Fresh Unstable Trochanteric Fracture in Elderly Patients: Mortality, Readmission and Reoperation After Primary Hemiarthroplasty

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Abstract

Objectives: Most unstable trochanteric fractures are treated with internal fixation often with high complication rates. Hemiarthroplasty is an alternative treatment to achieve early weight-bearing, early mobilization and acceptable functional outcomes. However, few have investigated the long-term outcomes after hemiarthroplasty for unstable trochanteric fracture. We investigated patients with fresh trochanteric fracture after primary hemiarthroplasty on their long-term outcomes, including mortality, readmission and reoperation.

Methods: We studied a total of 2,798 elderly adults who had received hemiarthroplasty for fresh unstable trochanteric fracture from 2000 to 2010, and followed them up until the end of 2012. Survival analysis and Cox model were used to characterize mortality. Competing risk analysis and Fine and Gray model were used to estimate the cumulative incidences of the first readmission and the first reoperation.

Results: The follow-up mortality rate for 1-year was 17.94%; 2-year, 29.76%; 5-year, 56.8%; and 10-year, 83.38%. The cumulative incidence of the first readmission was 16.4% for 1-year and 22.44% for 3-year. The cumulative incidence of the first reoperation was 13.87% for 1-year, 18.11% for 2-year, 25.79% for 5-year, and 38.24% for 10-year. Male, older age, larger CCI and lower insured amount were all risk factors for the overall mortality. Older age and larger CCI were risk factors for the first readmission. Older age was a protective factor for reoperation, which is likely due to the competing death.

Conclusion: Results are consistent with hemiarthroplasty being a robust alternative treatment for unstable trochanteric fracture among a heterogeneous elderly population.

Introduction

The incidence of osteoporotic hip fracture is increasing along with the expanding elderly population. Its treatment could end with excess mortality, morbidity and socioeconomic burden [1–3]. Osteoporotic hip fractures include either cervical fracture or the trochanteric fracture of femur in about 1:1 ratio of incidence. The optimal choice of operation and implant for unstable trochanteric fracture remains debatable [4, 5]. Most unstable intertrochanteric fractures are treated with internal fixation. However, internal fixation often leads to multiple surgical complications, like loss of fixation, lag screw cut-out, collapse, malunion and implant failure. All these result in reoperation or converting to arthroplasty [6, 7]. Therefore, arthroplasty is considered as an alternative treatment for unstable trochanteric fracture to achieve early weight-bearing, early mobilization, rapid rehabilitation and acceptable functional outcomes [7–10]. Grau et al. reported that 3.3% of 2,117,815 intertrochanteric fractures were treated by hemiarthroplasty and the use of hemiarthroplasty to treat trochanteric fracture has increased over the period from 1990 to 2007 [7].

Recently, a number of studies, typically enrolled limited samples, have reported the short-term outcomes after hemiarthroplasty to treat unstable trochanteric fractures [8–18]. Furthermore, few studies investigated the long-term outcomes [11, 15–17]. Here, we conducted a population-based retrospective cohort study on fresh intertrochanteric fracture investigating the mid- and long-term outcomes (like overall mortality, readmission and reoperation) after primary hemiarthroplasty. The method of competing risk analysis was used.

Methods

Data Sources

Data were retrospectively collected from two sources: the National Health Insurance Research Database (NHIRD) (details available at: <http://nhird.nhri.org.tw/en/index.htm>) and the National Register of Deaths Database (NRDD). These databases and another 70 health-related databases are real-world data and maintained by Taiwan's Ministry of Health and Welfare Health and Welfare (MOHW) Data Center. The completeness and accuracy of these two databases are > 98% and are endorsed by MOHW. Taiwan National Health Insurance (NHI) program was started in 1995, providing mandatory health insurance for > 99% of all the 23 million residents in Taiwan. The NHIRD contains individuals' e-claims of all NHI beneficiaries from 1996 to the present. Our study was approved by the Research Ethics Committee, China Medical University Hospital (certificate: CMUH-104-REC2-115).

Subjects

Like our previous report [19], inclusion criteria were subjects aged 60 years or older with the following two conditions: (a) a first discharge diagnosis code of intertrochanteric hip fracture based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes 820.20, 820.21, 820.30 and 820.31, and (b) a procedure code corresponding to surgery for hemiarthroplasty based on ICD9-CM codes 81.52 during the period from 1 January 2000 to 31 December 2010. The first admission date for trochanteric fracture was defined as the index date of surgery. The exclusion criteria were subjects with pathological fractures (ICD9-CM codes 733.14 and 733.15) or open hip fractures (ICD9-CM codes 820.1, 820.10, 820.11, 820.12, 820.19, and 820.9). To avoid confounding effects, we excluded subjects undergoing gone surgery before the index date for injuries to the pelvis, femur, or hip region. We extracted a total 2,798 subjects receiving hemiarthroplasty for fresh trochanteric fracture. According to the guideline of the National Health Insurance (NHI) program in Taiwan, all the hemiarthroplasty operations for trochanteric fractures were reviewed through a peer-review system within NIH program, by at least three board-certificated orthopedic surgeons and they approved the proposed operations. The end of the study was either the date of death, the date of exiting from NHI program, or December 31, 2012, the last follow-up date.

Outcomes of interest

Three endpoints were studied: (a) overall cumulative mortality; (b) cumulative incidence of the first readmission due to medical complications within 6 months after the index surgery; (c) cumulative incidence of the first reoperation due to surgical complications. The overall survival time was calculated from the index date to the date of death. Subjects who survived by the end of study, the date of exiting from NHI program or the end of the study date (December 31, 2012) were defined as censored. The first readmission time was the time from the index date to the date of the first readmission due to medical complications that required hospital readmission, within 6 months after the index surgery. The 6-month medical complications included stroke, acute myocardial infarction, pulmonary embolism, acute renal failure, and acute respiratory failure. The first reoperation time was calculated from the index date to the date of the first postoperative unplanned reoperation due to surgical complications secondary to hemiarthroplasty. Reoperations for surgical complications were debridement of previous operative wound, conversion to total hip arthroplasty, revision of hemiarthroplasty, removal of implant or close/open reduction for dislocation.

Statistical analysis

Overall survival rates were estimated using the Kaplan-Meier method. We explored effects of risk factors on the overall survival using both the log-rank test and multiple variables Cox's proportional hazards model. Elderly adults in our study typically had a high mortality rate due to ageing and multiple comorbidities. A high competing risk of death could interfere with the estimation of cumulative incidences on the first readmission and the first reoperation. The Kaplan-Meier method overestimates the cumulative incidences of the first readmission and the first reoperation if not considering competing death. Therefore, we estimated these cumulative incidences using the competing risk analysis with death treated as a competing event. In addition, we also explored risk factors on the first readmission time and the first reoperation time using the Gray's test and the Fine and Gray's model. These methods are multivariate subdistribution hazard models based on competing risk analysis [20, 21]. All data management and analyses were performed using the statistical package SAS 9.4 (SAS Institute, Cary, NC) and R libraries survival, cmprsk, and mstate, R 3.6.1 (available at <http://www.R-project.org/>, R Development Core Team (2019), R: A language and environment for statistical computing. (R Foundation for Statistical Computing, Vienna, Austria).

Results

During 2000 to 2010, a total of 76,798 subjects aged 60 years or older were admitted for the first time with a primary diagnosis of trochanteric fracture. Of these, 2,798 subjects were included in the study. They satisfied the inclusion/exclusion criteria and underwent hemiarthroplasty as the primary treatment for trochanteric fracture. As shown in Table 1, the cohort consisted of 1,903 (68.0%) women and 895 (32%) men. Their mean age was 79 years old. Females had slightly higher mean age, lower Charlson comorbidity index (CCI) score and higher insurance amount.

Table 1
Baseline characteristics of patients receiving hemiarthroplasty for intertrochanteric hip fractures stratified by gender

		Gender						
		Total		Male		Female		
		(n = 2,798)		(n = 895)		(n = 1,903)		
		N	%	N	%	N	%	P-value
Age (yrs)	Mean $\pm$ SD ^a	79.75 $\pm$ 7.86		78.74 $\pm$ 7.78		80.23 $\pm$ 7.85		< 0.001
	60–64	113	4.04	48	5.36	65	3.42	
	65–69	226	8.08	82	9.16	144	7.57	
	70–74	407	14.55	139	15.53	268	14.08	
	75–79	599	21.41	209	23.35	390	20.33	
	80–84	737	26.34	236	26.37	501	26.33	
	$\geq$ 85	716	25.59	181	20.22	535	28.11	
CCI ^b score	0	917	32.77	256	28.60	661	34.73	< 0.001
	1	694	24.80	203	22.68	491	25.80	
	2	372	13.30	137	15.31	235	12.35	
	3	228	10.29	102	11.40	186	9.77	
	$\geq$ 4	527	18.83	197	22.01	330	17.34	
Insurance amount (NT\$)	$\leq$ 21000	1704	60.90	640	71.51	1064	55.91	< 0.001
	> 21000	1094	30.10	255	28.49	839	44.09	
<i>Note:</i> ^a SD: standard deviation.								
^b CCI: Charlson Comorbidity Index.								

The 1-month, 3-month, 6-month, 1-year, 2-year, 5-year and 10-year cumulative mortality rates were 3.15%, 5.5%, 7.4%, 17.94%, 29.76%, 56.8% and 83.38%, respectively (Table 2). The 1-, 2-, 5-, and 10-years cumulative incidences of the first reoperation for surgical complications were 13.87%, 18.11%, 25.79% and 38.24%, respectively (Table 2). The 1-, 3-, and 6-month cumulative incidences of the first readmission for medical complications were 16.4%, 22.44% and 27.13%, respectively (Table 2). Females had lower cumulative mortality after 12-year follow-up (Table 2 and Fig. 1a). Females also had lower cumulative incidence of the first reoperation before 5-year follow-up; then, slightly higher cumulative incidences of the first reoperation after 8-year follow-up (Table 2 and Fig. 1b). Females had lower cumulative incidence of the first readmission (Table 2 and Fig. 1c).

Table 2
Cumulative mortality rates and cumulative incidence of first reoperation or readmission after
hemiarthroplasty for intertrochanteric hip fractures

Cumulative Incidence									
	Cumulative mortality (%)			Reoperation (%)			Readmission (%)		
Time	Total	Male	Female	Total	Male	Female	Total	Male	Female
1-month	3.15	3.24	3.10	6.55	8.43	5.67	16.40	16.98	16.13
3-month	5.50	6.48	5.04	10.06	12.77	8.79	22.44	24.58	21.65
6-month	7.40	8.83	6.73	11.93	14.38	10.83	27.13	31.06	25.28
1-year	17.94	22.23	15.92	13.87	16.38	12.81			
2-year	29.76	35.93	26.84	18.11	21.02	16.90			
5-year	56.80	63.11	53.78	25.79	27.69	25.20			
10-year	83.35	86.65	81.79	38.24	36.00	40.14			

The statistically significant risk factors for the overall survival were male gender, older age, larger CCI score and lower insured amount (Table 3). For each 1-year increase in age, the hazard ratio (HR) increased by 1.056 (95% CI: 1.047–1.064). Males had death risks higher than females, HR, 1.315 (95% CI: 1.166–1.482). Subjects with higher CCI scores had higher risks for death compared with those with CCI score equal to 0 (CCI = 1, HR 1.14, 95% CI: 1.12–1.55; CCI = 2, HR 1.69, 95% CI: 1.40–2.04; CCI = 3, HR 1.77, 95% CI: 1.45–2.16; CCI ≥ 4, HR 2.43, 95% CI: 2.07–2.86, respectively). The significant risk factor for the first reoperation was only younger age. For each 1-year increase in age, the sub-distribution hazard ratio (sHR) decreased 1.4% (sHR: 0.986, 95% CI: 0.974–0.998) (Table 3). Conversely, the significant risk factors for the first readmission were older age and higher CCI score. For each 1-year increase in age, the sub-distribution hazard ratio (sHR) increased by 1.024 (95% CI: 1.016–1.032) (Table 3).

Table 3

(a) Hazard ratios of the risk factors associated with death from cause-specific hazard model based on multivariate Cox's model, (b) subdistribution hazard ratio of the risk factors associated with the first reoperation, and (c) first readmission based on multivariate Fine and Gray's (subdistribution hazard ratio, sHR) model from competing risk analysis

		(a) Death			(b) Reoperation			(c) Readmission		
		HR	95% C.I.	P-value	sHR	95% C.I.	P-value	sHR	95% C.I.	P-value
Age (year)		1.056	(1.047–1.064)	< 0.001	0.986	(0.974–0.998)	0.025	1.024	(1.016–1.032)	< 0.001
Gender	Female	Ref. ^b			Ref.			Ref.		
	Male	1.315	(1.166–1.482)	< 0.001	0.966	(0.770–1.213)	0.768	0.951	(0.829–1.090)	0.468
CCI ^a	0	Ref.			Ref.			Ref.		
	1	1.139	(1.123–1.548)	< 0.001	1.038	(0.797–1.351)	0.784	1.365	(1.172–1.590)	< 0.001
	2	1.693	(1.404–2.041)	< 0.001	0.898	(0.634–1.270)	0.542	1.684	(1.388–2.044)	< 0.001
	3	1.766	(1.445–2.159)	< 0.001	1.087	(0.764–1.547)	0.642	1.656	(1.320–2.077)	< 0.001
	≥ 4	2.432	(2.070–2.856)	< 0.001	0.886	(0.648–1.210)	0.447	2.103	(1.752–2.524)	< 0.001
Insurance amount (NT\$)	≤ 21000	Ref.			Ref.			Ref.		
	> 21000	0.487	(0.425–0.557)	< 0.001	1.174	(0.950–1.450)	0.138	0.912	(0.803–1.036)	0.158
<i>Note:</i> ^a CCI: Charlson Comorbidity Index.										
^b Ref.: Reference.										

Subjects surviving after index surgery typically had multiple reoperations and readmissions due to complications. A total 356 subjects had at least one reoperation within 10 years after index surgery. Causes for reoperation were dislocation (30.4%), infection (40.73%), periprosthetic fracture (20.5%) and mechanical complications (41.2%). Surgical complications resulted in 40 revisions, 1.4% among total 2,798 subjects after the index surgery. For patients receiving reoperation after index surgery, the cumulative mortality rates after the first reoperation within 1-month, 3-month, 6-month, 1-year, 2-year, 5-year follow-up were 4.5%, 13.67%, 19.45%, 28.62%, 39.25% and 61.95% respectively (Table 4). A total 759 subjects had at least one readmission within 6 months after the index surgery. Causes for readmission in descending order were urinary tract infection (60%), pneumonia (37%), acute respiratory failure (25%), acute renal failure (10.9%) and major cardiovascular events. Cumulative mortality rates after first medical readmission within 1, 3 and 6 months after the index surgery were 14.17%, 23.61% and 30.85% respectively (Table 4).

Table 4
Causes of the first reoperation or readmission after hemiarthroplasty for intertrochanteric hip fracture

	1-month	3-month	6-month	1-year	2-year	5-year	10-year
Reoperation							
N ^a	127	199	228	250	283	330	356
Dislocation (% ^b)	36.22	41.71	40.97	40.00	36.04	31.82	30.34
Mechanical complications ^c (%)	35.43	36.18	37.72	39.20	40.99	41.21	40.43
Infection (%)	34.65	35.18	39.04	39.60	36.58	41.21	40.73
Removal of implant (%)	14.17	13.07	14.91	16.00	18.37	20.30	20.79
Conversion to / revision arthroplasty (%)	4.72	6.03	6.14	7.60	10.60	11.82	11.80
Isilateral femur fracture (%)	14.17	15.08	14.47	14.80	17.67	19.09	20.51
Readmission							
N	459	628	759				
Urinary tract infection (%)	55.34	58.28	60.87				
Pneumonia (%)	28.54	33.28	37.42				
Acute respiratory failure (%)	17.86	22.29	25.30				
Stroke (%)	10.46	11.15	10.67				
Acute renal failure (%)	8.50	11.31	10.94				
Acute myocardial infarction (%)	4.14	4.62	4.48				
Pulmonary embolism (%)	1.96	1.59	1.71				
Deep vein thrombosis (%)	0.87	1.43	1.45				

Discussion

Our main findings are various mortality rates of the study population (1-month, 3-month, 6-month, 1-year, 2-year, 5-year and 10-year cumulative mortality rates were 3.15%, 5.5%, 7.4%, 17.94%, 29.76%, 56.8% and 83.38%, respectively) (Table 2). Several other studies reported the short-term outcomes after hemiarthroplasty for unstable trochanteric fracture with various results [8–18]. Their sample sizes are rather small (from 29 to 277) and most (> 70%) of them had sample sizes < 100 [8–10, 12–14, 18, 22–28]. Discrepancy in mortality rates among studies could be due to differences in selection criteria, distributions of gender and age in the populations, pre-fracture physical activity, bone quality, nutrition, and comorbidities, in addition to sample sizes. Our one-month mortality was 3.15% in Taiwan, lower than 4–13.8% of the previous reports [9–12, 14, 28]. One possible reason is the progressive improvement in general medical care and healthcare with time. Our cohort started from 2000 which is a time more recent than most of those in the literature. The similar cohort effects can also be

found in the previous studies from Korean [9, 15, 28]. Our 3-month mortality was 5.5%, lower than 7.0–26.6% reported in the previous studies [10, 12, 28]. Our 6-month mortality of 7.42%, which is also lower than 23.5–26.4% reported in the literature [10, 22, 27]. Cornwall et al. investigated the short-term mortality rates of 4 types of hip fractures [29]. Their in-hospital and 6-month mortality rates were 0% and 5.7% for 70 nondisplaced femoral neck fractures, 2.2% and 15.8% for 181 displaced femoral neck fractures, 2.8% and 12.8% for 108 stable intertrochanteric fractures and 1.1% and 13.8% for 178 unstable intertrochanteric fractures [29]. However, our 1-year mortality rate was 17.9% higher than 2.5–14.6% of the previous studies [13, 25, 26], but still lower than 21.8–39.3% in most past studies [9–12, 14–18, 28]. Our 2-year mortality rate was 29.7%, which falls in the mid-range of 12.5–59.0%, as reported in the literature [8, 9, 12, 16, 25, 28]. One possible reason is the accessibility of the long-term healthcare services in Taiwan for these fragile seniors and disables. Our long-term healthcare services were started first in 2017. Before that time, our long-term healthcare system/service was worse than those of the major developed countries or welfare states. Therefore, our mortality rates after 1-year follow-up jumped into the middle range of the previous reports. Our 5-year mortality rate was 56.8% which was slightly higher than 52–64%, as reported in the literature for all hip fractures [2, 3, 19, 30]. Few studies reported 5-year mortality rates after hemiarthroplasty for unstable intertrochanteric fracture [16, 17]. Camurcu et al. and Cobden et al. reported their 5-year mortality rates as high as 94.4% and 90.25%, respectively [16, 17]. One important reason for the large differences in mortality rates between studies of ours and others [16, 17] is related to their smaller sample sizes. For a study with a smaller sample size study containing high mortality elderly adults, only a few number of survival subjects were left toward the end of the study such that a small number of deaths would cause huge impact on the change of the mortality rate and cause a sharp rise for the mortality rate at the end of the study.

Our short-term mortality rates after hemiarthroplasty for unstable trochanteric fracture are not higher than those hemiarthroplasty reported for cervical fracture and internal fixation for trochanteric fracture. For example, Forte et al. found 1-, 2-, and 3-month mortality rates among 192,365 elderly after internal fixations for trochanteric fractures are 7.92%, 12.34% and 15.19%, respectively [31]. The meta analyses of Mundi and Li et al. for the outcomes after trochanteric fractures found the 1-year mortality rate being 23% and 17% [32, 33]. Tucker et al. conducted a prospective including 3,230 unstable trochanteric fractures with internal fixations and found the 1-year mortality rate being 22.6% [34]. Mattisson et al. reported a study for trochanteric fracture based on a database from Swedish fracture register and found that the overall 30-day and 1-year mortality rates being 7.7% and 26% [35]. In contrast, our 5-year and 10-year mortality rates after hemiarthroplasty for unstable trochanteric fracture were 56.8% and 83.3%, which are all higher than those reported in the literature after hemiarthroplasty for cervical fracture [2, 3, 19, 30]. Lin and Liang examined the outcomes of subjects after hemiarthroplasty for displaced cervical fracture. They reported the 5- and 10-year mortality rates being 46.9% and 71% [19]. Studies reported that subjects with trochanteric fractures tended to be older, in worse health conditions and higher short-term mortality rates than those with femoral neck fractures [27, 36]. We believe that unstable trochanteric fracture with sequelae and aging both of which impact on the high mortality one year after fractures.

Other main findings of our study are the significant risk factors for overall survival rate being male gender, older age, larger CCI score and lower insured amount. Few studies reported on the risk factors for hemiarthroplasty after unstable trochanteric fracture [17]. Camurcu et al. reported 106 subjects after cementer bipolar hemiarthroplasty for unstable trochanter fracture and found that risk factors for 1-year mortality being American Society of Anesthesiologists (ASA) scores ≥ 3 , delayed postoperative mobilization ≥ 2 days and presence of ≥ 3

comorbidities. Camurcu et al. did not find age and male being risk factors for 1-year mortality. Several meta-analyses reported that older age, male gender and multiple preoperative comorbidities are significant risks for mortality and medical complications after hip fractures in the elderly [1, 37]. We found that males had a hazard 1.31 times of females and age had hazard yearly 1.05 times higher for the overall mortality. We used CCI score representing the number and severity of comorbidities. Other investigators used instead ASA score for unstable trochanteric fractures [11, 12, 14, 16, 23, 24, 28]. Higher CCI, aging, higher ASA scores and delayed surgery are highly correlated with one another. Multiple comorbidities and aging often result in high ASA scores. We found that CCI score had stronger association with mortality than ASA score (data not shown here). CCI score or ASA score are in positive and strong correlation. They are both good measures for the number and severity of comorbidities. Since several studies had shown CCI score as a significant risk factor associated with the mortality after hip fractures [38, 39]. For this reason, we had chosen CCI score as the measure for the severity of multiple comorbidities.

Several other studies reported readmission rates and reoperation rates after hemiarthroplasty for unstable trochanteric fracture [9–11, 13–15, 18, 22, 25, 28]. However these studies did not consider the interferences caused by the competing risk of deaths in estimating the cumulative incidence of the readmission and the reoperation rates. It is therefore difficult to compare their findings with ours. Other difficulties are the large variations in sample size across studies, the differences in the definition of causes for the readmissions, the follow-up times and the lost follow-up rates. We found that the 1-, 3-, and 6-month cumulative incidences of the first readmission after medical complications were 16.4%, 22.44% and 27.13%, respectively, using competing risk analysis. Previous studies reported the 1- to 6-month rates of medical complications ranged from 11.2–41.8% for subjects after hemiarthroplasty for unstable trochanteric fracture [9–11, 13, 18, 22, 25]. Several other studies reported the one-month readmission rates due to medical complications from 5.3–17.1% for all types of hip fractures [40–42]. Our cumulative incidences of the first readmission due to medical complications after hemiarthroplasty for trochanteric fracture seem higher than those cervical fracture reported in literature [9–11, 13, 18, 19, 22, 25, 40]. Subjects with trochanteric fracture are older than those with cervical fracture of femur. Therefore, the first readmission rates are often higher in trochanteric fracture. We found that older age and larger CCI score are risk factors for the first readmission. In the literature review of Ali and Gobbons, they summarized that age, preoperative comorbidities are strong independent predictors of readmission after hip fracture operations [43]. Male gender, unlike for mortality, was not found to be a risk factor for readmission in our study. Pollock et al. did not find male gender being a risk for readmission in 1,486 subjects after hip fracture operations [44]. Lizaar-Utrilla et al. found that female gender, higher ASA score and more than 2 comorbidities are risk factors for readmission among 732 subjects after hip fractures [45]. And French et al. also found that female gender and multiple comorbidities are risk factors for readmission in 41,331 subjects after hip fractures [46]. That females have similar or higher risk for readmission might be due to the lower competing risk of death. Although Ali and Gibbons also found that ASA score being a predictor of readmission more robust than the CCI score or individual comorbidities [43]. However, we found the association with readmission was stronger with CCI score than with ASA score.

We found that 1-, 2-, 5-, and 10-years cumulative incidences of the first reoperation were 13.87%, 18.11%, 25.79%, and 38.24%, respectively. In the literature, large disparities exist regarding surgical complications or reoperation rates after hemiarthroplasty for unstable trochanteric fractures [9–11, 13–15, 18, 22, 25, 28]. The 6-month surgical complication/reoperation rates are around 2.2% [22]; one-year surgical complication/reoperation rates

are from 2.6–20% [10, 13, 14] and 2-year surgical complication/reoperation rate are from 2.4–18.3% [9, 18, 25, 28]. Surgical site infection, dislocation and periprosthetic fracture are three major causes of the reoperations [9–11, 13–15, 18, 22, 25, 28]. The 1-year reoperation rates are from 2.9–16.3% after hemiarthroplasty for displaced femoral neck fracture in the literature [19, 47, 48]. By contrast, in our study, older age was a protective factor for reoperation. For each yearly increase in age, the sub-distribution hazard ratio (sHR) dropped by 1.4% (sHR: 0.986, 95% CI: 0.974–0.998) for reoperation. Again, the different directions of the risks between the long-term mortality and the reoperation were due to the competing risk of death. Therefore, the more healthy subjects would be left in the risk set for reoperation, resulting in lowering the risk for reoperation. The competing risk of death usually has a larger impact on the outcomes of long-term than of short-term. We did not identify other significant risk factors for reoperation apart from younger age. Competing risk of death partly explains for that. The reoperation rates of hemiarthroplasty for unstable trochanteric fracture are still comparable to hemiarthroplasty after femoral neck fracture. Therefore, we speculate that hemiarthroplasty is likely a robust alternative management for unstable trochanteric fracture among a heterogeneous elderly population.

Our retrospective population study has several limitations. The database, unlike hip fracture registry database or prospective study, does not contain all clinical parameters. Retrospective studies often are vulnerable to selection bias and unknown confounding factors. All the hemiarthroplasty operations were required to be approved in advance by 3 orthopedic surgeons through peer-review system of NIH program such that it could reduce large selection bias. However, no pre-approval was required for internal fixation. And no standard criteria or nor guidance existed for the diagnosis and implant selection of unstable trochanteric fracture for internal fixation. Therefore, we did not include internal fixation for trochanteric fracture as controls to avoid large selection bias. Subjects were enrolled from 2000 to 2010 and followed up from 2- to 10-year in the study. During the long study period and the long follow-up time, regular healthcare improvements take place in admission policy and postoperative period required. Therefore, some confounding factors or lurking factors were not completely controlled using statistical modeling approaches. The ICD codes for medical complications and surgical complications always had variations such that misclassifications existed to interfere in estimating the readmission rates and reoperation rates. The distinctions between medical complications and newly developed comorbidities were not well separated after a major surgery. We therefore interpreted a shorter time duration (from the index date to the date of the first medical readmission) reflecting a higher probability index surgery leading directly or indirectly to readmissions related to medical complications. Furthermore, extrapolations from the readmission rate and reoperation rate should be done with caution.

Conclusions

This is the first study to assess the long-term effects of fresh unstable trochanteric fracture treated with hemiarthroplasty. Male gender, older age and larger CCI score and lower insured amount were risk factors for the overall mortality. Older age and larger CCI score were risk factors for the first readmission. Conversely, we found that older age was a protective factor for reoperation, which is likely due to the competing death. Compared with previous studies, with respect to surgical complications, we speculate that hemiarthroplasty is a robust alternative treatment for unstable trochanteric fracture among a heterogeneous elderly population. More prospective studies and clinical trials are required in the future for the long-term outcomes after primary hemiarthroplasty for fresh unstable trochanteric fractures.

Abbreviations

NHIRD

National Health Insurance Research Database; NRDD:National Register of Deaths Database; MOHW:Ministry of Health and Welfare Health and Welfare; NHI:National Health Insurance; ICD-9-CM:International Classification of Diseases, 9th Revision, Clinical Modification; CCI:Charlson comorbidity index; HR:Hazard ratio; CI:Confidence interval; sHR:sub-distribution hazard ratio; ASA:American Society of Anesthesiologists.

Declarations

Acknowledgments

This study was based in part on data from the National Health Insurance Research Database provided by the Bureau of National Health Insurance, Department of Health and managed by the National Health Research Institutes. The interpretation and conclusions contained herein do not represent those of the National Health Insurance Administration, Department of Health, or National Health Research Institutes. We are grateful to Health Data Science Center, China Medical University Hospital, for providing administrative, technical, and funding support.

Author Contributions

All authors made substantial contributions to this work. TCL, WML, and JCFL designed the study; PWW and CTL facilitated acquisition of data; PWW, CTL and YJC performed the data analysis; TCL, WML, PWW, CTL, YJC, YJL, and JCFL interpreted the data; TCL, WML, and JCFL drafted the manuscript; and all authors critically revised the manuscript and approved the final version for submission.

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Availability of data and materials

The website of the Taiwan National Health Insurance Research Database is found at <http://www.mohw.gov.tw/>.

Ethics and consent to participate

The NHIRD is composed of anonymous secondary data released to the public for research purposes. All patients' data were encrypted using the same encryption algorithm to cross-link the data while protecting the privacy of the patients. This retrospective study was exempted from a full review by the local ethics review committee, but the protocol was approved by the Institutional Review Board (IRB) of China Medical University Hospital with a waiver of informed consent (certificate: CMUH-104-REC2-115). All methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Twelve-year cumulative incidence curves of (a) mortality stratified by gender, (b) the first reoperation stratified by gender, and (c) 180-day cumulative incidence curves of the first readmission stratified by gender.