Table 1 Preoperative characteristics and surgical information ($n = 74$)

OA grade[a] and deformity type	
Grade 2	3
Grade 3	41
Grade 4	23
Valgus type	3
RA	4
Diagnosis OA:RA	70:4
Femoral tibial angle (degrees)	186.3 ± 6.8 (167–201)
Range of motion of the knee (degrees)	
Flexion	118.3 ± 13.0 (80–145)
Extension	−7.9 ± 6.6 (−30 to 0)
Range of knee flexion and extension	110.9 ± 17.0 (65–135)
TKA type (PS:CR)	65:9
Tibial insert (cm)	11.1 ± 1.4 (10–15)

Data are presented as mean ± SD (range)

OA osteoarthritis, *RA* rheumatoid arthritis, *PS* posterior-stabilized, *CR* cruciate-retaining

[a] Kellgren and Lawrence grade (1–4)

Physical examinations

Preoperative and postoperative (baseline period) ROM of the knee (flexion, extension) and ankle (plantar flexion, dorsal flexion) were measured using a goniometer. All measurements were made with the patients sitting on the chair. All assessments were performed on the side that had been operated on, while for patients who had undergone bilateral TKA, we evaluated the side operated on last.

Anterior–posterior drawer test and varus–valgus stress test were performed to assess the instability of the knee on the TKA-affected side. With the patient lying supine, the examiner sat on the examination table in front of the involved knee and grasped the tibia just below the joint line of the knee. We quantify instability using a 4-point ordinal scale (0: rigid, 1: normal, 2: slightly instable, 3: more than moderately instable).

Muscle strength during knee extension on the TKA-affected side was recorded with a hand-held dynamometry (MUSCULATOR GT-10, OG Giken, Okayama, Japan).Each subject was seated in a chair with the hips flexed 90° and the relevant knee flexed to 75°[21]. The hand-held dynamometry was placed in front of facies anterior cruris and the examiner met the resistance of a 5-s maximal isometric knee extension. The measured value was divided by the subject's body weight (Nm/kg).

Hallux valgus was assessed using the Manchester scale [22]. We defined the hallux valgus on a scale from 1 (no deformity) to 4 (severe deformity).

To assess limitations of ankle mobility we used a modified Niki's method [23, 24]. This method evaluates limitation of mobility in the talocalcaneal joint (inversion and eversion). We defined "limitation" as the restriction of either inversion or eversion, and as with the other examinations, assessed it on the TKA-affected side or the side last operated on (in patients who had undergone bilateral TKA).

Kyphosis was assessed by Milne's method [25]. A 60-cm flexicurve was placed on the patient's back, with one end on the seventh cervical spine and closely applied to the midline of the back. Patients were then asked to stand as erect as possible. The level of the lumbosacral joint was marked on the flexicurve with a grease pencil, and the instrument was then laid on a piece of paper and the spinal curve was copied by running a pencil along the flexicurve. The index of kyphosis was represented by the height of the thoracic curve divided by spinal length. Kyphosis was defined as present if the index was greater than 15% [26].

Physical performance test

One-leg standing test

The one-leg standing test was performed on the leg on the TKA-affected side, and consisted of measuring the length of time a patient was able to stand on one leg. We asked patients to stand on one leg for as long as possible with arms resting by their sides. Patients who underwent bilateral TKA were assessed on the last-operated side.

10-m gait test

Patients were asked to walk 14 m at normal speed, with measurements taken only during the middle 10 m (i.e., between the 2- and 12-m points). The first and last 2 m were used to eliminate periods of acceleration and deceleration. We used a modified version of Tiedemann's method [27]. The time and steps required to walk 10 m at normal speed were assessed, and we used these to calculate gait speed (m/s) and step length (m).

Self-administered questionnaire

Japanese Knee Osteoarthritis Measure (JKOM)

Pain, limitation in mobility related to daily activity, and restriction of participation in social life and health perception were assessed with the JKOM. This measure has sufficient reliability and validity for studying clinical outcomes in Japanese people with knee OA. It consists of a visual analogue scale (VAS) and 25 questions (score range 25–125, with 125 being worst). It has shown good correlation with the Western Ontario and McMaster Universities index (WOMAC) and the Medical Outcome 36-Items Short Form (SF-36) [28].

Geriatric Depression Scale (GDS)

The GDS was administered and scored according to published procedures [29, 30]. GDS scores were interpreted as indicating no depression (GDS score ≤ 5), probable depression (GDS score >5 and ≤ 10), or definite depression (GDS score >10).

Modified Fall Efficacy Scale (MFES)

The MFES is a 14-item "balance efficacy" questionnaire that measures a person's confidence in their ability to avoid a fall during each of 14 essential, non-hazardous activities of daily living (ADLs) [31]. A higher score indicates greater independence or ability to balance (score range, 14–140, with 14 being worst). Full score means the patient has no fear of falling [32]. The MFES has been found to be internally consistent and demonstrates good test–retest reliability [33, 34].

Statistical analysis

All data are expressed as mean ± SD. Patients were classified as either "non-fallers" or "fallers" (one or more falls) based on data gathered during the prospective 6-month observation.

Differences between groups were determined using Pearson's chi-square test. The non-paired *t* test and Mann–Whitney U test were conducted to compare grading scales between non-fallers and fallers.

Both multivariate and univariate analyses were performed. Variables with a significance level of $P < 0.05$ as determined by univariate analysis were selected for multivariate analysis. Multivariate logistic regression was used to provide adjusted odds ratio estimates for associations with falls.

All data were analyzed using PASW statistical software (version 18 for Windows; SPSS Inc., Japan). For all analyses, a P value <0.05 was considered significant.

This study was approved by the local ethics committees of the Faculty of Medicine, Tottori University (No1264), and Hakuai Hospital.

Results

Of the 74 patients enrolled, 70 (94.6%) completed a 6-month prospective observation. One patient was unable to follow-up. Three patients were withdrawn from the study because contralateral TKA was performed during the study period.

Incidence of falls

Twenty-three of 70 patients (32.9%) fell during the observational period; 6 subjects fell twice each, while 4 subjects fell 3 times each. One patient sustained a dislocated shoulder and two patients had bruises and slight injuries due to falling. There were no fall-related fractures during the 6-month observational period.

Patient characteristics

Characteristics of non-fallers and fallers are presented in Table 2. There was no significant difference between the two groups except for the number of patients with eye problems, cardiac disease, and diabetes, which tended to be higher in fallers than non-fallers ($P = 0.051$, $P = 0.065$, $P = 0.058$, respectively).

Physical examinations and performance tests

Physical examination and performance test variables are presented in Table 3. Postoperative range of knee flexion (range 80–140°) was significantly lower in fallers than in non-fallers ($P = 0.016$). Six of 70 patients (8.6%) had less than 100° of knee flexion, 23 of 70 patients (32.9%) had less than 120° and more than 100° of knee flexion. 41 of 70 patients (58.6%) had more than 120° of knee flexion.

Postoperative ranges of knee flexion and extension (range 60–135°) and ankle plantar flexion (range 40–70°) were significantly lower in fallers than in non-fallers ($P = 0.037$, $P = 0.014$, respectively). Preoperative knee flexion (range 80–145°) and ankle dorsal flexion (range 5–30°) tended to be lower in fallers than non-fallers ($P = 0.055$, $P = 0.070$, respectively).

Two of 70 patients (2.9%) had more than moderate instability of the knee that had undergone TKA. 27 of 70 patients (38.6%) had hallux valgus (scale of 2–4) and 18 of 70 patients (25.7%) had limited ankle mobility. Mean index of kyphosis was 8.3 ± 3.6% (range 2–20%). There were no significant differences between the two groups in terms of preoperative range of knee extension, preoperative range of knee flexion and extension, postoperative range of knee extension, knee instability, muscle strength during knee extension, hallux valgus, degree of limitation of ankle mobility, and degree of kyphosis.

One-leg standing time (range 0–32.5 s), mean gait speed (range 0.3–1.53 s/m) and step length (0.2–0.71 m) showed no significant differences between the two groups.

Self-administered questionnaires

The results of the self-administered questionnaires (JKOM, GDS, and MFES) are presented in Table 4. 44 of 70 patients (62.9%) scored less than 50 on the JKOM (range 29–95). Based on GDS score, 21 of 70 patients (30.0%) had probable depression (GDS score >5 and ≤ 10) while 6

Table 2 Characteristics of non-fallers and fallers

	Total (n = 70)	Non-fallers (n = 47)	Fallers (n = 23)	P value
Age (years)	75.5 ± 6.0	76.2 ± 5.4	74.1 ± 6.9	0.156
Sex ratio (M:F)	(8:62)	(5:42)	(3:20)	0.766
Height (cm)	152.0 ± 7.5	152.5 ± 7.2	151.0 ± 8.3	0.435
Weight (kg)	57.4 ± 9.1	56.9 ± 8.9	58.5 ± 9.5	0.494
BMI (kg/m^2)	24.8 ± 3.2	24.4 ± 3.0	25.6 ± 3.3	0.142
TKA side				
Right (%)	31.4	31.9	30.4	0.969
Left (%)	22.9	23.4	21.7	
Bilateral (%)	45.7	44.7	47.8	
Diagnosis OA:RA	(66:4)	(44:3)	(22:1)	0.730
Mean time since surgery (month)	8.2 ± 2.7	8.1 ± 2.7	8.6 ± 2.7	0.444
Prior hip surgery (%)	4.3	2.1	8.7	0.986
Total no. of prescribed regular medications (number)	3.3 ± 2.6	3.3 ± 2.8	3.4 ± 2.5	0.843
Hearing problems (%)[a]	40.0	42.5	34.8	0.533
Eye problems (%)[a]	48.6	40.4	65.2	0.051
Complications				
Cardiac disease (%)	5.7	2.1	13.0	0.065
Diabetes (%)	11.4	6.3	21.7	0.058
Hypertension (%)	34.3	36.1	30.4	0.422
Ambulation				
Walking without device (%)	68.6	70.2	65.2	0.466
One cane (%)	30.0	29.8	30.4	
Walker (%)	1.4	0.0	4.3	

Data are mean ± SD (range)

[a] Self reported

of 70 patients (8.6%) had definite depression (GDS score >10). 45 of 70 patients (64.3%) did not achieve full scores on the MFES (range 22–140). There were no significant differences between the two groups in terms of JKOM, GDS, or MFES scores.

Multivariate logistic regression analysis

Postoperative range of knee flexion was divided into 6 groups of 10 degrees each (range 80–140°). Postoperative range of knee flexion and extension was similarly divided into 8 groups of 10 degrees each (range 60–135), and range of ankle plantar flexion was divided into 6 groups of 5 degrees each (range 40–70°).

In the multivariate analysis, postoperative range of knee flexion and ankle plantar flexion were determined to be significant risk factors (Table 5). Patients with a higher postoperative range of knee flexion were less likely to fall; a 10-degree increase significantly reduced the odds of falling during the observation period by 72.3%. Similarly, patients with a higher range of ankle plantar flexion were less likely to fall; a 5-degree increase significantly reduced the odds of falling by 40.6%.

Discussion

The present study examined for the first time the relationship between falls and physical function among elderly persons who had undergone TKA. Our prospective investigation demonstrated that 23 out of 70 elderly TKA patients fell at least once during the 6-month observation period. The incidence of falls was 32.9%, which was higher than one study's previously reported incidence range of 10–20%[35] among elderly in Japan, and another study's annual incidence of 29.3% among people between the ages of 75 and 79 [36], similar ages to the subjects in this study.

Swinkels et al. [14] examined whether or not the incidence of falls changed before and after TKA in patients with OA or RA. They found an incidence of 24.2% both before and after TKA. The authors speculated that TKA lowers fall incidence because the estimated incidence for community-dwelling elderly people was 33% and the number of falls was reduced after TKA. The annual incidence of falls among patients with RA was reported to be 50% [37], indicating that these patients are at risk. The incidence of falls among patients with OA is also speculated to be high. Levinger et al. [15] reported that 48% of

Table 3 Physical examinations and performance tests in fallers and non-fallers

	Total (n = 70)	Non-fallers (n = 47)	Fallers (n = 23)	P value
ROM of the knee (°)				
Preoperative				
Flexion	118.4 ± 13.0	120.3 ± 12.2	113.2 ± 14.0	0.055
Extension	−7.7 ± 6.6	−7.6 ± 7.3	−8.5 ± 4.6	0.561
Range of flexion and extension	110.5 ± 17.3	112.7 ± 16.9	104.7 ± 17.3	0.105
Postoperative				
Flexion	116.4 ± 15.3	119.5 ± 14.1	110.2 ± 16.1	0.016
Extension	−9.7 ± 4.6	−9.8 ± 4.4	−9.6 ± 5.0	0.850
Range of flexion and extension	106.7 ± 17.1	109.7 ± 15.9	100.6 ± 18.4	0.037
ROM of the ankle (°)				
Dorsal flexion	16.6 ± 5.1	17.3 ± 5.1	15.0 ± 4.8	0.070
Plantar flexion	57.9 ± 6.3	59.1 ± 6.1	55.2 ± 6.1	0.014
Instability (0–3; 3 = most unstable)[a]	0.9 ± 0.7	1.0 ± 0.8	0.8 ± 0.7	0.384
Muscles strengths of knee extension (Nm/kg)	2.1 ± 0.5	2.1 ± 0.5	2.1 ± 0.5	0.816
Hallux valgus (1–4; 4 = most severe)[b]	1.9 ± 1.0	2.0 ± 1.1	1.9 ± 0.9	0.867
Limitation of ankle mobility (%)[c]	25.7	25.5	26.1	0.960
Kyphosis (%)[d]	8.6	6.8	15.0	0.350
One-leg standing (s)	8.6 ± 7.7	8.9 ± 7.9	7.8 ± 7.6	0.578
10-m gait test				
Speed (m/s)	0.97 ± 0.2	0.98 ± 0.2	0.95 ± 0.2	0.612
Step length (m)	0.49 ± 0.1	0.50 ± 0.1	0.49 ± 0.1	0.686

Data are mean ± SD (range)

[a] Used 4-point ordinal scale (0 = rigid,1 = normal, 2 = slightly instable, 3 = more than moderately instable)

[b] Manchester scale (1 = no deformity, to 4 = severe deformity)

[c] ROM of talocalcaneal joint (inversion and eversion)

[d] Milne's method was used ("kyphosis" defined as an index greater than 15%)

Table 4 Self-administered questionnaires in non-fallers and fallers

	Total (n = 70)	Non-fallers (n = 47)	Fallers (n = 23)	P value
JKOM				
Total score (25–125; 125 = worst)	46.1 ± 15.9	45.5 ± 16.7	47.6 ± 14.5	0.601
VAS (0–10; 10 = worst)	1.9 ± 2.4	1.7 ± 2.4	2.2 ± 2.4	0.342
Pain (8–40; 40 = worst)	13.8 ± 5.3	13.8 ± 5.9	13.8 ± 4.1	0.985
Limitations of activity (10–50; 50 = worst)	18.6 ± 6.7	18.3 ± 6.9	19.6 ± 6.3	0.449
Restriction of participation (7–35; 35 = worst)	13.9 ± 5.6	13.7 ± 5.7	14.3 ± 5.6	0.679
GDS (0–15; 15 = worst)	4.2 ± 4.0	4.0 ± 4.2	4.8 ± 3.6	0.459
MFES (14–140; 14 = worst)	122.9 ± 24.4	123.3 ± 23.3	122.2 ± 27.1	0.874

Data are means ± SD (range)

JKOM Japanese Knee Osteoarthritis Measure, *VAS* Visual Analogue Scale, *GDS* Geriatric Depression Scale, *MFES* Modified Fall Efficacy Scale

patients fell during the year prior to TKA and another study showed that the annual incidence among elderly women with musculoskeletal pain in lower extremities was 39% [38]. Thus, although TKA may reduce the incidence of falls in patients with OA or RA, elderly people who underwent TKA are considered more likely to fall compared with healthy elderly people.

In the study by Swinkels et al. [14], subjects were surveyed using self-administered questionnaires that included the WOMAC and Activities-specific Balance Confidence (ABC) Scale before and after TKA. However, the results of these questionnaires did not demonstrate any risk factors for postoperative falls. Similarly, the results of the self-administered questionnaires in the present study, including

Table5 Selected risk factors for falls by multivariate analysis

	Odds ratio	95% IC	*P* value
Range of knee flexion (postoperative)[a]	0.277	0.088–0.869	0.028
Range of knee flexion and extension (postoperative)[b]	2.308	0.847–6.289	0.102
Range of ankle plantar flexion[c]	0.594	0.374–0.945	0.028

Variables for multivariate analysis were selected by univariate analysis using a significance level of $P < 0.05$

[a] Knee flexion categorized into 10-degree groups (80−140)

[b] Knee flexion and extension categorized into 10-degree groups (60−135)

[c] Ankle plantar flexion categorized into 5-degree groups (40−70)

the JKOM regarding ADLs, did not show any difference between fallers and non-fallers. The JKOM examines respondents' level of difficulty with daily activities due to pain at the time of the survey, while MFES measures the confidence of respondents in their ability to avoid a fall during ADLs. Nevertheless, considering the results of past studies which demonstrated inaccurate perceptions of postural stability borders among elderly people [39] and greater errors in estimated reach distance in the elderly who fell compared with those who did not fall [40], it is possible that our subjects who fell overestimated their ability to perform activities and selected the answers "no difficulty" or "I can do it" in self-administered questionnaires. Swinkels et al. [14] found that the preoperative GDS score was a risk factor for falls. In our study, although approximately 40% of subjects had either probable or definite depression, there was no difference between fallers and non-fallers. Therefore, no particular relationship between depression and falls was identified in this study.

In the present study, the occurrence of falls was prospectively examined after objectively evaluating the physical function of elderly individuals who underwent TKA. Our results showed significant differences in postoperative range of knee flexion, postoperative range of knee flexion and extension and range of ankle plantar flexion between fallers and non-fallers. Fallers demonstrated lower values in all three parameters. In addition, multivariate analysis showed that postoperative ranges of knee flexion and ankle plantar flexion were risk factors for falls among the elderly who underwent TKA.

Among activities of daily living, the motion in which limited knee flexion is most likely to cause falls is rising from a chair. Itokazu et al. [41] conducted biomechanical analyses of patients who underwent TKA to examine the relationship between knee flexion angle and the motion of rising from a chair, and showed that patients whose range of knee flexion was limited (100° or less) required higher angular velocity of the hip and higher swing velocity to lift the trunk forward than patients whose range of motion was larger. When individuals whose knee flexion is limited attempt to force themselves to rise from chairs by increasing the flexing action of the trunk and hip in order to compensate for limited knee flexion, they may fall forward or, if the center of gravity of their upper bodies does not sufficiently shift forward, lose their balance and fall backwards. These individuals may trip while ascending steps or experience difficulty in lowering their center of gravity while descending steps, leading to loss of balance and falls.

Limited knee flexion also frequently causes falls while walking. In normal walking, it is speculated that people repeat flexion and extension of their knees twice in a gait cycle with a maximum flexion angle of approximately 65° [42], while gait analysis after TKA [43] has revealed that the knee flexion angle of the swing phase is smaller than that of healthy elderly people. Therefore, patients who cannot sufficiently flex their knees while walking may trip over obstacles and fall. Moreover, crouching requires 130° or greater knee flexion [44]. Thus, these motions are difficult for elderly who have undergone TKA and have limited knee flexion, again potentially leading to loss of balance and falls.

Range of ankle plantar flexion is the most important ROM of joints during the push-off phase of the gait cycle and in ensuring the toe-off. Barak et al. [45] conducted a gait analysis of healthy elderly people in their seventies who fell during the past 6 months, and reported that their range of ankle plantar flexion during the push-off phase of the gait cycle was smaller than that of those who did not fall. Furthermore, another study showed that smaller range of ankle plantar flexion during the push-off phase leads to delayed heel-off, which is compensated for by movements including excessive ankle dorsal flexion of the foot and anteversion of the trunk in order to move forward [42]. Such compensation may disturb balance, pushing the body forward and causing falls. The small ranges of both knee flexion and ankle plantar flexion in the fallers in our study suggests that they may have joints with limited ROM throughout their bodies. We speculated that the decrease in ROM of the joints in the lower limbs, in particular, coupled with impaired motor skills, can cause falls.

One of the limitations of this study is its small sample size. However, as a result of the detailed physical examinations and performance tests we conducted on all subjects, sufficient objective data for various indices were obtained and significant risk factors for falls that are characteristic of elderly people who underwent TKA were obtained despite the small number of subjects. Another limitation is that the incidence of falls and physical function were not compared with those of any control group. Direct comparison of many of our examined variables could not be performed in this study, and we therefore compared our results with those of similar previous studies and characterized the incidence of falls among elderly individuals who had undergone TKA. In the future, this incidence should be compared with that of healthy elderly people or patients with OA or RA who have equivalent levels of physical function. In addition, comparison of physical function and studies on changes in the incidence of falls before and after TKA should also be performed.

In conclusion, this 6-month prospective study of elderly subjects who underwent TKA revealed a fall incidence of 32.9%, higher than that in elderly population in general. Reduced postoperative ranges of knee flexion and ankle plantar flexion were determined to be risk factors for falls among the elderly who underwent TKA. For patients with limited knee flexion, improvement of ROM by exercise therapy and patient education regarding the prevention of falls and fractures are considered necessary.

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The Timing of Hip Fracture Surgery and Mortality Within 1 Year

A Comparison Between the United States and Japan

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PURPOSE: This study compared patients who had hip fracture surgery in the United State and Japan, and analyzed whether the timing of surgery was related to mortality within 1 year after surgery.

METHODS: This is a retrospective observational study. Data were collected from medical records in 2 hospitals in the United States and 3 hospitals in Japan. A questionnaire was sent to patients and/or their family members about the patients' health outcomes after discharge.

RESULTS: The median length of hospital stay before surgery was 1 day in the United States and 5 days in Japan. In the United States, patients who had more number of comorbidities had longer lengths of stay before surgery. In Japan, the timing of surgery was not necessarily related to patients' conditions. Although the length of stay before surgery was longer in Japan, the mortality rate was not higher than that in the United States. After adjusting for patient factors, types of fracture, and country, there were no significant associations between the delaying surgery and higher mortality rate. On the contrary, patients who underwent surgery in 5 days or later after admission indicated better survival.

CONCLUSION: Providers should reduce unnecessary delays to surgery and they should carefully identify patients who are not suitable for early surgery.

Hip fracture is a leading cause of mortality and disability in the elderly population and results in a high rate of institutionalization and significant functional impairment across developed countries. The number of hip fractures is increasing every year because of the aging of the population (Hagino et al., 2009). The incidence of hip fracture at 80 years of age was 1,138 per 100,000 people in the United States and 642 per 100,000 people in Japan. Lifetime risk of hip fracture at 50 years of age was 15.8% in the United States and 13.6% in Japan (Kanis et al., 2002).

Surgical repair within 24 hr after admission to a hospital is recommended by The Royal College of Physicians' guidelines; however, the effect of operative delay on mortality remains controversial (Khan, Kalra, Khanna, Thiruvengada, & Parker, 2009). Some suggest that mortality is not due to the surgical delay itself, rather due to comorbidities complicating the surgical recovery. In prospective studies by Orosz et al. (2004) and Siegmeth, Gurusamy, and Parker (2005), the survival rate for patients who had surgery within 24 to 48 hr was greater than that for patients whose surgery was delayed more than 48 hr. However when, adjusting for patients' factors, such as age, gender, comorbidities, prefracture residence, and prefracture functional status, these authors concluded that mortality was caused by the medical problems that required a late surgery. The prolonged surgical delay did not increase the mortality itself. On the contrary, Shiga, Wajima, and Ohe (2008) systematically reviewed the literature and performed a meta-analysis, using published English-language reports that examined the effect of surgical delay on mortality in patients who underwent hip surgery. They concluded that operative delay beyond 48 hr after admission may increase the odds of a 30-day and a 1-year all-cause mortality significantly.

In Japan, the average length of stay (LOS) before hip fracture surgery is generally as long as 5 days (Committee for Orthopedic Treatment of the Japanese Orthopaedic Association, 2007). The mortality after hip fracture surgery, however, is not necessarily higher in Japan than in the United States (Hawkes, Wehren, Orwig, Hebel, & Magaziner, 2006; Kato et al., 2001; Koval, Chen, Aharonoff, Egol, & Zuckerman, 2004; Muraki, Yamamoto, Ishibashi, & Nakamura, 2006; Sakamoto et al., 2006). Of note is that systematic review of Shiga et al. (2008) did not include a study from Japan. Ichimura (2006) examined outcomes in Japanese patients who received surgery within 2 days versus 3–5 days after admission and reported that there were no significant differences in mortality, physical function, and residence after discharge between

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patients, thus concluding that there was no need to perform an early surgery. He selected patients whose timing of surgery was decided by the hospital's condition (operating room availability, availability of orthopaedic surgeons, etc.) and not by the patients' conditions.

The effect of delayed surgery by more than 5 days after admission is not known. Ideally, a randomized trial of early versus delayed surgery would be necessary to determine the effect of timing of surgery on mortality, but such a trial is unlikely to be done. As the LOS before surgery in Japan is exceptionally longer than that in other countries, and the timing of surgery is not always based on the patients' conditions, it is a good study population to examine the effect of timing of surgery on mortality. This study analyzed whether the timing of surgery was related to mortality within 1 year after surgery after adjusting for patients' characteristics and country. It used the same study population as an earlier study that examined the LOS after hip fracture surgery and associated mortality in the United States and Japan and found that too short a LOS after hip fracture surgery was associated with higher rates of mortality in the United States and Japan (Kondo et al., 2010).

Methods

Study Design Overview

Data were retrospectively collected from two hospitals in the United States (the number of beds ranged from 400 to 1,000) and three hospitals in Japan (the number of beds ranged from 200 to 700). Data on demographics, treatments, and health outcomes during the hospital stay were collected from the medical records. A questionnaire was sent to patients and/or their family members about the patients' health outcomes after discharge. Approvals were obtained from the institutional review board from a university in the United States and all study hospitals (Kondo et al., 2010).

Study Population

Hospitals in the United States included a university medical center and a private general community hospital in the Pacific Northwest. In Japan, one hospital was a university hospital in the mid-western area of Japan and the other two were private general community hospitals, one located in Tokyo and another in Western Island, Japan. The hospitals were selected because they were major hospitals in their local areas, which were considered to be reflective of current practice for hip fracture surgery and rehabilitation.

Inclusion criteria were patients who were 65 years or older, who had experienced hip fracture for the first time, and who were admitted to one of the five study hospitals for surgery during the study period, August 2005 to September 2007. Data were collected between the periods of October 2007 and February 2008. Exclusion criteria were hip fractures that occurred while in the hospital, patients who could not walk with or without assistance before hip fracture, hip fractures caused by metastatic cancer, or patients who had more than one fracture at the same time. These patients were excluded because their physical conditions could affect the timing of surgery and mortality.

Data Collection

In the United States, patients who were 65 years of age or older at the time of admission with an *International Statistical Classification of Diseases and Related Health Problems* (*ICD-9 CM*) code of 820.xx "Fracture of neck of femur," or 733.14 "Pathologic fracture of neck of femur" were selected. Surgical repairs of fractures were selected using the total hip replacement administrative procedure code (81.51), partial hip replacement code (81.52), or internal fixation codes (79.35, 78.55). The combination of malignant neoplasm and pathologic fracture was defined by *ICD-9 CM* codes of 170.7, 171.3, 195.5, 196.6, 198.5, 213.7, or 215.3 (malignant neoplasm) and 733.1 (pathologic fracture). Hospitals in Japan provided access to the medical records of patients who had hip fracture surgery during the study period. During the medical records review, patients were selected according to the above inclusion and exclusion criteria. The types of hip fractures were categorized into three distinct groups: (1) transcervical fracture (820.0x and 820.1x in the United States and intracapsular fracture in Japan), (2) pertrochanteric fracture (820.2x and 820.3x in the United States and extracapsular trochanteric and subtrochanteric fracture in Japan), and (3) others (unspecified part of neck of femur [820.8 and 820.9] or pathologic fracture of neck of femur [733.14]).

A letter was sent to the study patients who met the study inclusion criteria. The informed consent and surveys were sent to the billing addresses used at patients' last hospitalizations. Patients and/or their family members were asked to sign the consent form and complete and return the survey if they agreed to participate in the study. The survey asked the family member to provide the date and cause of death for patients who were already dead. This study collected data on all-cause mortality. The study patients were also asked to respond if they did not want to participate in the study, and these patients were excluded from the study. Because the response rate in the United States was very low (about 30%), follow-up telephone calls were also performed, and patients or family members were interviewed or asked to complete the survey.

Variables that were collected from medical records included patients' demographics, treatments, and outcomes during hospitalization. Patients' demographics included age, gender, comorbidities, body mass index, and date of fracture. Data about treatment variables included the dates of admission and discharge, dates and types of surgery, and amount of bleeding during surgery. Dates for outpatient visits after discharge and readmissions to the study hospitals were also reviewed to determine patients' survival or mortality.

The LOS before hip fracture surgery was calculated as the dates of surgery minus the dates of admission at the study hospitals. Data on whether patients were alive or not at 365 days after surgery were obtained from the surveys, telephone interviews, or the hospital records. *Follow-up days* were defined as days from surgery to death or the last date that the patients were known to be alive. *Comorbidities* were defined as the medical conditions that patients had prior to hip fracture surgery. The number of comorbidities was used for adjustment of patients' conditions (Feldt & Oh, 2000; Hannan et al., 2001; Koval, Friend, Aharonoff, & Zukerman, 1996) because a validated score such as American Society of Anesthesiologists physical status score was not available from medical charts in all hospitals. In this study, each comorbidity was collected using a 3-level score (0 = never had, 1 = used to have, but currently does not have, and 2 = currently has), which was considered to measure the severity of comorbid conditions more accurately than just summing the number of comorbidities. The main comorbidities included anemia, cancer, cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, heart failure, hypertension, myocardial infarction, osteoarthritis, osteoporosis, renal failure, pneumonia, rheumatoid arthritis, and others. The total score of comorbidities except dementia was calculated as a comorbidity score. Dementia was used as another independent variable.

Complications were defined as conditions that occurred during or after hip fracture surgery. Complications included anemia, urinary tract infection, delirium/dementia, deep vein thrombosis (DVT), respiratory disorders (pneumonia, pulmonary thrombosis, etc.), cardiovascular disorders (heart failure, myocardial infarction, etc.), neurological disorders (fibular nerve, sciatic nerve), problem of surgery site (infection, necrosis, dislocation, etc.), and others (gastrointestinal disorder, pressure ulcer, renal disease, etc.).

STATISTICAL ANALYSES

The SPSS version 15.0 for Windows was used for analyses (Chicago, Illinois). The LOS before surgery (continuous variable) was categorized into three groups: (1) surgery within 1 day (24 hr), (2) 2–4 days, and (3) 5 days or later after admission, and this categorical variable was called "timing of surgery." Pearson's chi-square tests or Fisher's exact tests were used to compare the categories/ratios of variables, such as gender, types of fracture, and types of surgery. Continuous variables, such as age and amount of bleeding, between two groups were compared using t tests and among three groups were compared by one-way analysis of variance. Ordinal measures, such as comorbidities and complications, were compared using Mann-Whitney U tests. The LOS was also compared using Mann-Whitney U tests because the variance of LOS between countries was significantly different. Pearson's correlation coefficients were used for the relationships of at least one continuous variable and Spearman's correlation coefficients were used for two ordinal variables.

Hospital and country-level heterogeneity was examined in patients' characteristics, the timing of surgery, and the 1-year mortality rate. Logistic regressions were used to analyze the difference in timing of surgery between hospitals and between countries after adjusting for patients' characteristics. The differences in the risk of mortality between countries and relationship between the timing of surgery and mortality after discharge from the study hospitals were tested by the Cox Proportional Hazards model. Factors that had empirical evidence or a theoretical basis to be related to mortality, and comorbidities that were related to both LOS before surgery and mortality in this population, were entered into the Cox Proportional Hazards model forcibly at the same time as covariates. The relationship between the timing of surgery and morality was examined in each country first, and then data from each country were combined and analyzed. Because this study used two kinds of hospitals (university and private general hospitals) in significantly different countries (the United States and Japan), the patients' baseline hazard can be different; therefore, the hospital or country was used as a strata variable in the Cox regression (Kleinbaum, 1996). An α level of less than .05 was considered as statistically significant.

RESPONSE TO QUESTIONNAIRE

Five hundred thirteen patients (217 patients from the three hospitals in Japan and 296 patients from the two hospitals in the United States) were selected. Of these patients, five (1.8%) in the United States and one (0.5%) in Japan died after surgery during hospitalization. In the United States, 20 patients (6.8%) refused to participate. In Japan, one patient (0.5%) refused to participate. Among patients who did not refuse to participate, 88 patients (31.9%) completed the questionnaire and 43 patients (15.6%) participated in the telephone interviews in the United States for a total response rate of 47.5%. In Japan, 149 patients (69.0%) completed the questionnaire. Most of the patients from the United States who did not participate could not be contacted by phone because the contact information was outdated. Medical records of 492 patients (276 from United States and 216 from Japan) who agreed to participate or who did not refuse to participate in the study, including patients who died during hospitalization, were reviewed. Mortality or survival data were obtained from 167 patients (60.5%) in the United States and 152 patients (70.4%) in Japan (overall 64.8%) by using survey data or their hospital records. Median follow-up days within 1 year after surgery were 156 days in the United States and 302 days in Japan ($p = .001$).

Results

FACTORS RELATED TO LENGTH OF STAY BEFORE SURGERY IN EACH COUNTRY

In the United States, the comorbidity score for patients who had surgery within 1 day after admission was significantly lower than that for patients who underwent surgery later than that ($p < .001$). Patients who had anemia ($p = .003$), angina pectoris ($p = .001$), arrhythmia ($p = .008$), cerebrovascular disease ($p = .023$), diabetes mellitus ($p = .014$), gastrointestinal disorder ($p = .025$), heart failure ($p = .003$), hypercholesterolemia ($p = .028$), hypertension ($p = .044$), pneumonia ($p = .021$), renal failure ($p = .011$), thyroid disease ($p = .041$), or ventricular heart disease ($p < .001$) as comorbidities before surgery had a significantly longer LOS before surgery. There were no significant differences in other patients' basic characteristics (see Table 1). In Japan,

TABLE 1. COMPARISON OF PATIENTS' CHARACTERISTICS

	Country					
	United States ($n = 276$)			Japan ($n = 216$)		
Timing of Surgery After Admission	Within 1 Day ($n = 213$)	2 Days or Later ($n = 63$)	p	Within 4 Days ($n = 99$)	5 Days or Later ($n = 117$)	p
Age, mean (*SD*)	82.8 (7.8)	81.5 (7.5)	.215[a]	82.1 (7.6)	82.5 (7.3)	.705[a]
Female, *n* (%)	155 (72.8)	40 (63.5)	.160[b]	80 (80.8)	94 (80.3)	1.000[b]
Body mass index, mean (*SD*)	23.3 (4.3)	25.4 (4.4)	.071[a]	20.9 (3.4)	20.4 (3.5)	.368[a]
Comorbidity score (mean rank)	124	189	<.001[c]	105	111	.444[c]
Dementia, *n* (%)	56 (26.3)	20 (31.7)	.424[b]	30 (30.3)	41 (35.0)	.472[b]
Types of fracture, *n* (%)						
Transcervical fracture	59 (27.7)	19 (30.2)	.637[d]	43 (43.4)	52 (44.4)	.876[d]
Peritrochantric fracture	83 (39.0)	27 (42.9)		40 (40.4)	49 (41.9)	
Others	71 (33.3)	17 (27.0)		16 (16.2)	16 (13.7)	

[a]Student's *t* test.
[b]Fisher's exact test.
[c]Mann-Whitney *U* test.
[d]Pearson's chi-square test.

there was no significant difference in patients' basic characteristics between patients who had surgery within 4 and 5 days or later after admission (see Table 1). There were no significant correlations between the LOS before surgery and any comorbidity. There were significant correlations between LOS before surgery and total LOS in both countries ($r = .423$, $p < .001$, in the United States, and $r = .236$, $p < .001$, in Japan).

COMPARISON OF PATIENTS' CHARACTERISTICS BETWEEN COUNTRIES

There was no difference in the average age between countries. A greater number of patients in the United States were male (29.3% vs. 19.4%, $p = .012$) or had anemia as a comorbidity compared with the patients in Japan ($p < .001$; see Table 2). The comorbidity score ($p < .001$) and body mass index ($p < .001$) were significantly higher in the United States than in Japan.

COMPARISON OF PATIENTS' CHARACTERISTICS, TIMING OF SURGERY, AND MORTALITY AMONG HOSPITALS IN EACH COUNTRY

In the United States, the comorbidity score was significantly higher and fewer patients had surgery within 1 day (55.1% vs. 81.9%, $p < .001$) in the university hospital than in the private community hospital. After adjusting for patients' characteristics, there were no significant differences in the timings of surgery between hospitals. There was no significant difference between hospitals in the proportion of patients who died within 1 year before or after adjusting for patients' characteristics between hospitals.

In Japan, patients in the university hospital were significantly younger ($p = .001$), fewer patients had anemia ($p < .001$) or dementia ($p < .001$) than patients in the private hospitals, and there was a significant difference in the types of hip fractures ($p < .001$). There was no

TABLE 2. COMPARISON OF CARE PROCESS AND OUTCOMES BETWEEN COUNTRIES

	Countries		
$N = 492$	United States ($n = 276$)	Japan ($n = 216$)	p
Days from fracture to admission, mean (*SD*)	2.0 (6.8)	1.9 (6.8)	.902[a]
Length of stay before surgery, median (range)	1 (0–11)	5 (0–19)	<.001[c]
Bleeding during surgery, mean (*SD*)	235.5 (219.5)	134.4 (267.7)	<.001[a]
Length of stay, median (range)	6 (2–83)	39 (6–233)	<.001[c]
Number of complications (mean rank)	270.5	215.9	<.001[c]
Anemia, *n* (%)	75 (27.2)	26 (12.0)	<.001[b]
Inpatient mortality, *n* (%)	5 (1.8)	1 (0.5)	.237[b]
Died within 1 year after surgery, *n* (%)	29 (10.5)	10 (4.6)	.018[b]
Follow-up days, median (range)	238 (2–365)	302 (5–365)	.001[c]

[a]Student's *t* test.
[b]Fisher's exact test.
[c]Mann-Whitney *U* test.
[d]Pearson's chi-square test.

TABLE 3. THE RELATIONSHIP BETWEEN TYPES OF FRACTURE AND SURGERY IN EACH COUNTRY[a]

	Country					
	United States (N = 276)			Japan (N = 216)		
Types of Fracture	Transcervical Fracture	Peritrochantric Fracture	Others	Transcervical Fracture	Peritrochantric Fracture	Others
Types of surgery, (%)	78	110	88	95	89	32
Internal fixation	15 (19.2)	103 (93.6)	11 (12.5)	40 (42.1)	89 (100.0)	17 (53.1)
Partial hip replacement	58 (74.4)	7 (6.4)	63 (71.6)	52 (54.7)	0 (0.0)	15 (46.9)
Total hip replacement	5 (6.4)	0 (0.0)	14 (15.9)	3 (3.2)	0 (0.0)	0 (0.0)
p		<.001			<.001	

[a]Pearson's chi-square tests.

significant difference, however, among the three hospitals in the timing of surgery or in the proportion of patients who died within 1 year after surgery.

COMPARISON OF CARE PROCESS AND OUTCOMES BETWEEN COUNTRIES

The LOS before surgery was significantly longer in Japan ($p < .001$; see Table 2). While most of the patients (90.9%) in the United States received surgery within 2 days after admission, only 14.8% of patients in Japan received surgery within 2 days ($p < .001$). There was a significant difference in the timing of surgery (within 2 days or not) between countries after adjusting for patients' age, gender, comorbidity score, dementia, and types of fracture (odds ratio = 0.014, $p < .001$). In the United States, surgeries were done as soon as patients' conditions allowed. In Japan, orthopaedic surgeries were not scheduled everyday even on weekdays. Patients who were taking anticoagulants before fractures were advised to wait for surgery for several days even though their Prothrombin Time was normal at the time of admission. On the contrary, there were no significant correlations between LOS before surgery and the amount of bleeding during surgery, number of complications, or anemia as a complication in either country.

More internal fixations were used rather than hip replacements in Japan ($p < .001$). Table 3 demonstrates the relationship between the types of fracture and surgery in each country. The amount of bleeding during surgery was higher in the United States ($p < .001$) and the amount of bleeding during surgery was higher in hip replacements than internal fixations in both countries ($p < .001$ each). The number of complications was significantly higher in the United States ($p < .001$), and the most frequent complication was anemia (27.2% for United States and 12.0% for Japan). In the United States, anticoagulants such as heparin were routinely used soon after surgery to prevent DVT. In Japan, anticoagulants were used, but only for patients whose risk of DVT was high. In both countries, compression stockings and an air-massage devices for legs were used to prevent DVT. There was no difference in the incidence of DVT after surgery between countries. The overall LOS was significantly longer in Japan ($p < .001$). The percentage of patients who were known to have died within 1 year after surgery was higher in the United States than in Japan ($p = .018$; see Table 2). There was no significant difference in the risk of mortality between countries after adjusting for patients' age, gender, comorbidity score, anemia as comorbidity, and types of fracture at an α level of .05 (hazard ratio = 2.042, $p = .065$).

FACTORS RELATED TO MORTALITY WITHIN 1 YEAR

There were no significant associations between the timing of surgery and mortality in each country and overall by bivariate analyses (see Table 4). Patient factors related to mortality within 1 year after surgery were cerebrovascular disease ($p = .021$), heart failure ($p = .002$), history of fracture of vertebra or lumber ($p = .045$), pneumonia ($p = .001$), renal failure ($p = .015$), and higher comorbidity score ($p = .005$) in the United States, and older age ($p = .026$), arrhythmia ($p = .030$), cancer ($p = .004$), chronic obstructive pulmonary disease ($p = .041$), liver disease

TABLE 4. COMPARISON OF MORTALITY WITHIN 1 YEAR AFTER SURGERY ACCORDING TO THE TIMING OF SURGERYA[a]

Timing of Surgery (Days After Admission)	Within 1 Day	2–4 Days	5 Days and Later	*p*
Patients who died, *n* (%)				
United States	19 (8.9)	9 (15.3)	1 (25.0)	.237
Japan	1 (10.0)	5 (5.6)	4 (3.4)	.538
Total	20 (9.0)	14 (9.5)	5 (4.1)	.202

[a] Pearson's chi-square tests.

TABLE 5. THE RELATIONSHIP BETWEEN TIMING OF SURGERY AND MORTALITY WITHIN 1 YEAR AFTER SURGERY IN THE UNITED STATES (STRATIFIED BY HOSPITAL)

Variable	*B*	SE	HR	95% CI for HR	*p*
Surgery at 2 days or later after admission	0.278	0.494	1.320	0.502–3.475	.574
Surgery at 5 days or later after admission	0.836	1.156	2.308	0.240–22.23	.469
Age	0.011	0.030	1.011	0.954–1.072	.703
Female gender	−0.449	0.401	0.638	0.291–1.399	.262
Peritrochantric fracture	−0.187	0.484	0.829	0.321–2.143	.699
Other types of fracture	0.032	0.485	1.033	0.399–2.671	.947
Comorbidity score	<0.001	0.047	1.000	0.912–1.098	.993
Dementia	0.253	0.236	1.288	0.811–2.047	.284
Cerebral vascular disorder	0.904	0.399	2.469	1.129–5.401	.024
Heart failure	0.693	0.261	2.001	1.199–3.338	.008
Pneumonia	0.745	0.326	2.107	1.112–3.989	.022
Renal failure	0.311	0.244	1.365	0.846–2.203	.203

Note. CI = confidence interval; HR = hazard ratio.
Cox regression, stratified by hospital.
Event 29 (10.5%), censored 245 (88.8%), cases with missing values 0.
Censored before the earliest event 2 (0.7%).
Reference variable of timing of surgery is "surgery within 1 day after admission."
Reference variable of types of surgery is "Transcervical fracture."

(p = .002), pneumonia (p = .015), renal failure (p = .039), and higher comorbidity score (p = .004) in Japan. There was no relationship between the types of fracture and mortality in either country.

The Relationship Between Timing of Surgery and Mortality Within 1 Year After Surgery

In either country, there were no significant associations between the timing of surgery and mortality after adjusting for patient factors, which was stratified by hospital (see Tables 5 and 6). There was no significant association between the timing of surgery and mortality after adjusting for patient factors in the combined data, which was stratified by country (see Table 7).

Discussion

This study examined the relationship between the timing of surgery and mortality within 1 year after hip fracture surgery in the five hospitals in the United States and Japan. The timing of surgery was significantly related to the patients' comorbid conditions in the United States. Patients with a higher comorbidity score and with severe comorbidities, such as cerebrovascular disease, heart failure, pneumonia, or renal failure, had longer LOS before hip fracture surgery and had higher mortality rates. In contrast, none of the patients' characteristics including comorbidities were related to the LOS before hip fracture surgery in Japan. The timing of surgery may have been decided because of a hospital's condition, such as the availability of the operating room, rather than the patients' conditions. In addition, early surgery tended to have higher mortality rate. Although the LOS before surgery was significantly longer in Japan, the mortality rate was not higher than that in the United States. In each country and when combined, there was no significant association between the timing of surgery and mortality after adjusting for

TABLE 6. THE RELATIONSHIP BETWEEN TIMING OF SURGERY AND MORTALITY WITHIN 1 YEAR AFTER SURGERY IN JAPAN (STRATIFIED BY HOSPITAL)

Variable	B	SE	HR	95% CI for HR	*p*
Surgery at 2 days or later after admission	−1.055	1.468	0.348	0.020–6.164	.472
Surgery at 5 days or later after admission	−0.339	0.740	0.713	0.167–3.040	.647
Age	0.140	0.069	1.150	1.004–1.318	.044
Female gender	−1.525	0.897	0.218	0.038–1.262	.089
Peritrochantric fracture	0.916	0.910	2.499	0.420–14.88	.314
Other types of fracture	1.198	1.209	3.313	0.310–35.45	.322
Comorbidity score	0.154	0.074	1.167	1.009–1.349	.037
Dementia	0.206	0.390	1.228	0.572–2.638	.598

Note. Cox regression, stratified by hospital.Event 10 (4.6%), censored 188 (87.0%), cases with missing values 0. Censored before the earliest event 18 (8.3%). Reference variable of timing of surgery is "surgery within 1 day after admission." Reference variable of types of surgery is "Transcervical fracture." HR = hazard ratio, CI = confidence interval.

TABLE 7. The Relationship Between Timing of Surgery and Mortality Within 1 Year After Surgery in Japan and the United States (Stratified by Country)

Variable	B	SE	HR	95% CI for HR	*p*
Surgery at 2 days or later after admission	0.170	0.446	1.185	0.495–2.839	.703
Surgery at 5 days or later after admission	−0.250	0.623	0.779	0.230–2.639	.688
Age	0.048	0.025	1.050	0.998–1.103	.058
Female gender	−0.550	0.346	0.577	0.293–1.138	.112
Peritrochantric fracture	0.020	0.401	1.020	0.465–2.238	.961
Other types of fracture	0.339	0.429	1.403	0.605–3.254	.430
Comorbidity score	0.007	0.035	1.007	0.941–1.078	.841
Dementia	0.177	0.192	1.194	0.820–1.738	.356
Cerebral vascular disorder	0.542	0.273	1.720	1.007–2.937	.047
Heart Failure	0.296	0.239	1.345	0.842–2.148	.215
Pneumonia	0.705	0.272	2.023	1.188–3.445	.009
Renal Failure	0.441	0.203	1.555	1.044–2.315	.030

Note. Cox regression, stratified by country. Event 39 (7.9%), censored 446 (90.7%), cases with missing values 0. Censored before the earliest event 7 (1.4%). Reference variable of timing of surgery is "surgery within 1 day after admission." Reference variable of types of surgery is "Transcervical fracture." HR = hazard ratio, CI = confidence interval.

patients' conditions. If the sample size was larger, there might have been a significant association. The hazard ratio, however, was even lower than 1 for the patients who had surgery at 5 days or later in Japan (see Table 5) and when both countries were combined (see Table 7). Therefore, the lack of difference is unlikely due to a low power to detect the difference and also it is unlikely that a delayed surgery itself caused a higher risk of mortality.

In the report by Shiga et al. (2008), more than half of the studies did not adjust for patients' conditions. Of the studies that have adjusted for patients' conditions, they all have had odds ratios of greater than 1, some of which were significant and others were not. It is not surprising that the odds ratio became significant when these data were combined and analyzed, because of the huge sample size ($n = 189{,}869$). Many studies have concluded that unnecessarily longer LOS before surgery should be reduced even though the LOS before surgery was not related to mortality. Early surgery was associated with less pain, reduced LOS, and fewer complications (Lefaivre et al., 2009; Orosz et al., 2004; Siegmeth et al., 2005). Early operation with hip fracture improved the ability of the patient to return to independent living (Al-Ani et al., 2008). In this study, however, a higher percentage of patients from Japan and from both countries when data were combined who had surgery earlier were more likely to die (see Table 4), although there was no significant association between the LOS before surgery and amount of bleeding during surgery, anemia, or the number of complications in either country. Therefore, providers should reduce unnecessary delays to surgery, but at the same time, they should carefully identify patients who are not suitable for early surgery.

In the United States, heparin was routinely used to prevent DVT soon after surgery. The rate of bleeding complications due to pharmacologic prophylaxis for DVT is very low in the United States (3%–5%; Greerts et al., 2008). Therefore, the cause for higher rates of anemia after surgery in the two U.S. hospitals is unknown. The inability to explain the causes for the higher rates of anemia in the two U.S. hospitals reflects the limitations of conducting retrospective chart reviews. Prospective studies are necessary to research the reason for higher rates of complications, especially anemia, after hip fracture surgery in the United States.

LIMITATIONS

In this study, data were collected in the United States and Japan, which have different healthcare systems. There might be confounders that could not be identified and adjusted. The sample size was small and one-third of patients were not followed until death or for 1 year, using the retrospective chart reviews and patient reports. The results about the relationship between the timing of surgery and mortality, however, were similar to those of previously reported studies (Al-Ani et al., 2008; Ichimura, 2006; Orosz et al., 2004; Siegmeth et al., 2005; Sund & Liski, 2005). The strength of this study is that it compared outcomes from patients with hip fractures between two countries that had significantly different timing of surgery.

Conclusion

This study compared outcomes from patients with hip fractures between the United States and Japan that had significantly different timing of surgery. Although the LOS before surgery was significantly longer in Japan, the mortality rate in Japan was not higher than that in the United States. There was no significant association between the timing of surgery and mortality within 1 year after surgery after adjusting for patients' conditions and country. On the contrary, delaying surgery by 5 days and longer indicated better survival. Providers should reduce unnecessary delays to surgery and they should carefully identify patients who are not suitable for early surgery.

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ORIGINAL RESEARCH

The Risk of a Second Hip Fracture in Patients after Their First Hip Fracture

Hiroshi Hagino · Takeshi Sawaguchi · Naoto Endo · Yasuyo Ito · Tetsuo Nakano · Yoshinobu Watanabe

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Abstract We investigated the incidence of additional fractures and the rate of prescription of osteoporotic pharmacotherapy after an initial hip fracture. We surveyed female patients aged 65 and over who sustained their first hip fracture between January 1, 2006, and December 31, 2007, treated at 25 hospitals in five geographic areas in Japan. Data for 1 year after the first hip fracture were collected from medical records, and questionnaires were mailed to all patients. In total, 2,663 patients were enrolled, and 335 patients were excluded based on exclusion criteria. The analysis was performed on 2,328 patients. During the 1-year follow-up period 160 fractures occurred in 153 patients and 77 subsequent hip fractures occurred in 77 patients. The incidence of all additional fractures among patients who sustained their first hip fracture was 70 (per 1,000 person-year) and that for second hip fracture was 34. In comparison to the general population, women ≥65 years of age who sustained an initial hip fracture were four times as likely to sustain an additional hip fracture. Antiosteoporosis pharmacotherapy was prescribed for 436 patients (18.7%), while 1,240 patients (53.3%) did not receive any treatment during the 1-year period. Patients who have sustained one hip fracture have a higher risk of a second hip fracture compared to the general population, and most of these women receive no pharmaceutical treatment for osteoporosis.

Keywords Hip fracture · Second hip fracture · Treatment of osteoporosis

The authors have stated that they have no conflict of interest.

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Introduction

Hip fractures are a common cause of morbidity and mortality in the elderly and are associated with considerable health expenditures in most industrialized countries. Several studies have suggested a worldwide geographic variation in the incidence of hip fractures, with the highest rates reported for northern European countries and the United States and the lowest rates reported in Africa and some Asian populations [1]. However, epidemiological information regarding the risk of sustaining subsequent hip fractures is limited compared to that of sustaining the first hip fracture as fewer studies have addressed this issue. Overall 1- and 5-year mortality rates after the first hip fracture are 15.9 and 45.4%, while rates after a second hip fracture are 24.1 and 66.5%, respectively [2].

The incidence of hip fractures had been increasing in Europe and the United States until about 10 years ago, when this rate plateaued or decreased [3–5]. Contrast this to Japan and other Asian countries, where the incidence of hip fractures has increased steadily from 1986 to 2006 [1, 6]. However, only a few epidemiological studies have been conducted to determine the incidence of sustaining a second hip fracture within the Asian population.

Because of the high risk of sustaining a second hip fracture in patients after their initial hip fracture, pharmacologic intervention is essential. However, reports suggest that pharmacotherapy is not necessarily prescribed adequately in these populations. Cadarette et al. [7] reported an increased proportion of hip-fracture patients treated with osteoporosis drugs; however, the overall proportion remains low, with fewer than one-third of these patients receiving pharmacotherapy. In another report, 9.2% of women and 4.1% of men began therapy after a hip fracture in 2004 [8]. Currently, no data are available concerning the rates of prescription for osteoporosis treatment after a first hip fracture based on an investigation of Asian patients.

The aim of this study was to elucidate the incidence of additional fractures in patients within 1 year after they sustained their first hip fracture. An additional aim was to investigate the frequency of prescription of antiosteoporotic pharmaceuticals in these patients.

Patients and Methods

Study Design and Overview

The present study was designed as a historical, register-based, uncontrolled, follow-up study. This study was approved by the local ethics committee at the Faculty of Medicine, Tottori University (no. 1096), and by each participating hospital. Data on demographics, treatments, and health outcomes during each patient's hospital stay were collected from medical records. Data on patients who were followed after the treatment for 1 year following the fracture were also collected from medical records at each hospital. A voluntary and confidential questionnaire was mailed to patients and/or their family members regarding the patients' health outcomes in the 1-year period after the initial hip fracture. The letter included an informed consent explaining the study purpose, with instructions on how to complete and return the survey.

Five geographic areas in Japan were selected for this study: Niigata, Toyama, Tokyo, Tottori, and Kumamoto. Within each area, four, five, two, nine, and five hospitals (total of 25) participated in the study, respectively. A tally of all female patients who sustained a hip fracture, 65 years or older, injured during the 2-year period from January 1, 2006, to December 31, 2007, and treated in these hospitals was conducted. All hospital data, registered anonymously by number, were sent to Tottori University and compiled.

Data Collection

Medical Record Review

Hip fractures were identified by hospital records with radiographs. Inclusion criteria were female patients 65 years or older who had experienced a hip fracture due to minor trauma for the first time and had been admitted to one of the 25 study hospitals during the study period (January 2006 to December 2007). Patients with pathological fractures or high-impact trauma, such as traffic accidents, were excluded from the enrollment. During the medical records review, all patients were selected according to the above inclusion and exclusion criteria by orthopedists.

Data collected from medical records were patient's age at the time of the first hip fracture, fracture site (right or left), fracture type (neck or trochanter), date of birth, body height, body weight, residence before the fracture, bone mineral density (BMD, percent of young adult mean, YAM), and if osteoporosis medications were taken. The patients' ambulatory ability before the first hip fracture was also recorded, divided into the following six categories: ability to walk without difficulty, ability to walk outside with a walking aid, ability to walk only inside with an aid, inability to walk without support, complete inability to walk, and unknown.

Comorbidities were defined as conditions that patients had before hip-fracture surgery. Main comorbidities included hypertension, heart failure, arrhythmia, diabetes mellitus, respiratory disease, a history of stroke, Parkinson disease, osteoarthritis, rheumatoid arthritis, and dementia. Dementia was defined as patients having fewer than 21 points on the revised version of Hasegawa's Dementia Scale. The presence of cognitive dysfunction was ascertained by a medical records review.

Treatment data included admission and discharge dates, type of surgery (osteosynthesis or arthroplasty), implants used for surgery, rehabilitation protocol, and if osteoporosis treatment was prescribed during the hospital stay. Medical record reviews at the treating hospitals confirmed whether follow-up data were available in the hospital, if the patient was currently alive or dead, the occurrence of new fractures within 1 year after the first hip fracture and treatment for those fractures, and if osteoporosis was treated. Fractures were verified by radiographs.

Questionnaire

A letter was sent from coinvestigators at each hospital to the patients who met the study inclusion criteria. The informed consent and surveys were sent to the billing addresses used at their last hospitalization. Patients and/or their family members were asked to sign the consent form and complete and return the questionnaire in a self-addressed, stamped envelope if they agreed to participate in the study. The questionnaire inquired if osteoporosis treatment had been prescribed and the occurrence of any new fractures. If the latter was present, the details about the new fracture site, the cause of the fracture, and treatment details were also asked.

Statistical Analysis

Age-specific incidence was calculated based on the number of fractures and observational year. Age- and gender-specific incidences (per 1,000 person-years), reported previously for the general population in Japan, were adopted to compare the risk of hip fracture among patients with a prior hip fracture. Age- and gender-specific incidences (per 1,000 person-years) of hip fracture for the general population in women are 1.9, 8.6, 24.5, and 25.4 in the age groups of 65–74, 75–84, 85–94, and ≥95 years, respectively, and the risk for all women 65 years old or older is 8.3 (data were analyzed based on the study by Hagino et al. [1]).

Continuous variables, including age, body height, body weight, and body mass index (BMI) before surgery, were compared using *t*-tests. Pearson's chi-squared tests or Fisher's exact tests were used to compare the categories/ratios of variables.

A multivariate analysis was performed in addition to a univariate analysis. Variables determined during the hospitalization with a significance level of $P < 0.05$, as determined by univariate analysis, were selected for multivariate analysis. Multivariate logistic regression analysis was used to provide adjusted odds ratio (OR) estimates for associations with subsequent fractures.

Statistical analysis was performed using SPSS software (SPSS II for Windows, version 11.0.1J; SPSS, Inc., Tokyo, Japan).

Results

Enrolled Patients and Response Rates for Questionnaires

Two hundred thirty-five patients from the Niigata area, 605 patients from the Toyama area, 216 patients from the Tokyo area, 892 patients from the Tottori area, and 715 patients from the Kumamoto area (in total 2,663 patients) were enrolled. Three hundred thirty-five patients were excluded according to the exclusion criteria: 213 had a fracture before or after the study period, 96 were under 65 years old, and 26 were lacking detailed data regarding the cause of the fracture including a suspicion of pathological fracture. The analysis was then conducted for 2,328 patients (Fig. 1). Fractures occurred on the right side in 1,200 patients and on the left side in 1,128 patients; 1,025 were neck fractures and 1,303 were trochanteric fractures. One thousand eighty-five (46.6%) of 2,328 patients returned their questionnaires. Sixty-one patients died during the follow-up period. Among the remaining patients, 1,076 were followed based on both medical records and patient questionnaires and 887 patients who did not return the patient questionnaires were followed by a medical record review. As a result, 304 were lost to follow-up.

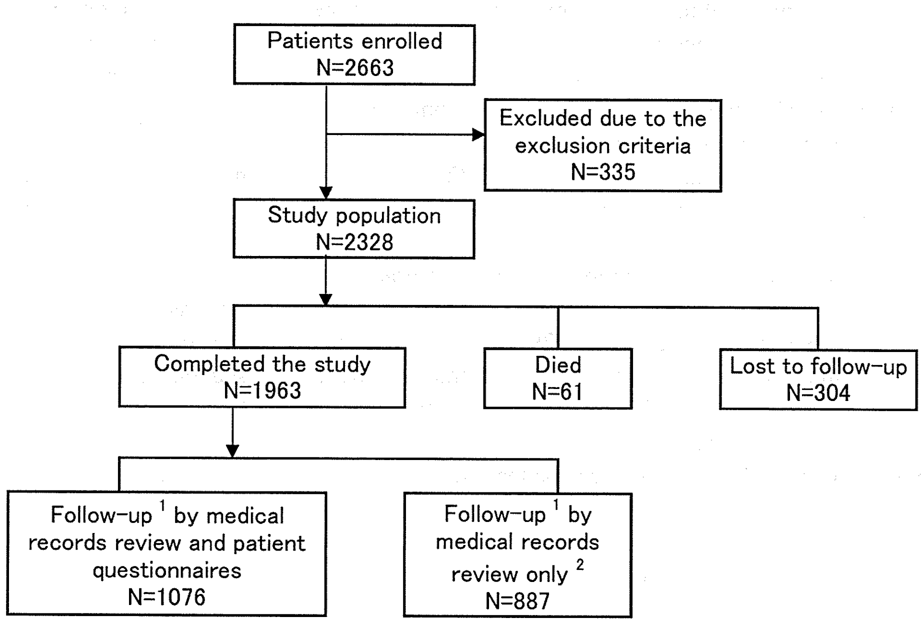

Fig. 1 Patient disposition. *1*, Duration of follow-up 1 year; *2*, patient questionnaires were not returned

Demographics of the Patients

The average age at the time of the initial fracture was 83.6 years (range 65–104). The place of residence, investigated by medical chart records, was the patient's own home in 1,550 patients, a nursing home in 482 patients, a hospital in 190 patients, other in 9 patients, and unknown in 97 patients.

Ambulatory abilities before the first hip fracture according to the medical charts were "Able to walk without difficulty" in 881 patients (37.8%), "Able to walk outside with a walking aid" in 670 patients (28.8%), "Able to walk only inside with aid" in 132 patients (5.7%), "Unable to walk without support" in 329 patients (14.1%), "Unable to walk" in 171 patients (7.3%), and unknown in 145 patients (6.3%).

Regarding comorbidities, hypertension was diagnosed in 1,030 patients, heart failure in 297 patients, arrhythmias in 123 patients, diabetes mellitus in 317 patients, respiratory disease in 148 patients, a history of stroke in 320 patients, Parkinson disease in 87 patients, osteoarthritis in 236 patients, and rheumatoid arthritis in 60 patients. Dementia was diagnosed in 500 patients (21.5%), was not diagnosed in 666 patients (28.6%), and was not examined in 1,139 patients (48.9%). Among those not examined, cognitive dysfunction was present in 472 patients (20.3%).

Osteoporosis was diagnosed before the first hip fracture in 274 patients (11.8%), was not diagnosed in 1,587 patients (68.2%), and status was unknown in 467 patients (20.1%). Antiosteoporosis medication was administered in 185 patients (7.9%). Importantly, no information regarding medications was available in 2,038 patients (87.5%).

BMD was measured in 365 patients (15.7%) before the first hip fracture or during the hospitalization for treatment of the first hip fracture. BMD measurements were performed using dual-energy X-ray absorptiometry of the lumbar spine and hip in 241 patients (66.0%) and of the forearm in 117 patients (32.1%). Radiographic absorptiometry of the metacarpal bone was measured in one patient (0.27%). The mean BMD value (YAM%) was 60.1 ± 15.2%, with a range of 27–127%.

Treatment during Hospitalization for First Hip Fracture

Among 2,328 patients, 2,192 (94.2%) were treated surgically. Among patients with femoral neck fractures treated surgically ($n = 951$), 630 (66.2%) were treated with arthroplasty, including hemiarthroplasty and total arthroplasty. Among patients with trochanteric fractures treated surgically ($n = 1{,}241$), 1,232 (99.3%) were treated with osteosynthesis (cannulated screw or pin 10, sliding hip screw 484, short femoral nail 726, other 12) and 8 (0.6%) were treated with arthroplasty (unknown 1). Postoperative rehabilitation was prescribed for 2,196 patients (94.3%), was not performed in 109 patients (4.7%), and status was unknown in 23 patients (1.0%). Antiosteoporotic pharmacotherapy was administered to 456 patients (19.6%) during their hospitalization. The mean duration of hospitalization was 48.6 ± 53.4 days for neck fractures and 48.0 ± 41.1 days for trochanteric fractures.

Treatment after Discharge from First Hospital Stay

Data regarding treatment after discharge from the first hospital stay were collected from the patient questionnaires and follow-up data, if available, and confirmed by hospital records. During this 1-year period, antiosteoporosis pharmacotherapy was given in 436 patients (18.7%) and 1,240 patients (53.3%) received no treatment. In 24.8% of patients the treatment status was unknown. Only 166 patients (36.4 %) among the 456 receiving antiosteoporosis pharmacotherapy during hospitalization continued treatment during the 1-year follow-up.

Fractures after the First Hip Fracture

During the 1-year follow-up period, 160 fractures occurred in 153 patients (Table 1). Among them, 129 were verified by radiography and confirmed by orthopedic doctors and 24 were self-reported in questionnaires. The average age in this subset of patients at the time of the first fracture was 84.0 years (range 68–98). Sixty-six (43.1%) fractures occurred within 6 months after the first hip fracture and 88 (57.5%) within 8 months (Fig. 2). Among these, 77 hip fractures occurred in 77 patients, 25 clinical vertebral fractures occurred in 25 patients, and 9 forearm fractures occurred in 9 patients within 1 year after the first hip fracture. Among the 77 hip fractures, 67 were verified by radiography and confirmed by orthopedic doctors and 10 were self-reported in questionnaires. Forty (51.9%) hip fractures occurred within 6 months after the first hip fracture and 48 (62.3%) within 8 months (Fig. 2). Subsequent hip fractures occurred on the opposite side in 58 patients (75.3%) and 63.3% were similar in fracture type to the first fracture.

The incidence of all fractures among patients with a first hip fracture was 70 (per 1,000 person-years), and that for hip fractures was 34. Age-specific incidences for subsequent fractures were highest in the ≥95 year age group; however, the differences between the age groups were small (Table 2). In comparison to the general population, women ≥65 years of age who sustained an initial hip fracture were four times as likely to sustain an additional hip fracture. The rate ratio among those with one hip fracture was as high as 18.6 times in the age group 65–74 years compared to that in the general population (Table 2).

Table 1 Characteristics of patients with subsequent fractures

	All fracture		*P*	Hip fracture		*P*
	(+) $n = 153$	(–) $n = 2,175$		(+) $n = 77$	(–) $n = 2,251$	
Age (years)	84.2 ± 7.0	83.6 ± 7.1	n.s.	84.4 ± 7.3	83.6 ± 7.1	n.s.
Body height (cm)	145.3 ± 7.2	146.7 ± 7.0	n.s.	144.8 ± 7.6	146.6 ± 7.0	n.s.
Body weight (kg)	42.8 ± 8.3	44.3 ± 8.6	0.038	42.2 ± 7.9	44.3 ± 8.6	0.046
Body mass index (kg/m^2)	20.1 ± 3.1	20.6 ± 3.4	n.s.	20.0 ± 3.0	20.6 ± 3.4	n.s.
Comorbid disease						
+	135	1,964		66	2,033	
–	17	159	n.s.	10	166	n.s.
Cognitive dysfunction						
+	70	902		35	937	
–	74	1,117	n.s.	39	1,152	n.s.
Ambulatory abilities before the first hip fracture						
No aid	24	476		12	488	
Dependent	123	1,560	0.049	61	1,622	n.s.
Fracture site (1st hip fracture)						
Right	80	1,120		41	1,159	
Left	73	1,055	n.s.	36	1,092	n.s.
Fracture type						
Neck	69	956		40	985	
Trochanteric	84	1,219	n.s.	37	1,266	n.s.
Surgical procedure						
Osteosynthesis	105	1,446		53	1,498	
Arthroplasty	43	595	n.s.	22	616	n.s.
Pharmacotherapy						
During hospitalization						
+	38	418		13	443	
–	107	1,717	n.s.	58	1,766	n.s.
Posthospitalization						
+	48	388		19	417	
–	103	1,715	<0.001	57	1,761	n.s.

n.s. Nonsignificant

Among patients with subsequent fractures, antiosteoporosis drugs were administered in 24 (15.7%, unknown 123 [80.4%]) before the first hip fracture, 38 (24.8%, unknown 8 [5.2%]) during the hospitalization, and 48 (31.4%, unknown 29 [19.0%]) during the 1-year follow-up period. Among 77 patients with a second hip fracture, antiosteoporosis drugs were administered in 11 (14.3%, unknown 64 [83.1%]) before the first hip fracture, 13 (16.9 %, unknown 6 [7.8%]) during the hospitalization, and 19 (24.7%, unknown 18 [23.4%]) during the 1-year follow-up period.

There were significant differences in body weight between patients with and without subsequent fractures (Table 1). Ambulatory abilities were divided into two categories of "no aid" and "dependent": "no aid" was "to

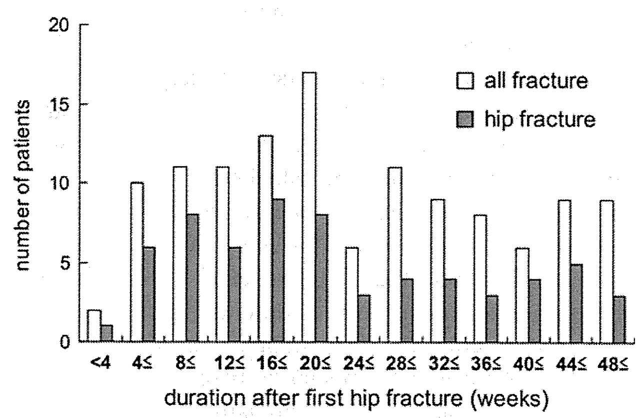

Fig. 2 Number of patients with subsequent fractures in selected time intervals after the first hip fracture