

## Incidence and Risk Factors for Falling in Patients after Total Knee Arthroplasty Compared to Healthy Elderly Individuals

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### ABSTRACT

**Background** It is possible that patients who have undergone total knee arthroplasty (TKA) are at a high risk of falling. However, there are insufficient data to confirm the incidence and risk factors for falling in patients after TKA compared with healthy elderly counterparts. The purpose of this study was to elucidate the incidence and risk factors for falling in patients after TKA compared to the age- and gender-matched healthy elderly.

**Methods** Subjects who underwent TKA consisted of 252 patients over 60 years of age. Controls were 150 healthy elderly individuals over 60 years of age living independently in the community. A self-administered questionnaire was mailed to patients after TKA and a similar questionnaire was distributed to the controls by investigators during the town-sponsored healthy aging program. The questionnaire included questions for ambulatory ability, functional status in daily living, knee pain, other joint pain and information on falls.

**Results** Self-administered questionnaires were returned by 192 of the 252 patients (76.1%) and 146 of the 150 controls (97.3%). Age and gender matching was performed for respondents between 70 and 80 years of age. There were 81 patients and 80 controls who fulfilled the inclusion criteria, and all of them agreed to participate. In the previous year, 34 of the 81 patients (38.2%) fell. The incidence of falls was significantly higher in patients than controls (23.8%,  $P = 0.041$ ). In controls, ability to stand up from a chair without using the arms and restriction from joining social activities due to knee pain showed the strongest association with recent falls. In patients, self-reported kyphosis showed the strongest association with recent falls.

**Conclusion** Patients after TKA are more likely to fall than the general Japanese population. Kyphosis showed the strongest association with recent falls in patients af-

ter TKA, which was different from the results obtained in the healthy elderly.

**Key words** elderly; falling; fractures; risk factor; total knee arthroplasty

Fragility fracture in the elderly has become a substantial societal problem because fractures reduce physical function and the ability to perform activities of daily living (ADLs). In particular, hip fracture is usually regarded as the most devastating fragility fracture with regards to morbidity, mortality and cost. Approximately 20 to 40% of individuals with a hip fracture who live independently without a walking device prior to the fracture require a walking device 1 year after fracture.<sup>1–3</sup> Since most fragility fractures are associated with falls, it is necessary to identify the elderly who have a high intrinsic fall risk and prevent them from falling.

Osteoarthritis (OA) of the knee, in particular, causes deformities of the joint and pain during walking. It has been reported to increase the risk of falls and fractures: the annual falling rate among the patients with end-stage knee OA was 48%.<sup>4</sup> Patients diagnosed as with knee OA have a greater risk of all non-vertebral and hip fractures than patients with knee pain alone.<sup>5</sup> Furthermore, 50% of patients with rheumatoid arthritis (RA) fall each year. Their health assessment questionnaire (HAQ) disability scores, tender joint counts and balance impairment scores are associated with an increased risk of falls.<sup>6–8</sup> Thus, it is important to treat joint disease in order to prevent falls in this population.

Total knee arthroplasty (TKA) is a common surgery for the management of severe pain in knee OA. TKA is a surgical intervention that eliminates pain and knee deformity and improves patient quality of life (QOL). Furthermore, TKA not only reduces pain in knee OA patients, but improves their gait performance and balance function.<sup>9, 10</sup> Thus, TKA may reduce falls, as well as fall-related fractures. However, previous studies have found that patients undergoing TKA have a higher prevalence of osteoporosis than the healthy elderly,<sup>11</sup> and postoperative increases in bone resorption and decreases in patient motor activity lead to a decrease in bone mineral density

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Abbreviations: ADL, activity of daily living; BMD, bone mineral density; BMI, body mass index; CI, confidence interval; HAQ, health assessment questionnaire; OA, osteoarthritis; OR, odds ratio; RA, rheumatoid arthritis; TKA, total knee arthroplasty

**Table 1. Questions on ambulatory ability, functional status, knee pain and other joint pain**

Domain	Questions
Ambulatory ability	Do you use a walking device? (without an assistive device, one cane or walker) How much do you walk in a day? (1: almost no walking, 2: walking in only one room, 3: walking mainly in the house, 4: walking outside, 5: walking over 1 km)
Functional status	Can you put on socks while standing? Can you climb up and down stairs? Can you stand up from a chair without using your arms? Are you very worried about falling? Do you have a regular exercise routine?
Knee pain	Do you have stiffness in your knees on a regular basis? Do you have knee pain while walking? Do you have knee pain while climbing up or down stairs? Do you have knee pain while standing up from a chair? Do you restrict from joining social activities due to knee pain in your daily life? Can you bend your knees in a sitting position? (1: excellent, 2: good, 3: average, 4: poor, 5: bad)
Other joint pain	Do you have joint pain in any other joints besides the knees?

(BMD) around the implant.<sup>12</sup> It is possible that elderly patients who have undergone TKA are at a high risk of periprosthetic fracture associated with falling.

There are relatively few studies on falls and fractures after TKA. At 1 year after TKA, the number of falls was lower than at 3 months before surgery,<sup>13</sup> and fear of falling had reduced 4 months after surgery.<sup>4</sup> In addition, a 6-month prospective study reported that TKA may reduce the incidence of falls in patients with OA or RA because the incidence of falling in patients after TKA is lower than previously reported rates for OA or RA patients.<sup>14</sup> These previous studies suggested that TKA reduces the incidence of falling in OA or RA patients within 1 year of operation. However, there were insufficient data to confirm the difference in incidence of falling and risk factors between patients after TKA and the healthy elderly. The purpose of this study was to elucidate the incidence and risk factors for falling in patients after TKA by comparing with the age- and gender-matched healthy elderly controls.

## MATERIALS AND METHODS

### Study design and overview

The present study was designed as a retrospective case-control study with matching by age and gender. We gained approval from the Ethics Committees of Tottori University Faculty of Medicine (Approval Number 1264) and the local ethics committees of Hakuai Hospital.

Cases consisted of patients who underwent TKA at Hakuai Hospital between April 2002 and March 2008. Data from the postoperative period and TKA laterality were retrieved from medical records. Controls consisted of participants to a town-sponsored healthy aging program. They had not received services covered by nursing care insurance.

A self-administered questionnaire was mailed to the patients in August 2009. A similar questionnaire was distributed to the controls by investigators during the healthy aging program between August and November 2009. The voluntary and confidential questionnaire included an informed consent form explaining the purpose of the study and instructions on how to complete and return the survey.

### Patients and controls

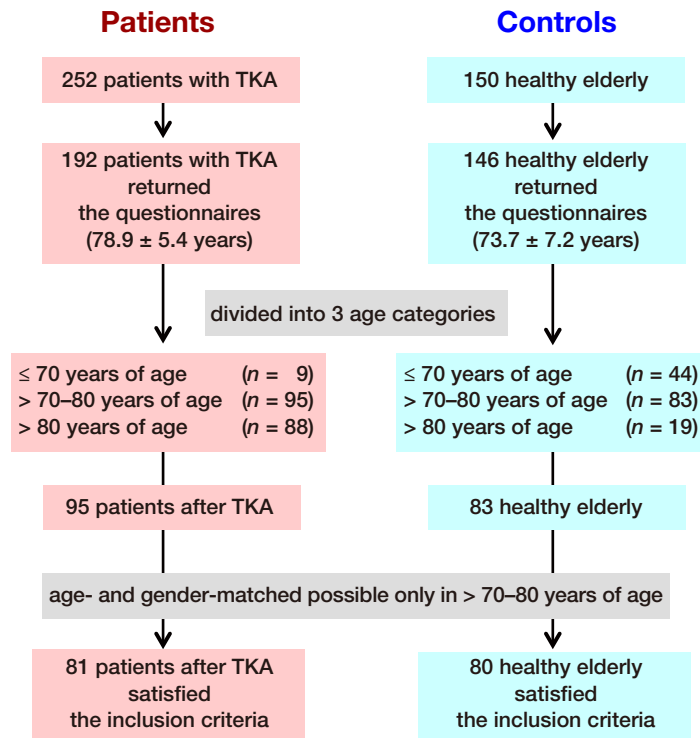
Participants were 252 patients aged over 60 years with bilateral and unilateral TKA. All surgeries were performed by 3 orthopedists with the standard medial parapatellar approach. The implants consisted of Scorpio (Stryker, Kalamazoo, MI) and LCS (DePuy, Warsaw, IN). Early joint motion and weight bearing were encouraged after surgery. Patients underwent standard inpatient rehabilitation. Controls consisted of 150 healthy elderly individuals over 60 years of age who lived independently in the community.

### Self-administered questionnaire

The questionnaire included questions on personal characteristics, ambulatory ability, functional status in daily living, knee pain, other joint pain and fall assessment. All data were self-reported and subjects were asked to indicate their responses by choosing Yes or No or using a 5-point ordinal scale.

### Personal characteristics of patients and controls

Both groups provided information on basic characteristics including age, sex, body height, body weight, total number of prescribed medications taken on a regular basis, use of hypnotic pills, hearing problems, eye problems, self-reporting kyphosis, self-reporting hallux valgus, diagnosis of cardiac disease, respiratory disease,



**Fig. 1.** Study flow chart. TKA, total knee arthroplasty.

diabetes, hypertension and other diseases. Patients were also asked whether they had previously undergone hip arthroplasty.

#### **Ambulatory ability, functional status, knee pain and other joint pain**

Questions on ambulatory ability, functional status, knee pain and other joint pain are presented in Table 1. The questionnaire was based on previous studies.<sup>15, 16</sup> Daily walking distance and range of motion with respect to flexion of the affected knee were assessed with a 5-point ordinal scale. In addition, controls were asked whether they had self-reported varus deformities of the knee and prior knee arthroplasty, and whether they had received diagnosis or treatment of knee OA by a doctor at least once in the past.

#### **Fall assessment**

Both groups were asked about the number of falls, injuries due to falling and fracture due to falling in the 12 months prior to the questionnaire. A fall was defined as unintentionally coming down to the ground or lower,<sup>17</sup> not as the result of a major intrinsic event such as a seizure, fainting or stroke.

#### **Statistical analysis**

All data were expressed as means  $\pm$  SD. Differences between groups were determined with Pearson's chi-squared test. The non-paired *t*-test was used to compare

grading scales between patients and controls or non-fallers and fallers from each group.

Both univariate and multivariate analyses were performed. Variables with a significance level of  $P < 0.10$  in the univariate analysis were retained in the multivariate analysis. Multivariate logistic regression was used to provide estimates of adjusted odds ratios (ORs) for associations with falls in the patients and controls. All data were analyzed using PASW statistical software (version 18 for Windows; SPSS, Tokyo, Japan). For all the analyses, a  $P$  value  $< 0.05$  was considered significant.

## **RESULTS**

### **Response rate for the self-administered questionnaire**

A flow chart of the study is presented in Fig.1. Self-administered questionnaires were returned by 192 of the 252 patients after TKA (76.1%) and 146 of the 150 controls (97.3%). The mean age was significantly higher in patients ( $78.9 \pm 5.4$  years) than controls ( $73.7 \pm 7.2$  years) ( $P < 0.001$ ). Each group was divided into 3 age categories:  $\leq 70$  years,  $> 70-80$  years and  $> 80$  years. We analyzed only the data from the age category of  $> 70-80$  years in each group, because the age and gender distributions in other age categories were significantly different between patients and controls with the non-paired *t* test and chi-squared test. In each group, persons who met the following qualifications

**Table 2. Characteristics of the patients and controls**

	Patients ( <i>n</i> = 81)	Controls ( <i>n</i> = 80)	<i>P</i> value
<b>Personal characteristics</b>			
Age, mean ± SD (year)	75.9 ± 2.3	75.7 ± 3.0	0.622
Sex ratio (male/female)	(7/74)	(12/68)	0.211
Height, mean ± SD (cm)	151.1 ± 6.4	151.0 ± 7.4	0.494
Weight, mean ± SD (kg)	57.4 ± 10.0	50.0 ± 8.4	< 0.001
BMI, mean ± SD (kg/m <sup>2</sup> )	25.3 ± 4.6	22.0 ± 2.9	< 0.001
Total number of prescription medications, mean ± SD	3.2 ± 2.5	2.5 ± 1.9	0.060
Use of hypnotic pills (%)	18.4	15.0	0.567
Time since surgery (year)	3.8	–	–
Prior hip arthroplasty (%)	14.8	–	–
TKA laterality (bilateral/right/left)	(43/18/20)	–	–
<b>Physical problems</b>			
Hearing problems (%)	34.3	25.3	0.231
Eye problems (%)	56.8	58.8	0.802
Kyphosis (%)	34.4	65.6	0.017
Hallux valgus (%)	16.9	28.7	0.085
<b>Complication</b>			
Cardiac disease (%)	11.1	15.0	0.464
Respiratory disease (%)	3.7	5.0	0.687
Diabetes (%)	18.5	7.5	0.038
Hypertension (%)	42.0	42.5	0.946
<b>Ambulatory ability</b>			
Walking without assistive device (%)	44.2	85.0	< 0.001
One cane (%)	33.8	13.8	
Walker (%)	22.0	1.2	
<b>Grading of walking distance</b>			
i) Almost no walking (%)	0.0	0.0	0.182
ii) Walking in only one room (%)	0.0	0.0	
iii) Walking mainly in the house (%)	11.4	6.2	
iv) Walking outside (%)	53.2	45.0	
v) Walking over 1 km per day (%)	35.4	48.8	
<b>Functional status</b>			
Putting on socks while standing (%)	32.1	66.3	< 0.001
Climbing up and down stairs (%)	67.5	86.3	0.005
Standing up from a chair without using the arms (%)	59.2	86.3	< 0.001
Fear of falling (%)	45.3	22.5	0.003
Regular exercise (%)	67.5	66.3	0.864

BMI, body mass index; TKA, total knee arthroplasty.

were excluded from the study: i) whether they received services covered by nursing care insurance (because they were suspected of having dementia or frailty); ii) whether they were unable to walk and iii) whether they had RA or Parkinson's disease. Persons treated with TKA were excluded from the control group. Ultimately, 81 patients (mean age, 75.9 ± 2.3 years; 7 males, 74 females) and 80 controls (mean age, 75.7 ± 3.0 years; 12 males, 68 females) satisfied the inclusion criteria.

#### Characteristics of the patients and controls

Of the 80 (35.0%) controls, 28 reported that they had a varus knee deformity. Furthermore, 18 of the 80 controls (22.5%) have received diagnosis or treatment of knee OA by a doctor at least once in the past.

The characteristics and knee pain and other joint pain in patients and controls are presented in Tables 2 and 3. Comparison between both groups showed significantly higher levels for patients in weight ( $P < 0.001$ ), body mass index (BMI) ( $P < 0.001$ ), the prevalence of diabetes ( $P = 0.038$ ), fear of falling ( $P = 0.003$ ) and ankle pain ( $P = 0.027$ ).

Comparison between both groups showed significantly lower levels for patients in the percentage of kyphosis ( $P = 0.017$ ), walking without assistive device ( $P < 0.001$ ), ability to put on socks while standing ( $P < 0.001$ ), ability to climb up and down stairs ( $P = 0.005$ ), ability to stand up from a chair without using the arms ( $P < 0.001$ ), knee pain while climbing up or down stairs ( $P = 0.046$ ), and knee flexion range of motion ( $P < 0.001$ ).

**Table 3. Knee pain, knee flexion range of motion and other joint pain**

	Patients ( <i>n</i> = 81)	Controls ( <i>n</i> = 80)	<i>P</i> value
<b>Knee pain</b>			
Regular stiffness (%)	36.3	47.5	0.158
Pain while walking (%)	22.0	35.0	0.073
Pain while climbing up or down stairs (%)	22.0	40.0	0.046
Pain while standing (%)	19.7	26.2	0.110
Restriction from joining social activities due to knee pain (%)	25.0	19.0	0.468
<b>Knee flexion range of motion</b>			
i) Excellent (%)	27.6	82.5	< 0.001
ii) Good (%)	36.0	6.3	
iii) Average (%)	22.3	5.0	
iv) Poor (%)	5.2	3.7	
v) Bad (%)	3.9	2.5	
<b>Other joint pain</b>			
Spine (%)	43.2	46.2	0.698
Hip (%)	4.9	2.5	0.414
Ankle (%)	13.5	3.7	0.027

**Table 4. Numbers of fallers and fractures in the patients and controls**

	Patients ( <i>n</i> = 81)	Controls ( <i>n</i> = 80)	Chi-squared	Df	<i>P</i> value
Number of fallers (%)	38.2	23.8	4.189	1	0.041
Multiple falls (%)	19.8	13.8	1.039	1	0.308
Bruises and minor injuries due to falling (%)	11.1	7.5	0.621	1	0.431
Fracture due to falling (%)	6.2	3.8	0.500	1	0.479

Df, degree of freedom.

The rate of persons who had prescribed medications on a regular basis was higher in patients than controls ( $P = 0.060$ ). The percentage of hallux valgus and knee pain while walking tended to be lower in patients than controls ( $P = 0.085$  and  $P = 0.073$ , respectively). The other variables showed no significant differences between both groups.

### Numbers of falls and fractures

The numbers of falls and fractures during the previous year observed in patients and controls are presented in Table 4. In the patients, 31 of 81 patients (38.2%) fell; 6 patients fell twice, and 10 patients fell 3 times. In the controls, 19 of 80 subjects (23.8%) fell; 7 subjects fell twice, and 4 subjects fell 3 times. The incidence of falls was significantly higher in patients than controls ( $P = 0.041$ ). Rates of multiple falls, injuries and fractures due to falling were not significantly different between both groups. Those who sustained fall-related fractures within the last year were 5 in patients and 3 in controls.

### Non-fallers and fallers

In the overall analysis of the incidence of falling, the percentage of persons who underwent TKA and who

had fear of falling was significantly higher in fallers than non-fallers ( $P = 0.041$  and  $P = 0.016$ , respectively). The ability to stand up from a chair without using the arms and the knee flexion range of motion were significantly worse in fallers ( $P = 0.001$  and  $P = 0.043$ , respectively).

The comparison of fallers and non-fallers in both groups is presented in Tables 5 and 6. Personal characteristics and complications were not significantly different between fallers and non-fallers in both groups. In patients, the percentage of kyphosis was significantly higher in fallers than non-fallers ( $P = 0.030$ ). Knee flexion range of motion was significantly lower in fallers than non-fallers ( $P = 0.005$ ). More fallers had a fear of falling and regular stiffness of the knee than non-fallers ( $P = 0.082$  and  $P = 0.069$ , respectively). The percentage of the ability to stand up from a chair without using the arms tended to be lower in fallers ( $P = 0.061$ ). In controls, the percentage of restriction from joining social activities due to knee pain was significantly higher in fallers than non-fallers ( $P = 0.030$ ). The percentage of the ability to stand up from a chair without using the arms was significantly lower in fallers than non-fallers ( $P = 0.011$ ).

**Table 5. Comparison of characteristics of fallers and non-fallers in the patients and controls**

	Patients			Controls		
	Non-fallers (n = 50)	Fallers (n = 31)	P value	Non-fallers (n = 61)	Fallers (n = 19)	P value
<b>Surgery information</b>						
Time after surgery (year)	3.7 ± 1.7	4.2 ± 2.1	0.226	–	–	–
Prior hip arthroplasty (%)	14.3	16.7	0.775	–	–	–
TKA laterality (bilateral/right/left)	(27/10/13)	(16/8/7)	0.830	–	–	–
<b>Physical problems</b>						
Hearing problems (%)	33.3	37.0	0.753	36.8	21.7	0.185
Eye problems (%)	56.8	58.6	0.879	57.9	59.0	0.931
Kyphosis (%)	23.8	50.0	0.030	50.8	57.9	0.590
Hallux valgus (%)	15.2	20.8	0.554	31.1	21.1	0.396
<b>Complications</b>						
Cardiac disease (%)	10.2	12.9	0.710	18.0	5.3	0.173
Respiratory disease (%)	0.0	6.1	0.160	6.6	0.0	0.252
Diabetes (%)	18.4	19.4	0.912	6.6	10.5	0.566
Hypertension (%)	42.9	38.7	0.714	44.3	36.8	0.568
<b>Ambulatory ability</b>						
Walking without assistive device (%)	43.8	42.9	0.349	88.5	73.7	0.170
One cane (%)	39.6	25.0		9.8	26.3	
Walker (%)	16.6	32.1		1.6	0.0	
<b>Grading of walking distance</b>						
i) Almost no walking (%)	0.0	0.0		0.0	0.0	0.746
ii) Walking in only one room (%)	0.0	0.0		0.0	0.0	
iii) Walking mainly in the house (%)	14.3	6.9	0.284	6.6	5.3	
iv) Walking outside (%)	57.1	48.3		42.6	52.6	
v) Walking over 1 km per day (%)	28.6	44.8		50.8	42.1	
<b>Functional status</b>						
Putting on socks while standing (%)	34.7	25.0	0.377	68.9	57.9	0.378
Climbing up and down stairs (%)	70.8	60.7	0.365	78.9	88.5	0.290
Standing up from a chair without using the arms (%)	66.7	44.4	0.061	91.8	68.4	0.011
Fear of falling (%)	38.3	59.3	0.082	19.7	31.6	0.278
Regular exercise (%)	68.8	64.3	0.689	68.9	57.9	0.378

TKA, total knee arthroplasty.

### Multivariate logistic regression analysis

In the overall analysis of the incidence of falling, ability to stand up from a chair without using the arms showed the strongest association with recent falls [OR = 0.340, 95% confidence interval (CI) = 0.145–0.799,  $P = 0.013$ ]. Multivariate logistic regression was analyzed with fall risk factors as the dependent variable in both groups. In patients, kyphosis showed the strongest association with recent falls (OR = 3.909, 95% CI = 1.113–13.730,  $P = 0.033$ ). In controls, the ability to stand up from a chair without using the arms (OR = 0.060, 95% CI = 0.009–0.382,  $P = 0.003$ ) and restriction from joining social activities due to knee pain (OR = 8.277, 95% CI = 1.527–44.880,  $P = 0.014$ ) showed the strongest association with recent falls.

### DISCUSSION

This is the first study to compare the incidence and risk factors for falling between patients after TKA and the

age- and gender-matched healthy controls. Compared to controls, patients had significantly worse ambulatory ability and physical function in all ADLs despite a lower proportion of persons with knee pain while climbing up or down stairs. Knee pain and functional status improved after TKA, but persons are often plagued with quadriceps muscle impairment and functional limitations compared to their healthy elderly counterparts.<sup>18</sup> Additionally, patients after TKA were significantly worse at 6 months after surgery in the timed up and go test, stair climbing test, 6-min walk test and 1-leg standing test compared to the healthy elderly.<sup>9</sup> Our assessment included questions about putting on socks while standing, climbing up and down stairs and standing up from a chair without using the arms. We speculate that the questions are associated with extremity muscle function and standing balance, which were assessed in the previous studies.<sup>9</sup> Thus, our study indicated that patients who have undergone TKA have lower levels of physical



**Table 6. Comparison of state of the knee and joint pain of fall and non-fall groups in the patients and controls**

	Patients			Controls		
	Non-fallers (n = 50)	Fallers (n = 31)	P value	Non-fallers (n = 61)	Fallers (n = 19)	P value
<b>Knee pain</b>						
Regular stiffness (%)	29.2	50.0	0.069	47.7	47.4	0.990
Pain while walking (%)	22.9	21.4	0.881	34.4	36.8	0.847
Pain while climbing up or down stairs (%)	27.1	22.2	0.642	39.3	42.1	0.830
Pain while standing (%)	14.9	17.9	0.735	26.2	26.3	0.994
Restriction from joining social activities due to knee pain (%)	25.0	25.9	0.929	13.6	41.7	0.030
<b>Knee flexion range of motion</b>						
i) Excellent (%)	41.7	3.7	0.005	80.3	84.2	0.548
ii) Good (%)	37.5	48.1		4.9	10.5	
iii) Average (%)	14.6	33.3		6.6	0.0	
iv) Poor (%)	2.1	11.1		4.9	0.0	
v) Bad (%)	4.2	3.7		1.6	5.3	
<b>Other joint pain</b>						
Spine (%)	40.8	48.3	0.506	45.9	47.3	0.911
Hip (%)	8.1	0.0	0.103	3.2	0.0	0.424
Ankle (%)	12.1	16.1	0.623	4.9	0.0	0.324
Varus deformity of the knee (%)	–	–	–	31.7	47.4	0.212

functioning than healthy elderly controls, consistently with the previous reports.<sup>9, 18</sup>

The fall incidence among the general Japanese population aged 65 years and over is between 10% and 20%.<sup>19</sup> In comparison, the incidence of falls among the controls in the present study was considerably higher. Among the present controls, 35% had a varus deformity and 22.5% of them had received diagnosis or treatment of knee OA by a doctor at least once in the past. The present controls showed a higher morbidity of knee OA and musculoskeletal pain, which are risk factors for falling.<sup>5, 21</sup> This fact may evidence higher prevalence of falling in them, but the prevalence of knee OA showed no significant difference between the present controls and Japanese general population.<sup>20</sup> In contrast, 31 of 81 patients (38.2%) had falls during the previous 12 months. The incidence of injuries and fractures due to falling in patients were not significantly different from controls, but the incidence of falling was significantly higher. Previous prospective studies<sup>13, 14</sup> reported that the annual postoperative fall rate was 24.2% to 32.9% among patients after TKA. These rates of falling are lower than those previously reported for OA or RA patients. Thus, although TKA may reduce the incidence of falls in OA or RA patients, OA patients who undergo TKA are considered more likely to fall than the age- and gender-matched general Japanese.

We compared the risk factors for falling between patients after TKA and age- and gender-matched healthy controls. The overall analysis showed that TKA was not an independent risk factor for falling. However,

the percentage of patients after TKA was significantly higher in fallers than non-fallers in univariate analysis. It is possible that functional decline and lower extremity muscle weakness after TKA are associated with falling. In controls, standing up from a chair without using the arms and restriction from joining social activities due to knee pain showed the strongest association with recent falls. These are common risk factors for falling among the elderly in general.<sup>22, 23</sup> Inability to stand up from a chair without using the arms is statistically significantly associated with poor physical function.<sup>22</sup> As a result, pain and poor physical function leads to restricted from joining social activities.<sup>23</sup>

In contrast, kyphosis showed the strongest association with recent falls among elderly individuals who underwent TKA. Previous studies<sup>4, 13, 14</sup> reported several risk factors for falling in patients after TKA. It is interesting that risk factors differed in healthy elderly individuals. Postoperative falling in patients after TKA was predicted by depression symptomatology and, knee pain, stiffness, function scores in The Western Ontario and McMaster Universities Osteoarthritis Index and balance confidence scores did not show the strongest correlation with recent falls.<sup>13</sup> Besides this, the postoperative limited range of knee flexion and ankle plantarflexion were significant risk factors, and knee muscle strength and the duration of 1-leg standing were similar between fallers and non-fallers.<sup>14</sup> We speculate that common risk factors for falls may not be suitable to stratify the risk of falling in patients after TKA, because they have worse motor function of lower extremity muscle strength and

balance than the healthy elderly. The hyperkyphotic posture is an easily identifiable independent risk factor for falls in the general population.<sup>24, 25</sup> Despite the fact that the incidence of kyphosis in the controls was higher, the present study showed a relationship between falling and kyphosis in the patients. According to a previous study,<sup>26</sup> a meaningful increase was observed in the sacral slope in patients after TKA who achieved an increase in the range of knee extension greater than 10°. We speculated that a change in sagittal spinal alignment after TKA may lead to decreased awareness of kyphosis. In contrast, even if TKA eliminated knee pain, patients who had a spinal problem after surgery may be likely to fall. However, we are unable to determine the likely direction of the relationship between TKA and kyphosis from our data.

Our study had several limitations. First, there is the possibility of selection bias. The response rate for the questionnaire was low in patients. In the present study, it was probable that patients, who were on the average much older than controls, could not answer and send the questionnaire, and so analysis was limited to respondents between 70 and 80 years of age. Second, physical function in both groups was only assessed through the self-administered questionnaire, which lacks objectivity. The present study could not assess cognitive impairment; however, we thought that our subjects had enough comprehension to answer our questions. Third, controls in the present study may have had better physical function, and the incidence rates of falls reported here should be compared to those in OA or RA patients who have equivalent levels of physical function. However, we used age- and gender-matched controls, and the incidence of falls in patients after TKA seemed to be substantially higher than that in the general population. Fourth, we could not objectively assess kyphosis and range of motion of the knee. Further prospective studies will need to assess the relationship between kyphosis and falling with objective methods. We should identify the period of time after surgery when the tendency to fall and sustain a fracture is elevated. The details of falls, the situation, location and season, should be assessed, as well.

In conclusion, patients after TKA have worse motor function, such as lower extremity muscle strength and balance, than the healthy elderly. They are considered more likely to fall than the general Japanese population. Kyphosis showed the strongest association with recent falls in patients after TKA, which was different from the findings in healthy elderly controls. For patients with kyphosis, improvement of physical function with exercise and patient education on fall prevention is necessary.

*The authors declare no conflict of interest.*

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