Original Article
Clinics in Orthopedic Surgery 2024;16:217-229 • https://doi.org/10.4055/cios23282

Comparative Interrupted Time Series Analysis of Direct Medical Expense and Length of Stay in Elderly Patients with Femoral Neck Fractures Who Underwent Total Hip Arthroplasty and Hemiarthroplasty: A Real World Nationwide Database Study

Seung-Hoon Kim, MD, Suk-Yong Jang, MD*, Yonghan Cha, MD[†], Bo-Yeon Kim[‡], Hyo-Jung Lee[§], Gui-Ok Kim[§]

Department of Preventive Medicine, Eulji University College of Medicine, Daejeon,
**Department of Healthcare Management, Graduate School of Public Health, Yonsei University, Seoul,*
[†]*Department of Orthopaedic Surgery, Daejeon Eulji Medical Center, Eulji University School of Medicine, Daejeon,*
[‡]*Healthcare Review and Assessment Committee, Health Insurance Review and Assessment Service, Wonju,*
[§]*Quality Assessment Department, Health Insurance Review and Assessment Service, Wonju, Korea*

Background: The objective of our study was to analyze the postoperative direct medical expenses and hospital lengths of stay (LOS) of elderly patients who had undergone either hemiarthroplasty (HA) or total hip arthroplasty (THA) for femoral neck fractures and to determine the indication of THA by comparing those variables between the 2 groups by time.

Methods: In this comparative large-sample cohort study, we analyzed data from the 2011 to 2018 Korean National Health Insurance Review and Assessment Service database. The included patients were defined as elderly individuals aged 60 years or older who underwent HA or THA for a femoral neck fracture. A 1:1 risk-set matching was performed on the propensity score, using a nearest-neighbor matching algorithm with a maximum caliper of 0.01 of the hazard components. In comparative interrupted time series analysis, time series were constructed using the time unit of one-quarter before and after 3 years from time zero. For the segmented regression analysis, we utilized a generalized linear model with a gamma distribution and logarithmic link function.

Results: A total of 4,246 patients who received THA were matched and included with 4,246 control patients who underwent HA. Although there was no statistically significant difference in direct medical expense and hospital LOS for the first 6 months after surgery, direct medical expenses and hospital LOS in THA were relatively reduced compared to the HA up to 24 months after surgery ($p < 0.05$). In the subgroup analysis, the THA group's hospital LOS decreased significantly compared to that of the HA group during the 7 to 36 months postoperative period in the 65 ≤ age < 80 age group ($p < 0.05$). Direct medical expenses of the THA group significantly decreased compared to those of the HA group during the period from 7 to 24 months after surgery in the men group ($p < 0.05$).

Conclusions: When performing THA in elderly patients with femoral neck fractures, the possibility of survival for at least 2 years should be considered from the perspective of medical expense and medical utilization. Additionally, in healthy and active male femoral neck fracture patients under the age of 80 years, THA may be more recommended than HA.

Keywords: *Hip fracture, Neck fracture, Hemiarthroplasty, Total hip arthroplasty, Health care costs*

Clinics in Orthopedic Surgery • pISSN 2005-291X eISSN 2005-4408

Received September 12, 2023; Revised November 8, 2023; Accepted November 8, 2023
Correspondence to: Yonghan Cha, MD
Department of Orthopaedic Surgery, Daejeon Eulji Medical Center, Eulji University School of Medicine, 95 Dunsanseo-ro, Seo-gu, Daejeon 35233, Korea
Tel: +82-42-611-3280, Fax: +82-42-611-3283, E-mail: naababo@hanmail.net

Treatment methods for the elderly with femoral neck fractures include hip arthroplasty and internal fixation.[1] Among them, hemiarthroplasty (HA) or total hip arthroplasty (THA) is the main surgical option for fractures with displacement.[2] Compared to THA, HA has a shorter surgical time, lower blood loss, lower dislocation rate, and lower initial cost.[1] However, acetabular erosion after HA is one of the complications that reduce patient satisfaction in long-term follow-up.[3] Therefore, THA can be performed for high activity and low comorbidity elderly patients with displaced femoral neck.[4] However, it seems that there are no adequate criteria for high activity and low comorbidity. Moreover, in a systematic review and meta-analysis of randomized controlled trials comparing HA and THA for displaced femoral neck fractures by Ekhtiari et al.,[5] there was no difference in the complication rates such as revision rate, periprosthetic fracture, and dislocation between the 2 groups and neither mortality nor functional results. Judge et al also reported that it could not be concluded that 1 of the 2 surgical methods was superior.[6] Therefore, we believe that medical expense is an important consideration when choosing a surgical method.

In several developed countries, national guidelines have been proposed for the treatment of hip fractures, including femoral neck fractures.[7,8] The cost-effectiveness of each treatment method must be demonstrated before it can be recommended for use in patients. This is because the socioeconomic burden of hip fractures is becoming a significant issue, and efforts are being made to reduce the medical expenses associated with treating osteoporotic fractures.[9] Therefore, analyzing the differences in medical expenses between different treatment methods for femoral neck fractures can be an important basis for selecting treatment methods and providing appropriate surgical indications.

Thus, the objective of our study was to analyze the postoperative direct medical expenses and hospital lengths of stay (LOS) of elderly patients who received HA or THA for femoral neck fractures and to determine the indication of THA by comparing those variables between the 2 groups by time.

METHODS

The design and protocol of this study were approved by the Institutional Review Board of Daejeon Eulji Medical Center (No. EMC 2021-12-011). The requirement of written informed consent was waived owing to the retrospective nature of the study.

Data and Patient Sample

In this comparative large-sample cohort study, we utilized data from the 2011 to 2018 Korean National Health Insurance Review and Assessment Service (HIRA) database. The HIRA collects data from claims submitted by healthcare providers for reimbursement under Korea's universal healthcare insurance system, with a fee-for-service model that covers the entire South Korean population.[10] Information in the database includes all inpatient and outpatient medical claims data, including treatment procedure codes and diagnostic codes. Therefore, medical claims data for all hip arthroplasty that occurred during the study period were identified.

Identification of THA and HA

Considering previous studies, the inclusion criteria for the incident femoral neck fracture were as follows:[11,12] (1) First admission from 2011 to 2018 to an acute care hospital (index admission) with codes of femoral neck fractures (International Statistical Classification of Diseases and Related Health Problems, 10th Revision S720); (2) Patients who underwent operations including HA or total arthroplasty (hip); and (3) Patients aged 60 years or older. The time-zero (incidence date) of femoral neck fracture was defined as the admission date to the hospital. The patients finally included in the study were classified into the THA group and the HA group.

Cumulative Direct Medical Expenses

Quarterly, personal-level direct medical expenses were calculated for 3 years before and after the incidence date of neck fracture. The patients' quarterly direct medical expenses were recorded. Total medical expense was defined as the sum of the amount paid by the National Health Insurance Corporation and the patient's co-payments for insured medical services, excluding payments for out-of-coverage services. According to the National Health Insurance Act, Korean patients pay co-payment for insured medical services and out-of-pocket fees for uninsured services. Among them, the HIRA database only archives co-payments for insured medical services.

The total medical expense is a summation of expenses for outpatient and inpatient services, oriental medicine charges, dental services, prescriptions, and drugs, along with benefits covered by the National Health Insurance Services.[13] Expenses for long-term care hospitals were included, but long-term care service expenses were not. All medical expenses were converted to Korean won using the 2023 conversion index.[10] Finally, the won was then exchanged for U.S. dollars by applying a rate of 1,300 won per dollar (March, 31, 2023).

Medical Utilization

The medical utilization outcome variables were classified into LOS of all admission cases and the total number of outpatient visits that included clinic and hospital visits. The unit of analysis was the patients' quarterly variables.

Risk-Set Matching with Propensity Scores in Patients with Neck Fractures

Although the HIRA database was constructed retrospectively, this study was carried out prospectively.[14] Furthermore, to maximize the comparability of the effect of surgery on direct medical expenses and medical utilization, risk-set-matching was performed between patients with similar comorbidity, medical utilization, and direct medical expenses before surgery. Based on propensity score, risk-set matching was first performed to assign controls that reflect subjects who underwent HA with the same sex, age, and year of surgery distribution of the THA group at time zero.[14,15] If patients who received THA passed away within the follow-up period, patients whose time of death was within 1 month were matched to increase the comparability of medical utilization and expenses of the 2 groups. This process of risk-set matching was repeated until the patients who received THA were all matched.[14,16-18] Ultimately, the propensity score was matched 1:1 successively for each risk set with the use of the nearest neighbor-matching algorithm and a maximum caliper width of 0.01 for probabilities. Probabilities were estimated as propensity scores from the logistic regression model and the matching variables were age, sex, Charlson Comorbidity Index (CCI) for 3 years immediately before surgery, medical utilization (including hospitalization and outpatient visits), direct medical expenses for 1 year immediately before surgery, and year of surgery.[15,19] Then, patients who were matched from the risk sets were excluded to prevent overlapping samples. The process was duplicated within consecutive risk sets until subjects who underwent THA were no longer reflected in the risk set.

Statistical Analysis

In this comparative interrupted time series analysis, time series were constructed using the time unit of one-quarter before and after 3 years from time zero. The time series were divided into 7 divisions before time zero and every half year after time zero. Changes in baseline trends and intercepts were considered before time zero, but only intercept changes were considered in divisions after time zero. In other words, the difference between before and after surgery of the THA and HA groups was compared. We performed segmented regression analysis by adjusting all independent variables including seasonality and CCI.

We used a generalized linear model with a gamma distribution and logarithmic link function for the segmented regression analysis. We used a generalized estimating equation using a robust standard error to avoid overestimation of the standard errors of the parameter estimates. All calculated p-values were two-sided, and p-values < 0.05 were considered significant. All analyses were performed using SAS Enterprise Guide version 7.1 software (SAS Institute). Baseline characteristics, including age, sex, calendar year of surgery, CCI, medical history, medication history, and seasonality, were investigated as covariates. The CCI was calculated by weighting and scoring comorbid conditions using Quan's method, with additional points given to comorbidities that affect the health outcomes of patients.[20] Prescriptions of more than 90 days for antihypertensive, antidiabetic, and lipid-lowering agents were considered for patients who had taken the corresponding medications. Medical history included admission within 1 year before surgery and the number of outpatient visits. Furthermore, stratified analysis was performed to investigate the effect of surgery type on medical utilization and expense in patients according to the age group (≥ 60 & < 65 years, ≥ 65 & < 80 years, ≥ 80 years) and sex (male or female).

RESULTS

Baseline Characteristics of Matched Cohort

There were 8,869 patients who underwent THA in the HIRA database from 2011 to 2018. Among them, 821 patients who underwent THA surgery in 2011 were excluded because it was difficult to predict the patient's condition at the time of surgery due to a lack of medical expense and utilization records for the year immediately before surgery. In the course of the risk-set-matching process, 2,027 subjects undergone THA were not completely matched with the HA cohort in terms of sex, age, and year of surgery. Finally, in propensity score matching using a nearest neighbor-matching algorithm, 1,775 patients who did not meet the maximum caliper width of 0.01 for probabilities were excluded. As a result, 4,246 patients who received THA and 4,246 matched control patients who received HA were included (Table 1). The mean age was 71.1 years for both groups, and 67.2% were women.

Table 1. Baseline Characteristics of Study Participants

Variable	Total arthroplasty	Hemiarthroplasty	Standardized difference*
Number (total = 8,492)	4,246 (50.0)	4,246 (50.0)	-
Sex			0.002
Male	1,394 (32.8)	1,394 (32.8)	
Female	2,852 (67.2)	2,852 (67.2)	
Age (yr)	71.1 ± 9.9	71.1 ± 9.9	0.002
Age group			0.008
≥ 60 & < 65 yr	1,073 (25.3)	1,063 (25.0)	
≥ 65 & < 80 yr	2,301 (54.2)	2,318 (54.6)	
≥ 80	872 (20.5)	865 (20.4)	
Charlson Comorbidity Index			0.038
0	1,229 (28.9)	1,273 (30.0)	
1	1,084 (25.5)	1,096 (25.8)	
2	776 (18.3)	718 (16.9)	
≥ 3	1,157 (27.2)	1,159 (27.3)	
Medical history			
Number of outpatient visits within 1 year before surgery			0.096
≥ 0 & < 21	494 (11.6)	600 (14.1)	
≥ 21 & < 47	1,075 (25.3)	1,153 (27.2)	
≥ 47 & < 85	1,266 (29.8)	1,174 (27.6)	
≥ 85	1,411 (33.2)	1,319 (31.1)	
Number of admission within 1 year before surgery			0.032
0	2,558 (60.2)	2,488 (58.6)	
≥ 1	1,690 (39.8)	1,758 (41.4)	
Antihypertensive agents			0.016
No	1,530 (36.0)	1,563 (36.8)	
Yes	2,716 (64.0)	2,683 (63.2)	
Antidiabetic agents			0.012
No	3,182 (74.9)	3,160 (74.4)	
Yes	1,084 (25.5)	1,086 (25.6)	

Table 1. Continued

Variable	Total arthroplasty	Hemiarthroplasty	Standardized difference*
Lipid-lowering agents			0.064
No	2,554 (60.2)	2,687 (63.3)	
Yes	1,692 (39.8)	1,559 (36.7)	
Month at the time of surgery			0.197
Jan–Mar	1,219 (28.7)	1,067 (25.1)	
Apr–Jun	1,098 (25.9)	991 (23.3)	
Jul–Sep	1,055 (24.8)	955 (22.5)	
Oct–Dec	874 (20.6)	1,233 (29.0)	
Year of surgery			0.000
2012	533 (12.6)	533 (12.6)	
2013	592 (13.9)	592 (13.9)	
2014	701 (16.5)	701 (16.5)	
2015	742 (17.5)	742 (17.5)	
2016	881 (20.7)	881 (20.7)	
2017	797 (18.8)	797 (18.8)	
Anesthesia			0.347
General	1,833 (43.2)	1,140 (26.8)	
Spinal	2,413 (56.8)	3,106 (73.2)	

Values are presented as number (%) or mean ± standard deviation.
*Standardized difference of less than 0.1 (10%) is generally considered negligible.

Differences in Direct Medical Expenses

Table 2 shows differences in differential changes in direct medical expenses of the THA and HA groups before and after time zero. Although direct medical expenses were relatively increased in the THA group by 6.9% in comparison to the HA group for 6 months after time zero, there was no statistically significant difference. However, thereafter, direct medical expenses in the THA group were relatively reduced compared to those in the HA group. The relatively significant reductions in direct medical expenses in the THA group persisted up to 24 months after surgery. Difference-in-difference [DID] estimate ratio for 12 months was 0.822 (95% confidence interval [CI], 0.734–0.944; $p = 0.004$); 0.855 for 18 months (95% CI, 0.750–0.999 ; $p = 0.049$); and 0.835 for 24 months (95% CI, 0.707–0.987; $p = 0.034$).

Fig. 1 shows direct medical expenses per quarter in both groups. The direct medical expenses per quarter of the 2 groups were similar before time zero. However, in the first quarter, the medical expense of the THA group was higher than that of the HA group, and after that, the expense of the HA group was higher than that of the THA group. The total medical expenses of the 2 groups, as well as the mean changes in medical expenses before and after time zero, can be found in Table 3.

Differences in Medical Utilization

Table 2 shows the differences in differential changes in medical utilizations of the THA and HA groups before and after time zero. There was no statistically significant difference in hospital LOS for 6 months after time zero between the 2 groups. However, thereafter, hospital LOS in the THA group was relatively reduced compared to that in the HA group. The relatively significant reductions in hospital LOS in the THA group persisted up to 24 months after surgery. DID estimate ratio for 7–12 months was 0.799 (95% CI, 0.651–0.981; $p = 0.032$); 0.761 for 13–18 months (95% CI, 0.603–0.960; $p = 0.021$); and 0.750 for

Table 2. Differences in Differential Changes in Direct Medical Expenses and Medical Utilizations between the THA (Case Group) and Matched HA Cohorts (Control Group) before and after Time Zero

Direct medical expenses of the episode		Ratio	95% CI	*p*-value
Indication of predicted graph*	Baseline medical expense mean difference (USD)[†]	201.543	155.393–261.400	< 0.001
	Ratio of baseline direct medical expense difference	0.975	0.833–1.142	0.757
	Ratio of direct medical expense increase per quarter	1.014	1.006–1.022	0.001
	Ratio of difference in the slope of direct medical expense increase[‡]	1.001	0.990–1.012	0.855
Difference in difference estimate[§]	1–6 mo	1.069	0.969–1.179	0.184
	7–12 mo	0.822	0.734–0.944	0.004
	13–18 mo	0.855	0.750–0.999	0.049
	19–24 mo	0.835	0.707–0.987	0.034
	25–30 mo	0.863	0.716–1.041	0.124
	31–36 mo	0.894	0.724–1.105	0.300
Hospital LOS				
Indication of predicted graph*	Baseline LOS mean difference (day)[†]	0.143	0.096–0.214	< 0.001
	Ratio of baseline LOS difference	0.756	0.568–1.007	0.056
	Ratio of LOS increase per month	0.986	0.973–1.000	0.045
	Ratio of difference in the slope of the LOS increase[‡]	1.012	0.993–1.030	0.224
Difference in difference estimate[§]	1–6 mo	0.969	0.811–1.157	0.728
	7–12 mo	0.799	0.651–0.981	0.032
	13–18 mo	0.761	0.603–0.960	0.021
	19–24 mo	0.750	0.574–0.977	0.034
	25–30 mo	0.762	0.563–1.032	0.079
	31–36 mo	0.781	0.558–1.094	0.150
Number of outpatient visits				
Indication of predicted graph*	Baseline number of outpatient visits mean difference (number)[†]	14.323	12.451–16.477	< 0.001
	Ratio of baseline number of outpatient visits difference	1.039	0.961–1.124	0.334
	Ratio of number of outpatient visits increase per month	1.003	0.999–1.007	0.164
	Ratio of difference in the slope of the number of outpatient visits increase[‡]	0.998	0.993–1.004	0.538

Table 2. Continued

Direct medical expenses of the episode		Ratio	95% CI	*p*-value
Difference in difference estimate§	1–6 mo	1.024	0.972–1.078	0.380
	7–12 mo	1.035	0.976–1.097	0.249
	13–18 mo	1.049	0.981–1.122	0.161
	19–24 mo	1.013	0.936–1.096	0.745
	25–30 mo	1.009	0.923–1.103	0.840
	31–36 mo	1.001	0.904–1.107	0.979

THA: total hip arthroplasty, HA: hemiarthroplasty, CI: confidence interval, USD: U.S. dollar, LOS: length of stay.
*Indication of the predicted graph: indicators of the predicted graph for direct medical expenses considering the increase in direct medical expenses of both groups before matching. †Baseline medical expense difference: difference in direct medical expense, length of stay, and number of outpatient visits between THA and HA group at 3 years before time zero. ‡Slope difference: difference in the slope of the increase in direct medical expenses, length of stay, and number of outpatient visits in the patients with THA and HA. §Difference in difference estimate: the ratios of direct medical expenses, length of stay, and number of outpatient visits at each time point, considering the difference in direct medical expenses, length of stay, and number of outpatient visits before and after time zero in the THA group and the difference in direct medical expenses, length of stay, and number of outpatient visits before and after time zero in the HA group.

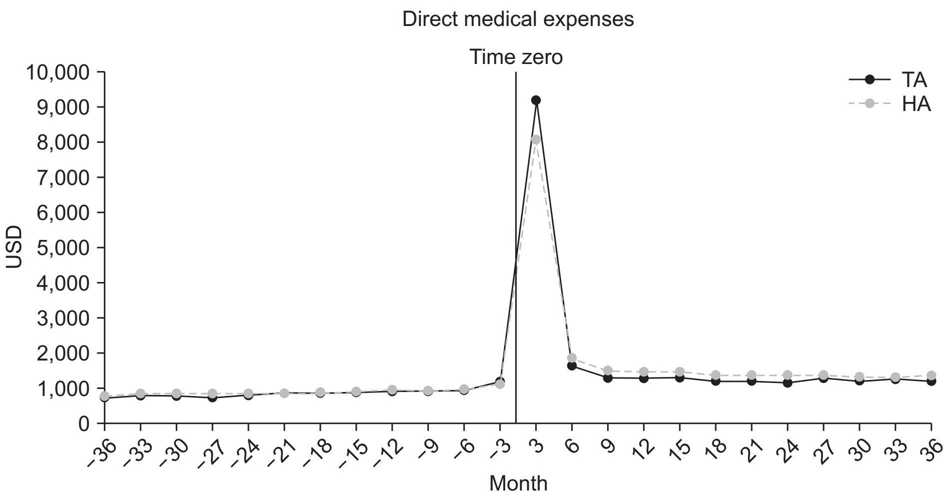

Fig. 1. Trends of direct medical expenses during the study period. USD: U.S. dollar, TA: total arthroplasty, HA: hemiarthroplasty.

Table 3. The Incurred Medical Expenses in the THA Group and the HA Group, as well as the Mean Differences in the Incurred Medical Expenses at 6-Month Intervals before and after the Femoral Neck Fractures

Period	THA (case group, USD)	HA (control group, USD)	Mean difference (95% CI, USD)*	*p*-value
Direct medical expenses before time zero				
30–36 mo	1,472 ± 2,695	1,560 ± 4,768	–88 (–220.5 to 44)	0.189
24–30 mo	1,461 ± 2,534	1,633 ± 4,606	–172 (–293.7 to –50)	0.010
18–24 mo	1,632 ± 3,407	1,658 ± 4,417	–25 (–149.3 to 98)	0.687
12–18 mo	1,683 ± 3,057	1,740 ± 4,319	–58 (–171.5 to 56)	0.322
6–12 mo	1,766 ± 3,771	1,850 ± 4,488	–84 (–208.6 to 41)	0.187
Time zero–6 mo	2,063 ± 3,397	2,062 ± 4,482	1 (–118.1 to 121)	0.981

Table 3. Continued

Period	THA (case group, USD)	HA (control group, USD)	Mean difference (95% CI, USD)*	*p*-value
Direct medical expenses after time zero				
Time zero–6 mo	10,746 ± 5,914	9,905 ± 10,048	840 (649.9 to 1,031)	< 0.001
6–12 mo	2,536 ± 2,627	2,894 ± 3,011	–358 (–506.4 to –210)	< 0.001
12–18 mo	2,460 ± 4,257	2,791 ± 5,097	–270 (–416.6 to –124)	< 0.001
18–24 mo	2,295 ± 3,963	2,655 ± 4,647	–360 (–502 to –218)	< 0.001
24–30 mo	2,428 ± 4,376	2,640 ± 4,596	–212 (–371 to –54)	0.009
30–36 mo	2,365 ± 4,106	2,570 ± 4,421	–205 (–367.5 to –43)	0.013

Values are presented as mean ± standard deviation unless otherwise indicated.
THA: total arthroplasty, HA: hemiarthroplasty, USD: U.S. dollar, CI: confidence interval.
*Mean difference: the difference in direct medical expenses between the patients who underwent THA and the matched patients who underwent HA.

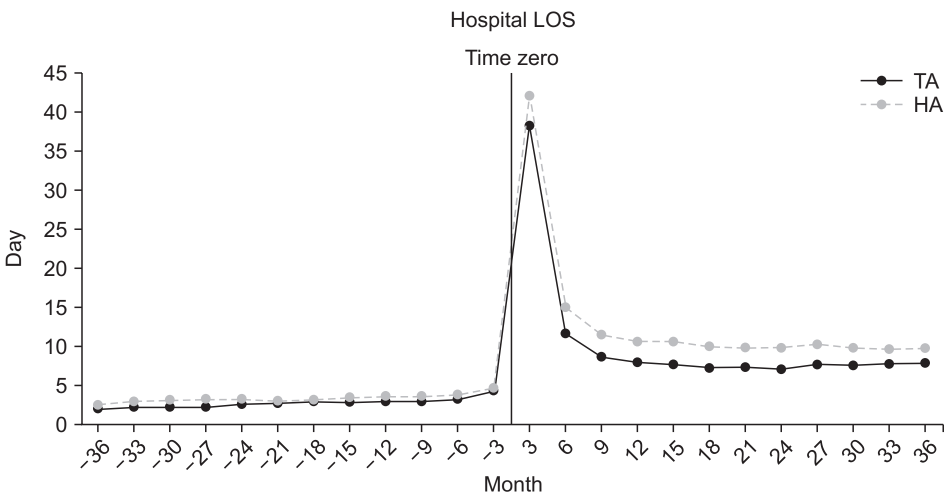

Fig. 2. Trends of hospital length of stay (LOS) during the study period. TA: total arthroplasty, HA: hemiarthroplasty.

19–24 months (95% CI, 0.574–0.977; $p = 0.034$). Although a marginal statistically significant difference was observed in hospital LOS, the DID estimate ratio was 0.762 at 25–30 months (95% CI, 0.563–1.032; $p = 0.079$). Fig. 2 shows hospital LOS per quarter in both groups. During the entire observation period, the hospital LOS of the HA group was longer than the LOS of the THA group. There was no statistically significant difference in the number of outpatient visits between the 2 groups during the whole observation period.

Differences by Sex and Age

Table 4 shows differences in differential changes in direct medical expenses and hospital LOS of the THA and HA groups according to age group. In the subgroup analysis, hospital LOS of the THA group decreased significantly in comparison to that of the HA group during the period from 7 months to 36 months after surgery in the 65 ≤ age < 80 group ($p < 0.05$).

Table 5 shows differences in differential changes in direct medical expenses and hospital LOS of the THA and HA groups according to sex. In the subgroup analysis, direct medical expenses in the THA group significantly decreased compared to those in the HA group during the period from 7 to 24 months after surgery in the men group ($p < 0.05$).

DISCUSSION

The main findings of this study are as follows: Firstly, although direct medical expenses were relatively increased in the THA group by 6.9% in relation to the HA group for 6 months after time zero, there was no statistically significant difference. However, from 7 to 24 months after surgery, reductions in medical expenses and hospital LOS were observed. Secondly, in the subgroup analysis, when

Table 4. Differences in Differential Changes in Medical Expenses and Hospital LOS between the THA (Case Group) and Matched HA Cohorts (Control Group) before and after Time Zero According to Age Group

		Age < 65 yr		65 ≤ age < 80 yr		Age ≥ 80 yr	
		Ratio (95% CI)	*p*-value	Ratio (95% CI)	*p*-value	Ratio (95% CI)	*p*-value
Direct medical expenses of the episode							
Indication of predicted graph*	Baseline medical expense mean difference (USD)†	141.324 (76.331–261.655)	< 0.001	281.807 (176.779–449.236)	< 0.001	1,133.764 (429.735–2,991.193)	< 0.001
	Ratio of baseline medical expense difference	1.116 (0.741–1.679)	0.600	0.903 (0.740–1.101)	0.312	0.985 (0.752–1.290)	0.912
	Ratio of medical expense increase per quarter	1.011 (0.990–1.032)	0.329	1.012 (1.002–1.023)	0.026	1.027 (1.014–1.044)	0.002
	Ratio of difference in the slope of the medical expense increase‡	0.999 (0.971–1.027)	0.936	1.004 (0.991–1.018)	0.551	0.990 (0.981–1.018)	0.921
Difference in difference estimate§	1–6 mo	0.919 (0.797–1.167)	0.488	1.080 (0.955–1.222)	0.220	1.131 (1.025–1.439)	0.025
	7–12 mo	0.720 (0.521–0.995)	0.047	0.828 (0.709–0.967)	0.017	0.904 (0.724–1.152)	0.445
	13–18 mo	0.783 (0.541 –1.134)	0.196	0.866 (0.724–1.037)	0.117	0.923 (0.701–1.151)	0.396
	19–24 mo	0.667 (0.451–1.049)	0.082	0.857 (0.694–1.058)	0.152	0.987 (0.651–1.158)	0.337
	25–30 mo	0.741 (0.459–1.194)	0.218	0.851 (0.674–1.075)	0.175	1.055 (0.691–1.309)	0.760
	31–36 mo	0.731 (0.421–1.270)	0.267	0.869 (0.670–1.128)	0.291	1.093 (0.782–1.602)	0.539
Hospital LOS*							
Indication of predicted graph*	Baseline LOS mean difference (days)†	0.939 (0.327–2.695)	0.907	0.074 (0.032–0.173)	< 0.001	0.252 (0.051–1.255)	0.093
	Ratio of baseline LOS difference	0.776 (0.442–1.361)	0.376	0.669 (0.457–0.979)	0.039	0.973 (0.518 –1.828)	0.931
	Ratio of LOS increase per month	0.960 (0.934–0.988)	0.005	0.978 (0.960–0.995)	0.013	1.032 (1.002– 1.062)	0.034
	Ratio of difference in the slope of the LOS increase‡	1.015 (0.977–1.054)	0.459	1.019 (0.994–1.045)	0.132	0.993 (0.955–1.032)	0.805
Difference in difference estimate§	1–6 mo	0.816 (0.555–1.200)	0.302	0.906 (0.719–1.141)	0.399	1.231 (0.846–1.792)	0.277
	7–12 mo	0.717 (0.464–1.108)	0.135	0.676 (0.516–0.885)	0.004	1.090 (0.711–1.672)	0.692
	13–18 mo	0.716 (0.439–1.167)	0.180	0.653 (0.480–0.888)	0.007	1.009 (0.623–1.635)	0.960
	19–24 mo	0.603 (0.341–1.066)	0.082	0.657 (0.461–0.936)	0.020	1.046 (0.605–1.810)	0.872
	25–30 mo	0.589 (0.301–1.150)	0.121	0.649 (0.434–0.971)	0.035	1.146 (0.619–2.121)	0.665
	31–36 mo	0.599 (0.284–1.264)	0.179	0.613 (0.392–0.961)	0.033	1.346 (0.681–2.662)	0.393

The *p*-values < 0.05 are statically significant.
LOS: length of stay, THA: total hip arthroplasty, HA: hemiarthroplasty, CI: confidence interval, USD: U.S. dollar.
*Indication of the predicted graph: Indicators of the predicted graph for direct medical expenses and LOS, considering the increase in direct medical expenses and LOS of both groups before surgery. †Baseline medical expense difference: difference in direct medical expense and LOS between THA and HA groups at 3 years before time zero. ‡Slope difference: difference in the slope of the increase in direct medical expenses and LOS in the patients with THA and HA. §Difference in difference estimate: the ratios of direct medical expenses and LOS at each time point, considering the difference in direct medical expenses and LOS before and after time zero in THA group and the difference in direct medical expenses and LOS before and after time zero in HA group.

Table 5. Differences in Differential Changes in Medical Expense and Hospital LOS between the THA (Case Group) and Matched HA Cohorts (Control Group) before and after Time Zero According to Sex

		Male		Female	
		Ratio (95% CI)	*p*-value	Ratio (95% CI)	*p*-value
Direct medical expenses of the episode*					
Indication of predicted graph*	Baseline medical expense mean difference (USD)[†]	251.840 (164.649–385.203)	< 0.001	196.146 (133.362–240.116)	< 0.001
	Ratio of baseline medical expense difference	0.961 (0.702–1.316)	0.806	0.975 (0.870–1.243)	0.786
	Ratio of medical expense increase per quarter	1.007 (0.992–1.023)	0.373	1.018 (1.015–1.032)	0.000
	Ratio of difference in the slope of the medical expense increase[‡]	1.005 (0.984–1.027)	0.653	1.000 (0.983–1.007)	0.930
Difference in difference estimate[§]	1–6 mo	0.960 (0.800–1.152)	0.661	1.131 (1.007–1.270)	0.037
	7–12 mo	0.728 (0.572–0.928)	0.010	0.882 (0.762–1.022)	0.094
	13–18 mo	0.753 (0.568–0.998)	0.049	0.915 (0.775–1.079)	0.292
	19–24 mo	0.718 (0.522–0.987)	0.041	0.891 (0.735–1.081)	0.243
	25–30 mo	0.774 (0.543 –1.104)	0.157	0.901 (0.724–1.120)	0.347
	31–36 mo	0.726 (0.477– 1.107)	0.137	0.978 (0.769–1.243)	0.854
Hospital LOS*					
Indication of predicted graph*	Baseline LOS mean difference (day)[†]	0.384 (0.194–0.758)	0.006	0.088 (0.054–0.145)	< 0.001
	Ratio of baseline LOS difference	0.741 (0.460–1.195)	0.219	0.752 (0.527–1.072)	0.115
	Ratio of LOS increase per month	0.965 (0.944–0.987)	0.002	0.996 (0.980–1.013)	0.661
	Ratio of difference in the slope of the LOS increase[‡]	1.017 (0.984–1.050)	0.320	1.010 (0.988–1.033)	0.384
Difference in difference estimate[§]	1–6 mo	0.874 (0.634–1.205)	0.411	1.013 (0.819–1.254)	0.906
	7–12 mo	0.771 (0.534–1.114)	0.166	0.813 (0.635–1.039)	0.098
	13–18 mo	0.702 (0.460–1.070)	0.100	0.786 (0.595–1.037)	0.089
	19–24 mo	0.680 (0.419–1.103)	0.118	0.777 (0.566–1.071)	0.124
	25–30 mo	0.700 (0.404–1.213)	0.203	0.788 (0.548–1.133)	0.198
	31–36 mo	0.647 (0.350–1.196)	0.165	0.835 (0.558–1.250)	0.381

LOS: length of stay, THA: total hip arthroplasty, HA: hemiarthroplasty, CI: confidence interval, USD: U.S. dollar.
*Indication of the predicted graph: Indicators of the predicted graph for direct medical expenses and LOS, considering the increase in direct medical expenses and LOS of both groups before surgery. [†]Baseline medical expense difference: difference in direct medical expense and LOS between THA and HA groups at 3 years before time zero. [‡]Slope difference: difference in the slope of the increase in direct medical expenses and LOS in the patients with THA and HA. [§]Difference in difference estimate: the ratios of direct medical expenses and LOS at each time point, considering the difference in direct medical expenses and LOS before and after time zero in THA group and the difference in direct medical expenses and LOS before and after time zero in HA group.

THA was performed on femoral neck fracture patients in the 65 ≤ age < 80 group, hospital LOS was reduced from 7 months to 3 years after surgery compared to when HA was performed. Additionally, in male patients who underwent THA, a reduction in direct medical expenses was observed from 7 months to 2 years after surgery compared to when HA was performed.

Ravi et al.[21] conducted a study between April 2004 and March 2014 to analyze healthcare expenses for 1 year in elderly femoral neck fracture patients aged 60 years or older who underwent either HA or THA. They utilized propensity score matching to select a sample of 2,689 patients in each group. They reported that while there was no statistically significant difference in hospital expenses between the 2 groups, rehabilitation expenses and yearly total healthcare expenses were significantly lower in the THA group in comparison to the HA group. Axelrod et al.[22] analyzed the cost-effectiveness of HA or THA in femoral neck fracture patients by utilizing data on healthcare resource utilization and health-related quality of life. They analyzed that performing THA on all femoral neck fracture patients compared to HA was not cost-effective. Larranaga et al.[23] also conducted a cost-utility analysis on 5,867 patients who underwent HA or THA from 2010 to 2016, and they also reported that THA had a higher expense and higher utility. Reporting differing results from these studies may be due to differences in the expenses associated with each surgical procedure in the medical system in which the patients were included and demographic factors of the patient population. However, all of the studies analyzed medical expenses on an annual basis and did not analyze the effects of surgery at different time intervals after surgery. In addition, the cost analysis did not reflect the variation in pre-fracture medical expenses that may differ depending on the severity of the disease, even if the CCI is the same. However, in our study, we segmented the data into 6-month intervals after surgery and analyzed the expenses incurred at each time interval up to 3 years after surgery in detail. We also addressed the shortcomings of previous studies by analyzing the variation in pre-fracture medical expenses using comparative interrupted time series analysis. Our findings were similar to those of Ravi et al.[21] in that there was no difference in medical expenses between the 2 groups for the initial 6 months after surgery. However, in our study, the reduction in medical expenses in the THA group was observed from 7 to 24 months after surgery. This is thought to be influenced by 2 factors. First, the hospital LOS in the THA group was shorter than that in the HA group. Ravi et al.[21] addressed no difference in the complication rate between the groups; however, the dislocation rate within 1 year after surgery was higher in the THA group (1.7%) than in the HA group (1.0%). However, the risk of revision arthroplasty within 1 year was lower in the THA group in relation to the HA group. In our analysis, we also observed that hospital LOS was shorter for the THA group than the HA group. Secondly, it is suggested that THA had a favorable effect on functional outcomes compared to the HA group, particularly in active elderly patients, which could have an impact on their health status. Zelle et al.[24] claimed that THA could result in more favorable functional outcomes in active elderly patients, and increased activity in femoral neck fracture patients could be effective in preventing complications such as pneumonia, psoas abscess, and thromboembolic events. This is also one of the reasons why the hospital LOS for THA patients may be shorter than that for HA patients. Therefore, when performing THA on femoral neck fracture patients, we believe that the possibility of survival for more than 2 years should be considered from the perspective of medical expense and medical utilization. However, additional research seems necessary to develop a tool that can predict a patient's survival period.

There are several available options for the surgical treatment of femoral neck fractures, including internal fixation, HA, and THA.[25] There appears to be some consensus that internal fixation should be performed in young patients or for nondisplaced fractures, while HA is preferred for elderly patients with limited physical activity. However, it is still unclear whether to choose HA or THA for patients over the age of 60 years. Guyen[25] argues that in self-sufficient, physically active patients, THA has better functional outcomes and a lower risk of revision surgery compared to HA. Zelle et al.[24] also argue that in selected elderly patients who are active, THA may attain favorable early functional outcomes than HA. Studies analyzing cost-effectiveness have also reported similar results. Axelrod et al.[22] reported that compared to HA, THA in all femoral neck fracture patients was not cost-effective, but THA in the subgroup analysis for patients under the age of 73 years was more cost-effective than HA. Larranaga et al.[23] conducted a cost-utility analysis on 5,867 patients who underwent HA or THA from 2010 to 2016. They performed subgroup analyses based on the American Society of Anesthesiologists physical status (ASA) class and age and reported that THA was not cost-effective for 80 years and older patients with ASA class III-IV, while it was more cost-effective compared to HA for younger patients. Our subgroup analysis yielded similar results, showing that hospital LOS was significantly shorter in the THA group compared to the HA group for patients aged 65 to 80 years. We believe that THA in younger femoral neck fracture patients may prevent complications such as pneumonia, psoas, and thromboembolic events and reduce hospital LOS, but THA did not show a significant effect in patients under 65 years of age due to the characteristics of interrupted time series analysis. The medical expenses during the quarter when surgical treatment was performed increased suddenly compared to the medical expenses before the occurrence of the fracture, and this could potentially impact the analysis of later medical expenses. Generally, male hip fracture patients have higher morbidity and mortality rates than females.[26] Mizrahi et al.[27] reported that functional scores were higher in females than in males, while Kempen et al.[28] claimed that pre-injury level was the determining factor for functional recovery, and gender differences did not influence short-term functional results. They also argued that male patients showed better recovery than females after 1 year, as females had more disabling conditions and diseases such as arthritis and migraine headaches, and fall-related injuries may induce depressive symptoms that could affect functional recovery. Our subgroup analysis showed that THA in male patients reduced direct medical expenses for 7–24 months after surgery compared to the HA group, but there was no expense reduction observed in females. We believe that THA may help in functional recovery for male femoral neck fracture patients, as Kempen et al.[28] suggested, leading to a decrease in medical expenses. Therefore, we believe that THA may be recommended over HA for active and healthy patients under 80 years old, especially male patients with femoral neck fractures.

There are several limitations in our study. First, diagnostic codes may not accurately reflect the patient's disease status, since it is a fundamental limitation of the insurance database. Nevertheless, we can assume that the incidence of femoral neck fractures is relatively accurate since almost all hospitals implement the fee-for-service system and all surgical or other treatment procedures are claimed. Despite these limitations, the HIRA database provides a large sample size with a relatively high follow-up rate due to the nature of the national administration data. Furthermore, the HIRA database represents all population in South Korea. Thus, it reflects all the elderly femoral neck fracture patients in South Korea. Second, since this study is solely based on the South Korean database and each country has a different medical system, it is possible to have potential regional biases. Thirdly, we could not analyze the functional outcomes in cases of femoral neck fracture. Lastly, our study did not account for the differences in the indications for THA and HA performed on femoral neck fracture patients. For instance, if femoral neck fracture patients have concomitant advanced hip osteoarthritis, THA is more likely to be performed instead of HA. However, we cannot determine the presence or severity of hip osteoarthritis in our study. Nevertheless, we made efforts to overcome this limitation by adjusting for important factors in the surgical decision-making process, such as age, comorbidities, medication use, and past healthcare utilization. Consideration of this aspect is necessary when interpreting the study results.

In conclusion, when performing THA in elderly patients with femoral neck fractures, the possibility of survival for at least 2 years should be considered from the perspective of medical expense and medical utilization. Additionally, in healthy and active male femoral neck fracture patients under the age of 80 years, THA may be more recommended than HA.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGEMENTS

This study was conducted as a Joint Project on Quality Assessment Research of Health Insurance Review & Assessment Service. This study was based on data from the HIRA (research data no. M20220219833). This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant no. HI22C0494).

ORCID

Seung-Hoon Kim https://orcid.org/0000-0002-7704-6213
Suk-Yong Jang https://orcid.org/0000-0003-0558-1505
Yonghan Cha https://orcid.org/0000-0002-7616-6694
Bo-Yeon Kim https://orcid.org/0000-0003-0921-2352
Hyo-Jung Lee https://orcid.org/0000-0002-0131-5771
Gui-Ok Kim https://orcid.org/0000-0002-5509-4943

REFERENCES

1. Peng L, Liu H, Hu X, Liu J. Hemiarthroplasty versus total hip arthroplasty for displaced femoral neck fracture in patients older than 80 years: a randomized trial protocol. Medicine (Baltimore). 2020;99(50):e23530.
2. Lu Y, Uppal HS. Hip fractures: relevant anatomy, classification, and biomechanics of fracture and fixation. Geriatr Orthop Surg Rehabil. 2019;10:2151459319859139.
3. Schiavi P, Pogliacomi F, Colombo M, Amarossi A, Ceccarelli F, Vaienti E. Acetabular erosion following bipolar hemiarthroplasty: a role for the size of femoral head? Injury. 2019;

50 Suppl 4:S21-5.

4. Chammout G, Kelly-Pettersson P, Hedbeck CJ, Stark A, Mukka S, Skoldenberg O. HOPE-trial: hemiarthroplasty compared with total hip arthroplasty for displaced femoral neck fractures in octogenarians: a randomized controlled trial. JB JS Open Access. 2019;4(2):e0059.

5. Ekhtiari S, Gormley J, Axelrod DE, Devji T, Bhandari M, Guyatt GH. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fracture: a systematic review and meta-analysis of randomized controlled trials. J Bone Joint Surg Am. 2020;102(18):1638-45.

6. Judge A, Metcalfe D, Whitehouse MR, Parsons N, Costa M. Total hip arthroplasty versus hemiarthroplasty for intracapsular hip fracture. Bone Joint J. 2020;102(6):658-60.

7. Walker LC, Lee LH, Webb M, et al. Provision of total hip replacement for displaced intracapsular hip fracture and the outcomes: audit of local practice based on NICE guidelines. Hip Int. 2016;26(2):153-7.

8. Chesser TJ, Handley R, Swift C. New NICE guideline to improve outcomes for hip fracture patients. Injury. 2011;42(8): 727-9.

9. Carroll C, Stevenson M, Scope A, Evans P, Buckley S. Hemiarthroplasty and total hip arthroplasty for treating primary intracapsular fracture of the hip: a systematic review and cost-effectiveness analysis. Health Technol Assess. 2011; 15(36):1-74.

10. Health Insurance Review and Assessment Service (HIRA). HIRA bigdata open portal [Internet]. HIRA; 2023 [cited 2023 Oct 25]. Available from: https://opendata.hira.or.kr/home.do

11. Lee YK, Ha YC, Choi HJ, et al. Bisphosphonate use and subsequent hip fracture in South Korea. Osteoporos Int. 2013; 24(11):2887-92.

12. Jang SY, Cha YH, Mun YS, Kim SH, Kim HY, Choy WS. Acute cholecystitis in elderly patients after hip fracture: a nationwide cohort study. J Korean Med Sci. 2019;34(5):e36.

13. Jang SY, Lee JW, Kim KJ, Kim HY, Choy WS, Cha Y. Comparative interrupted time series analysis of long-term direct medical costs in patients with hip fractures and a matched cohort: a large-database study. Clin Orthop Relat Res. 2022; 480(5):891-902.

14. Li YP, Propert KJ, Rosenbaum PR. Balanced risk set matching. J Am Stat Assoc. 2001;96(455):870-82.

15. Lu B. Propensity score matching with time-dependent covariates. Biometrics. 2005;61(3):721-8.

16. Andersen LW, Granfeldt A, Callaway CW, et al. Association between tracheal intubation during adult in-hospital cardiac arrest and survival. JAMA. 2017;317(5):494-506.

17. Suissa S, Moodie EE, Dell'Aniello S. Prevalent new-user cohort designs for comparative drug effect studies by time-conditional propensity scores. Pharmacoepidemiol Drug Saf. 2017;26(4):459-68.

18. Jang SY, Rou WS, Kim SH, Lee BS, Eun HS. Association between new-onset liver cirrhosis and suicide risk in South Korea: a nationwide cohort study. Clin Mol Hepatol. 2021; 27(2):283-94.

19. Haukoos JS, Lewis RJ. The propensity score. JAMA. 2015; 314(15):1637-8.

20. Quan H, Li B, Couris CM, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol. 2011;173(6):676-82.

21. Ravi B, Pincus D, Khan H, Wasserstein D, Jenkinson R, Kreder HJ. Comparing complications and costs of total hip arthroplasty and hemiarthroplasty for femoral neck fractures: a propensity score-matched, population-based study. J Bone Joint Surg Am. 2019;101(7):572-9.

22. Axelrod D, Tarride JE, Ekhtiari S, et al. Is total hip arthroplasty a cost-effective option for management of displaced femoral neck fractures?: a trial-based analysis of the HEALTH Study. J Orthop Trauma. 2020;34 Suppl 3:S37-41.

23. Larranaga I, Etxebarria-Foronda I, Ibarrondo O, Gorostiza A, Ojeda-Thies C, Martinez-Llorente JM. Stratified cost-utility analysis of total hip arthroplasty in displaced femoral neck fracture. Gac Sanit. 2022;36(1):12-8.

24. Zelle BA, Salazar LM, Howard SL, Parikh K, Pape HC. Surgical treatment options for femoral neck fractures in the elderly. Int Orthop. 2022;46(5):1111-22.

25. Guyen O. Hemiarthroplasty or total hip arthroplasty in recent femoral neck fractures? Orthop Traumatol Surg Res. 2019;105(1S):S95-101.

26. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. JAMA. 2009;302(14):1573-9.

27. Mizrahi EH, Arad M, Fleissig Y, Adunsky A. Gender differences in functional outcome of elderly hip fracture patients. Geriatr Gerontol Int. 2014;14(4):845-50.

28. Kempen GI, Sanderman R, Scaf-Klomp W, Ormel J. Gender differences in recovery from injuries to the extremities in older persons: a prospective study. Disabil Rehabil. 2003; 25(15):827-32.