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Medical resource utilization and costs for intraoperative and early postoperative periprosthetic hip fractures following total hip arthroplasty in the medicare population

A retrospective cohort study

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Abstract

This study assessed the impact of intraoperative and early postoperative periprosthetic hip fractures (PPHFx) after primary total hip arthroplasty (THA) on health care resource utilization and costs in the Medicare population.

This retrospective observational cohort study used health care claims from the United States Centers for Medicare and Medicaid Standard Analytic File (100%) sample. Patients aged 65+ with primary THA between 2010 and 2016 were identified and divided into 3 groups – patients with intraoperative PPHFx, patients with postoperative PPHFx within 90 days of THA, and patients without PPHFx. A multi-level matching technique, using direct and propensity score matching was used. The proportion of patients admitted at least once to skilled nursing facility (SNF), inpatient rehabilitation facility (IRF), and readmission during the 0 to 90 or 0 to 365 day period after THA as well as the total all-cause payments during those periods were compared between patients in PPHFx groups and patients without PPHFx.

After dual matching, a total 4460 patients for intraoperative and 2658 patients for postoperative PPHFx analyses were included. Utilization of any 90-day post-acute services was statistically significantly higher among patients in both PPHFx groups versus those without PPHFx: for intraoperative analysis, SNF (41.7% vs 30.8%), IRF (17.7% vs 10.1%), and readmissions (17.6% vs 11.5%); for postoperative analysis, SNF (64.5% vs 28.7%), IRF (22.6% vs 7.2%), and readmissions (92.8% vs 8.8%) (all $P < .0001$). The mean 90-day total all-cause payments were significantly higher in both intraoperative ($30,114 vs $21,229) and postoperative ($53,669 vs $ 19,817, $P < .0001$) PPHFx groups versus those without PPHFx. All trends were similar in the 365-day follow up.

Patients with intraoperative and early postoperative PPHFx had statistically significantly higher resource utilization and payments than patients without PPHFx after primary THA. The differences observed during the 90-day follow up were continued over the 1-year period as well.

Abbreviations: CCI = Charlson comorbidity index, CMS = Centers for Medicare and Medicaid Services, ESRD = end-stage renal disease, ICD-10-CM = international classification of diseases, tenth revision, clinical modification, ICD-9-CM = international classification of diseases, ninth revision, clinical modification, IRF = inpatient rehabilitation facility, PPHFx = periprosthetic hip fractures, SNF = skilled nursing facility, Std Diff = standardized differences, THA = total hip arthroplasty.

Keywords: costs, early postoperative periprosthetic hip fractures, intraoperative periprosthetic hip fractures, medical resource utilization, medicare, total hip arthroplasty

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1. Introduction

Total hip arthroplasty (THA) is recognized to be an effective procedure for treating pain and restoring mobility in patients with hip joint pathology. The effectiveness of THA has led to increasing numbers of procedures being undertaken. In the United States, the overall frequency for THA has risen over the course of recent decades and it is projected to reach an annual incidence of 572,000 by 2030.[1]

Periprosthetic hip fracture (PPHFx) is a major and devastating complication which can occur in patients who have undergone THA. It is associated with an increase in other postoperative complications, which may lead to a worse clinical outcome,[2] as well as an increased mortality rate. Recent literature suggests an 11% 1-year mortality rate after PPHFx, pointing out that age and type of surgery are the potential risk factors.[3,4] Increased life expectancy combined with the increased numbers of arthroplasties is contributing to an increase in the number of PPHFx in the United States and worldwide.[4]

PPHFx is categorized into intraoperative and postoperative fractures. Intraoperative PPHFx occur during the course of the initial THA procedure, while the postoperative PPHFx occur after the initial THA procedure, most commonly within the first month postoperatively.[5] In a meta-analysis, Sidler-Maier et al determined that the incidence of PPHFx ranges from 0.1% to 27.8% for intraoperative and from 0.07% to 18% for postoperative PPHFx.[6,7] The prevalence of intraoperative PPHFx has increased in recent years due to the increased use of cementless press-fit implants, while the increase in postoperative PPHFx appears associated with the overall increase of the at-risk population undergoing arthroplasty.[8,9] In terms of treatment, the postoperative PPHFx require complicated and serious reoperations while recognized intraoperative PPHFx can be treated during primary surgery causing a lighter financial burden.[6] Ravi et al showed that among other risk factors, the surgeon's yearly volume can also affect the rate of PPHFx. In their study, for the patients operated on by surgeons who had $\leq$35 procedures per year, the risks for complications increased by more than 40%.[10]

Considerable attention has been given to characteristics that affect the risk of PPHFx. Published studies revealed that most important risk factors were patient demographics (age, sex, and body mass index), and clinical characteristics (preoperative diagnosis, comorbidities, medical/reoperation history). PPHFx is complications which not only lead to both functional and psychological impacts on patients, but also cause financial burden for the patients and healthcare system.[5,6,11,12] Though there were some studies done on PPHFx showing financial burden to be $24,831 for the average hospital length of stay of 6.3 ± 8.8 days,[13] €26,436 (equivalent to $29,995) for the average length of stay of 21.0 days,[14] £33,789 (equivalent to $42,630) for >30 days of hospital stay[15] there is still insufficient or no data to clearly characterize the burden imposed separately by intraoperative and early postoperative ($\leq$90 days) PPHFx in terms of medical resource utilization and costs.

This study aimed to assess the burden associated with intraoperative and early postoperative ($\leq$90 days) PPHFx following primary THA on 90-day and 1-year health care resource utilization and costs in the Medicare population.

2. Methods

2.1. Data sources

Medicare is one of the largest health insurance programs in the United States, providing coverage to persons 65 years or older and persons younger than 65 years who have end-stage renal disease (ESRD) or who are disabled. This study used data from the United States Centers for Medicare and Medicaid Services (CMS) Standard Analytic File. The data included Medicare Part A and Part B claims which captured Fee-for-Service services. Medicare Advantage Patients were not captured. Medicare Part A captures inpatient hospital visits and related claims including diagnosis (The International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification, ICD-9-CM, ICD-10-CM), procedures, Medicare Severity Diagnosis Related Group, dates of service, hospital provider number, and beneficiary demographic information. Medicare Part B is available for institutional outpatient providers only. Examples of institutional outpatient providers include hospital outpatient departments, rural health clinics, renal dialysis facilities, outpatient rehabilitation facilities, comprehensive outpatient rehabilitation facilities, and community mental health centers. Available data elements include diagnosis (ICD-9 and ICD-10), Healthcare Common Procedure Coding System, dates of service, outpatient provider number, revenue center codes, and beneficiary demographic information. Once an individual enrolls in Medicare they generally remain enrolled until death; hence, this database is ideal for longitudinal studies.

The use of CMS database are Health Insurance Portability and Accountability Act compliant and thus exempt from institutional review board approvals.

2.2. Study population

This study used a retrospective longitudinal cohort design identifying patients aged 65+ with a claim for primary THA and diagnosis of hip osteoarthritis. The "Index" date for each patient was defined as the day of discharge from initial THA. All patients were required to have continuous availability of data for at least 365 days before THA and 90 days after the index date. Three cohorts were identified

(1) Patients with intraoperative PPHFx identified between 2010 and 2016. Intraoperative PPHFx was defined as a combination of codes for THA and fixation or arthroplasty of hip-related procedure during same hospitalization.
(2) Patients with postoperative PPHFx identified between 2010 and 2016. Postoperative PPHFx was defined as a combination of codes for periprosthetic fractures (ICD-9-CM, 996.44) and other hip-related fracture diagnosis; or using ICD-10-CM PPHFx codes. Only patients with postoperative PPHFx within 90 days of the index date were included.
(3) Patients without PPHFx anytime during the study period, the control group.

Patients were excluded if they

(1) had a non-Medicare primary payer,
(2) were eligible for Medicare due to ESRD, or
(3) died anytime during the 90 days after the index discharge.

2.3. Outcome variables

Ninety (90) and 365-day direct medical resource utilization were analyzed. These included distinct visits (percentage of patients with any visits as yes/no and mean [standard deviation] number of days/visits) and Medicare payment amounts across service types and settings of care (excluding retail pharmacy): skilled nursing facility (SNF), outpatient hospital department, inpatient rehab facility, readmissions.

2.4. Matching

A multi-step approach to maximize similarity between patients with and without PPHFx was used. Patients in the PPHFx cohort were matched 1:1 with the control cohort, using both direct and propensity score matching. Patient were first matched directly on the year of THA, surgeon and hospital and then further matched using the propensity scores based on the following covariates: age, gender, race, body mass index, obesity, morbid obesity, congestive heart failure, osteoporosis, opioid dependence or abuse, diabetes, tobacco use and Charlson comorbidity index (CCI). The propensity score matching method involved nearest

neighbor technique with calipers of width equal to 0.2 of the pooled standard deviation of the logit of the propensity score.

2.5. Data analysis

Frequency counts and proportions were provided for categorical variables. Means and standard deviations were provided for continuous variables. Standardized differences (Std Diff) and tests of significance were used to compare the differences between the cohorts, with and without PPHFx, for the patient demographic and clinical characteristics before and after matching. A Std Diff below 0.1 was concluded to indicate a negligible difference between compared groups for each measure. Health care resource utilization and costs over 90 days and 365 days were compared using Wilcoxon signed rank test for continuous variables and McNemar test for categorical variable. The costs were not adjusted for inflation as Medicare payments have shown minimal changes to inflation.

3. Results

3.1. Pre-matched cohorts: Baseline characteristics

The study included 2976 patients with intraoperative, 1479 patients with postoperative PPHFx and 473,602 patients without PPHFx. Baseline (pre-match) patient demographic and clinical characteristics for the intraoperative and postoperative PPHFx cohorts versus pre-matched control cohort are presented in Tables 1 and 2. The mean age of the intraoperative and postoperative cohorts were 76.4 (±7.0) years and 75.1 (±6.5) years, respectively. There were greater proportions of women in intraoperative (75.9%, Std Diff = 0.30) and postoperative (77.3%, Std Diff = 0.32) cohorts as compared to the pre-matched control cohort (62.4%). Patients in the intraoperative PPHFx cohort were more likely to have osteoporosis than the control cohort (36.1% vs 19.8%, Std Diff = 0.37). Patients in the postoperative PPHFx cohort were more likely to have obesity (25.3% vs 18.2%, Std Diff = 0.17), morbid obesity (8.8% vs 5.3%, Std Diff = 0.14), osteoporosis (27.0% vs 19.8%, Std Diff = 0.17), and tobacco use (32.9% vs 23.4%, Std Diff = 0.21) than the control cohort. In addition, patients with intraoperative (41.7% vs 34.2%, Std Diff = 0.17) or postoperative (37.7% vs 34.2%, Std Diff = 0.11) PPHFx were more likely than control cohort to have a CCI score greater than 1.

3.2. Matched cohorts: Baseline characteristics

After applying direct and propensity-score matching techniques, 4460 patients (2230 intraoperative and 2230 controls) and 2658 patients (1329 postoperative and 1329 controls), remained available for comparative analysis for intraoperative and postoperative PPHFx, respectively. No significant between-group differences in baseline patient demographic and clinical characteristics were observed for these matched cohorts. Patients with intraoperative PPHFx were similar to control patients with respect to mean age (75.7 ± 6.5 vs 75.9 ± 6.5, Std Diff = 0.03), gender (73.9% females vs 74.8% females, Std Diff = −0.02), race (93.1% Whites vs 92.8% Whites, Std Diff = 0.03), and various comorbid conditions and CCI score (all Std Diff < 0.1, indicating negligible differences). Similarly, patients with postoperative PPHFx were similar to control patients with respect to mean age (75.0 ± 6.4 vs 79.9 ± 6.3, Std Diff = 0.01), gender (76.9% females vs 76.9% females, Std Diff = 0.00), race (94.8% Whites vs 95.4% Whites, Std Diff = 0.07), and various comorbid conditions and CCI score (all Std Diff < 0.1, indicating negligible differences).

3.3. Matched cohorts- direct medical resource utilization and payments

Tables 3–6 depict the information about the patient utilization, days of service and Medicare claim payments associated with treatment of intraoperative and postoperative PPHFx patients for 90- and 365-day periods after hospitalization.

Patients with intraoperative PPHFx had significantly higher hospital length of stay for the index THA procedure which involved fixing the intraoperative fracture when compared to matched patients in the control group (4.55 ± 3.86 days vs 3.16 ± 1.54 days, $P < .0001$) (Table 3).

Utilization of any 90-day post-acute services (Table 3) was also significantly higher among patients in the intraoperative cohort versus those in the control cohort: SNF (41.7% vs 30.8%, $P < .0001$), inpatient rehabilitation facility (17.7% vs 10.1%, $P < .0001$), and readmissions (17.6% vs 11.5%, $P < .0001$). The length of stay in each of these settings was also significantly higher in the intraoperative PPHFx cohort: SNF (13.34 ± 21.22 days vs 6.78 ± 14.06 days, $P < .0001$), inpatient rehabilitation facility (2.24 ± 5.25 days vs 1.08 ± 3.55 days, $P < .0001$), and readmissions (1.27 ± 3.96 days vs 0.62 ± 2.59 days, $P < .0001$).

Similarly, patients with early postoperative PPHFx had significantly higher hospital length of stay for the index THA procedure when compared to matched patients in the control group (2.79 ± 1.60 days vs 2.56 ± 1.28 days, $P < .0001$) (Table 4).

Utilization of any 90-day post-acute services (Table 4) was also significantly higher among patients in the early postoperative PPHFx cohort versus those in the control cohort: SNF (64.5% vs 28.7%, $P < .0001$), inpatient rehabilitation facility (22.6% vs 7.2%, $P < .0001$), and readmissions (92.8% vs 8.8%, $P < .0001$). The length of stay in each of these settings were also significantly higher in the early postoperative PPHFx cohort: SNF (21.03 ± 23.10 days vs 5.26 ± 11.49 days, $P < .0001$), inpatient rehabilitation facility (3.16 ± 6.82 days vs 0.77 ± 2.99 days, $P < .0001$), and readmissions (5.95 ± 5.74 days vs 0.43 ± 1.86 days, $P < .0001$).

All trends were similar in the 365-day follow up for both intraoperative and early postoperative PPHFx cohorts (Tables 5 and 6)

Mean 90-day total all-cause payments were significantly higher for patients with intraoperative cohort versus control patients ($30,114 vs $21,229, $P < .0001$) (Table 3). These included significantly higher payments for index hospitalizations ($15,546 vs $12,827, $P < .0001$), SNF ($6331 vs $3341, $P < .0001$), inpatient rehabilitation facility ($2962 vs $1454, $P < .0001$), and readmissions ($2720 vs $ 1493, $P < .0001$). Similarly, mean 365-day total all-cause payments were significantly higher for patients with intraoperative cohort versus control patients ($37,542 vs $26,611, $P < .0001$) (Table 5).

For patients with early postoperative PPHFx the mean 90-day total all-cause payments were significantly higher versus control patients ($53,669 vs $ 19,817, $P < .0001$) (Table 4). These included significantly higher payments for index hospitalizations ($13,059 vs $12,545, $P < .0001$), SNF ($10,444 vs $2665, $P < .0001$), inpatient rehabilitation facility ($4598 vs $1069, $P < .0001$), and readmissions ($21,885 vs $ 1071, $P < .0001$). Similarly, mean 365-day total all-cause payments were significantly higher for patients with early postoperative cohort versus control patients ($65,525 vs $25,672, $P < .0001$) (Table 6).

Table 1

Baseline patient characteristics before (Table 1a) and after (Table 1b) matching for patients with intraoperative PPHFx and control group (patients with THA and no PPHFx).

Table 1a. Before matching

	All		Intraoperative PPHFx		Control group			
	N	%	N	%	N	%	Std. diff	*P* value
N	476,578	100.00%	2976	100.0%	473,602	100.0%		
Age category							0.2778	<.0001
65–69	127,639	26.8%	565	19.0%	127,074	26.8%		
70–74	129,942	27.3%	728	24.5%	129,214	27.3%		
75–79	107,595	22.6%	731	24.6%	106,864	22.6%		
80–84	73,384	15.4%	522	17.5%	72,862	15.4%		
85–89	31,427	6.6%	322	10.8%	31,105	6.6%		
90+	6591	1.3%	108	3.6%	6,483	1.4%		
Gender							0.2961	<.0001
Male	178,720	37.5%	716	24.1%	178,004	37.6%		
Female	297,858	62.5%	2260	75.9%	295,598	62.4%		
Race							0.0445	.1817
White	444,736	93.3%	2757	92.6%	441,979	93.3%		
Black	20,732	4.4%	151	5.1%	20,581	4.3%		
Asian	1464	0.3%	12	0.4%	1452	0.3%		
Hispanic	1819	0.4%	14	0.5%	1805	0.4%		
Other/unknown	7827	1.6%	42	1.4%	7785	1.6%		
Admission source							0.2183	.0316
Clinic referral	114,439	24.0%	624	21.0%	113,815	24.0%		
Hospital transfer	1132	0.2%	67	2.3%	1071	0.2%		
Non-health location	358,008	75.1%	2228	74.9%	355,780	75.1%		
Other/unknown	1621	0.3%	24	0.8%	1597	0.3%		
Transfer from SNF or ICF	905	0.2%	22	0.7%	905	0.2%		
Transfer from other facility	424	0.1%	11	0.4%	413	0.1%		
Year of THA							0.1431	<.0001
2010	55,127	11.6%	386	13.0%	54,741	11.6%		
2011	53,958	11.3%	435	14.6%	53,523	11.3%		
2012	56,597	11.9%	416	14.0%	56,181	11.9%		
2013	58,755	12.3%	415	13.9%	58,340	12.3%		
2014	60,147	12.6%	401	13.5%	59,746	12.6%		
2015	72,875	15.3%	449	15.1%	72,426	15.3%		
2016	104,789	22.0%	474	15.9%	104,315	22.0%		
BMI category							0.1291	<.0001
Unknown	409,860	86.0%	2,526	84.9%	407,334	86.0%		
<19	1240	0.3%	25	0.8%	1215	0.3%		
19–24	2473	0.5%	29	1.0%	2444	0.5%		
25–29	8857	1.9%	80	2.7%	8777	1.9%		
30–39	39,763	8.4%	205	6.9%	39,558	8.4%		
>=40	14,385	3.0%	111	3.7%	14,274	3.0%		
Health problems at THA								
Obesity at THA	86,551	18.2%	526	17.7%	86,025	18.2%	−0.0128	.4
Morbid obesity at THA	25,508	5.3%	188	6.3%	25,320	5.3%	0.0414	.01
Osteoporosis at THA	94,740	19.9%	1075	36.1%	93,665	19.8%	0.3704	<.0001
Tobacco use at THA	111,655	23.4%	693	23.3%	110,962	23.4%	−0.0034	.8
Diabetes at THA	100,185	21.0%	675	22.7%	99,510	21.0%	0.0404	.02
Opioid dependence or abuse at THA	5235	1.1%	62	2.1%	5173	1.1%	0.0412	.01
CCI category							0.1733	<.0001
0–1	313,387	65.8%	1736	58.3%	311,651	65.8%		
2–3	115,571	24.2%	807	27.1%	114,764	24.2%		
4–5	33,414	7.0%	292	9.8%	33,122	7.0%		
6+	14,206	3.0%	141	4.7%	14,065	3.0%		

Table 1b. After matching

	All		Intraoperative PPHFx		Control group			
	N	%	N	%	N	%	St diff	*P* value
N	4460	100.0%	2230	100.0%	2230	100.0%		
Age category							0.0	1
65–69	868	19.5%	445	20.0%	423	19.0%		
70–74	1144	25.7%	576	25.8%	568	25.5%		
75–79	1152	25.8%	571	25.6%	581	26.1%		
80–84	800	17.9%	391	17.5%	409	18.3%		
85–89	428	9.6%	217	9.7%	211	9.5%		
90+	68	1.5%	30	1.4%	38	1.7%		

(*continued*)

Table 1

(continued).

Table 1b. After matching

	All		Intraoperative PPHFx		Control group			
	N	%	N	%	N	%	St diff	*P* value
Gender							0	1
Male	1144	25.7%	582	26.1%	562	25.2%		
Female	3316	74.4%	1,648	73.9%	1,668	74.8%		
Race							0.0254	.9576
White	4147	93.0%	2077	93.1%	2070	92.8%		
Black	217	4.9%	104	4.7%	113	5.1%		
Asian	18	0.4%	NR	NR	NR	NR		
Hispanic	12	0.3%	NR	NR	NR	NR		
Other/unknown	66	1.5%	33	1.5%	33	1.5%		
Admission source							0.051	.112
Clinic referral	1013	22.7%	480	21.5%	533	23.9%		
Hospital transfer	53	1.2%	46	2.1%	NR	NR		
Non-health location	3348	75.1%	1669	74.8%	1679	75.3%		
Other/unknown	20	0.5%	15	0.7%	NR	NR		
Transfer from SNF or ICF	17	0.4%	13	0.6%	NR	NR		
Transfer from other facility	NR	NR	NR	NR	NR	NR		
Year of THA							0.000	1
2010	580	13.0%	290	13.0%	290	13.0%		
2011	624	14.0%	312	14.0%	312	14.0%		
2012	602	13.5%	301	13.5%	301	13.5%		
2013	612	13.7%	306	13.7%	306	13.7%		
2014	570	12.8%	285	12.8%	285	12.8%		
2015	664	14.9%	332	14.9%	332	14.9%		
2016	808	18.1%	404	18.1%	404	18.1%		
BMI category							0.0916	.1808
Unknown	3871	86.8%	1906	85.5%	1965	88.1%		
<19	NR	NR	NR	NR	NR	NR		
19–24	28	0.6%	15	0.7%	13	0.6%		
25–29	89	2.0%	53	2.4%	36	1.6%		
30–39	316	7.1%	168	7.5%	148	6.6%		
>=40	148	3.3%	85	3.8%	63	2.8%		
Health problems at THA								
Obesity at THA	779	17.5%	418	18.7%	361	16.2%	0.0673	.01
Morbid obesity at THA	276	6.2%	145	6.5%	131	5.9%	0.0261	.37
Osteoporosis at THA	1,343	30.1%	695	31.2%	648	29.1%	0.0459	.01
Tobacco use at THA	999	22.4%	529	23.7%	470	21.1%	0.0635	.02
Diabetes at THA	1005	22.5	506	22.7%	499	22.4%	0.0075	.8
Opioid dependence or abuse at THA	81	1.8%	46	2.1%	35	1.6%	0.052	.02
CCI category							0.0356	.36
0–1	2742	61.5%	1367	61.3%	1375	61.7%		
2–3	1180	26.5%	589	26.4%	591	26.5%		
4–5	392	8.8%	194	8.7%	198	8.9%		
6+	146	3.3%	80	3.6%	66	3.0%		

BMI = body mass index, ICF = intermediate care facility, NR = not reported due to low-count restrictions, PPHFx = periprosthetic hip fractures, SNF = skilled nursing facility, THA = total hip arthroplasty.

4. Discussion

In this study, we assessed the impact of PPHFx during or after THA on 90-day and 1-year costs in the Medicare population. The patients with intraoperative PPHFx had economically important and statistically significantly higher resource utilization when compared to patients without PPHFx. Similarly, patients with postoperative PPHFx had statistically significantly higher resource utilization and payments than patients without PPHFx. These differences were observed during the 90-day follow up and continued over the 1-year period as well.

Thillemann et al found that intraoperative PPHFx increase the risk of revision during the first 6 months postoperatively. The overall cumulative revision rate was 3.4% within 6 months postoperatively for patients with intraoperative PPHFx versus 0.9% for patients without intraoperative PPHFx fractures ($P < .001$). The authors also found a significant increase in hospital stay for those patients with intraoperative PPHFx (11 days to 13 days $P < .001$)[16] Although our research did not evaluate the rate of revision after intraoperative PPHFx, we have evaluated the overall readmission rates, of which some would be for revision, over the 90-day and 1-year period after the index operation. We found that patients with intraoperative PPHFx had higher rate of all-cause readmissions (17.6% vs 11.5% at 90-day; 33.5% vs 27.1% at 1-year) as compared to patients without intraoperative fractures.

Nishihara et al found that patients with intraoperative PPHFx achieved significantly lower ability to walk with cane within 13 days after THA as compared to the group without PPHFx ($P < .05$).[17] Intraoperative PPHFx can result in a prolonged

Table 2

Baseline patient characteristics before (Table 2a) and after (Table 2b) matching for patients with early postoperative PPHFx and control group (patients with THA and no PPHFx).

Table 2a. Before matching

	All		Postoperative PPHFx		Control group			
	N	%	N	%	N	%	St diff	*P* value
N	475,081	100.0%	1479	100.0%	473,602	100.0%		
Age category							0.0913	.0291
65–69	127,426	26.8%	352	23.8%	127,074	26.8%		
70–74	129,612	27.3%	398	26.9%	129,214	27.3%		
75–79	107,201	22.6%	337	22.8%	106,864	22.6%		
80–84	73,126	15.4%	264	17.8%	72,862	15.4%		
85–89	31,211	6.6%	106	7.2%	31,105	6.6%		
90+	6505	1.4%	22	1.5%	6,483	1.4%		
Gender							0.3277	<.0001
Male	178,340	37.5%	336	22.7%	178,004	37.6%		
Female	296,741	62.5%	1143	77.3%	295,598	62.4%		
Race							0.0753	.1339
White	443,378	93.3%	1399	94.6%	441,979	93.3%		
Black	20,628	4.3%	47	3.2%	20,581	4.3%		
Asian	1454	0.3%	NR	NR	1452	0.3%		
Hispanic	1809	0.4%	NR	NR	1805	0.4%		
Other/unknown	7812	1.6%	27	1.8%	7785	1.6%		
Admission source							0.0729	.021
Clinic referral	114,240	24.0%	425	28.7%	113,815	24.0%		
Hospital transfer	1079	0.2%	NR	NR	1071	0.2%		
Non-health location	356,813	75.1%	1033	69.8%	355,780	75.1%		
Other/unknown	1599	0.3%	NR	NR	1597	0.3%		
Transfer from SNF or ICF	908	0.2%	NR	NR	905	0.2%		
Transfer from other facility	417	0.1%	NR	NR	413	0.1%		
Year of THA							0.2785	<.0001
2010	54,772	11.5%	31	2.1%	54,741	11.6%		
2011	53,551	11.3%	28	1.9%	53,523	11.3%		
2012	56,214	11.8%	33	2.2%	56,181	11.9%		
2013	58,370	12.3%	30	2.0%	58,340	12.3%		
2014	59,781	12.6%	35	2.4%	59,746	12.6%		
2015	72,758	15.3%	332	22.4%	72,426	15.3%		
2016	105,305	22.2%	990	66.9%	104,315	22.0%		
BMI category							0.2096	<.0001
Unknown	408,499	86.0%	1165	78.8%	407,334	86.0%		
<19	1222	0.3%	NR	NR	1215	0.3%		
19–24	2452	0.5%	NR	NR	2444	0.5%		
25–29	8802	1.9%	25	1.7%	8777	1.9%		
30–39	39,747	8.4%	189	12.8%	39,558	8.4%		
>=40	14,359	3.0%	85	5.7%	14,274	3.0%		
Health problems at THA								
Obesity at THA	86,399	18.2%	374	25.3%	86,025	18.2%	0.1732	<.0001
Morbid obesity at THA	25,450	5.3%	130	8.8%	25,320	5.3%	0.1348	<.0001
Osteoporosis at THA	94,064	19.8%	399	27.0%	93,665	19.8%	0.1714	<.0001
Tobacco use at THA	111,448	23.4%	486	32.9%	110,962	23.4%	0.2117	<.0001
Diabetes at THA	99,810	21.0%	300	20.3%	99,510	21.0%	−0.0173	.5
Opioid dependence or abuse at THA	5200	1.1%	27	1.8%	5173	1.1%	0.0198	<.0001
CCI category							0.114	<.0001
0–1	312,572	65.8%	921	62.3%	311,651	65.8%		
2–3	115,124	24.2%	360	24.3%	114,764	24.2%		
4–5	33,259	7.0%	137	9.3%	33,122	7.0%		
6+	14,126	3.0%	61	4.1%	14,065	3.0%		

Table 2b. After matching

	All		Postoperative PPHFx		Control group			
	N	%	N	%	N	%	St diff	*P* value
N	2658	100.0%	1329	100.0%	1329	100.0%		
Age category							0	1
65–69	625	23.5%	322	24.2%	303	22.8%		
70–74	728	27.4%	357	26.9%	371	27.9%		
75–79	640	24.1%	311	23.4%	329	24.8%		
80–84	442	16.6%	229	17.2%	213	16.0%		
85–89	185	7.0%	93	7.0%	92	6.9%		
90+	38	1.4%	17	1.3%	21	1.6%		

(*continued*)

Table 2

(continued).

Table 2b. After matching

	All		Postoperative PPHFx		Control group			
	N	%	N	%	N	%	St diff	*P* value
Gender							0	1
Male	614	23.1%	307	23.1%	307	23.1%		
Female	2044	76.9%	1022	76.9%	1022	76.9%		
Race							0.0685	.8495
White	2528	95.1%	1260	94.8%	1268	95.4%		
Black	69	2.6%	41	3.1%	28	2.1%		
Asian	NR	NR	NR	NR	NR	NR		
Hispanic	NR	NR	NR	NR	NR	NR		
Other/unknown	54	2.0%	25	1.9%	29	2.2%		
Admission source							0.032	.421
Clinic referral	775	29.2%	384	29.0%	391	29.4%		
Hospital transfer	NR	NR	NR	NR	NR	NR		
Non-health location	1859	69.9%	928	69.8%	931	70.1%		
Other/unknown	NR	NR	NR	NR	NR	NR		
Transfer from SNF or ICF	NR	NR	NR	NR	NR	NR		
Transfer from other facility	NR	NR	NR	NR	NR	NR		
Year of THA							0.000	1
2010	48	1.8%	24	1.8%	24	1.8%		
2011	46	1.7%	23	1.7%	23	1.7%		
2012	56	2.1%	28	2.1%	28	2.1%		
2013	56	2.1%	28	2.1%	28	2.1%		
2014	60	2.3%	30	2.3%	30	2.3%		
2015	586	22.1%	293	22.1%	293	22.1%		
2016	1806	68.0%	903	68.0%	903	68.0%		
BMI category							0.065	.916
Unknown	2118	79.7%	1050	79.0%	1068	80.4%		
<19	16	0.6%	NR	NR	NR	NR		
19–24	15	0.6%	NR	NR	NR	NR		
25–29	42	1.6%	25	1.9%	17	1.3%		
30–39	339	12.8%	171	12.9%	168	12.6%		
>=40	128	4.8%	69	5.2%	59	4.4%		
Health problems at THA								
Obesity at THA	622	23.4%	326	24.5%	296	22.3%	0.0533	.12
Morbid obesity at THA	205	7.7%	108	8.1%	97	7.3%	0.031	.39
Osteoporosis at THA	672	25.3%	346	26.0%	326	24.5%	0.0346	.28
Tobacco use at THA	872	32.8%	438	33.0%	434	32.7%	0.0064	.85
Diabetes at THA	537	20.2%	265	19.9%	272	20.5%	−0.0131	.72
Opioid dependence or abuse at THA	36	1.4%	22	1.7%	14	1.1%	0.0192	.64
CCI category							0.0402	.95
0–1	1701	64.1%	837	63.1%	864	65.1%		
2–3	608	22.9%	317	23.9%	291	21.9%		
4–5	236	8.9%	116	8.7%	120	9.0%		
6+	109	4.1%	57	4.3%	52	3.9%		

BMI = body mass index, ICF = intermediate care facility, NR = not reported due to low-count restrictions, PPHFx = periprosthetic hip fractures, SNF = skilled nursing facility, THA = total hip arthroplasty.

surgery and delay in full weight bearing after surgery. Consequently, patients with intraoperative PPHFx may need higher post-acute care after THA as compared to patients without. Our research shows statistically significantly higher percent of utilization and days of service for SNF (41.7% vs 30.8%; 13.3 days vs 6.8 days) and inpatient rehab facility (17.7% vs 10.1%; 2.2 days vs 1.1 days) in the 90-day follow-up after THA for patients with intraoperative PPHFx as compared to patients without PPHFx.

Studies have shown approaches to mitigate the risk of intraoperative PPHFx. Nishihara et al describe a series of patients that were hand-rasped vs a series of patients that were robotically milled. In the robotically milled group (n = 78) there were no reported intraoperative femoral fractures compared with the hand-rasped patients, where 5/78 procedures resulted in intraoperative femoral fractures.[17] Another method that might benefit patients relates to an adjustment of "hammering force" during stem impaction. An experimental in-vitro study by Sakai et al used finite element analysis to demonstrate that 2 hammer strikes were sufficient to seat the femoral stem, with further hammer strikes of similar force having little effect on the stem displacement but instead increasing the risk of microfracture due to stress concentration in the medial calcar region.[18]

Early postoperative PPHFx as defined in this study were those fractures occurring within 90 days post-THA. These fractures sometimes may be linked to an undiagnosed intraoperative PPHFx, which probably is an important risk factor for predicting an early postoperative fracture. Our study showed statistically significantly higher healthcare utilization and costs in patients

Table 3

Healthcare utilization, days of service, and Medicare payments associated with treating intraoperative periprosthetic hip fracture over a 90-d period after discharge from hospitalization for THA (intraoperative PPHFx and control groups) (N = 4460).

	Healthcare utilization (intraoperative PPHFx)		Healthcare utilization (control)			Days of service (intraoperative PPHFx)		Days of service (control)			Average payment (intraoperative PPHFx)		Average payment (control)		
Type of service	**N**	**%**	**N**	**%**	***P* value**	**Mean**	**SD**	**Mean**	**SD**	***P* value**	**Mean**	**SD**	**Mean**	**SD**	***P* value**
THA hospitalization	2230	100.0%	2230	100.0%	1.000	4.55	3.86	3.16	1.54	<.0001	$15,546	$7701	$12,827	$3681	<.0001
Home health agency	1171	52.5%	1102	49.4%	.005	8.96	11.56	7.63	10.46	<.0001	$1760	$1961	$1568	$1807	<.0001
Skilled nursing facility	930	41.7%	686	30.8%	<.0001	13.34	21.22	6.78	14.06	<.0001	$6331	$11,625	$3341	$6726	<.0001
Inpatient rehab facility	395	17.7%	225	10.1%	<.0001	2.24	5.25	1.08	3.55	<.0001	$2962	$6805	$1454	$4727	<.0001
Readmissions	392	17.6%	257	11.5%	<.0001	1.27	3.96	0.62	2.59	<.0001	$2720	$8130	$1493	$5868	<.0001
Hospice	NR	NR	NR	NR	<.0001	0.05	1.48	0.00	0.00	.14	$7	$235	$0	$0	<.0001
Long-term care hospital	13	0.6%	NR	NR	.003	0.15	2.22	0.04	1.01	<.001	$184	$2597	$39	$1074	<.0001
Outpatient	1630	73.1%	1639	73.5%	.73	2.59	3.13	2.57	3.02	.8214	$603	$1656	$508	$941	.015
Average total payment	–	–	–	–		–	–	—	–		$30,114	$20,414	$21,229	$12,394	<.0001

NR = not reported due to low-count restrictions.

Table 4

Healthcare utilization, days of service, and Medicare claim payments associated with treating postoperative periprosthetic hip fracture patients over a 90-d period after discharge from hospitalization for THA (postoperative PPHFx and control groups) (N = 2658).

	Healthcare utilization (postoperative PPHFx)		Healthcare utilization (control)			Days of service (postoperative PPHFx)		Days of service (control)			Average payment (postoperative PPHFx)		Average payment (control)		
Type of service	**N**	**%**	**N**	**%**	***P* value**	**Mean**	**SD**	**Mean**	**SD**	***P* value**	**Mean**	**SD**	**Mean**	**SD**	***P* value**
THA hospitalization	1329	100.0%	1329	100.0%	1.000	2.79	1.60	2.56	1.28	<.0001	$13,059	$4925	$12,545	$2948	<.0001
Home health agency	946	71.2%	785	59.1%	<.0001	12.75	12.71	8.60	10.29	<.0001	$2471	$2153	$1880	$1828	<.0001
Skilled nursing facility	857	64.5%	381	28.7%	<.0001	21.03	23.10	5.26	11.49	<.0001	$10,444	$13,742	$2665	$5718	<.0001
Inpatient rehab facility	301	22.6%	96	7.2%	<.0001	3.16	6.82	0.77	2.99	<.0001	$4598	$9574	$1069	$4074	<.0001
Readmissions	1233	92.8%	117	8.8%	<.0001	5.95	5.74	0.43	1. 86	<.0001	$21,885	$13,987	$1071	$4302	<.0001
Hospice	NR	NR	NR	NR	<.0001	0.05	1.32	0.00	0.00	.145	$9	$209	$0	$0	<.0001
Long-term care hospital	20	1.5%	NR	NR	<.0001	0.34	3.10	0.04	0.97	<.0001	$388	$3702	$45	$1105	<.0001
Outpatient	1048	78.9%	930	70.0%	<.0001	2.90	3.37	2.35	2.74	<.0001	$815	$2686	$543	$1227	.007
Average total payment	–	–	–	–		–	–	–	–		$53,669	$23,849	$19,817	$10,549	<.0001

NR = not reported due to low-count restrictions.

with postoperative PPHFx as compared to patients without PPHFx. In addition, a numerical higher difference in the costs was observed with postoperative than intraoperative PPHFx as compared to patients without PPHFx indicating serious clinical implications, including the treatment and outcome with postoperative PPHFx.

Our study showed that a majority of patients with PPHFx – higher than 75.0% in both intraoperative and post-operative treatment cohorts – were women. This may be due to higher prevalence of osteoporosis in women and differences in bone structure. Other studies in past also had results confirming this finding and showed higher risk of PPHFx in women.[19] Jasvinder

Table 5

Healthcare utilization, days of service, and Medicare claim payments associated with treating intraoperative periprosthetic hip fracture patients over a 365-d period after discharge from hospitalization for THA (intraoperative PPHFx and control groups) (N = 4130).

	Healthcare utilization (intraoperative PPHFx)		Healthcare utilization (control)			Days of service (intraoperative PPHFx)		Days of service (control)			Average payment (intraoperative PPHFx)		Average payment (control)		
Type of service	**N**	**%**	**N**	**%**	***P* value**	**Mean**	**SD**	**Mean**	**SD**	***P* value**	**Mean**	**SD**	**Mean**	**SD**	***P* value**
THA hospitalization	2065	100.0%	2065	100.0%	1.000	4.52	3.89	3.16	1.51	<.0001	$15,432	$7687	$12,822	$3592	<.0001
Home health agency	1166	56.5%	1059	51.3%	<.0001	14.20	23.54	10.15	16.84	<.0001	$2638	$3390	$1998	$2665	<.0001
Skilled nursing facility	872	42.2%	647	31.3%	<.0001	15.41	26.60	7.85	17.70	<.0001	$7232	$13,711	$3892	$8631	<.0001
Inpatient rehab facility	388	18.8%	228	11.0%	<.0001	2.49	5.78	1.23	3.91	<.0001	$3306	$7574	$1658	$5258	<.0001
Readmissions	692	33.5%	560	27.1%	<.0001	2.62	6.14	1.55	4.15	.213	$6140	$14,144	$4229	$10,593	<.0001
Hospice	NR	NR	NR	NR	<.0001	0.22	5.30	0.19	5.97	.8927	$38	$919	$32	$960	.002
Long-term care hospital	23	1.1%	NR	NR	<.0001	0.37	3.84	0.07	1.36	<.0001	$448	$4696	$89	$1734	<.0001
Outpatient	1886	91.3%	1877	90.9%	.61	8.18	8.77	7.42	7.64	.0009	$2308	$5283	$1890	$3498	.002
Average total payment	–	–	–	–		–	–	–	–		$37,542	$29,667	$26,611	$19,791	<.0001

NR = not reported due to low-count restrictions.

Table 6

Healthcare utilization, days of service, and Medicare claim payments associated with treating postoperative periprosthetic hip fracture patients over a 365-d period after discharge from hospitalization for THA (postoperative PPHFx and control groups) (N = 2148).

	Healthcare utilization (postoperative PPHFx)		Healthcare utilization (control)			Days of service (postoperative PPHFx)		Days of service (control)			Average payment (postoperative PPHFx)		Average payment (control)		
Type of service	N	%	N	%	*P* value	Mean	SD	Mean	SD	*P* value	Mean	SD	Mean	SD	*P* value
THA hospitalization	1074	100.0%	1074	100.0%	1.000	2.80	1.60	2.58	1.26	<.0001	$13,004	$5052	$12,549	$2931	<.0001
Home health agency	840	78.2%	664	61.8%	<.0001	22.38	25.79	11.37	16.38	<.0001	$4199	$3914	$2372	$2711	<.0001
Skilled nursing facility	708	65.9%	332	30.9%	<.0001	26.48	31.21	6.66	15.01	<.0001	$12,934	$17,697	$3347	$7286	<.0001
Inpatient rehab facility	261	24.3%	84	7.8%	<.0001	3.72	7.84	0.91	3.37	<.0001	$5378	$11,024	$1305	$4779	<.0001
Readmissions	1022	95.2%	261	24.3%	<0.001	7.58	8.45	1.28	3.88	<0.001	$26,720	$19,578	$3787	$9261	<.001
Hospice	NR	NR	NR	NR	.03	0.65	10.14	0.02	0.70	.04	$105	$1586	$3	$109	.001
Long-term care hospital	15	1.4%	NR	NR	<.0001	0.62	6.12	0.08	1.37	<.0001	$711	$7313	$86	$1586	<.0001
Outpatient	1015	94.5%	964	89.8%	<.0001	9.05	8.96	7.18	7.65	<.0001	$2474	$4667	$2222	$4929	.024
Average total payment	–	–	–	–		–	–	–	–		$65,525	$36,678	$25,672	$18,268	<.0001

NR = not reported due to low-count restrictions.

et al showed that gender was significantly associated with the higher risk of PPHFx within 1 year with hazard ratio 2.61 (95% confidence interval, 1.68, 4.05). The same study showed that CCI was significantly associated with higher risk of PPHFx both <1 year and >1 year.[20,21] This finding also is consistent with our findings, as our study has also shown statistically significant difference between PPHFx (both intraoperative and postoperative) and control groups in terms of CCI category in the unmatched cohorts.

Our study has important strengths and limitations. In particular, it is unique for the use of rigorous patient-matching techniques spanning patient demographic and clinical characteristics and exact matching on the hierarchical variables like surgeon and hospital that influence outcomes. An additional strength arises from the large sample size which provides the study with adequate power. This was also the first study to our knowledge that characterized data for different settings of care separately for intraoperative and postoperative PPHFx following THA. Limitations of the study include use of combination of codes from the claims data to define intraoperative and postoperative PPHFx, which may result in underreporting on the incidence of PPHFx. However, another reason for underreporting intraoperative fractures, not related to the study design, is that they are not recognized during surgery. Schwartz et al reported that half of their intraoperative PPHFx were not detected during surgery but diagnosed on postoperative radiographs.[22] This study is further limited by excluding pharmaceuticals, durable medical equipment, and indirect costs. The analysis is limited to a Medicare fee-for-service population, and therefore cannot draw conclusions about results for patients with other payers, including commercial insurers. As with any retrospective study, unmeasured factors (eg, patient expectations) could not be matched and may have contributed to between-group differences.

5. Conclusion

After direct and propensity score matching it was found that the patients with PPHFx during or following primary THA had significantly increased healthcare utilization and costs during the 90 days and 1-year follow-up than patients without PPHFx for both intraoperative and early postoperative PPHFx. Approaches that could mitigate the risk of PPHFx are warranted to reduce the healthcare burden.

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