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Original research

Fixation vs Arthroplasty for Femoral Neck Fracture in Patients Aged 40-59 Years: A Propensity-Score-Matched Analysis

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ABSTRACT

Background: Internal fixation (IF) has historically been favored for the treatment of femoral neck fractures (FNFs) in young, nongeriatric patients. However, recent literature reporting high reoperation rates among those receiving IF, taken in conjunction with favorable survivorship of modern bearing surfaces in total hip arthroplasty (THA), has begun to question this paradigm. Our study sought to compare outcomes between IF and THA for FNFs in patients aged 40-59 years.

Methods: Using the Truven MarketScan Database, we performed a retrospective propensity-score-matched cohort study on patients aged 40-59 years who underwent surgical management of an isolated FNF (THA or IF). Patients with pathologic fracture were not included. Analysis was conducted on patients aged 40-49 and 50-59 years separately. A subgroup analysis was performed on those patients with 1 year and 3 years of follow-up. Multivariate analysis, controlling for baseline patient information, was then performed.

Results: Seven hundred sevety-eight 40- to 49-year-old patients and 3470 50- to 59-year-old matched patients (IF and THA) were included in this study. A multivariate analysis found that patients aged 40-49 years who underwent IF were at higher odds of both 1-year (odds ratio 2.35, 95% confidence interval 1.22-4.54, $P = .011$) and 3-year (odds ratio 5.68, 95% confidence interval 2.21-14.60, $P < .001$) reoperation. Similar results were found in those aged 50-59 years. While complication rates were similar, postoperative anemia and 90-day visits to the emergency room were more common after THA in both age cohorts.

Conclusions: While THA is associated with increased postoperative anemia and resource utilization compared with IF, patients aged 40-59 years who undergo IF for FNF are at increased risk of reoperation in the first 3 postoperative years. This information should be used to assist in shared decision-making with patients in this age group.

Introduction

Femoral neck fractures (FNFs) represent a common orthopedic injury, and in the geriatric population, these are associated with significant morbidity and mortality [1-13]. Owing to their intracapsular nature and the tenuous blood supply to the femoral head, FNFs treated with internal fixation (IF) are at high risk for nonunion, osteonecrosis, and subsequent posttraumatic osteoarthritis [14-19]. For this reason, in the geriatric population, displaced FNFs have historically been managed with prosthetic replacement, absolving potential complications of fracture fixation and allowing

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immediate weight-bearing. A robust body of literature has now established arthroplasty as the gold standard for the treatment of displaced FNFs in elderly patients [1-12,20,21].

In contrast, FNFs in younger patients have historically been treated with IF [1,21-23]. However, when IF fails to promote fracture union or osteonecrosis of the femoral head occurs, salvage procedures have been shown to yield suboptimal results [22]. Specifically, salvage arthroplasty for failed FNF fixation tends to produce inferior results when compared with primary replacement [16,24,25] although consistent improvements in patient-reported outcomes can be achieved [26]. This is important to acknowledge considering IF has reported failure rates between 8% and 45% [14,21,23,27-30]. Given this knowledge, coupled with the improved wear properties of modern bearing surfaces [31-38], whether primary arthroplasty may be preferable to fixation in middle-aged patients with a FNF warrants further investigation.

While it has been reported that surgeons are already increasingly managing FNFs with total hip arthroplasty (THA) in adults younger than 65 years, the evidence to support this practice is sparse [23,39,40]. Nonetheless, optimal management for this patient population is of particular importance given their potential to rejoin the workforce, longer life expectancy, and presumably higher functional demands. Therefore, the purpose of this study was to compare primary THA and IF for the treatment of acute, isolated FNFs in propensity matched patients aged 40-59 years. We hypothesized that IF in this cohort would be associated with a significantly higher reoperation rate at 1- and 3-year follow-up.

Methods

Data source

The Truven MarketScan Commercial Claims and Encounters and Medicare Supplemental and Coordination of Benefit databases (Truven Health, Ann Arbor, MI) was used for the conduction of this retrospective cohort study. This is a national insurance claims database that collects information on both patients with private insurance and those with Medicare and a private insurance supplement. Claims are recorded from all facets of patient care (inpatient, outpatient, and pharmaceutical), and patients can be tracked longitudinally so long as they remain enrolled with their insurance plan. The database has amassed many included patients, allowing for the study of uncommon conditions. Not surprisingly, this database has become increasingly used in the orthopedic literature [41-43].

Patient identification and cohort inclusion

The Truven database was queried from 2009 to 2018 to identify patients who had undergone THA for FNF or operative fixation of a FNF. This was performed by using Current Procedural Terminology (CPT) codes, and the following codes were used: 27130 (THA), 27235 (percutaneous skeletal fixation of femoral fracture, proximal end, neck), 27236 (open treatment of femoral fracture, proximal end, neck, IF, or prosthetic replacement). Given the nonspecific nature of CPT code 27236, these patients were separated into THA or fixation cohorts using International Classification of Diseases (ICD) procedural codes (THA was identified using ICD-9 procedural code 81.51 and ICD-10 codes 0SRB and 0SR9; IF patients were identified using ICD-10 procedural codes 0QS604Z, 0QS606Z, 0QS636Z, 0QS644Z, and 0QS646Z and ICD-9 codes 79.15 and 79.35.). Patients initially undergoing hemiarthroplasty were not included in this study, and all included patients were confirmed to have a diagnosis of FNF using ICD-9 or ICD-10 diagnosis codes. These included the following ICD-9 codes and their ICD-10 equivalents: 820.8 (closed fracture of unspecified part of neck of femur), 820.0 (closed fracture of intracapsular portion of femoral neck), 820.01 (closed fracture of upper neck of femur), 820.02 (closed fracture of mid-cervical section of neck of femur), 820.03 (closed fracture of base of neck of femur). While all fixation techniques (percutaneous pinning, intramedullary nail, sliding hip screw, and so on) were included given the nonspecific nature of CPT and ICD codes, only FNFs (and not intertrochanteric femur fractures) were included.

At this point, given the aims of the investigation, all patients younger than 40 years and aged 60 years or older were excluded. Patients with open fractures or concurrent lower extremity (pelvic ring, acetabular, femoral shaft, tibia fracture) were not included, again using ICD diagnosis codes. Finally, to be included in the final analysis, we required patients be enrolled in the database for at least 90 days postoperatively. Those without this minimal enrollment were also excluded. Patients were then separated into one of two cohorts: operative fixation and THA. We chose to analyze patients who were aged 40-49 and 50-59 years at the time of their injury separately. Subgroups of patients with longer term follow-up (1 year and 3 years) were also identified for further analysis.

Baseline patient information

We collected the following information for each included patient: patient age, sex, comorbidity status, and smoking status. We additionally noted the type of coded fracture. Comorbidities were accounted for categorically using the Elixhauser Comorbidity Index as previously described [44]. Each comorbidity was weighted equally, and patients were grouped based on the number of comorbidities present: 0, 1, 2, 3, or 4+. Baseline differences were identified between cohorts, and therefore, propensity score matching was performed, after which cohort balance was achieved.

Postoperative complications and health-care utilization data

Postoperative utilization parameters and complication data were collected for 90 days postoperatively. Health-care utilization parameters included the following: 30- and 90-day readmissions, 90-day emergency department (ED) visit, extended length of stay (LOS; defined as >4 days), and non-home discharge (ie, discharge to subacute rehabilitation or skilled nursing facility). Postoperative complications included postoperative sepsis, wound dehiscence, 90-day reoperation, myocardial infarction, postoperative anemia (hemoglobin <12 g/dL in women and <13 g/dL in men), pneumonia, acute kidney injury, and urinary tract infection. We additionally collected reoperation data for 1 year and 3 years after surgery for those patients with adequate follow-up. Reoperation included both irrigation and debridement as well as revision surgery, and these procedures were identified by using CPT codes. For the purposes of this study, we included the following as revision surgery: revision THA (in patients initially treated with THA; CPT codes 27134, 27137, 27138), removal of components with or without placement of antibiotic spacer (ie, septic revision arthroplasty; CPT codes 27090, 27091), conversion arthroplasty (in those treated initially with IF; CPT codes 27130, 27132, 27125), revision fixation (CPT 27235, 27236), bone grafting (CPT 27170), free vascularized fibula transfer (CPT 20955), and femoral osteotomy and fixation (ie, valgus producing osteotomy, CPT 27165). Irrigation and debridement included location-specific irrigation and debridement codes as well as CPT 27090 and 27091 (removal of prosthesis, with or without antibiotic spacer). Laterality modifiers were used to ensure reoperation was occurring on the same side as the index operation.

Statistical analysis

Baseline characteristics were compared using chi-square analysis or independent samples t-tests. Multiple baseline differences existed between cohorts for both the 40- to 49-year-olds and the 50- to 59-year-olds. To limit this influence, 1-to-1 propensity score matching was performed to ensure baseline patient characteristics were similar for both cohorts. Individual propensity scores were calculated using binary logistic regression with surgery type (fixation or arthroplasty) as the outcome variable. This propensity score model included the variables listed in Tables 1 and 2. Variables which were continuous (ie, age) were included as continuous variables, and those which were categorical (sex, comorbidity index, fracture type, smoking status) were included as categorical variables. Patients who underwent surgical fixation of their fracture were then matched to those undergoing THA using a Greedy matching algorithm based on caliper matching with a caliper width defined at 0.20 standard deviations of the logit of the propensity score. In the circumstance that multiple patients in the fixation group equally matched a patient in the arthroplasty group, the included patient was chosen at random.

We performed separate propensity score matching models for patients with 90-day, 1-year, and 3-year outcomes. After propensity-score-matching was performed and finalized, a univariate analysis confirmed there were no persistent baseline differences and that standardized differences were found to be less than 10% in all variables listed in Tables 1 and 2. Thereafter, postoperative utilization and complication data were compared between the matched cohorts, first with chi-squared analysis and subsequently with binomial logistic regression. This regression model controlled for age, sex, Elixhauser comorbidity status, fracture type, and smoking status. The statistical analysis was conducted using SAS (version 9.4, Cary, NC), and a P value of <.05 was considered significant.

Results

Baseline patient characteristics

After propensity score matching, the fixation and arthroplasty cohorts had similar baseline characteristics in both the 40- to 49-year-old and 50- to 59-year-old groups (Tables 1 and 2). Ultimately, 389 IF patients and 389 THA patients were enrolled in the 40- to 49-year-old group, and 1735 IF patients and 1735 THA patients in the 50- to 59-year-old group (Tables 1 and 2). Average patient age in the 40- to 49-year-old cohort was 45 years, and in the 50- to 59-year-old cohort, 55 years. No preoperative differences with regard to age, sex, comorbidities, fracture type, and smoking status were present between the postmatch fixation and arthroplasty cohorts (Tables 1 and 2).

Ninety-day postoperative resource utilization and complications: fixation vs arthroplasty

In the 40- to 49-year-old group, postoperative utilization and complications were generally similar on univariate analysis. However, this analysis did reveal that a significantly higher number of patients who received arthroplasty had a postoperative ED visit (fixation vs arthroplasty; 11.3% vs 21.1%, respectively; $P < .001$) and postoperative anemia (8.2% vs 23.1%, respectively; $P < .001$) (Table 3). These findings were confirmed on a multivariate analysis (Table 4).

In the 50- to 59-year-old group, the findings were overall similar, but on univariate analysis, there were significant differences identified in ED visits (fixation vs arthroplasty; 15% vs 21.8%, $P < .001$), extended LOS (42.8% vs 46.2%, $P = .044$), non-home discharge (12.9% vs 19.3%, $P < .001$), and postoperative anemia (8.8% vs 24.8%, $P < .001$). These findings were confirmed on multivariate analysis where the fixation cohort had lower odds of

Table 1
Fixation vs total hip arthroplasty for femoral neck fracture, 40-49 y.

Characteristics	Unmatched			Matched		
	Fixation	Arthroplasty	P value	Fixation	Arthroplasty	P value
Total	761	431	-	389	389	
Age, y (mean ± SD)	45.13 ± 2.87	45.98 ± 2.70	<.001	45.69 ± 2.79	45.81 ± 2.74	.570
Sex						
Male	391 (51.98)	229 (53.13)	.561	210 (53.98)	209 (53.73)	.943
Female	370 (48.62)	202 (46.87)		179 (46.02)	180 (46.27)	
Elixhauser						
0	335 (55.98)	114 (26.45)	<.001	122 (31.36)	114 (29.31)	.533
1	190 (24.97)	120 (27.84)		110 (28.28)	115 (29.56)	
2	115 (15.11)	92 (21.35)		74 (19.02)	75 (19.28)	
3	59 (7.75)	50 (11.60)		41 (10.54)	41 (10.54)	
4+	31 (4.07)	25 (5.80)		21 (5.40)	22 (5.66)	
Fracture type[a]						
1	16 (2.10)	3 (0.70)	<.001	2 (0.51)	3 (0.77)	.891
2	111 (14.59)	27 (6.26)		21 (5.40)	27 (6.94)	
3	143 (18.79)	25 (5.80)		26 (6.68)	25 (6.43)	
4	94 (12.35)	47 (10.90)		45 (11.57)	47 (12.08)	
5	397 (52.17)	329 (76.33)		295 (75.84)	287 (73.78)	
Smoking status						
No	643 (84.49)	336 (77.96)	.005	322 (82.78)	321 (85.52)	.925
Yes	118 (15.51)	95 (22.04)		67 (17.22)	68 (17.48)	

SD, standard deviation.
Elixhauser Comorbidity Index with patients grouped categorically by number of comorbidities present.
[a] Fracture type 1 = closed fracture of upper neck of femur; 2 = closed fracture of midcervical section of neck of femur; 3 = closed fracture of base of neck of femur; 4 = closed fracture of intracapsular section of neck of femur, unspecified; 5 = closed fracture of unspecified part of neck of femur.

Table 2
Fixation vs total hip arthroplasty for femoral neck fracture, 50-59 y.

Characteristics	Unmatched			Matched		
	Fixation	Arthroplasty	*P* value	Fixation	Arthroplasty	*P* value
Total	2335	1971	-	1735	1735	-
Age, y (mean ± SD)	55.33 ± 2.74	55.59 ± 2.75	.002	55.49 ± 2.72	55.47 ± 2.77	.781
Sex						
Male	851 (36.45)	758 (38.46)	.174	616 (35.50)	641 (36.95)	.377
Female	1484 (63.55)	1213 (61.54)		1119 (64.50)	1094 (63.05)	
Elixhauser						
0	734 (31.34)	425 (21.65)	<.001	422 (24.32)	425 (24.50)	.592
1	602 (25.78)	519 (26.33)		459 (26.46)	473 (27.26)	
2	413 (17.69)	424 (21.51)		356 (20.52)	349 (20.12)	
3	258 (11.05)	285 (14.46)		217 (12.51)	220 (12.68)	
4+	137 (5.87)	166 (8.42)		122 (7.03)	125 (720)	
Fracture type[a]						
1	56 (2.40)	25 (1.27)	<.001	26 (1.50)	25 (1.44)	.993
2	381 (16.32)	204 (10.35)		198 (11.41)	204 (11.76)	
3	356 (15.25)	200 (10.15)		207 (11.93)	200 (11.53)	
4	354 (15.16)	208 (10.55)		206 (11.87)	208 (11.99)	
5	1188 (50.88)	1334 (67.68)		1098 (63.29)	1098 (63.29)	
Smoking status						
No	1931 (82.70)	1677 (85.08)	.034	1456 (83.92)	1457 (83.98)	.963
Yes	404 (17.30)	294 (14.92)		279 (16.08)	278 (16.02)	

SD, standard deviation.
Elixhauser Comorbidity Index with patients grouped categorically by number of comorbidities present.
[a] Fracture type 1 = closed fracture of upper neck of femur; 2 = closed fracture of midcervical section of neck of femur; 3 = closed fracture of base of neck of femur; 4 = closed fracture of intracapsular section of neck of femur, unspecified; 5 = closed fracture of unspecified part of neck of femur.

90-day ED visits, extended LOS, non-home discharge, and postoperative anemia (odds ratio [OR] 0.28, 95% confidence interval [CI] 0.23-0.35, *P* < .001; Tables 3 and 4).

Fixation vs arthroplasty: 1-year and 3-year reoperation

A subgroup of patients in both the 40- to 49-year-old and 50- to 59-year-old groups were identified who had 1-year and 3-year continual enrollment. In the 40- to 49-year-old group, there were 566 matched patients with 1-year follow-up and 230 with 3-year follow-up. Univariate analysis found that reoperation was significantly higher in the fixation cohort than in the arthroplasty cohort (10.95% vs 4.95%, *P* = .008) at 1-year and 3-year follow-up (23.48% vs 5.22%, *P* < .001). Multivariate analysis found that patients who underwent operative fixation were at higher odds of both 1-year (OR 2.35, 95% CI 1.22-4.54, *P* = .011) and 3-year (OR 5.68, 95% CI 2.21-14.60, *P* < .001) reoperation. Of note, there were no differences found in rates of irrigation and debridement, and most patients undergoing revision surgery after fixation had conversion arthroplasty (9.2% at 1 year and 18.26% at 3 years; Table 5).

In the 50- to 59-year-old group, 2630 matched patients had 1-year follow-up, and 1092 matched patients were available for analysis at 3 years. In this age category, univariate analysis also found fixation patients to have significantly higher rates of reoperation at 1 year (12.55% vs 3.5%, *P* < .001) and 3 years (20% vs 7%, <0.001). Multivariate analysis confirmed that patients undergoing fixation had significantly higher odds of reoperation at 1 year (OR 4.03, 95% CI 2.88-5.66, *P* < .001) and 3 years (OR 3.36, 95% CI 2.27-4.98, *P* < .001). Of note, of those undergoing revision after fixation, the majority underwent conversion arthroplasty (8.67% at 1 year and 14.84% at 3 years; Table 6).

Discussion

FNFs are common injuries, and their optimal management continues to spur debate within the orthopedic community. While

Table 3
Univariate analysis of 90-d complications in matched cohorts.

Characteristics	40-49 y			50-59 y		
	Fixation	Arthroplasty	*P* value	Fixation	Arthroplasty	*P* value
Health-care utilization						
30-d Readmission	46 (11.83)	57 (14.65)	.245	274 (15.79)	262 (15.10)	.573
90-d Readmission	71 (18.25)	76 (19.54)	.647	363 (20.92)	356 (20.52)	.769
ED visit	44 (11.31)	82 (21.08)	**<.001**	260 (14.99)	378 (21.79)	**<.001**
Extended LOS (>4 d)	135 (34.70)	136 (34.96)	.940	742 (42.77)	801 (46.17)	**.044**
Non-home discharge	38 (9.77)	43 (11.05)	.557	223 (12.85)	334 (19.25)	**<.001**
Postoperative complications						
Sepsis	5 (1.29)	7 (1.80)	.561	37 (2.13)	28 (1.61)	.260
Wound dehiscence	6 (1.54)	11 (2.83)	.220	31 (1.79)	33 (1.90)	.801
Early reoperation	5 (1.29)	11 (2.83)	.130	28 (1.61)	36 (2.07)	.313
Myocardial infraction	1 (0.26)	1 (0.26)	.999	6 (0.35)	6 (0.35)	.999
Anemia	32 (8.23)	90 (23.14)	**<.001**	153 (8.82)	430 (24.78)	**<.001**
Pneumonia	3 (0.77)	3 (0.77)	.999	22 (1.27)	16 (0.92)	.328
Acute kidney injury	4 (1.03)	8 (2.06)	.245	56 (3.23)	65 (3.75)	.405
Urinary tract infection	17(4.37)	14 (3.60)	.582	128 (7.38)	112 (6.46)	.284

Bolded values are statistically significant.

Table 4
Multivariate analysis of 90-d complications in matched cohorts, 40-49 y.

Characterisitics	40-49 y		50-59 y	
	Odds ratio[a]	*P* value	Odds ratio[a]	*P* value
Health-care utilization				
30-d Readmission	0.79 (0.52-1.22)	.303	1.05 (0.87-1.26)	.602
90-d Readmission	0.94 (0.65-1.36)	.755	1.01 (0.86-1.20)	.833
ED visit	0.48 (0.32-0.71)	**<.001**	0.61 (0.51-0.73)	**<.001**
Extended LOS (>4 d)	1.01 (0.74-1.39)	.906	0.85 (0.73-0.97)	**.022**
Non-home discharge	0.89 (0.55-1.44)	.653	0.60 (0.50-0.72)	**<.001**
Postoperative complications				
Sepsis	0.75 (0.23-2.44)	.644	1.38 (0.83-2.28)	.211
Wound dehiscence	0.53 (0.19-1.46)	.22	0.94 (0.57-1.54)	.812
Early reoperation	0.44 (0.15-1.29)	.138	0.76 (0.46-1.26)	.303
Myocardial infarction	0.98 (0.06-16.11)	.992	1.10 (0.32-3.18)	.978
Anemia	0.28 (0.18-0.44)	**<.001**	0.28 (0.23-0.35)	**<.001**
Pneumonia	1.09 (0.20-5.73)	.915	1.36 (0.70-2.62)	.355
Acute kidney injury	0.53 (0.15-1.86)	.321	0.86 (0.59-1.25)	.432
Urinary tract infection	1.18 (0.57-2.47)	.646	1.13 (0.87-1.48)	.351

Bolded values are statistically significant.
[a] Arthroplasty as reference category for OR.

Table 6
Multivariate analysis of 1-y and 3-y complications in matched cohorts, 50-59 y.

Characteristics	Fixation	Arthroplasty	*P* value
1 y			
Total	1315	1315	
Any reoperation (n, %)	**165 (12.55)**	**46 (3.50)**	**<.001**
Odds ratio	**4.03 (2.88-5.662)**	**ref**	**<.001**
I and D, (n, %)	10 (0.76)	12 (0.91)	.669
Odds ratio	0.88 (0.37-2.06)	[ref]	.774
Revision (n, %)	**161 (12.24)**	**36 (2.74)**	**<.001**
Odds ratio	**5.03 (3.47-7.31)**	**[ref]**	**<.001**
3 y			
Total	546	546	
Any reoperation (n, %)	**109 (19.96)**	**38 (6.96)**	**<.001**
Odds ratio	**3.36 (2.27-4.98)**	**ref**	**<.001**
I and D, (n, %)	5 (0.92)	8 (1.47)	.403
Odds ratio	0.64 (0.20-2.01)	[ref]	.453
Revision, (n, %)	**107 (19.60)**	**36 (6.59)**	**<.001**
Odds ratio	**3.48 (2.33-5.20)**	**[ref]**	**<.001**

Revision includes revision arthroplasty, conversion arthroplasty, revision fixation, or valgus producing osteotomy. Bold values represent those which are statistically significant.

it is clear that arthroplasty is the preferable management option for patients older than 65 years with a displaced FNF [1-12,20,21], the ideal management of the middle-aged patient remains unclear. In this cohort of patients, the need for long-term survivorship of THA and possibly increased perioperative complications must be weighed against fixation failure and its associated revision surgery, which has been reported to be necessary anywhere from 8% to 45% of the time [14,21,23,27-30]. Prior literature on FNFs in this age population is scarce and is largely confined to small series that did not control for comorbidities [23,39,40]. Given this ambiguity, the present study seeks to clarify the outcomes associated with these treatment options within propensity-matched cohorts of 40- to 59-year-old patients. We found that while there are higher rates of perioperative resource utilization (ED visits, longer LOS, and non-home discharge) and postoperative anemia in the THA group, reoperation was substantially higher in the fixation group at 1-year and 3-year follow-up, and many of these reoperations were conversion to arthroplasty. These findings warrant further discussion.

First, we found a higher incidence of anemia in patients undergoing THA for FNFs. This is perhaps not unexpected given that perioperative blood loss after THA has been cited to be approximately 1-1.5L, while blood loss during IF is reported to approach only 500 ml [45-50]. Furthermore, preoperative and postoperative anemia is more common in patients undergoing THA for FNFs than in those undergoing elective THA [46,49,50]. While we found rates of postoperative anemia as high as 24% in this study, this is still lower than the 40%-93% rates of postoperative anemia reported in the literature for hip fracture populations. These differences are likely methodological in nature as prior literature has focused on the geriatric patient population [49,51,52]. The repercussions of postoperative anemia in the hip fracture population are unclear. While postoperative anemia may be associated with early decreased mobility [51], it does not seem to correlate with functional scores or patient-reported outcomes [49,50,52-55]. However, in a geriatric population, postoperative anemia has been shown to be associated with increased LOS, higher readmission rates, and increased mortality [49]. Whether the same is true in younger patients is not known, but it is reasonable to assume that the nongeriatric patient is likely to have a higher physiologic reserve and that these associations may, therefore, be attenuated.

Second, resource utilization was increased in the arthroplasty cohort. Both age groups had increased postoperative ED visits in this study. A 2017 study by Nedza et al. found approximately 20% of patients undergoing arthroplasty for fracture had a postoperative ED visit—nearly twice the rate seen in an elective population [56]. We found a similar incidence of 90-day ED visits as 21%-22% of patients in this study had a 90-day ED visit after THA for FNF. Other published series have demonstrated similar rates of ED visits after hip replacement (ranging from 5% to 25%) [56-62]. While we did not examine the indication for ED presentation in our study, prior literature has shown these visits are most commonly due to pain, swelling, and impaired mobility [56,60,61]. Given that complication rates were overall similar between treatment cohorts, it is reasonable to assume that the increased ED visits in the THA cohort were driven by similar indications. Specific to the young FNF population, patients treated with IF are often kept partial or non-weight-bearing while those treated with THA are allowed immediate weight-bearing. This emphasis on early mobilization and ambulation and its associated pain may contribute to the higher rate of perioperative ED visits seen in our THA cohort. For similar reasons, along with the higher rates of postoperative anemia, non-home discharge and readmissions may be higher in the replacement cohort. Furthermore, extended LOS itself has also been shown to predict non-home discharges in THA patients [59,63,64] and may have contributed to these results. Finally, while the database used in this study lacked the granularity to examine the influence of

Table 5
Multivariate analysis of 1-y and 3-y complications in matched cohorts, 40-49 y.

Characteristics	Fixation	Arthroplasty	*P* value
1 y			
Total	283	283	
Any reoperation (n, %)	**31 (10.95)**	**14 (4.95)**	**.008**
Odds ratio	**2.353 (1.22-4.536)**	**[ref]**	**.011**
I and D, (n, %)	1 (0.35)	6 (2.12)	.057
Odds ratio	0.16 (0.02-1.36)	[ref]	.094
Revision, (n, %)	**30 (10.60)**	**10 (3.53)**	**.010**
Odds ratio	**3.25 (1.55-6.82)**	**[ref]**	**.002**
3 y			
Total	115	115	
Any reoperation (n, %)	**27 (23.48)**	**6 (5.22)**	**<.001**
Odds ratio	**5.68 (2.21-14.60)**	**[ref]**	**<.001**
I and D, (n, %)	0	2 (1.74)	.156
Odds ratio	-	-	-
Revision, (n,%)	**27 (23.48)**	**5 (4.35)**	**<.001**
Odds ratio	**6.86 (2.49-18.83)**	**[ref]**	**.002**

Revision includes revision arthroplasty, conversion arthroplasty, revision fixation, or valgus producing osteotomy. Bold values represent those which are statistically significant.

surgeon on non-home discharge, prior research has indicated that fellowship-trained arthroplasty surgeons have higher rates of discharge to home after arthroplasty for fracture [65].

The main finding of this study is that reoperation is far more common in patients aged 40-59 years who undergo operative fixation rather than THA for a FNF. These differences were not subtle as patients aged 40-49 years who underwent operative fixation were over 5 times more likely to have had a reoperation at 3-year follow-up on multivariate analysis. The reoperation rates reported after fixation in this study are similar to those previously reported. In a study of nearly 800 patients younger than 50 years undergoing operative fixation of FNFs, 14% were converted to THA at a median of 2 years [66]. This is similar to our findings in patients aged 40-49 years that 9.2% and 18.3% at 1 and 3 years, respectively, were converted to arthroplasty after initial fixation. Similarly, in a meta-analysis, Slobogean et al. reported a 20% reoperation rate after fixation of FNFs in young patients [67]. In another study, Duckworth et al. found fixation failure was more common in patients older than 40 years [27]. It should be noted that while THA may be used acutely, prior fixation does not preclude future THA. In fact, THA and HA are the most common means of revision surgery in patients older than 45 years with failure of prior IF for FNFs [22,23,27,66,68,69]. This, too, was reflected in our results. However, studies have shown that conversion THA patients have significantly worse functional scores and infection rates than those undergoing acute THA for hip fracture [3,40,70,71]. This, taken in conjunction with the waning concern over long-term issues with the advent of highly cross-linked polyethylene and other modern bearing surfaces, makes acute THA a potentially attractive option in this patient population [31-38,72,73].

With this in mind, Swart et al. performed a Markov Analysis comparing IF to THA for FNFs in patients aged 40-65 years [23]. Their results indicated equivalent cost effectiveness (THA vs IF) [23]. In another analysis, Anderson et al. showed that patients aged 45-65 years who underwent THA for FNF had less disability, fewer days out of work, and lower indemnity cost than those who had fixation [40]. While implant longevity remains a relevant concern in young patients, modern bearing surfaces with highly cross-linked polyethylene are now approaching 2 decades of longitudinal data with results in young populations (<50 years old) showing excellent survivorship and minimal evidence of wear or osteolysis [31,35,36,38]. Still, despite the inequitable rates of early reoperation between treatment options, it should be acknowledged that when successful, fixation represents a durable, and likely preferable, treatment option. It should also not be ignored that while 3 years is reasonable follow-up, this relatively shorter follow-up period may bias an analysis of reoperation toward favoring arthroplasty which provides immediate stability and is not reliant on osseous healing.

While this study has strengths, there are multiple limitations that should be discussed. First, as is the case with the analysis of any large database, this study is reliant on the complete and accurate coding of procedures, diagnoses, and complications—the accuracy of which cannot be confirmed. Second, while we controlled for baseline characteristics and performed our analysis on matched cohorts, the possibility exists that uncaptured factors may have influenced both the surgical procedure chosen as well as postoperative complications. Along the same lines, we weighted each comorbidity equally in our analysis, and this may not reflect clinical realities. Third, we did not include patients receiving hemiarthroplasty. While this clearly makes for a cleaner analysis, this does limit generalizability to this cohort. In a younger cohort, however, hemiarthroplasty is likely not the treatment of choice [23], and, therefore, this limitation is felt to be small. Fourth, it is possible that some patients who underwent operative fixation simply had progression of primary osteoarthritis leading to conversion THA. While this may bias the results toward arthroplasty, it seems unlikely that this had significant influence. Fifth, we are limited in what we can analyze by variables contained within the Truven database. Therefore, other outcomes of interest such as mechanism of injury, patient functional level, patient-reported outcome scores, radiographic outcomes, among others cannot be analyzed and remain unknown. It is possible that a healed FNF is functionally superior to function after a THA, but our study cannot comment on this relationship. Similarly, some perioperative factors that would be of interest given their perceived or known association with outcome (ie, time to surgery, radiographic reduction, bone quality, fracture classification) could also not be evaluated or controlled for in the fixation groups. Along the same lines, the morbidity associated with reoperation varies, and we did not analyze complications or outcomes after these revision procedures. Finally, there was significant cohort attrition with longer term follow-up, but our analysis at 1 and 3 years still represent the largest series reported to date. While this attrition has the potential to introduce bias, separate propensity matches were performed at 1 year and 3 years to mitigate these concerns. Still, despite these limitations, the Truven MarketScan database allows for the analysis of a large number of patients with an otherwise uncommon injury in this age category, a major strength of the study.

Conclusions

This study is the largest to date to compare THA with IF for management of FNFs in the adult populations aged between 40 and 59 years. The results of the current investigation continue to add to mounting literature that shows a significantly decreased risk of early reoperation after primary THA for FNF in the middle-aged population when compared to operative fixation. This lower rate of early reoperation should be discussed with patients as part of a shared decision-making process and should be weighed against the potential benefits of native femoral head retention. Our data, taken in conjunction with prior work, would therefore suggest that primary THA for the treatment of FNFs in the middle-aged patient may offer some advantages and can be considered in the clinically appropriate patient. Future prospective studies should aim to identify which patients have high chance of reoperation and compare reoperation-free survivorship over longer term follow-up.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: One author receives IP Royalties from TJO, Inc. and Zimmer. One author is a paid consultant for TJO, Inc. and Zimmer-Biomet. One author receives research support from KCI, Smith and Nephew, and OrthoSensor and receives research and institutional support from Stryker. One author receives other financial or material support from Zimmer-Biomet.

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