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Original research

Total Hip Arthroplasty for Developmental Dysplasia of Hip vs Osteoarthritis: A Propensity Matched Pair Analysis

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ABSTRACT

Background: The purpose of this study was to use the American College of Surgeons National Surgical Quality Improvement Program to compare the perioperative and postoperative outcomes after total hip arthroplasty (THA) for DDH and primary OA via a propensity-matched pair analysis and the valuation of THA between both groups.

Material and Methods: All patients who underwent THA between 2008 and 2016 were identified from National Surgical Quality Improvement Program database via the current procedural terminology (CPT) code. Patients were further identified and stratified based on International Statistical Classification of Diseases and Related Health Problems–9/International Statistical Classification of Diseases and Related Health Problems–10 diagnosis codes for primary OA (n = 115,166) and DDH (n = 603), which included codes for congenital hip dislocation, hip dysplasia, or juvenile osteochondrosis. Demographic variables were used to create 557 propensity-matched pairs.

Results: The DDH group was associated with a significantly longer operative time (120.3 vs 95.9 min), higher postoperative transfusion rate (12% vs 6.6%), and longer hospital length of stay (2.8 vs 2.5 days) compared with the primary OA group ($P < .001$, $P < .001$, and $P = .002$, respectively). There were no statistically significant differences found between the two groups with respect to inpatient complications, discharge disposition ($P = .123$), readmissions ($P = .615$), or reoperations ($P = .404$).

Conclusions: Health policy makers should be cognizant of the higher complexity of THA for DDH when determining whether DDH and primary OA should be in the same bundle. Owing to the limitations of our data set, all the observed associations are likely an underestimate of the true risk posed to patients with severe DDH, as these patients were unable to be stratified in the present analysis.

Introduction

In recent years, there has been increasing interest in alternative payment models, such as bundled payments, in total hip arthroplasty (THA) [1]. As bundled payments continue to evolve, recent studies have shown that not all indications for THA belong in the same bundle owing to differences in the patient population and clinical outcomes [2,3]. Consequently, it is important to continue to evaluate other indications for THA to determine optimal bundles [4].

Developmental dysplasia of hip (DDH) is a spectrum of disease that comprises one of the leading causes of secondary degenerative osteoarthritis (OA) [5] and is associated with a variety of pathomorphologies, such as congenital hip dysplasia and pelvic malformation that can distort anatomy leading to a more technically demanding surgery at the time of THA [6,7]. Although some studies have shown satisfactory long-term results [8-10], other studies have suggested higher failure rates [11] or worse clinical outcomes

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[12] when THA is performed for DDH as opposed to primary OA. In fact, in the 1970s, Charnley suggested that THA should be avoided in all patients with congenital dislocation of the hip and inadequate bone stock [13]. However, the majority of available studies are case series [8-12], and to our knowledge, there are no any large registry studies to compare the outcomes of THA for DDH with primary OA.

Therefore, the purpose of this study was to (1) evaluate the differences in demographics of patients undergoing THA for DDH and primary OA; (2) evaluate differences in short-term perioperative and postoperative outcomes between the two groups via a propensity-matched pair analysis compiled from the National Surgical Quality Improvement Program (NSQIP) database; (3) evaluate procedural THA valuation between the two cohorts. We hypothesize that the two cohorts are different, therefore, necessitating added risk stratification for patients undergoing primary THA for hip dysplasia in bundled payment models.

Material and methods

All patients who underwent THA between 2008 and 2016 were identified from the American College of Surgeons NSQIP database via the common procedural test code for primary THA (27,130). These patients were then stratified based on diagnosis in two cohorts. The first cohort consisted of all patients who had an International Statistical Classification of Diseases and Related Health Problems 9 (ICD-9) code (715.XX) or ICD-10 code (M16.xx) for primary OA. The second cohort consisted of all patients who had DDH, which was defined as one of the following diagnosis codes: congenital hip dislocation (754.30 for ICD-9, Q65.XX for ICD-10), hip dysplasia (M16.XX, Q65.XX), or congenital pelvic malformation (Q74.2, Q89.8) (Table 1). Patients were given a diagnosis code that was either ICD-9 or ICD-10 without overlap, depending on the year of entry. Patients with a diagnosis of Legg-Calve-Perthes disease or slipped capital femoral epiphysis were not included in this analysis. The THA for primary OA cohort consisted of 115,166 patients, and the THA for DDH group consisted of 603 patients.

The nearest neighbor caliper is used for propensity matching to identify close pairs. A regression algorithm based on risk factors of interest is used to generate a propensity score for each subject [14]. Then the two groups (osteoarthritis and DDH patients) are paired to the "nearest neighbor" by identifying an osteoarthritis patient with a propensity score within 1×10^{-4} of the propensity score of a DDH patient to control for these confounders by making all other factors similar except for the diagnosis of OA versus DDH to try to isolate the independent contribution of DDH on risk of negative outcomes. The nearest neighbor matching caliper was set to 1×10^{-4}, and the algorithm matched patients on body mass index, gender, age, and diabetes mellitus. Five hundred fifty-seven matched pairs were identified from the data set and included in our analysis. Demographics of the two cohorts can be seen in Appendix 1.

All patients were assessed for variability in operative time, length of stay (LOS), and postoperative complications. Outcomes of interest collected in the NSQIP database are assessed for 30 days from the date of surgery. Outcomes for this study included operating room (OR) time, procedural relative value units (RVUs), hospital LOS, death within 30 days, pulmonary complications, cardiac complications, surgical site infection, blood loss requiring postoperative transfusion, sepsis, discharge disposition, readmission, and reoperation.

Statistical analyses were performed using Stata, version 14.2 (StataCorp, College Station, TX). Continuous variables were assessed via t-test or Mann-Whitney U test when appropriate. Categorical variables were assessed via chi-squared or Fischer's exact test, when appropriate.

Table 1
Codes used for developmental dysplasia of hip and primary osteoarthritis.

Diagnosis code	Primary THA for developmental dysplasia of hip codes	N = 603
ICD-9	754.30 (Congenital hip dislocation)	52
	755.63 (Other congenital deformity of hip joint)	274
ICD-10	M16.3 (unilateral OA from hip dysplasia)	9
	M16.30 (unilateral OA from hip dysplasia)	4
	M16.31 (right hip OA from hip dysplasia)	107
	M16.32 (left hip OA from hip dysplasia)	73
	Q65.01 (Right hip congenital dislocation)	2
	Q65.02 (Left hip congenital dislocation)	1
	Q65.1 (Bilateral hip congenital dislocation)	1
	Q65.30 (congenital partial hip dislocation)	1
	Q65.6 (congenital unstable hip)	1
	Q65.8 (other congenital deformities of hip)	6
	Q65.89 (other specified congenital hip deformities)	67
	Q65.9 (unspecified congenital hip deformity)	3
	Q74.2 (Other congenital malformation of pelvic girdle)	1
	Q89.8 (Other specified congenital malformation)	1
	Primary THA for OA Codes	N = 115,166
ICD-9	715.15 (primary unilateral OA)	14,098
	715.35 (localized OA, unspecified type, pelvis)	50,669
	715.95 (generalized or localized OA, unspecified)	15,920
ICD-10	M16.0 (bilateral primary hip OA)	1443
	M16.11 (unilateral right hip OA)	18,024
	M16.12 (unilateral left hip OA)	15,012

THA, total hip arthroplasty; OA, osteoarthritis.

Descriptive statistics are presented as means with standard deviations for continuous variables, frequencies with proportion for categorical variables, and odds ratios with 95% confidence intervals for the propensity-matched multivariate regression [14]. Bonferroni correction was used to accommodate for multiple analyses (10 outcomes: OR time, death, cardiac complications, postoperative transfusion, sepsis, hospital LOS, discharge home, readmission within 30 days, reoperation within 30 days, procedural RVUs), to minimize a type 1 error by reducing the *P*-value threshold by the number of tests/outcomes being evaluated [15]. A *P*-value <.005 (0.05 divided by 10) was selected for the alpha value, threshold for statistical significance after this correction.

Results

Patients in the DDH cohort were younger, women, and had fewer medical comorbidities, except smoking status, compared with the primary OA cohort (Table 2). After propensity-matched scoring, the OR time was 95.9 (±39) minutes for the primary OA group and 120.3 (±61.8) minutes for the DDH group, which was statistically significant ($P < .001$). The DDH cohort had a statistically significant higher rate of blood loss requiring postoperative transfusion than the primary OA cohort (12% vs 6.6%, $P = .002$) Hospital LOS was 2.5 (±1.2) days for the primary OA group and 2.8 (±1.8) days for the DDH group ($P < .001$). There were no other statistically significant differences between the primary OA group and DDH groups with respect to death ($P = .317$), cardiac complications ($P = .316$), sepsis ($P = .316$), or discharge disposition ($P = .123$). There was no identifiable difference in work RVU between the cohorts (21.1 ± 0.5, $P = .769$). No pulmonary complications of surgical site infections occurred in the matched cohort. There were 15 (2.9%) readmissions in the primary OA group and 18 (3.4%) in the DDH cohort ($P = .615$). There were 9 (1.7%) reoperations in the primary OA group and 13 (2.4%) in the DDH group ($P = .404$) (Table 3).

A multivariate regression model controlling for gender, body mass index, age, race, anesthesia type, preoperative functional

Table 2
Overall demographics of osteoarthritis and developmental dysplasia of hip disease.

Demographics	Osteoarthritis (n = 115,166)	DDH (n = 603)	*P*-value
Age (y)			<.001***
<70 y	73,699 (64.0%)	574 (95.2%)	
≥70 y	41,467 (36.0%)	29 (4.8%)	
Gender			<.001***
Male	51,482 (40.7%)	160 (26.5%)	
Female	63,618 (55.3%)	443 (73.5%)	
Ethnicity			<.001***
White	91,826 (90.0%)	426 (89.3%)	
Black	7998 (7.8%)	20 (4.2%)	
Hispanic	1452 (1.4%)	25 (5.2%)	
Hawaiian	293 (0.3%)	1 (0.2%)	
American Indian	409 (0.4%)	5 (1.0%)	
Functional status			<.001***
Independent	112,446 (98.0%)	586 (97.3%)	
Partially dependent	2206 (1.9%)	13 (2.2%)	
Totally dependent	81 (0.1%)	3 (0.5%)	
ASA class			<.001***
I-II	67,682 (58.8%)	452 (75.0%)	
III-IV	47,483 (41.2%)	151 (25.0%)	
Comorbidities			
Obesity (BMI>30 kg/m^2)	53,984 (46.9%)	239 (39.6%)	<.001***
Diabetes	13,300 (11.6%)	30 (5.0%)	<.001***
Hypertension	65,729 (57.1%)	180 (29.9%)	<.001***
Smoker	14,037 (12.2%)	98 (16.3%)	.002***
COPD	4310 (3.7%)	10 (1.7%)	<.001***
Chronic steroids	3483 (3.0%)	14 (2.3%)	.315
Dialysis	209 (0.2%)	0 (0.0%)	.295
Cancer	183 (0.2%)	0 (0.0%)	.327
Baseline low HCT (<30)	856 (0.8%)	3 (0.5%)	.488
Baseline renal insufficiency (Cr ≥ 2 mg/dL)	7515 (6.7%)	49 (8.4%)	.104
Baseline low albumin (≤3.5 g/dL)	2038 (3.6%)	10 (3.8%)	.840
Baseline low platelets (≤100 billion cells/L)	626 (0.5%)	1 (0.2%)	.207
Baseline high bilirubin (≥2 mg/dL)	61,474 (53.4%)	365 (60.5%)	<.001***
General anesthetics	60,076 (52.2%)	313 (52.2%)	.982

COPD, chronic obstructive pulmonary disease; ASA, anesthesia physical classification; BMI, body mass index; HCT, hematocrit; DDH, developmental dysplasia of hip.
***Statistical significant, $P < .05$.

status, American Society of Anesthesiologists score, diabetes, hypertension, smoking, steroid use, chronic obstructive pulmonary disease, dialysis, history of cancer, and preoperative lab values (hematocrit, creatinine, albumin, platelets, bilirubin) demonstrated similar results except transfusion rate with regard to the outcomes of interest between the OA and DDH groups. (Table 4).

Discussion

As alternative payment models continue to evolve, there is a continued need to evaluate different indications to optimize bundles [1]. As evidenced by the differences in complication rates of THA for femoral neck fractures compared with primary OA [16], different indications for THA have different risk profiles [2,3]. Therefore, we sought to evaluate DDH, one of the leading causes of secondary OA to determine whether additional risk stratification is appropriate for this group of THA patients. In this study, we found that patients undergoing THA for DDH were younger, a greater proportion were women, and had fewer comorbidities. After controlling for these variables with propensity-matched regression, the only statistically significant differences were longer operative times, higher transfusion rates, and longer, though clinically insignificantly different, LOS.

Our finding that patients with DDH undergoing THA were significantly younger and healthier than those with primary OA (49.6 vs 65.3 years) is consistent with previously reported literature

Table 3
Propensity analysis of outcomes within 30 days of THA for OA compared with DDH.

Results	Osteoarthritis (n = 557)	DDH (n = 557)	*P*-value
OR time, min ±SD	95.9 ± 39.0	120.3 ± 61.8	<.001[a]
Death, n (%)	1 (0.2%)	0 (0%)	.317
Pulmonary, n (%)	0 (0%)	0 (0%)	N/A
Cardiac, n (%)	3 (0.5%)	1 (0.2%)	.316
Surgical site infection, n (%)	0 (0%)	0 (0%)	N/A
Transfusions, n (%)	37 (6.6%)	67 (12.0%)	.002[a]
Sepsis, n (%)	1 (0.2%)	3 (0.5%)	.316
Hospital LOS, d ±SD	2.5 ± 1.4	2.8 ± 1.8	<.001[a]
Discharge to home, n (%)	469 (89.0%)	455 (85.9%)	.123
Readmission, n (%)	15 (2.9%)	18 (3.4%)	.615
Reoperations, n (%)	9 (1.7%)	13 (2.4%)	.404
Procedural RVU, n ± SD	21.1 ± 0.5	21.1 ± 0.5	.769

SD, standard deviation; OR, operating room; LOS, length of stay; RVU, relative value unit; DDH, developmental dysplasia of hip; OA, osteoarthritis.
[a] *P*-value for significance set at <.005 after Bonferroni correction for 10 outcomes.

[5]. As other studies have reported [17,18], we found that female sex and ethnicity were also associated with patients undergoing THA for DDH. There are several risk factors for DDH that we were unable to assess because of availability in the database including breech presentation at birth, family history, first child, or postdate babies [18,19].

The authors believe that the variety of pathomorphologies seen in DDH and possibility for previous hardware owing to periacetabular osteotomies or proximal femoral osteotomies may be responsible for the longer operative times. Studies have shown a linear relationship between longer operative times with higher risk of readmissions, reoperations, surgical site infections, wound dehiscence, renal or systemic complications, and allogenic blood transfusions [20-22]. In a multivariable analysis of 99,444 patients who underwent TJA, Duchman et al. [21] found that overall complications were increased in patients with operative times greater than 120 minutes (5.9%) as compared with patients with operative times less than 60 minutes or 60 to 120 minutes (4.6%, 4.8%, respectively). In addition, each 30-minute increase in operative time beyond 120 minutes further increased risk [21]. Our study also found higher rates of transfusion rates in the DDH cohort. This is concerning as higher allogeneic blood transfusion after arthroplasty have been associated with higher odds of mortality and increased superficial and deep wound infections [23,24].

Although readmissions, reoperations, and systemic sepsis did not meet statistical significance, the higher rates in the DDH group, albeit small, may still be clinically relevant. In addition, the risks associated with severe DDH are underestimated by the findings of this study, as severe and mild DDH could not be stratified. It is presumable that patients with severe DDH would have longer

Table 4
Multivariate logistic regression of propensity matches.

Results	OR	95% CI	*P*-value
Complication (OA vs DDH)			
Death (within 30 d)	N/A	-	-
Surgical site infection	N/A	-	-
Cardiac	0.33	0.03 to 3.20	.306
Pulmonary	N/A	-	-
Transfusions (DDH)	1.92	1.26 to 2.92	.002***
Sepsis	3.01	0.31 to 29.03	.306
Reoperation (within 30 d)	1.43	0.61 to 3.40	.402
Readmissions (within 30 d)	1.20	0.59 to 2.39	.615
Discharge home	0.75	0.52 to 1.08	.123

OR, odds ratio; CI, confidence interval.
***Statistical significant, $P < .05$.

operative times and more perioperative complications than patients with mild DDH, who would be more similar to patients with primary OA.

Value-based and bundled payment models should accommodate for higher cost and need for resources to provide a primary THA for patients with DDH, given the greater operative times, greater risk of transfusions, and clinically significant higher rates of complications. This is further alarming as our results demonstrate work RVU for both cohorts were identical (21.1 ± 0.5) because there is no separate code available to indicate THA complexity related to patients with DDH. Our findings support continued development of proper bundled payment risk stratification [4,25] and provide guidelines for health policy makers for RVU adjustment based on case complexities and increased risk [26].

Strengths of this study include the large number of patients used in the registry and the propensity-matched design to control for the differences in the population. However, this study has several limitations. First, this is a retrospective registry study that is highly dependent on the validity of the data collected. Other registry studies [27] that have higher volume of DDH patients may be due to more accurate mechanisms for identifying DDH diagnosis than NSQIP, which is a general surgical database and not specific to orthopedics. Second, as ICD-10 and CPT codes were used for identification, it was not possible to collect certain variables such as those with prior hardware, which may not have been coded in the NSQIP. These variables may be responsible for the increase in operative time seen with DDH. Third, there may be selection bias in our study because complex dysplasia cases are more likely to be performed by higher-volume and fellowship-trained surgeons. As surgeon volume and arthroplasty fellowship training are associated with lower complication rates, lower operative times, and improved outcomes [28-36], this would bias the dysplasia group to trend towards improved outcomes in comparison with the general OA cohort. Surgeon volume and fellowship training are not available via the NSQIP database which prevented stratification of this potential effect. Fourth, the study period includes both ICD-9 and ICD-10 coding designations, which may present confounding bias. However, we do not believe there to is a significant difference because there was no coding overlap that would warrant eliminating the patients from the ICD-9 or ICD-10 groupings. Finally, the main limitation of our study is the inability for the NSQIP database (based on ICD-9/ICD-10 coding) to designate dysplasia severity. While THA for mild dysplasia has shown to have good outcomes [37-39], patients with more severe dysplasia have greater rates of revision, nerve palsy, fracture, blood transfusion, infection, instability, and complications overall in comparision to THA cohorts as a whole [27,40-43]. Pooling mild and severe dysplasia groups likely underestimates the true risks associated with THA for severe dysplasia.

Conclusions

In summary, patients who underwent THA for DDH were younger with a greater proportion being women and generally healthier compared to patients with OA. When controlling for these variables via a propensity-matched analysis, we found that THA for DDH was associated with a nearly 30-minute longer operative time, higher rates of postoperative transfusion and statistically significant but clinically insignificant longer length of hospital stay (0.3 days). As these findings are likely manifestations of the different anatomic morphologies seen in the spectrum of DDH, the authors advocate for acknowledgment of potential intraoperative complexity, which should be identified through thorough preoperative planning. A formal cost analysis is needed to determine whether DDH and primary OA should be in the same bundle and valued with the same RVUs.

Conflict of interest

Wudbhav N. Shankar reports board member/committee appointments for Pediatric Orthopaedic Society of North America, Committee chair and royalties, financial or material support from Wolters Kluwer. Neil P.Sheth reports paid consultant for Zimmer, Smith and Nephew and Medacta and royalties, financial or material support from Elsevier.

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Appendix Table 1
Demographics of the propensity matched pair.

Demographics	Osteoarthritis (n = 557)	DDH (n = 557)	*P*-value
Age, y ±SD	51.1 ± 11.6	51.2 ± 11.6	.908
BMI (kg/m^2)	29.4 ± 6.5	29.6 ± 7.0	.289
Gender			.549
Male	161 (28.9%)	152 (27.3%)	
Female	396 (71.1%)	405 (72.7%)	
Ethnicity			.969
White	408 (82.9%)	392 (89.1%)	
Black	68 (13.8%)	19 (4.3%)	
Hispanic	11 (2.2%)	23 (5.2%)	
Hawaiian	2 (0.4%)	1 (0.2%)	
American Indian	3 (0.6%)	5 (1.1%)	
Functional status			.484
Independent	546 (98.2%)	541 (97.3%)	
Partially dependent	9 (1.6%)	12 (2.2%)	
Totally dependent	1 (0.2%)	3 (0.5%)	
ASA class			.180
I-II	393 (70.6%)	413 (74.2%)	
III-IV	164 (29.4%)	144 (25.8%)	
Comorbidities			
Obesity (BMI>30 kg/m^2)	232 (41.7%)	225 (40.4%)	.670
Diabetes	33 (5.9%)	30 (5.4%)	.697
Hypertension	177 (31.8%)	176 (31.6%)	.949
Smoker	136 (24.4%)	89 (16.0%)	>.999
COPD	21 (3.8%)	10 (1.8%)	.450
Chronic steroids	14 (2.5%)	14 (2.5%)	>.999
Dialysis	0 (0.0%)	0 (0.0%)	N/A
Cancer	0 (0.0%)	0 (0.0%)	N/A
Baseline low HCT (<30)	7 (1.3%)	3 (0.6%)	.207
Baseline renal insufficiency (Cr ≥ 2 mg/dL)	49 (9.0%)	45 (8.3%)	.686
Baseline low albumin (≤3.5 g/dL)	11 (4.2%)	10 (4.0%)	.925
Baseline low platelets (≤100 billion cells/L)	2 (0.4%)	1 (0.2%)	.563
Baseline high bilirubin (≥2 mg/dL)	309 (55.5%)	333 (59.8%)	.146
General anesthetics	303 (54.6%)	285 (51.4%)	.293

SD, standard deviation; COPD, chronic obstructive pulmonary disease; ASA, anesthesia physical classification; BMI, body mass index; HCT, hematocrit; DDH, developmental dysplasia of hip.