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ORTHOPAEDIC SURGERY

# Reoperation rate, mortality and ambulatory ability after internal fixation versus hemiarthroplasty for unstable intertrochanteric fractures in elderly patients: a study on Korean Hip Fracture Registry

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## Abstract

**Introduction** The treatment of unstable intertrochanteric fracture in elderly patients is challenging and how to treat these patients remains controversial. The purposes of this study were to compare (1) reoperation rate, (2) mortality and (3) the postoperative change of walking ability between patients undergoing internal fixation (IF) and those undergoing bipolar hemiarthroplasty (HA) due to this type of fracture based on the data from the Korean Hip Fracture Registry.

**Materials and methods** Between July 2014 and June 2016, we extracted 623 unstable intertrochanteric fractures (616 patients aged ≥ 65 years) according to the classification of the Association for the Study of Internal Fixation-American Orthopaedic Trauma Association. Among the 564 patients, 396 were treated with IF (IF group) and 168 with bipolar HA (HA group). We compared the reoperation rate and mortality between IF group and HA group. In patients, who were followed up more than 2 years after the surgery, we compared the postoperative change of walking activity from ambulatory outdoors (Koval's grade 1, 2, 3) to housebound (Koval's grade 4, 5, 6).

**Results** The rate of reoperation was higher in the IF group (24/396, 6.1%) than in the HA (4/168, 2.4%) ($p = 0.046$). At the final follow-up, 79 (35.7%) of the 221 IF patients became housebound, whereas 21 (23.3%) of the 90 HA patients became housebound ($p = 0.022$).

**Conclusion** This study showed HA was associated with lower rate of reoperation and lower decrement rate of walking ability compared to IF in elderly patients with unstable intertrochanteric fractures.

**Keywords** Hip · Unstable intertrochanteric fracture · Internal fixation · Bipolar hemiarthroplasty · Reoperation · Mortality

## Introduction

The number and incidence of hip fractures in elderly population are increasing worldwide [1–3]. The treatment of hip fractures in the elderly is challenging and technically demanding, due to underlying comorbidities and poor bone quality [4, 5]. Among the elderly hip fractures, unstable intertrochanteric fractures are difficult to manage because they are often comminuted and severely displaced. Internal fixation (IF) of these fractures is associated with high failure rates due to nonunion, metal failure or femoral head perforation of fixating screw [6–8].

Arthroplasty enables early ambulation and rapid rehabilitation in hip fracture patients [9]. In displaced femoral neck fractures of elderly patients, primary arthroplasty reportedly has better results than IF in terms of the need for reoperation, functional outcomes, and mortality [7, 10].

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However, the role of arthroplasty in patients with unstable intertrochanteric fractures remains controversial. Only a few studies have compared IF and primary arthroplasty for these types of fractures in limited number of elderly patients, and their results are inconsistent [4, 9, 11–13].

We compared cardiopulmonary complications, reoperation rate, mortality, postoperative leg length discrepancy, postoperative change of walking ability between patients undergoing IF and those undergoing bipolar hemiarthroplasty (HA) using data from the Korean Hip Fracture Registry.

## Patients and methods

### Study population

The subjects of this study were extracted from a hospital-based multicenter cohort including proximal femoral fractures in South Koreans aged ≥ 50 years. The cohort was established in July 2014, since when eligible patients had been registered from 16 university hospitals. Patients' data were collected at the central office using the Korea National Institute of Health web-based system (Internet-based Clinical Research and Trial Management system (iCreaT, Cheongju, South Korea).

The fractures were classified according to the criteria of Association for the Study of Internal Fixation-American Orthopaedic Trauma Association (AO/OTA) [14].

The inclusion criteria of this study were (1) patients who sustained unstable intertrochanteric fractures due to low-energy trauma [15], (2) those who were operated with either IF or bipolar HA, and (3) those who were aged 65 years or more at the time of surgery. The exclusion criteria were (1) patients with metabolic bone diseases, (2) those with pathological fractures, (3) those who had previous hip surgery or trauma on either ipsilateral or contralateral hip, (4) those who had been treated with anticoagulants, and (5) those who underwent total hip arthroplasty. Surgeons considered fracture type, patient's age, activity level before the injury, presence of osteoporosis and underlying comorbidities, when they chose the type of operation.

This study was performed in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). Approval for the study was obtained from the concerned Institutional Review Board at each study site. Patients were informed that their medical data would be used for scientific studies, and written informed consent was obtained from all patients.

We identified 2012 fractures of the proximal femur in 1930 patients, who were operated during the enrolment periods and aged ≥ 50 years at the time of surgery. Among them 616 patients (623 fractures) met the inclusion criteria. Of the 616 patients, four patients (4 fractures) with metabolic bone disease; one patient with osteogenesis imperfect, one with Paget disease, and two patients with fibrous dysplasia were excluded. Twenty-five patients (32 fractures), who had previous hip fracture or surgery on ipsilateral side or contralateral side. Sixteen patients (16 fractures), who had been treated with anticoagulants were excluded, because the use of anticoagulants have been known to be associated with a risk of bleeding, a need of blood transfusion and a high first-year mortality. The anticoagulant use might act as a confounding factor in the evaluation of hip fracture surgery [16]. Seven patients (7 fractures), who were treated with total hip arthroplasty, were excluded. Fifty-seven patients, who took aspirin or other antiplatelet medications before the trauma, were not excluded, because their medications were discontinued 3–7 days before the surgery.

This left 564 elderly patients (564 unstable intertrochanteric fractures), who were subjects of this study. Among them, 396 were treated with IF; intramedullary nailing in 360 patients and dynamic hip screw fixation in 36 patients. The remaining 168 patients underwent cementless bipolar HA (Fig. 1).

All patients underwent Dual Energy X-ray Absorptiometry (DEXA) before the operation.

In IF group, 158 patients had 31-A2.1 fracture type, 140 had a 31-A2.2, 53 had a 31-A2.3, 7 had a 31-A3.1, 13 had a 31-A3.2 and 25 had a 31-A3.3. In HA group, 25 patients had 31-A2.1 fracture type, 67 had a 31-A2.2, 49 had a 31-A2.3, 6 had a 31-A3.1, 11 had a 31-A3.2 and 10 had a 31-A3.3 according to AO/OTA classification (Table 1).

In HA patients, we exclusively used cementless stems. After the insertion of stem into the femoral canal, trochanteric fragments were reduced and fixed with two vertical wires and one transverse wire according to the technique of Lee et al. (Fig. 2) [5].

In both HA and IF groups, patients were encouraged to walk using assistive devices; walker or crutches from the second postoperative day. We recommended to use assistive devices for 1 month in HA patients and 2 months in IF patients.

The occurrence of symptomatic VTE after hip fracture surgery is rare in East Asian patients even without any thromboprophylaxis [17–19]. Thus, intermittent pneumatic compression was used for prophylaxis of VTE in all patients [20, 21]. Only patients, who had risk factors for VTE, were medicated with thromboprophylactic agents.

We compared major outcomes: perioperative cardiopulmonary complications, reoperation rate, mortality and postoperative change of walking ability. We also compared minor outcomes: operative time, estimated blood loss, intra- and post-operative transfusion, length of hospital stay, and postoperative leg length discrepancy.

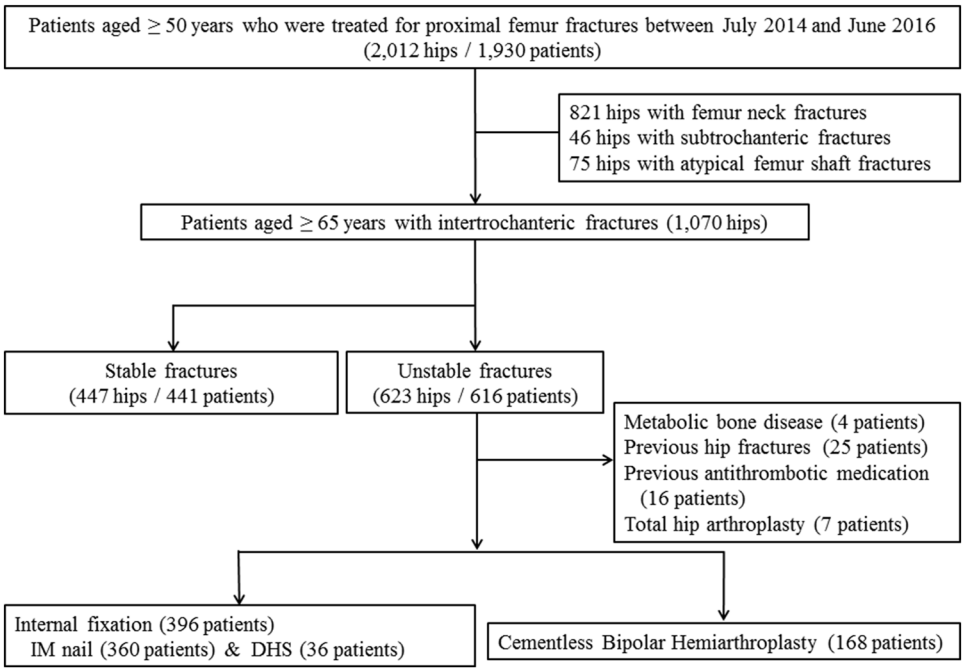


**Fig. 1** Flow chart to identify elderly patients with unstable intertrochanteric factures among Korean Hip Fracture Registry

**Table 1** AO/OTA classification and surgical methods of 564 unstable intertrochanteric fractures

| AO/OTA classification | IF group (396 hips) (%) | HA group (168 hips) (%) |
|---|---|---|
| 31-A2.1 | 158 (39.9) | 25 (14.9) |
| 31-A2.2 | 140 (35.4) | 67 (39.9) |
| 31-A2.3 | 53 (13.4) | 49 (29.2) |
| 31-A3.1 | 7 (1.8) | 6 (3.6) |
| 31-A3.2 | 13 (3.3) | 11 (6.5) |
| 31-A3.3 | 25 (6.3) | 10 (5.9) |

*AO/OTA* Association for the Study of Internal Fixation-American Orthopaedic Trauma Association, *IF* internal fixation, *HA* hemiarthroplasty

After the operation, clinical signs of pulmonary embolism (PE) were routinely monitored. A diagnosis of PE was made by a ventilation/perfusion scan or pulmonary CT angiography.

Routine follow-up visit were scheduled for 6 weeks, 3, 6, 9 and 12 months, and every year thereafter. Patients, who did not attend follow-up appointment, were contacted by telephone and clinical information was collected by doctors or nurses at each hospital. A systemic search for death certificate was conducted at the National Statistical Office for patients who did not return to follow-up.

Mortality status was identified using hospital records and/or by interviewing with patient's family. A search for death certificate at the National Statistical Office was conducted

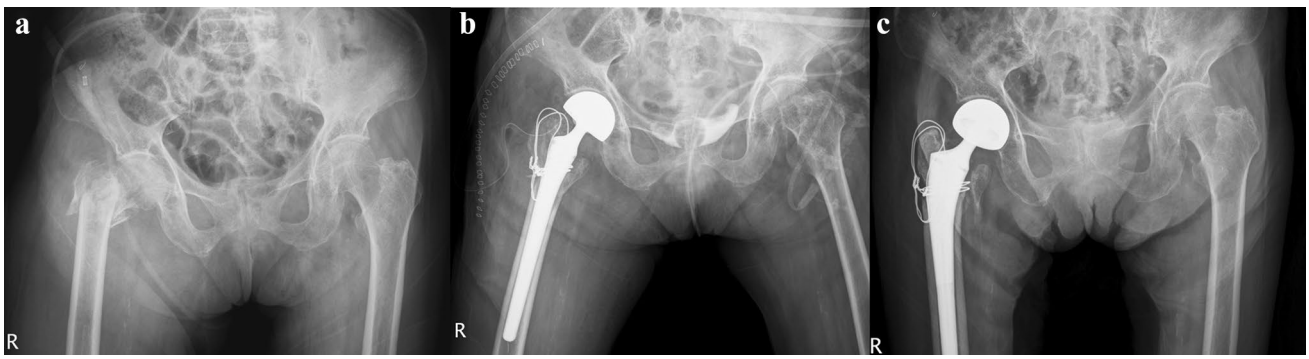


**Fig. 2** An 89-year-old woman had right hip pain after fall down injury. **a** Radiograph shows comminuted intertrochanteric fracture, **b** she underwent bipolar hemiarthroplasty, **c** three-year follow-up radiograph shows well-fixed femoral stem

for patients, who were lost to follow-up [22]. The mortality was measured at postoperative 30 days, 3 months, 1 year and 2 years.

Postoperative changes of walking ability were evaluated at minimum of 2 years after the surgery using Koval's grades [23] by interviewing patients or their family members. The ambulatory levels were categories into ambulatory outdoors (Koval's grade 1, 2, 3) and housebound (Koval's grade 4, 5, 6). We identified patients, who had a postoperative decrement of walking activity from ambulatory outdoors to housebound.

To evaluate limb length discrepancy, the distance between the inter-teardrop line and the lower margin of the lesser trochanter was measured on radiographs. This distance was compared between the operated and the contralateral limbs. A difference $\geq 1$ cm was defined as failure of leg length equalization.

Radiographs were taken before and immediately after surgery, and at the time of each visit. Two independent observers, who did not participate in the index operation, reviewed to assess nonunion, perforation of a screw or blade, sliding of screw or blade, periprosthetic fractures and stem loosening.

### Statistical analysis

All database management and statistical analyses were performed using the SPSS software version 22.0 (IBM Corp., Armonk, NY, USA). We used the independent *t* test for continuous variables, and the Chi square test or the Fisher's exact test for categorical variables. $p$ values $< 0.05$ were considered statistically significant.

## Results

Patients' demographics, comorbidities on the basis of the modified Charlson's comorbidity index [24], ASA score [25], time interval between the trauma and surgery, type of anesthesia, length of hospital stay, limb length discrepancy and follow-up period are presented in Table 2.

There were 412 women and 152 men, and their mean age at the time of surgery was 81.3 years (65–102). The mean body mass index was 22.0 kg/m$^2$ (12.4–37.2), and 382 patients; 250 IF patients and 132 HA patients had osteoporosis on the preoperative DEXA. Among them, 133 IF patients (133/250, 53.2%) and 67 HA patients (67/132, 50.8%) were treated with antiosteoporotic medications; 108 IF patients and 37 HA patients with bisphosphonate, 25 IF patients and 22 HA patients with selective estrogen receptor modulator (SERM), and 8 HA patients with recombinant parathyroid hormone after the operation.

The interval between the trauma and the operation was 3.1 days (1–33) (Table 2).

The mean age of HA patients 83.0 years (65–102) were higher than that of IF patients 79.5 years (65–102) ($p < 0.001$). Osteoporosis ($T$ score $\leq -2.5$) was more frequent in HA patients (132/168, 78.6%) than in IF patients (250/396, 63.1%) ($p < 0.001$).

The proportion of ambulatory outdoors before the trauma was higher in IF group (86.4%) than in HA group (69.6%) ($p < 0.001$).

Time interval between the trauma and surgery of IF patients (mean 3.5 days, 1–33) was longer than that of HA patients (mean 2.6 days, 1–21) ($p = 0.006$). Estimated blood loss was larger in the HA patients 296.3 ml (50–1200) than in the IF patients 228.4 ml (10–1560) ($p = 0.001$). The length of hospital stay was not different between the two groups (Table 2).

Three (0.8%, 3/396) IF patients and one (0.6%, 1/168) HA patient had symptomatic pulmonary embolism ($p = 0.204$) within 3 weeks after the surgery. The embolism was fatal in two patients. Myocardial infarction occurred in two (0.5%, 2/396) IF patients and one (0.6%, 1/168) HA patient ($p = 0.517$). None of the three died during the admission.

One hundred and forty patients (83.3%) in the HA group and 208 patients (52.5%) in the IF group started ambulation with a walker or crutches within 7 days after surgery ($p < 0.001$).

Reoperation rate was 6.1% (24/396 hips) in the IF group and 2.4% (4/168 hips) in the HA group ($p < 0.05$). In the IF group, eight patients underwent conversion hip arthroplasty due to nonunion, 11 patients due to cut-out or cut-through of lag screw. Three patients underwent a nail change due to nonunion, and one patient due to metal fracture. One patient underwent debridement due to infection. In the HA group, two patients underwent two-staged revision due to infection, and two patients underwent stem revision due to periprosthetic fractures.

Two-year mortality rates (65/396; 16.4% in the IF group and 28/168; 16.7% in the HA group) were similar between the two groups ($p = 0.515$).

In the IF group, eight patients died within 30 days, 14 patients within 90 days, 17 patients between 90 days and 1 year, and 26 patients between 1 and 2 years. In the HA group, six patients died within 30 days, three patients within 90 days, five patients between 90 days and 1 year, and 14 patients between 1 year and 2 years (Fig. 3).

The limb length discrepancy was not different between the two groups (Table 2).

Based on the search for death certificate, 331 IF patients and 140 HA patients survived longer than 2 years after the surgery.

**Table 2** Demographics, length of hospital stay, limb length discrepancy and follow-up period of 564 patients with unstable intertrochanteric fractures

| Parameters | IF group (396 hips) | HA group (168 hips) | *p* value |
|---|---|---|---|
| Sex (female:male) | 276 (67.8%):120 (30.3%) | 136 (81.0%):32 (19.0%): | 0.003 |
| Age (years) | 79.5 (65–102) | 83.0 (65–102) | < 0.001 |
| BMI (kg/m$^2$ ) | 22.0 (12.4–33.9) | 21.9 (12.5–37.2) | 0.739 |
| Side (right:left) | 193 (48.7%):203 (51.3%) | 76 (45.2%):92 (54.8%) | 0.252 |
| Number of comorbidities[a] | | | 0.553 |
| 0 | 189 (47.7%) | 80 (47.6%) | |
| 1 | 136 (34.3%) | 64 (38.1%) | |
| 2 | 53 (13.4%) | 21 (12.5%) | |
| ≥ 3 | 18 (4.6%) | 3 (1.8%) | |
| BMD (*T* score) | | | < 0.001 |
| Normal/osteopenia | 146 (36.9%) | 36 (21.4%) | |
| Osteoporosis (*T* score ≤ − 2.5) | 250 (63.1%) | 132 (78.6%) | |
| Prefracture walking ability | | | |
| A (Koval's grade I–III) | 342 (86.4%) | 117 (69.6%) | < 0.001 |
| B (Koval's grade IV–VII) | 54 (13.6%) | 51 (30.4%) | |
| ASA class | | | |
| A (ASA 1 and 2) | 192 (48.5%) | 97 (57.7%) | 0.027 |
| B (ASA 3 and 4) | 204 (51.5%) | 71 (42.3%) | |
| Type of anesthesia | | | |
| Regional | 247 (62.4%) | 130 (77.4%) | < 0.001 |
| General | 149 (37.6%) | 38 (22.6%) | |
| Interval between trauma and surgery (days) | 3.5 (1–33) | 2.6 (1–21) | 0.006 |
| Operation time (min) | 73.6 (20–365) | 78.6 (30–285) | 0.071 |
| Estimated blood loss (ml) | 228.4 (10–1560) | 296.3 (50–1200) | 0.001 |
| Amount of transfusion (ml) | 339.3 (0–1200) | 429.2 (0–1120) | 0.143 |
| Hospital stay (days) | 21.3 (1–94) | 22.4 (2–85) | 0.559 |
| Limb length discrepancy (cm) | − 0.2 (− 0.9 to 0.8) | − 0.1 (− 0.8 to 0.8) | 0.196 |
| Follow-up period (months) | 29.4 (1–39) | 27.8 (1–38) | 0.073 |

*IF* internal fixation, *HA* bipolar hemiarthroplasty, *BMD* bone marrow density, *ASA score* American Society of Anesthesiologists score, *BMI* body mass index

[a]Charlson comorbidity index

Seventy-seven IF patients and 37 HA patients did not return for follow-up 2 years after the surgery. Of them, 32 IF patients and 15 HA patients were contacted by telephone.

Thus, 286 IF patients and 118 HA patients were followed for more than 2 years (mean 29.4 months; range 24–39 months). Among them, 221 patients in IF group and 90 patients in HA group were ambulatory outdoors before the trauma. At the final follow-up, 79 (35.7%) of the 221 IF patients became housebound, whereas 21 (23.3%) of the 90 HA patients became housebound ($p = 0.022$) (Table 3).

## Discussions

Two major surgical options of unstable intertrochanteric fractures in elderly patients are IF and HA, and it remains controversial which one is superior among the two. In our registry study, HA resulted in lower rate of reoperation and lower impairment of ambulatory ability compared with IF.

In elderly patients, reoperation should be avoided whenever possible, because they have high risk of mortality, morbidity and functional decrement after repeated operation [9, 11–13]. In our study, reoperation rate of IF group was higher than that of HA group. This finding is consistent with results from previous studies (Table 4). Intertrochanteric fractures, whatever their type, have been treated with internal fixation, and arthroplasty was a relatively unusual option. However, recent studies reported comparable or better results of HA compared to IF in unstable intertrochanteric fractures [9, 12]. Based on evidences of these studies, we treated 29.8% (168/396) of our patients with bipolar HA.

In previous studies, reoperation rate after IF was higher than that after hip arthroplasty in elderly patients with unstable trochanteric fractures. Bonnevialle et al. [12] compared osteosynthesis with use of nail ($n = 113$) to hip arthroplasty

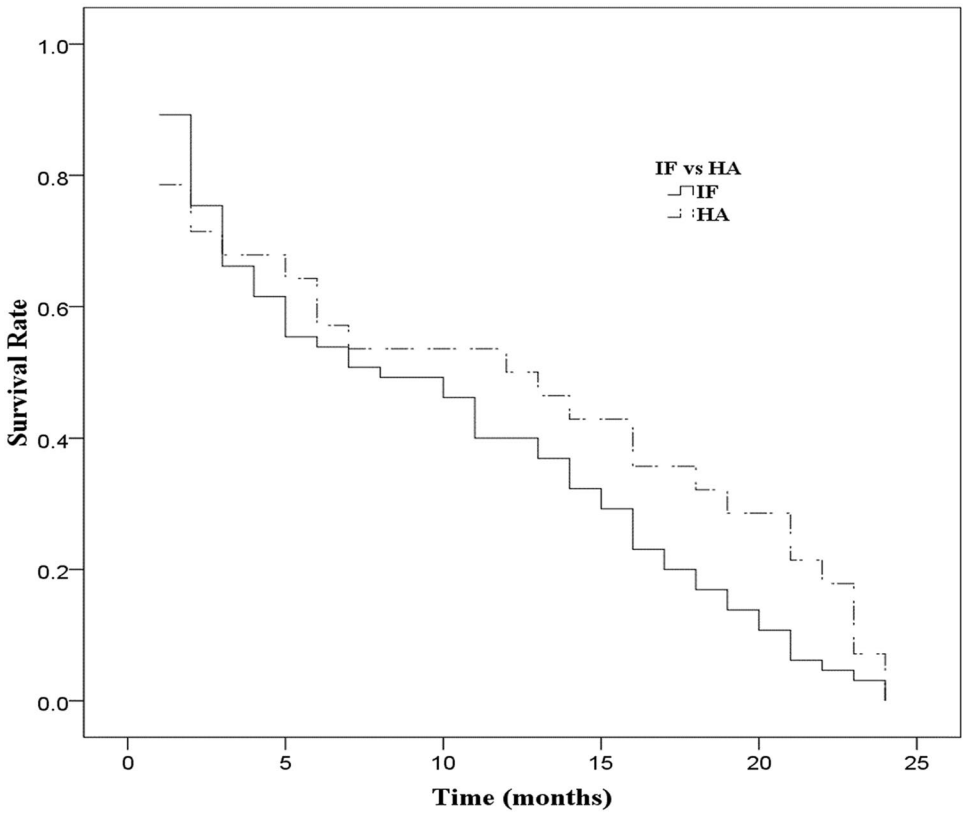


**Fig. 3** Kaplan–Meier survival curve at 24 months with death as the endpoint

**Table 3** Change of ambulatory levels in 471 patients who were followed for more than 2 years

| Parameters | IF group (286 hips) | BHA group (118 hips) | *p* value |
|---|---|---|---|
| Preinjury activity | | | 0.125 |
| Koval's group A | 221 (77.3%) | 90 (76.3%) | |
| Koval's group B | 65 (22.7%) | 28 (23.7%) | |
| Activity at final follow-up | | | 0.108 |
| Koval's group A | 144 (50.3%) | 69 (58.5%) | |
| Koval's group B | 142 (49.7%) | 49 (41.5%) | |
| Number of patients with decreased activity | 79 (35.7%) | 21 (23.3%) | 0.022 |

*IF* internal fixation, *HA* hemiarthroplasty

**Table 4** Studies on the rates of reoperation and mortality after internal fixation and bipolar hemiarthroplasty in patients with unstable intertrochanteric fractures

| Study | Cases (IF/HA) | Minimum follow-up | Reoperation rate (IF/HA) | Mortality rate (IF/HA) |
|---|---|---|---|---|
| Shen et al. [4] | 64/60 | 2 years | Not mentioned/3.3% | 7.8%/5% |
| Bonnevialle et al. [12] | 113/134 | 6 months | 5.3%/2.2% | 26.9%/26.4% |
| Kayali et al. [13] | 45/42 | 6 months | 13.3%/0% | 16%/24% |
| Kim et al. [11] | 29/29 | 2 years | 3.4%/0% | 13.7%/27.5% |
| Current study | 396/168 | 2 years | 6.1%/2.4% | 16.4%/16.7% |

*IF* internal fixation, *HA* bipolar hemiarthroplasty

($n = 134$) in 247 patients aged > 75 years and reoperation rate was higher in the nailing groups (5.3% vs. 2.2%). Kayali et al. [13] compared 32 HA patients and 38 IF patients and the reoperation rate was 13.3% in the IF patients, while no HA patients underwent revision at a minimum 6-month follow-up. Kim et al. [11] conducted a randomized clinical trial on 58 elderly patients with unstable intertrochanteric fractures and the reoperation rate was 3.4% in the IF group, while none of the HA patients necessitated reoperation over minimum 2-year follow-up. In our study, 11 IF patients (2.8%, 11/396) underwent conversion hip arthroplasty due to cut-out or cut-through of lag screws. The conversion rate in our patients was similar with that of a previous study by Murena et al., which reported a cut-out rate of 2.2% (18 patients) among 813 petrotrochanteric facture patients undergoing short cephalomedullary nailing [26].

Comparison of mortality rates is also important to assess outcomes of hip fracture surgeries in elderly patients because these patients have underlying comorbidities and a high mortality rate after the surgery [1, 27]. Mortality rates between IF and arthroplasty after unstable intertrochanteric fractures are not consistent across studies. In two studies, the postoperative mortality rate was higher in the arthroplasty group [11, 13]. In contrast, Shen et al. reported higher mortality in the IF group [4]. In our study, the mortality rates were similar in the two groups over a minimum of 2-year follow-up (Table 4).

The evaluation of walking ability is important to assess the functional outcome of hip fracture surgery in elderly patients, because many of them have a decrement of walking ability after the surgery. In the study of Bonnevialle et al. [12] walking ability was better in the arthroplasty group than in the nailing group. Kayali et al. [13] reported that HA patients achieved earlier mobilization than the IF patients. Yoo et al. [9] performed a meta-analysis on ten available clinical studies (2 randomized controlled trials and 8 comparative studies). They reported that arthroplasty enables early rehabilitation in patients with unstable intertrochanteric fractures. Pfeufer et al. [28] also showed that postoperative weight-bearing restriction in elderly hip fracture patients leaded to a reduction of postoperative mobility of the patient. Early rehabilitation after surgical intervention might be related with better functional outcomes, and shorter hospital stay.

It might be argued that surgeon's factor might have affected the outcome of hip surgeries. In our study, both of HAs and IFs were performed by same surgeon or surgeons at each hospital. Surgeons had 15–26 years' experience, and each of them performed more than 100 hip surgeries per year.

Lee et al. showed that bipolar HA with use of cementless stems for osteoporotic unstable intertrochanteric fractures was not associated with cement-related cardiopulmonary complications and the results were satisfactory without stem loosening [29]. Thus, our surgeons exclusively used cementless stems in our patients because they were concerned about cement-related cardiopulmonary complications.

In our study, the time to operation after the fracture was shorter in the HA group than in the IF group (2.6 days vs 3.5 days, $p = 0.006$). Although the difference was statistically significant it was less than 1 day. We note limitations of our study. We note the limitations of our study. First, our study was a retrospective review. Our patients were extracted from 16 referral hospitals. The preoperative status and preoperative ambulatory level were not similar between the two groups. The mean age [83.0 years (65–102) versus 79.5 years (65–102)], the proportion of osteoporotic patients (78.6% versus 63.1%) and the proportion of patients with Koval's grade IV–VII before the trauma (86.4% versus 69.6%) were higher in the HA group than in the IF group. Nevertheless, the revision rate and the proportion of patients, who had impaired walking ability after the operation, were lower in the HA group compared to the IF group. Second, surgeon's preference in the treatment method; IF versus HA, might have induced a selection bias. Third, various fixation devices and prostheses were used according to the surgeon's preference. However, our surgeons exclusively used cementless stems to avoid cement-related cardiopulmonary complications and previous study showed that the results of bipolar HA with use of cementless stems were satisfactory in senile patients with osteoporosis [29]. Fourth, we evaluated only Koval's grade in the evaluation of functional outcomes and other hip scores were not compared because our subjects were elderly patients.

In our study, the mortality rates of the HA group and IF group were similar. However, reoperation rate and the postoperative impairment of walking ability were lower in the HA group than in the IF group. Our results showed that HA is a safe and satisfactory option to treat unstable intertrochanteric fractures in elderly patients. To date, only a limited number of studies compared HA and IF in unstable intertrochanteric fractures of elderly patients and these studies reported conflicting results [4, 9, 12, 29]. To guide a better treatment of these challenging fractures, a large-scale randomized clinical trial is warranted.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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