28 (5)	29 (6)
	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	p value
Sex						
Male	18,007 (42)	1788 (42)	281 (42)	13,478 (43)	736 (40)	1724 (44)
Female	24,415 (58)	2435 (58)	385 (58)	18,264 (58)	1112 (60)	2219 (56)
Missing	16 (0)	3 (0)	1 (0)	5 (0)	3 (0)	4 (0)
Race						
White	31,939 (75)	3460 (82)	470 (71)	23,576 (74)	1504 (81)	2929 (74)
Black	3265 (8)	176 (4)	68 (10)	2567 (8)	135 (7)	319 (8)
Hispanic	3035 (7)	202 (5)	28 (4)	2432 (8)	82 (4)	291 (7)
Native American	88 (0)	4 (0)	2 (0)	69 (0)	6 (0)	7 (0)
Asian	1469 (4)	129 (3)	16 (2)	1164 (4)	38 (2)	122 (3)
Other	328 (1)	23 (1)	5 (1)	255 (1)	16 (1)	29 (1)
Multirace	272 (1)	22 (1)	3 (0)	214 (1)	15 (1)	18 (1)
Missing	2042 (5)	210 (5)	75 (11)	1470 (5)	55 (3)	232 (6)
DePuy's ASR Hip Component						
Ceramic on ceramic	649 (2)	43 (1)	5 (1)	486 (2)	8 (0)	107 (3)
Ceramic on constrained	564 (1)	75 (2)	4 (1)	436 (1)	2 (0)	47 (1)
Ceramic on conventional	12 (0)	0 (0)	0 (0)	12 (0)	0 (0)	0 (0)
Ceramic on crosslinked	126 (0)	6 (0)	1 (0)	95 (0)	0 (0)	24 (1)
Ceramic on metal	9111 (22)	824 (20)	158 (24)	6777 (210)	598 (32)	754 (19)
Metal on constrained	122 (0)	10 (0)	3 (0)	63 (0)	28 (2)	18 (1)
Metal on conventional	37 (0)	2 (0)	1 (0)	30 (0)	1 (0)	3 (0)
Metal on crosslinked	1780 (4)	110 (3)	25 (4)	1433 (5)	0 (0)	212 (5)
Metal on metal	24,685 (58)	2579 (61)	367 (55)	18,533 (58)	1077 (58)	2129 (54)
Missing	5114 (12)	534 (13)	88 (13)	3743 (12)	102 (6)	647 (16)
ASA						
1	887 (2)	86 (2)	20 (3)	625 (2)	43 (2)	113 (3)
2	1390 (3)	151 (4)	26 (4)	996 (3)	67 (4)	150 (4)
≥ 3	24,704 (58)	2421 (57)	405 (61)	18,472 (58)	1124 (61)	2282 (58)
Missing	15,022 (35)	1578 (37)	214 (32)	11,344 (36)	581 (31)	1305 (33)
Uncemented	1322 (3)	76 (2)	22 (3)	935 (3)	79 (4)	210 (5)
Hybrid	35,024 (83)	3653 (86)	580 (87)	27,145 (86)	1768 (96)	1878 (48)
Cemented	4185 (10)	408 (10)	48 (7)	3488 (11)	3 (0)	238 (6)
Missing	226 (1)	15 (0)	7 (1)	169 (1)	0 (0)	35 (1)
Missing	3003 (7)	150 (4)	32 (5)	945 (3)	80 (4)	1796 (46)

**Table 1.** continued

Variables	Total	Anterolateral	Direct lateral	Posterior	Direct anterior	Missing
Total number (%)	42,438					3947 (9)
Mean age (years; SD)	66 (12)					65 (12)
Mean BMI (kg/m <sup>2</sup> ; SD)	29 (6)					29 (6)
	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	p value
Head size (mm)						
< 28	8002 (19)	758 (18)	77 (12)	6438 (20)	63 (3)	666 (17)
32	14,418 (34)	1485 (35)	201 (30)	11,034 (35)	423 (23)	1275 (32)
36	15,441 (36)	1502 (36)	264 (40)	11,119 (35)	1166 (63)	1390 (35)
> 36	3882 (9)	412 (10)	112 (17)	2678 (8)	159 (9)	521 (13)
Missing	695 (2)	69 (2)	13 (2)	478 (2)	40 (2)	95 (2)

BMI = body mass index; ASA = American Society of Anesthesiologists.

imputations, which estimated the values for the missing data points in an attempt to reduce bias and increase precision relative to removing cases with missing information. Although our proportion of loss to followup is small (4282 out of 42,438 hips [10%]), it is still a limitation of our study. However, because there was no differential loss to followup among the posterior, anterolateral, and direct lateral approaches, we do not believe that this introduced bias in our estimates of event rates across these groups. We had a median followup of 2 years (IQR, 0.8–4 years) on the patients who were lost to followup, which means these patients' data contributed to our estimates for this amount of time as well. There was a slightly lower proportion of patients with direct anterior approaches who were lost to followup, which would increase the chances of us finding events on these cases during the followup, but because this was not the case, we believe that our estimations of dislocation risk may actually be conservative for this approach. The lack of information on surgeon experience or surgeon volume is also a potential limitation of our study because these may be confounders of the associations studied.

Few studies have investigated the influence of surgical approach on revision rate [2, 32, 39]. In our study, there were no differences in aseptic revision rates across the various approaches. The risk of aseptic revision for either the direct anterior or the anterolateral approaches was not different than the posterior approach. Our results are comparable to a prospective, nonrandomized, multicenter study of 1089 THAs comparing anterolateral with posterior approaches. At 5 years they observed no differences in revision rates between the groups [32, 39]. The Swedish Hip Register reported a complex relationship among surgical approach, implant used, and revision rate. A reduced risk of dislocation with increased risk of aseptic revision was observed in the anterolateral transgluteal approach as compared with the posterior approach with a specific implant type [32]. The authors attributed this to possible acetabular cup malpositioning (inclination angle of greater than 50°), which was more common with the anterolateral approach [9].

A number of previous studies have indicated that the approaches from the front of the joint have a distinct advantage of reducing the rate of postoperative dislocation [14, 43, 45]. Our findings confirm these observations. The rate of dislocation was lowest with the anterolateral approach and a substantially lower adjusted risk of dislocation for both the anterolateral and anterior approaches was observed compared with the posterior approach. As compared with some older studies [16, 36], the overall rate of dislocation after THA reported in contemporary joint arthroplasty registries has been low [4, 26]. This lower rate has been attributed to newer surgical approaches, use of

**Table 2.** Crude septic revision, aseptic revision, and dislocation rates and event density by surgical approach

Outcome	Total	Anterolateral	Direct lateral	Posterior	Direct anterior	Missing
Septic revision, number (%)	213 (0.5)	19 (0.5)	7 (1.1)	158 (0.5)	9 (0.5)	20 (0.5)
Total observation years	146,538	12,952	2202	115,299	2407	13,679
Revisions/100 observation years (% [95% CI])	0.15 (0.13–0.17)	0.15 (0.09–0.23)	0.32 (0.15–0.67)	0.14 (0.12–0.16)	0.37 (0.19–0.72)	0.15 (0.09–0.23)
Aseptic revision, number (%)	785 (1.9)	59 (1.4)	12 (1.8)	612 (1.9)	20 (1.1)	82 (2.1)
Total observation years	146,538	12,952	2202	115,299	2407	13,679
Revisions/100 observation years (% [95% CI])	0.54 (0.5–0.57)	0.46 (0.35–0.59)	0.55 (0.31–0.96)	0.53 (0.49–0.57)	0.83 (0.54–1.29)	0.6 (0.48–0.74)
Dislocation, number (%)	276 (1.2)	8 (0.4)	3 (1.8)	233 (1.4)	9 (0.8)	23 (1.3)
Total observation years	47,453	4368	370	37,361	1562	3793
Dislocations/100 observation years (% [95% CI])	0.58 (0.52–0.65)	0.18 (0.09–0.37)	0.81 (0.26–2.52)	0.62 (0.55–0.71)	0.58 (0.3–1.11)	0.61 (0.4–0.91)

CI = confidence interval.

**Table 3.** Adjusted risk of revision (septic, aseptic) and dislocation by surgical approach, hazard ratio, 95% confidence intervals, and Wald chi square p value

Surgical approach	HR	95% CI	p value
<b>Septic revision</b>			
Posterior (reference)	1.00	–	–
Anterolateral	0.98	0.60–1.61	0.947
Direct lateral	2.15	0.95–4.83	0.065
Direct anterior	1.27	0.54–3.00	0.578
<b>Aseptic revision</b>			
Posterior (reference)	1.00	–	–
Anterolateral	0.82	0.52–1.30	0.401
Direct lateral	1.10	0.54–2.25	0.789
Direct anterior	0.98	0.60–1.62	0.950
<b>Dislocation</b>			
Posterior (reference)	1.00	–	–
Anterolateral	0.29	0.13–0.63	0.002
Direct lateral	1.30	0.30–5.60	0.724
Direct anterior	0.44	0.22–0.87	0.017

HR = hazard ratio; CI = confidence interval.

larger diameter femoral heads, and improved posterior capsular repair after a posterior approach [8, 19, 20, 22, 27, 47]. Most published studies have indicated that use of larger femoral heads has resulted in overall reduction in rate of dislocation [14, 19, 20, 22, 47]. Although 45% of our patients had large femoral head size (36 mm or greater), this was controlled for in our statistical analysis. We believe that the lower risk dislocation in anterior approaches is the result of the nature of surgical approaches per se. Reliability of registry data must also be considered, as noted by Devane et al. [13], who reported that registry data included only the dislocation event that led to revision. The true rate of all dislocations, inclusive of those requiring closed reduction, in their study was almost two times higher (3%) [13] than reported in the registry data. We believe our data reflect a very close estimation of the true dislocation rate. Our findings were based on the stable patient population and a very robust data collection system.

The strengths of our study include a large and representative sample of patients and very robust follow up data collection process. Our data reflect outcomes in a community-based setting where some surgeons may have learned the newer anterior approaches either during their fellowship training or through training courses. Because many community-based surgeons are gradually adopting anterior approaches in their practices, we believe that our results reflect the risks and benefits of these approaches as applied in nonacademic settings. The data for this study were mostly extracted from a total joint replacement registry database, which prospectively collects the information

using predetermined data capture templates and uses active surveillance techniques for detecting outcomes as well as confirmation of these outcomes by chart review. This guarantees the internal validity of the information being presented in this study. The results of our study support the idea that approaches from the front of the joint are associated with a lower risk of dislocation. It is conceivable that one can forego dislocation precautions during the postoperative period facilitating early rehabilitation; however, specific clinical studies should evaluate this premise.

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