BMD among Caucasians. Second, this study is a retrospective analysis, and we had no intervention for the effects of medications. Third, we had no data about the subjects' physical activities at the baseline survey. We did not know whether subjects had habits of exercise or not. In addition, although our analyses are adjusted by sex, age, weight, weight change, smoking status, and alcohol consumption, it is not clear if other confounders needed to be taken into account.

In conclusion, our study suggests that careful consideration should be given to use of ACE inhibitors and BZDs, which may be responsible for reducing BMD in elderly patients. Although the mechanisms underlying the effects of ACE inhibitors and BZDs on BMD are not well understood at this time, it is certainly conceivable that angiotensins are involved. It is important to design and conduct statistically valid, randomised clinical trials to ensure that the cause-effect relationship between medications such as ACE inhibitors and BZDs and BMD can be properly ascertained.

ACKNOWLEDGMENTS

The Radiation Effects Research Foundation (RERF), Hiroshima and Nagasaki, Japan is a private, non-profit foundation funded by the Japanese Ministry of Health, Labour and Welfare and the U.S. Department of Energy (DOE), the latter through the National Academy of Sciences. This publication was supported by RERF Research Protocol RP #3-89.

(Received November 2, 2007)
(Accepted December 7, 2007)

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Osteoporos Int
DOI 10.1007/s00198-008-0761-5

ORIGINAL ARTICLE

Sequential change in quality of life for patients with incident clinical fractures: a prospective study

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Received: 25 January 2008 / Accepted: 18 August 2008

Abstract

Summary Health-related quality of life in elderly women with sustained incident fractures was assessed prospectively for 1 year, using the EuroQol standard. Loss of QOL was more severe in patients after hip or vertebral fractures than those with wrist fracture. QOL was not completely restored in patients suffering from hip fracture.

Introduction Osteoporosis-related fractures decrease mobility, social interaction, and emotional well-being. All of these characteristics determine health-related quality of life (HR-QOL). In this study, we assessed HR-QOL in elderly women following incident clinical fractures.

Methods Thirty-seven patients with hip fractures (mean age 76.1 years), 35 with vertebral fractures (mean age 72.6 years), and 50 with wrist fractures (mean age 68.6 years) were enrolled. HR-QOL was prospectively measured using EuroQol (EQ-5D) before the fracture, 2 weeks, 3 months, 6 months, and 1 year after the fracture.

Results During the observation period, reduction of EQ-5D values was greatest in the hip fracture group. In the wrist fracture group, EQ-5D values at 6 months after the fracture showed recovery; however, in the hip and vertebral fracture groups, recovery was significantly lower than before the fracture. One year after the fracture, EQ-5D values were not significantly different from prefracture values in the vertebral and wrist fracture groups, but remained significantly lower in the hip fracture group.

Conclusions Loss of QOL was more severe in patients after hip or vertebral fractures than in patients with wrist fracture. HR-QOL was not completely restored in patients suffering from hip fracture.

Keywords Hip fracture · Quality of life · Vertebral fracture · Wrist fracture

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Introduction

The severity of osteoporosis ranges widely from mild cases with no symptoms or only a single minor fracture during a lifetime to severe cases with multiple fractures and sequelae. The risk of vertebral and limb fractures, such as those of the hip and wrist, increases with the progression of osteoporosis. Among the elderly, osteoporosis-related fractures are so prevalent that they cause significant morbidity. Data from the 1990s or later from Northern Europe [1] and North America [2–4] indicate that the incidence of hip fractures does not increase with time; however, most reports from Asian countries, including Japan, do show an increase [5, 6]. According to a survey performed between 1986 and 1995, the incidence of wrist and proximal humerus fractures also significantly increases with time [7]. With the rapidly increasing elderly population in Asian countries, osteoporosis-related fractures are becoming responsible for considerable health expenditures.

In addition to causing pain and disturbance of physical function, fractures may decrease mobility, social interaction, and emotional well-being [5]. All of these characteristics determine quality of life (QOL). A growing number of studies show that fragility fractures in elderly patients have a considerable impact on QOL; however, there have been only a few studies of generic health-related quality of life (HR-QOL) measured prospectively in patients with incident fractures [8–10]. There have been no reports specifically describing the prospective measurement of HR-QOL after incident fractures among elderly patients in Japan or any Asian country.

Recent anti-osteoporosis pharmaceutical therapies can reduce the risk of fragile fractures by up to 50% [11]. However, due to limited health care resources, there is an increased need to demonstrate the cost-utility of these therapies. The influence of fragility fractures on HR-QOL specifically needs to be incorporated into cost-effectiveness analyses [12]. Thus, the present study sought to assess HR-QOL in elderly women following incident hip, vertebral, and wrist fractures using a prospective observational study.

Materials and methods

Patients

For this study, we recruited patients meeting the following criteria: women 45 years old and over who sustained incident clinical fracture of the vertebra, hip, or wrist (distal radius), caused by minor trauma such as falls while standing and who were consecutively treated at one of four hospitals in Tottori Prefecture between 2004 and 2005. Exclusion criteria were pathological fractures resulting from metastatic disease or those resulting from high-energy trauma such as traffic accidents or falls from heights. Incident vertebral fractures were diagnosed by lateral radiographs of the spine as well as physical findings, and the diagnoses were confirmed by magnetic resonance images (MRI) and/or vertebral height loss or sclerotic changes evaluated from subsequent radiographs. Patients with dementia and those who could not complete the questionnaire due to severe cognitive dysfunction were also excluded. All subjects were identified at the time of their first visit or admission and prospectively followed for 1 year.

The study was approved by the local research ethics committee of the Faculty of Medicine, Tottori University and performed in accordance with the Declaration of Helsinki. All enrollments were carried out after obtaining informed consent.

Although informed consent was initially provided, two patients with hip and two patients with wrist fracture withdrew from the study before the evaluation 3 months after the fracture; these four patients were excluded from the analysis. A total of 37 patients with hip fractures (mean age 76.1 years) including 16 with femoral neck and 21 with trochanteric fractures, 35 with vertebral fractures (mean age 72.6 years), and 50 with wrist fractures (mean age 68.6 years) were enrolled and followed in this study (Table 1). Mean patient age was significantly higher, and body mass index (BMI) was significantly lower, in the hip fracture group than in the other two groups. If a patient sustained new fractures during the course of the study, not only second fracture but also other clinical fractures, the HR-QOL evaluation was stopped for that patient. Among the enrolled patients, one in each group was eliminated by new fractures; one of the hip fracture patients dropped out due to a newly developed complication; three of the hip fracture patients, three vertebral fracture patients, and nine wrist fracture patients dropped out due to loss of contact for no specified reason, and one of the hip fracture patients and one of the vertebral fracture patients died during the observational period.

In the hip, the vertebral, and the wrist fracture groups, 5, 8, and 5 patients, respectively, had been diagnosed as having osteoporosis before the fracture. The numbers of patients receiving anti-osteoporosis drugs before and after the fracture are presented in Table 1. It was unclear whether some patients were receiving the medications, since they had been prescribed by other doctors and details could not be obtained. Nine patients in the hip fracture group, 8 in the vertebral fracture group, and 12 in the wrist fracture group had previous fractures. Several patients had comorbidities before the fracture: In the hip fracture group, four patients had cancer, three had stroke, and two had rheumatoid arthritis; there were 2, 3, and 0 in the vertebral fracture group, and 1, 2, and 1 in the wrist fracture group, respectively. Among patients with vertebral fractures, the fracture level was defined at the T9, T11, T12, L1, L2, and L3 vertebra in 2, 3, 8, 11, 7, and 4 patients, respectively. Four patients had prevalent lumbar fractures.

All patients with hip fractures, 22 of those with vertebral fractures, and 25 of those with wrist fractures were admitted to the hospital for treatment. Mean durations of hospitali-

Table 1 Characteristics of patients

	Hip fracture	Vertebral fracture	Wrist fracture	*p*-value[a]
Number of patients	37	35	50	
Age(years)	76.1±9.8*	72.6±10.1	68.6±10.3	0.002
Range	49–91	48–91	49–88	
Body height (cm)	148.8±6.2	152.4±7.4	150.5±6.7	0.255
Body weight (kg)	45.8±8.4*	48.7±2.4	52.2±8.0	0.011
Body mass index (kg/m^2)	20.7±3.3*	21.1±2.4	23.0±3.2	0.010
Previous fracture (*n*)	9	8	12	
Surgical treatment (*n*)	37	0	22	
Hospitalized (*n*)	37	22	25	
Receiving anti-osteoporosis drug[b] (*n*)	3, 11 (11), 7 (13)	5, 21 (5), 16 (10)	4, 18 (7), 16 (10)	
Receiving NSAIDS[c] (*n*)	4 (8), 4 (8), 2 (11)	7 (1), 6 (5), 4 (9)	7 (1), 6 (5), 4 (9)	

Data are means±SD

* $p<0.05$ vs. wrist fracture by Tukey's test

[a] *p* value was calculated by one-way ANOVA

[b] Each number indicates numbers of patient receiving anti-osteoporosis drug before the fracture, at 6 months, and 1 year after the fracture, respectively (numbers of unknown patients are presented in parentheses)

[c] Each number indicates numbers of patient receiving nonsteroidal anti-inflammatory drug at 3 months, 6 months, and 1 year after the fracture, respectively (numbers of unknown patients are presented in parentheses)

zation for primary treatment were 61.3 days (range 9–157, median 56.0), 25.9 days (7–58, 22.0), and 16.2 days (1–48, 14.0) in the hip, vertebral, and wrist fracture groups, respectively. All patients with hip fractures, none of those with vertebral fractures, and 22 of those with wrist fractures were treated with surgery. The numbers of patients receiving nonsteroidal anti-inflammatory drugs (NSAIDs) are presented in Table 1.

Health-related quality of life

HR-QOL was measured using the EuroQol standard (EQ-5D) [13]. EQ-5D is a generic questionnaire with a visual analogue scale (VAS). Each of the five dimensions or domains of the EQ-5D profile [EQ-5D(profile); mobility, self-care, performance of usual activities, pain/discomfort, and anxiety/depression (not to be confused with clinically diagnosed depression)] is divided into three levels of difficulty: no problem, some problem, or extreme problem. This is expressed as a health profile, and each of the 243 possible health states defined by this profile has been assigned a health utility rating (EQ-5D(utility)) based on data collected from a representative sample of the Japanese general population [14, 15]. The anchor points for EQ-5D(utility) are "perfect health"=1 and "death"=0. Since calculation of the weighted health utility score requires comparison with the general population, we have used the Japanese general population as our comparator. Age-specific normative values (mean±SD) for EQ-5D (utility) have been reported for Japanese women aged 65 to 69 years, 70 to 74 years, 75 to 79 years, 80 to 84 years, and 85 years and over as 0.862±0.167, 0.810±0.187, 0.771±0.182, 0.769±0.173, and 0.684±0.230, respectively [16]. We used these values and calculated the age-adjusted values of EQ-5D (utility) for our patients (since age-specific normative values for Japanese women are available only for those aged 65 and older, age-adjusted QOL values were calculated for patients age 65 years and older).

Baseline questionnaires inquired about prefracture mental status and prefracture comorbidities. When necessary, these questions were asked of patients' relatives. EQ-5D (profile) and VAS (EQ-5D (vas), with "perfect health"=100 and "worst possible health"=0) were prospectively evaluated for the period before the fracture as well as for 2 weeks, 3 months, 6 months, and 1 year after the fracture. Prefracture QOL was evaluated based on the patient's recollection. Questionnaires were self-completed, but assistance was provided by relatives if necessary because of pain or hearing difficulties.

Statistical analysis

Multiple comparisons among groups were performed using Tukey's test after a repeated-measures analysis of variance (ANOVA) for age, body height, body weight, and BMI. Nonparametric multiple comparisons with prefracture values were performed using Dunn's test for EQ-5D (utility). For comparisons between two groups, the Mann–Whitney test was performed. Statistical analysis was performed using SPSS (SPSS II for Windows Version 11.0.1J, SPSS Japan, Tokyo, Japan) and Stat Flex (Version 5, Arteck, Osaka, Japan); $p<0.05$ was considered statistically significant.

Results

EQ-5D(utility)

Prefracture values

Mean values of EQ-5D(utility) for patients with hip, vertebral, and wrist fractures were 0.795, 0.882, and 0.934, respectively (Table 2). EQ-5D(utility) for patients with hip fractures was the lowest among the three groups, and there was a significant difference between the hip fracture and wrist fracture groups ($p<0.01$ by Dunn's test). There were no significant differences before the fracture between fracture types (neck and trochanteric) among patients with hip fractures, thoracic or lumbar fractures among patients with vertebral fractures, or surgical and nonsurgical treatment among patients with wrist fractures. Mean value of EQ-5D (utility) for patients with vertebral fractures admitted to hospital was 0.838 (median 0.887) and that for those not admitted was 0.973 (median 1.000), showing a significant difference ($p=0.024$, by Mann–Whitney). There was no significant difference between these two groups for patients with wrist fractures.

Mean (median) values of age-adjusted EQ-5D(utility) in patients aged 65 years and over were 102.1% (100%), 111.7% (119.7%), and 116.9% (123.5%) for the hip, vertebral, and wrist fracture groups, respectively (Fig. 1).

Sequential changes

Mean values of EQ-5D(utility) for patients with hip fractures at 2 weeks, 3 months, 6 months, and 1 year after the fracture were 0.373, 0.635, 0.634, and 0.680, respectively (Table 2). Those for patients with vertebral fractures were 0.531, 0.758, 0.746, and 0.838, respectively. Those for patients with wrist fractures were 0.717, 0.812, 0.873, and 0.881, respectively.

Among the vertebral fracture patients, there was no significant difference between patients with thoracic and lumbar fractures except at 6 months after the fracture, when EQ-5D(utility) was 0.827 for thoracic and 0.695 for lumbar fractures, with a significant difference ($p=0.028$, by Mann–Whitney). There were no significant differences in EQ-5D (utility) throughout the observational period between neck and trochanteric fractures among patients with hip fractures or between surgical and nonsurgical treatment among patients with wrist fractures. In the vertebral and wrist fracture groups, there were no significant differences in EQ-5D (utility) between patients admitted and not admitted to the hospital at any time after the fracture.

Among the hip and wrist fracture groups at 3 months after the fracture, values of EQ-5D (utility) were significantly lower in patients who received analgesics than in those not receiving analgesics ($p=0.023$ and $p=0.012$, respectively, by Mann–Whitney); this was also the case in

Table 2 Sequential changes in EQ-5D scores for patients with incidental fragility fractures

	Duration after fracture				
	Before fracture	2 weeks	3 months	6 months	1 year
Hip fracture					
N	37	37	37	31	30
Mean±SD	0.795±0.174	0.373±0.270	0.635±0.158	0.634±0.184	0.680±0.244
Median (75% tile, 25% tile)	0.768 (1.000, 0.693)**	0.444 (0.587, 0.115)^{a,}***	0.649 (0.721, 0.533)^{b,a,}***	0.631 (0.693, 0.577)^{a,}***	0.640 (0.902, 0.587)^{b}#***
Vertebral fracture					
N	35	35	35	31	30
Mean±SD	0.882±0.168	0.531±0.173	0.758±0.176	0.746±0.159	0.838±0.171
Median (75% tile, 25% tile)	1.000 (1.000, 0.768)	0.533 (0.649, 0.473)^{a,}***	0.749 (1.000, 0.605)^{b}	0.724 (0.768, 0.596)^{a,}**	0.768 (1.000, 0.693)
Wrist fracture					
N	50	50	50	43	40
Mean±SD	0.934±0.125	0.717±0.137	0.812±0.184	0.873±0.150	0.881±0.148
Median (75% tile, 25% tile)	1.000 (1.000, 0.947)	0.679 (0.775, 0.608)^{a}	0.768 (1.000, 0.724)^{a}	1.000 (1.000, 0.724)	1.000 (1.000, 0.768)

*$p<0.05$

**$p<0.01$

***$p<0.001$ vs. wrist fracture

#$p<0.05$ vs. vertebral fracture (by Dunn's test)

$^{a}p<0.01$

$^{b}p<0.05$ vs. values before fracture (by Dunn's test)

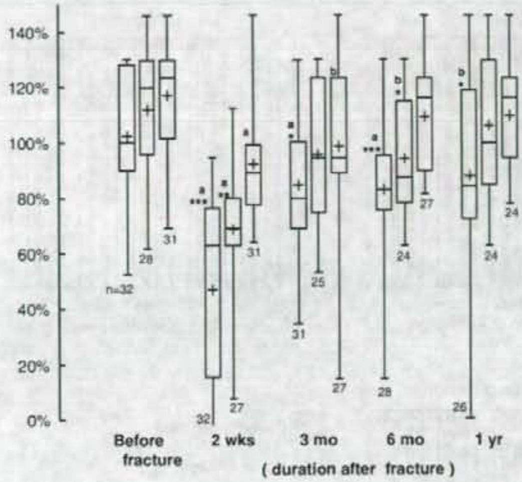

Fig. 1 Sequential changes in age-adjusted EQ-5D (utility) for patients aged 65 years and over. *Left box* represents hip fracture group, *middle box* represents vertebral fracture group, and *right box* represents wrist fracture group at each observational point (before fracture, at 2 weeks, 3 months, 6 months, and 1 year after the fracture). Data points represent EQ-5D (utility) age-adjusted to values for the Japanese general population aged 65 years and over. The *vertical bars* indicate the range (maximum and minimum), and the horizontal boundaries of the *boxes* represent the first quartile, median, and third quartile. +indicates mean values. $^*p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ vs. wrist fracture (by Dunn's test). *a* $p<0.01$, *b* $p<0.05$ vs. values before fracture (by Dunn's test)

the vertebral fracture group at 1 year after the fracture ($p=0.031$). However, there were no significant differences at the other observational points from 3 months to 1 year after the fracture. There were no significant differences in EQ-5D (utility) throughout the observational period between patients administered and not administered anti-osteoporosis drugs in all fracture groups.

Percent changes (means±SD) of EQ-5D(utility) from baseline (before fracture) for patients with hip fracture at 2 weeks, 3 months, 6 months, and 1 year after the fracture were −55.1±32.9% (range from −112.9% to 0%), −19.1±22.8 (−55.6 to 10.6), −16.6±24.8 (−80.5 to 31.9), and −12.9±33.1 (−99.6 to 70.4), respectively. Those for vertebral fractures were −37.5±23.6 (−94.8 to 0.0), −13.8±22.3 (−54.1 to 30.2), −13.2±25.7 (−42.3 to 87.6), and −7.8±17.3 (−40.4 to 30.2), respectively. Those for wrist fractures were −22.2±16.2 (−54.1 to 30.2), −12.9±19.4 (−88.5 to 29.2), −5.9±18.2 (−39.2 to 38.1), and −5.8±15.9 (−36.9 to 44.3), respectively.

The reduction of EQ-5D(utility) during the observational period was greatest in the hip fracture group. In the wrist fracture group, EQ-5D (utility) at 6 months after the fracture showed recovery; however, values in the hip and vertebral fracture groups were significantly lower than before the fracture. One year after the fracture, EQ-5D (utility), values were not significantly different from prefracture values in the vertebral and wrist fracture groups, but remained significantly lower in the hip fracture group (Table 2).

Changes in age-adjusted EQ-5D (utility) for patients aged 65 years and over are presented in Fig. 1. The reduction of age-adjusted EQ-5D (utility) during the observational period was greatest in the hip fracture group; mean (median) values of percent changes from baseline at 2 weeks, 3 months, 6 months, and 1 year after the fracture were 46.9%(62.8%), 84.8%(80.1%), 83.2%(83.1%), and 88.1%(84.4%), respectively.

EQ-5D (profile)

Among the groups, the proportion of patients reporting problems in each of the five health domains of EQ-5D (profile) was higher in the hip fracture group than in the other two groups (Fig. 2). The difference between the hip fracture and other groups was most evident in the "mobility" and "usual activity" domains.

EQ-5D (vas)

Changes in EQ-5D (vas) were similar to those in EQ-5D (utility) (Fig. 3). There were no significant differences in EQ-5D (vas) between neck and trochanteric fractures among patients with hip fractures, between thoracic and lumbar fractures among patients with vertebral fractures, or between surgical and nonsurgical treatment among patients with wrist fractures throughout the observational period.

Discussion

The present study demonstrates that among clinical fragility fractures, hip and vertebral fractures have the highest impact on patients' HR-QOL. HR-QOL indices of these two fractures did not return to prefracture levels even one full year after the fracture occurrence. These findings are in accordance with previous reports [9, 17–19]. This is the first report to describe the prospective measurement of HR-QOL in Asian patients with incident fragility fractures.

Measurement of the effects of diseases on HR-QOL is of importance, since it allows a broad assessment of health domains not always captured in standard clinical or disease-specific assessments [20]. The EQ-5D is a generic measure of health status developed by the EuroQol Group and was originally standardized for use in England and Northern Europe. Translations have been undertaken in several languages; the official Japanese version of the EQ-5D instrument was developed in May 1998 (Japanese EuroQol Translation Team, 1998) [15]. EQ-5D is a self-completed,

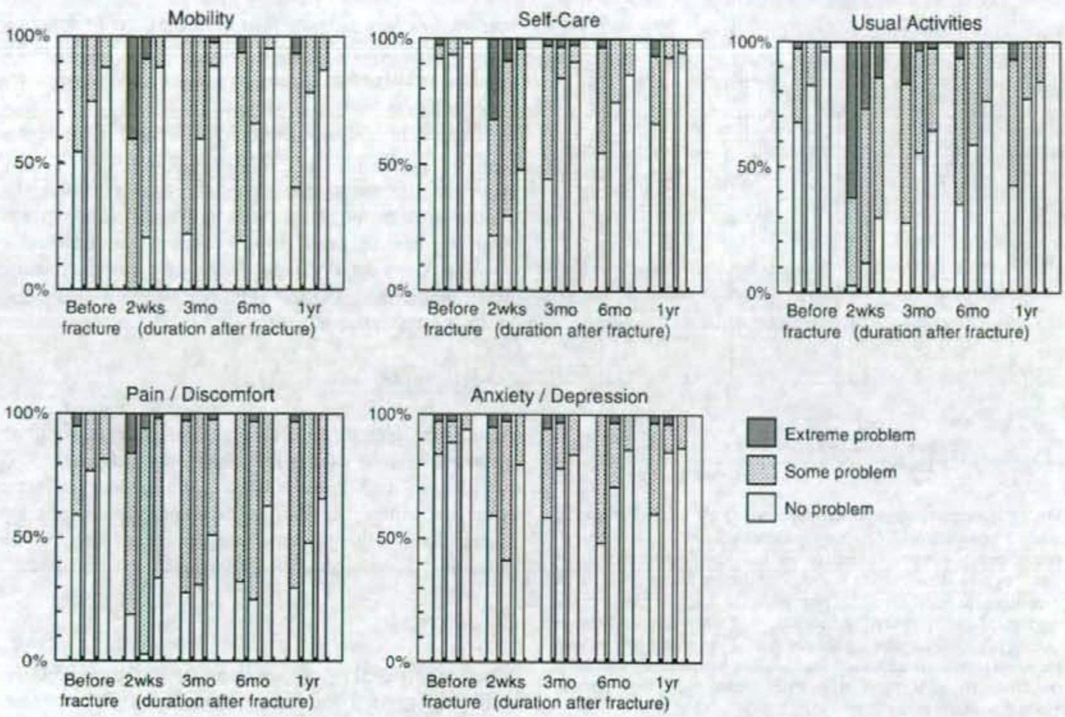

Fig. 2 Sequential changes in health profile. *Left box* represents hip fracture group, *middle box* represents vertebral fracture group, and *right box* represents wrist fracture group at each observational point (before fracture, at 2 weeks, 3 months, 6 months, and 1 year after the fracture). Data points represent the percentage of patients reporting no problem, some problems, or extreme problems in each domain of EQ-5D profile

easy-to-use questionnaire that provides a health profile with a VAS [20]. Because this study targeted aged patients, we adopted EQ-5D for its simplicity and ease of use. EQ-5D also allows measurement of health utility, which forms the basis for estimation of quality-adjusted life years (QALY) [13].

Hip fractures cause acute pain and loss of function and nearly always require surgery. Recovery is slow and rehabilitation is often incomplete. We reported that the ratio of patients who could go out with assistance was 69% before hip fracture, whereas only 40% could go out at 1 year after the fracture [21]. Therefore, a considerable reduction of HR-QOL, as well as impairment of physical function, occurs after hip fractures [8, 9, 22–24]. A prospective, case-control study showed significant reductions of HR-QOL in the SF-36 domains: −51% for Physical Function, −24% for Vitality, and −26% for Social Function at 3 months after fracture [25]. Tidermark et al. demonstrated that EQ-5D scores decreased from 0.78 before the fracture to 0.59 at 4 months after surgery, and further decreased to 0.51 at 17 months after surgery, in relatively healthy elderly patients treated with internal fixation [10]. Our data from before and 3 months after fracture were very

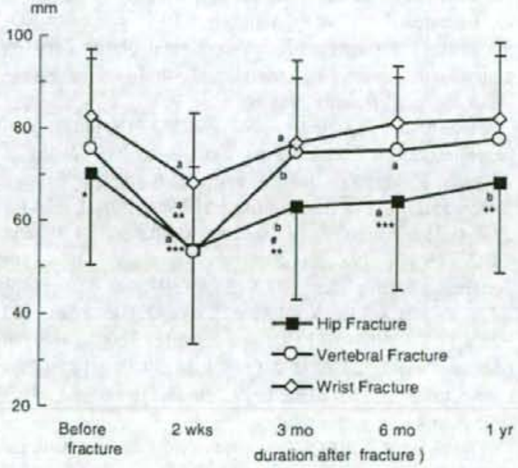

Fig. 3 Sequential changes in VAS. Data represent means±SD. **p*< 0.05, ***p*<0.01, ****p*<0.001 vs. wrist fracture, #*p*<0.05 vs. vertebral fracture (Dunn's test). *a p*<0.01, *b p*<0.05 vs. values before fracture (Dunn's test)

close to the scores of Tidermark et al. from before and 4 months after fracture, indicating that the impact of hip fracture on HR-QOL dose not differ much between the two populations in spite of the cultural differences.

The morbidity of vertebral fractures varies from mild cases, with only slight pain, to severe and multiple fracture cases with acute pain and many reoccurrences. Several studies have investigated the impact of prevalent or incident vertebral fractures on HR-QOL. A progressive worsening trend in HR-QOL with an increasing number of prevalent fractures has been observed [26]. Incident vertebral fractures have an adverse impact on HR-QOL regardless of symptomatology, and QOL score changes for patients with subclinical (absence of symptoms) vertebral fractures were intermediate between those for patients with clinical (symptomatic) vertebral fractures and patients without incident vertebral fractures [19]. The adverse health impact was most marked among patients with incident fractures who had a prevalent vertebral fracture, suggesting that the effect of multiple fractures on HR-QOL is cumulative [19, 27]. In the current study, only clinical fractures were evaluated, and we did not find any difference in the impact on HR-QOL between patients with and without prevalent vertebral fractures. This might be due to the small number of patients; only four patients presented with prevalent vertebral fractures. We showed a statistical difference in HR-QOL between patients with thoracic and lumbar fractures that is in agreement with previous studies [26]. This difference occurs because lumbar fractures are more often symptomatic than thoracic fractures, due to stabilization of the thoracic spine by the rib cage.

Wrist fractures cause pain and loss of function, but fracture healing and regain of function are usually favorable. Dolan et al. observed considerable loss in the first 3 months, but recovery was fast, and the HR-QOL impairment was small [28]; these findings are compatible with our observations.

In a previous study, each of the five dimensions or domains of the EQ-5D (profile) were collected from a representative sample of the Japanese general population aged 65 years and over [16]. The percentages reporting "some" or "extreme" problems were 29.2% and 0.8% for mobility, 6.0% and 1.5% for self-care, 21.5% and 3.4% for usual activity, 40.3% and 2.0% for pain/discomfort, and 15.5% and 1.1% for anxiety/depression, respectively. Compared with these data, the percentage of patients complaining of "some" or "extreme" problems in each domain seemed to recover to normal levels by 6 months in the wrist fracture group, and by 1 year in the vertebral fracture group; however, in the hip fracture group, a substantially higher percentage of patients complained of "some" or "extreme" problems in all domains throughout the observational period.

In North America, QALY loss in the first year after hip fracture was 0.4681, mainly due to the hospital and nursing home stay, whereas the QALY loss after a vertebral fracture with severe pain was up to 0.5000 [29, 30]. This type of analysis is indispensable, but has not been done in Japan, since to date, there have been no data available to estimate QALY loss after fragility fractures among the Japanese population. The data presented in this study could make possible a cost-utility analysis of osteoporosis therapies.

This study had several limitations. First, the number of the subjects was limited, which might introduce some sampling biases. In this study, patients who could not complete the EQ-5D questionnaire were not enrolled, which could lead to overestimation of HR-QOL scores for hip and vertebral fracture patients. Second, the dropout rate could have affected the results. Most patients who dropped out were in the wrist fracture group; many of them fully recovered and thereafter lost contact. This could have led to underestimation of HR-QOL scores. Third, the severity of the fracture may affect QOL status, i.e., patients with more severe fractures may become more pessimistic, while patients with slight fractures may be more optimistic even at the time of recollection. Therefore, patients with more severe disabling fractures may overestimate prefracture quality of life. Hospitalization or residence at the evaluation point might affect the HR-QOL scores: hospitalized patients showed lower prefracture QOL scores for vertebral fractures, and patients who received analgesics tended to have lower QOL scores. The findings could represent possible biases in the pre- and postfracture QOL assessment. Finally, further studies are required to assess the influence of comorbidity on HR-QOL scores in patients with osteoporosis-related fractures.

In conclusion, HR-QOL data obtained in this study showed that loss of quality of life is more severe after hip or vertebral fractures than after wrist fracture. HR-QOL was not completely restored in patients suffering from hip fracture. Collectively, these data suggest that prevention of osteoporotic fractures is of the utmost importance for maintaining quality of life.

Acknowledgments The authors thank Masatoshi Nakashima, M.D., Masaaki Shimizu, M.D., Kimiko Tsuda, M.D., and Noboru Yamagata, M.D., for their help and support.

Conflicts of interest None.

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Osteoporos Int
DOI 10.1007/s00198-008-0685-0

ORIGINAL ARTICLE

Recent trends in the incidence and lifetime risk of hip fracture in Tottori, Japan

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Received: 3 February 2008 / Accepted: 29 May 2008

Abstract
Summary Hip fracture incidence from 2004 to 2006 in the Tottori prefecture of Japan was investigated and compared with previously reported rates. The age- and gender-specific incidence of hip fracture in the Tottori prefecture has not plateaued, as has been reported for populations in Northern Europe or North America.
Introduction Recent data from Northern Europe and North America indicate that the incidence of hip fracture has plateaued, whereas most reports from Asia indicate that the incidence is increasing. The aims of this study were to investigate the recent incidence of hip fracture in the Tottori prefecture, Japan, and to compare it with previous reports.
Methods All hip fractures in patients aged 35 years and older occurring between 2004 and 2006 were surveyed in all of the hospitals from the Tottori prefecture. The age- and gender-specific incidence rates were then calculated. Using these and previously reported data, the estimated number of hip fracture patients was determined using the age- and gender-specific incidence rates in each year from 1986 to 2006.
Results The survey identified 851, 906, and 1,059 patients aged 35 years and older, in 2004, 2005, and 2006 respectively. The residual lifetime risk of hip fracture for individuals at 50 years of age was estimated to be 5.6% for men and 20.0% for women. The estimated number of patients from 1986 to 2006 showed a significant increase over time for both genders.
Conclusions The age- and gender-specific incidence of hip fracture in the Tottori prefecture, Japan has not plateaued for either gender.

Keywords Epidemiology · Hip fracture · Incidence · Lifetime risk · Osteoporosis

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Introduction

Hip fracture is the most significant osteoporotic fracture in terms of health outcomes, quality of life, and cost. As a result of the aging population, the burden of these fractures on our health care systems is increasing and the absolute number of hip fractures is expected to increase significantly during the next few decades. It has been estimated that the total number of hip fractures worldwide will increase from 1.3 million in 1990 to 2.6 million by the year 2025 and to 4.5 million by the year 2050 [1]. To predict the number of patients requiring treatment for hip fractures during the coming decades, however, it is necessary to determine whether the number of fractures is rising more rapidly than can be accounted for by demographic changes alone.

A growing number of epidemiological surveys show an exponential increase in the incidence of hip fracture with age among different ethnic groups. In addition, data obtained beginning in the 1990s from Northern Europe [2, 3], North America [4], and Australia [5] indicate that previously observed age-specific increases in the incidence of hip fracture have plateaued. We previously performed a hip fracture survey in the Tottori prefecture and found that the incidence of hip fracture increased from 1986 to 2001; this agreed with most other studies from Asia, which indicated an increase in the incidence of hip fracture over time [6].

To estimate the real burden of this problem, a long-term prospective population-based study specifically examining the age distribution and changes in the incidence rates of hip fracture is essential. There is, however, a paucity of long-term data on the changes in these rates in men and women within defined communities. The aims of this study were to investigate hip fracture incidence rates in the Tottori prefecture from 2004 to 2006 and to compare them with previously reported rates.

Patients and methods

Data sources

In 2006, the Tottori prefecture, which is located in midwestern Japan, had a population of 603,987, including 176,255 men and 208,582 women aged 35 years and older. The percentages of the population aged 65 years and older, 75 years and older, 85 years and older, and 90 years and older in 2006 were 24.6% (20.4% of men; 28.4% of women), 12.9% (9.4% of men; 16.1% of women), 3.5% (1.8% of men; 5.0% of women), and 1.4% (0.6% of men; 2.0% of women) respectively.

As previously stated [6], all hip fractures in patients 35 years and older that occurred between 2004 and 2006 were surveyed in all of the hospitals in the Tottori prefecture. This included 30 hospitals with orthopedic or general surgery departments; according to the hospital records, survey registration was performed by the doctors or medical staff in each of these hospitals. Registration information included gender, age, area of residence, date of fracture, type of fracture (neck or trochanteric), and treatment. Patients residing in other prefectures were excluded. Duplication of cases was determined using the patients' ages, dates of fracture, types of fracture, and areas of residence. As previously reported [6], we investigated the data collection methods at the three hospitals with the most hip fracture patients in each year, which covered one-third of the total number of patients in this prefecture. This confirmed that the methods used to register the patients with hip fractures were consistent with those used in previous observational periods.

The study was approved by the local ethics research committee at the Faculty of Medicine, Tottori University.

Statistical analysis

The patients were divided into groups according to their age (subdivided into 5-year increments), gender, and fracture type (neck or trochanteric fracture). The age- and gender-specific incidence rates (per 100,000 person years) were calculated based on the population of the Tottori prefecture during each year. Every 5 years in Japan, a national census is performed on 1 October, including in 2005 during the observation period. The age- and gender-specific populations for each survey year were estimated by the Bureau of Statistics of the Tottori prefecture government office according to resident registration records.

To determine recent trends in the hip fracture incidence, a test of trends of proportions in quantitatively ordered samples was used [7]. The age- and gender-specific incidence (per 100,000 person years) from 1986–1988, 1992–1994, and 1998–2001, which we have previously reported [6, 8], were used for this analysis. The expected number of patients, age-adjusted to the population structure from 1986 in the Tottori prefecture (35 years and older), was calculated from the age- and gender-specific incidence rates in each observation year. The overall and slope Chi-squared values were examined. Additionally, we elucidated the influence of the expansion in the elderly population using the age-adjusted incidence in two age groups: 85–89 years old and 90 years and older.

Lifetime risks of hip fracture for 50-year-old men and women in the population were estimated by simple approximation using the incidence data and the age- and gender-specific incidence and life tables for the Japanese population in 2006 released by the Ministry of Health, Labour and Welfare of Japan (http://www.mhlw.go.jp/english/database/index.html).

To compute the lifetime risks, Pr was defined as the probability of having no hip fracture until death for a 50-year-old man or woman. This probability may be discretely approximated using the following formula:

$$\begin{aligned}\Pr &= d50(1-I50) + (1-d50)(1-I50)d51(1-I51)\\ &\quad + (1-d50)(1-I50)(1-d51)\\ &\quad \times (1-I51)d52(1-I52) + \cdots\end{aligned}$$

where $d50$ is the probability of dying between the ages of 50 and 51 years, $I50$ is the probability of having a fracture between the ages of 50 and 51 years, and so on. These values were replaced with the corresponding incidence or mortality rates in this study. The residual lifetime risk of an individual aged 50 years experiencing a hip fracture is then estimated by 1 − Pr.

The significance of the difference in proportions of patients with left or right fractures was examined using Chi-squared testing. The monthly variation in the number of patients was tested using the Friedman test. $P<0.05$ was regarded as significant.

Results

Characteristics of patients aged 35 years and older with hip fracture

Registration was performed in all hospitals during the entire observation period. As a result, this survey covered all patients with hip fractures. The survey identified 851 (161 men and 690 women), 906 (170 men and 736 women), 1,059 (191 men and 868 women) patients aged 35 years and older in 2004, 2005, and 2006 respectively. Categorizing the patients by fracture type, there were 360 neck fractures (63 men and 297 women) and 487 trochanteric fractures (97 men and 390 women) in 2004 (4 fractures were undetermined); 338 neck fractures (61 men and 277 women) and 547 trochanteric fractures (103 men and 444 women) in 2005 (21 fractures were undetermined); and 424 neck fractures (84 men and 340 women) and 617 trochanteric fractures (102 men and 515 women) in 2006 (18 fractures were undetermined).

Right hips were fractured in 1,421 patients and left hips were fractured in 1,395 patients, with no significant difference between the numbers of right and left fractures. The maximum number of fractures occurred in January (267), whereas the smallest number occurred in August (189). There was no statistically significant difference among months during the 3-year period from 2004 to 2006. Including the data from the previous observational periods (1986–1988, 1992–1994, 1998–2001, and 2004–2006), a significant seasonal change in the incidence was noted, with a higher incidence observed in the winter and a lower incidence identified in the summer months ($p<0.006$, by Friedman test).

Incidence of hip fracture between 2004 and 2006

In the population aged 35 years and older, the crude incidence of hip fractures was 244.8 per 100,000 person years from 2004 to 2006, and the gender-specific incidence was 99.1 per 100,000 person years for men and 368.0 per 100,000 person years for women. Although the incidence rate of hip fractures increased with age (Table 1), the absolute number of hip fractures peaked in the 80- to 84-year-old population of men and in the 85- to 89-year-old population of women.

After categorizing the fracture types, the incidence of neck fractures averaged during the 3-year period (from 2004 to 2006) in men and women was 58.6 and 143.7 (70- to 74-year-old group), 101.1 and 309.0 (75- to 79-year-old group), 160.9 and 477.9 (80- to 84-year-old group), 301.6 and 634.7 (85- to 89-year-old group), and 391.5 and 820.1 (≥90-year-old group) respectively. The incidence of trochanteric fractures was 62.9 and 105.5 (70- to 74-year-old group), 128.8 and 244.7 (75- to 79-year-old group), 289.7 and 730.2 (80- to 84-year-old group), 575.4 and 1,470.5 (85- to 89-year-old group), and 619.6 and 2,070.0 (≥90-year-old group) respectively.

Table 1 Age- and gender-specific incidence of hip fracture in Tottori Prefecture, Japan

Age group	Men						Women						Average	
(years)	2004	*n*	2005	*n*	2006	*n*	2004	*n*	2005	*n*	2006	*n*	Men	Women
35–39	0.0	0	6.0	1	11.5	2	5.9	1	5.9	1	5.7	1	5.8	5.8
40–44	5.8	1	5.8	1	12.2	2	0.0	0	0.0	0	5.8	1	7.9	1.9
44–49	24.9	5	26.0	5	26.8	5	5.0	1	0.0	0	26.5	5	25.9	10.5
50–54	8.5	2	17.6	4	13.7	3	39.2	9	22.6	5	4.7	1	13.3	22.1
55–59	13.4	3	24.8	6	34.6	9	31.6	7	33.5	8	50.7	13	24.3	38.6
60–64	61.3	11	16.6	3	47.1	8	71.6	14	31.0	6	88.3	16	41.7	63.7
65–69	110.7	18	106.4	17	81.7	13	163.7	32	78.8	15	164.4	31	99.6	135.7
70–74	150.8	24	88.6	14	131.5	21	270.3	53	192.9	39	299.2	60	123.6	254.1
75–79	185.5	24	249.0	33	270.6	36	508.0	96	568.7	109	620.8	120	235.0	565.8
80–84	441.8	31	554.9	43	391.7	33	1,163.7	163	1,301.9	196	1,258.3	196	462.8	1,241.3
85–89	665.3	22	915.0	31	1,107.3	39	2,035.8	166	1,953.7	174	2,437.5	230	895.9	2,142.3
90+	1,246.9	20	730.8	12	1,116.7	20	2,605.6	146	3,089.1	183	3,024.6	191	1,031.5	2,906.5

Incidence data are per 100,000 person years

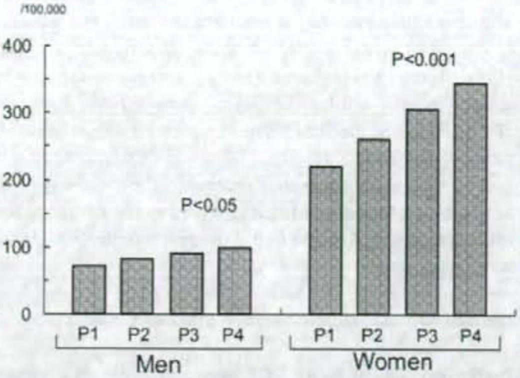

Fig. 1 Trends in the incidence of hip fracture per annum (patients aged 35 years and older). Data are the expected number of patients adjusted for the age- and gender-specific incidence in each year standardized using the 1986 population structure in the Tottori prefecture. In the population aged 35 and older, 154,774 individuals were men and 183,157 were women in 1986. P1: 1986–1988; P2: 1992–1994; P3: 1998–2001; P4: 2004–2006. The incidence in the periods 1986–1988, 1992–1994, and 1998–2001, which we have previously reported [6, 8], was used. χ^2 (overall) was 24.7 ($p<0.05$) for men and 110.0 ($p<0.001$) for women. χ^2 (slope) was 16.4 ($p<0.01$) for men and 97.7 ($p<0.001$) for women

The residual lifetime risk of hip fracture for individuals aged 50 years was estimated to be 5.6% for men and 20.0% for women.

Changes in incidence during the 20-year period

During the 20-year observational period, the total population aged 35 years and older in this area grew 1.14-fold, whereas that aged 85 years and older grew 3.18-fold (from 6,662 to 21,163). From 1986 to 1988, 916 hip fractures were reported in patients 35 years and older, whereas 2,816 hip fractures were identified in this patient population in the period from 2004 to 2006. The number of hip fractures among women increased 3.3-fold, from 692 to 2,294, and that among men increased 2.3-fold, from 224 to 522.

The expected number of patients adjusted for the age- and gender-specific incidence in each year and standardized using the population structure of 1986 showed significant increases from 1986 to 2006 for both genders (Fig. 1). The mean age- and female-specific incidence in the 85- to 89- and ≥90-year-old age groups was 1,179.2 and 1,506.9 per 100,000 person years from 1986 to 1988, 1,632.8 and 1,838.0 per 100,000 person years from 1992 to 1994, 1,810.9 and 2,407.5 per 100,000 person years from 1998 to 2001, and 2,142.3 and 2,906.5 per 100,000 person years from 2004 to 2006 respectively. Those for men in the 85- to 89- and ≥90-year-old age groups were 551.5 and 871.9 per 100,000 person years from 1986 to 1988, 572.6 and 887.3 per 100,000 person years from 1992 to 1994, 632.9 and 1,059.3 per 100,000 person years from 1998 to 2001, and 895.9 and 1,031.5 per 100,000 person years from 2004 to 2006 respectively.

Figure 2 shows the average age- and gender-specific incidence for neck and trochanteric fractures from the periods 1986–1988, 1992–1994, 1998–2001, and 2004–2006. For both genders, the incidence of both types of fracture was significantly higher in 2004–2006 than in all other survey periods. The expected numbers of patients with neck fracture adjusted for the age- and gender-specific incidence in each year and standardized by the population structure of 1986 was 22.0 for men and 87.0 for women in 1986, and 47.2 for men and 175.0 for women in 2006. The expected numbers of trochanteric fractures in men and

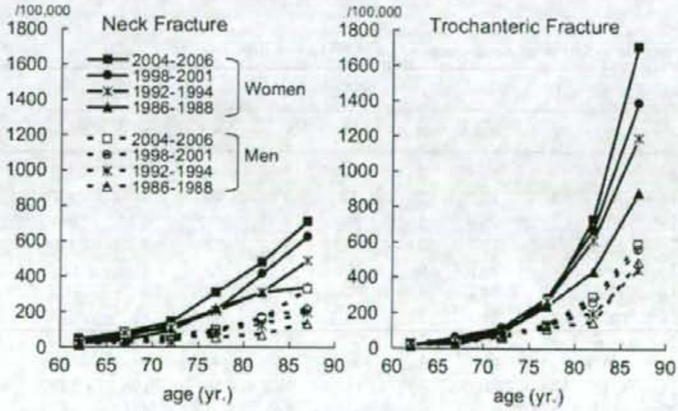

Fig. 2 Age- and gender-specific incidence of neck and trochanteric fractures between 1986 and 2006. Incidence data are per 100,000 person years. Incidence from the periods 1986–1988, 1992–1994, and 1998–2001, which we have previously reported [6, 8], were used for comparison

women were 39.0 and 119.0 in 1986 and 57.0 and 202.2 in 2006 respectively. These increases were statistically significant, with the exception of trochanteric fractures in men.

Discussion

In this study, we have demonstrated that the age-specific incidence of hip fracture in the Tottori prefecture has not stabilized, but rather has slightly increased during the past two decades. This observational study began in 1986 and has been carried out using 3-year intervals, except for the 4-year survey from 1998 to 2001. The catchment area, the methods of identifying hip fracture patients, and the definitions of fracture were identical to those used in previous studies [6, 8]. The proportion of the population aged 65 years and older in the whole of Japan was 20.8% in 2006, whereas it was 24.6% in Tottori. In the Tottori prefecture, there are 6.6 general hospitals per 100,000 persons (6.2/100,000 persons for the whole of Japan) and the average monthly income is ¥504,729 (US$4,799) per family unit (¥525,716 [US $4,997] for the whole of Japan) in 2006. Based on these data, the Tottori prefecture has a higher percentage of seniors, but is representative of Japan based on the medical resources and family economics. Because the Tottori prefecture is on the coast and is surrounded by mountains, all patients with fractures must be treated at a hospital within the prefecture. Japanese citizens are legally obliged to belong to one of several government-subsidized health insurance programs, and thus every patient with hip fracture is treated in a hospital. These circumstances contribute to the validity of this longitudinal survey. The incidence observed during the 20-year period in the Tottori prefecture was in the middle of the range observed within Japan as a whole over the same period [9, 10], suggesting that the data from this study are representative of the Japanese population.

Several studies have suggested a wide geographic variation in hip fracture incidence between countries, with the highest rates reported for northern European countries [2, 3] and the United States [11], and the lowest rates reported in Africa and some Asian populations [6, 12, 13]. The Japanese incidence presented in the current study is slightly higher than that reported recently in Korea [14] or Taiwan [15]. In general, people who live in latitudes farther from the equator seem to have a higher incidence of fracture [16].

The lifetime risk of hip fractures for individuals aged 50 years is estimated to be 22.9% for women and 10.7% for men in Sweden, and 11.4% and 3.1% respectively in the UK [17, 18]. The average life expectancy at birth for Japanese individuals has steadily increased, reaching 78.56 years for men and 85.52 years for women in 2005. The life expectancy for 50-year-old men was 29.26 years and that for women was 35.94 years in 2005. Although the incidence of hip fracture in Japan is lower than that in Sweden, longer lifespans have elevated the residual lifetime fracture risk for individuals 50 years of age.

This type of increase has been observed in longitudinal data from several areas within Japan [19] and in nationwide surveys [10], in which the incidence was increased in both men and women, particularly among individuals at least 80 years old; the present study demonstrated the same tendency. In the Tottori prefecture, the total population decreased by 2.1% from 1986 to 2006, whereas the population aged 85 years and older more than tripled. This expansion in the elderly population may have affected our findings. To address this possibility, we compared the age-adjusted incidence with previous observations in the population aged between 85 and 89 years and in that aged 90 years and older. We found a substantial increase in women in the incidence in these age groups and in men 85 to 89 years old. This age-specific increase in these older populations indicates that the increase in hip fracture incidence is not completely due to a proportional change in the population structure.

Decreases in the incidence of hip and wrist fractures have been observed in Ontario, Canada; the authors suggested that the higher diagnosis rates for osteoporosis and the shift from specialist to primary care observed in the late 1990s resulted in a greater number of women with osteoporosis receiving appropriate diagnosis and treatment, which coincided with the reduction in fracture rates [20]. A nationwide decline in the incidence of hip fracture has been also been reported in Finland; potential reasons proposed by the authors included a cohort effect toward a healthier elderly population, increased body mass index, improved functional ability in the elderly, specific actions to prevent and treat osteoporosis, and effective programs and interventions for fall prevention [21]. Bone mineral density in older Japanese individuals has been increasing recently. The Miyama study conducted in 1990 and in 2000 showed significant improvements in the bone density of the femoral neck in men in their 60s and in women in their 50s, suggesting that bone fragility may be generally less severe than before in Japan [22]. This is probably a result of increased body weight among Japanese individuals; increases in obesity, however, may result in decreases in hip fracture similar to the data described from Northern Europe. Therefore, risks of fracture other than bone fragility should be assessed to help explain the increase in the incidence in Japan. We reported that one significant preventive factor for distal radius fractures among Japanese individuals was the use of a futon (as opposed to a bed) [23]. We speculated that futon use helps to maintain some level of physical activity, resulting in a reduced risk of falls. Moreover, the overall decrease in physical activity of a Westernized lifestyle may explain the increase in fracture incidence among Japanese patients. Another explanation may be that more seniors with poor health due to other conditions are being treated, which results in people living longer at a time when their risk of falling is considerably high.

The incidence of neck fracture is higher than that of trochanteric fracture in Northern European and African populations, whereas neck fracture is less common in Japanese populations [3, 13, 24, 25]. This study showed that an increasing number of patients in the Tottori prefecture are suffering neck fracture relative to trochanteric fracture; the increases in age-standardized incidence during the two decades for neck fracture was 115% in men and 101% in women, and those for trochanteric fracture were 46% and 70% respectively. On the other hand, a recent survey in Sweden showed that the neck-to-trochanteric fracture incidence ratio had leveled off [2]. Although the reason for these trends is uncertain, the neck-to-trochanteric fracture ratio in Japan is approaching values observed in Northern European populations.

Our study has some limitations, particularly with regard to the data collection. The method of data collection was consistent, and, as mentioned before, we checked patient enrollment in three monitoring hospitals [6]. Second hip fractures in the same patient during the observational period were not specifically identified in the present survey, which may have affected the result. Moreover, hip fracture patients living in the Tottori prefecture and treated outside the prefecture may have been missed during the registration. The number of such patients, however, is likely to be very small.

We conclude that the age- and gender-specific incidence of hip fracture in the Tottori prefecture of Japan has not plateaued as it has for populations in Northern Europe and North America. This presents a remarkable challenge to the Japanese health care system. An estimated 12 million patients have osteoporosis in Japan, and only 20–25% are being treated with anti-osteoporotic medication. Appropriate diagnosis and treatment of osteoporosis is essential, and more effective interventions for preventing falls are needed.

Acknowledgements The authors sincerely acknowledge the staff members of the hospitals in the Tottori prefecture that participated in this study. The authors also acknowledge the Japanese Orthopedic Society. The authors would like to express sincere thanks to Motoko Sasaki for her secretarial help. This study was supported by a grant-in-aid from the Ministry of Health, Labour and Welfare of Japan (grant H18-Choujyu Ippann-036).

Conflicts of interest None.

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J Orthop Sci (2008) 13:39–45
DOI 10.1007/s00776-007-1189-z

JOURNAL OF
ORTHOPAEDIC SCIENCE
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Original article

High tibial osteotomy using two threaded pins and figure-of-eight wiring fixation for medial knee osteoarthritis: 14 to 24 years follow-up results

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Abstract

Background. High tibial osteotomy (HTO) is an established surgical treatment for medial knee osteoarthritis (OA). Several studies have reported the deterioration of clinical results with time, especially after more than 10 years. The purpose of this study was to evaluate the long-term results after HTO using our originally developed fixation method and to clarify the factors affecting the long-term clinical outcome.

Methods. Sixty-eight HTO treatments in 55 patients were evaluated. Eighteen patients were unable to be analyzed, thus reducing the study to 48 knees in 37 patients. The follow-up rate of the knee joint was 70.6% and the mean follow-up period was 17.1 years. The first evaluation was performed at a mean of 6.5 years postoperatively, and the most recent evaluation was done at more than 10 years postoperative follow-up. A closing-wedge osteotomy was performed, and the osteotomy site was fixed with two threaded pins and a figure-of-eight wiring technique. The Japanese Orthopaedic Association knee rating score (JOA score) was used for the clinical assessment. The change of the femorotibial angle (FTA) and progression of knee OA were radiographically analyzed. The whole knees were subsequently divided into two groups, satisfactory group and unsatisfactory group, according to the JOA score at the most recent follow-up.

Results. The mean JOA score was 59.1 before HTO and 83.1 at the most recent evaluation. In comparing the satisfactory and unsatisfactory groups, the JOA score before HTO was the same, but the JOA score of the unsatisfactory group was significantly lower at the first evaluation. The FTA in the unsatisfactory group was the same as in the satisfactory group preoperatively, but it was significantly larger after HTO. The radiographic OA was significantly progressed at the most recent evaluation, but no difference was observed in the distribution of the preoperative OA grade between the two groups.

Conclusions. HTO with two threaded pins and figure-of-eight wiring fixation showed an acceptable clinical outcome, but careful attention was needed for correction loss in early postoperative periods. In addition, the proper correction angle is necessary in order to achieve satisfactory long-term results.

Offprint requests to: G. Omori
Received: March 2, 2007 / Accepted: October 10, 2007

Introduction

Osteoarthritis (OA) is the most common form of degeneration of the joints. The knee joint is the key structure in the lower extremity and has much influence on the activity of daily life (ADL) and the quality of life (QOL) in elderly persons. These include standing, walking, running, jumping, stair climbing, deep knee bending such as squatting or Japanese-style sitting, and other lower extremity tasks. Approximately 10% to 15% of people aged 60 years and older have symptomatic knee OA.[1] Therefore, knee OA is a major source of chronic disability and is becoming a serious public health problem.

High tibial osteotomy (HTO) is one of the successful surgical treatments for medial compartment knee OA. HTO was first described by Jackson and Waugh,[2] and it is now widely accepted as an attractive procedure with good pain relief and preservation of knee function. Previous studies of early to midterm results of HTO have shown excellent outcomes in more than 80% of cases.[3–5] However, several studies with long-term follow-up reported that the results of HTO deteriorated with time, especially after more than 10 years. Several factors have been identified as affecting the results of HTO, but they remain controversial. These include sex, age at surgery, body weight, preoperative severity of knee OA, method of osteotomy and fixation, correction angle, amount of preoperative adduction moment, and postoperative period.[6–14]

Among these factors, the type of fixation following osteotomy remains important, and, in the past, the following methods have been reported: bone staples, blade plate with screws, one third tubular plate with a cortical screw (tension bend principle), L-buttress plate, and external fixator.[3,15-20] We developed a fixation method using two threaded pins and figure-of-eight wire and used this method for our consecutive HTO cases.

The purpose of this retrospective study was to assess the long-term results after HTO using our fixation method and to clarify the factors affecting the long-term clinical outcome.

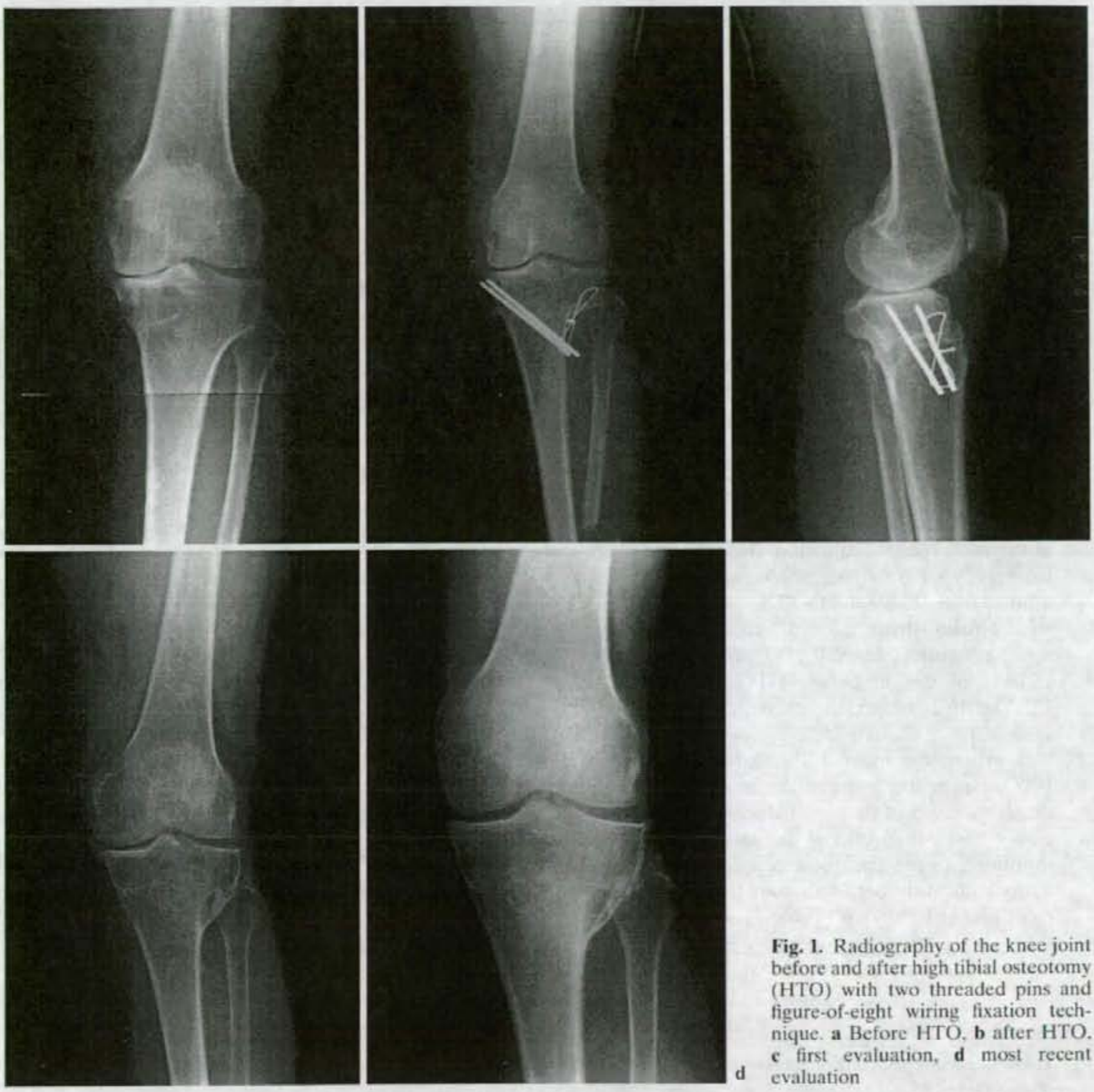
Subjects and methods

Our indications for HTO were basically as follows: (1) degenerative change was mainly located in medial compartment (medial knee osteoarthritis), (2) normal or mild degeneration in lateral and patello-femoral compartment, (3) patient was younger than 70 years old and had relatively high activity in ADL, and (4) good range of motion and no remarkable knee joint instability. Between 1980 and 1990, HTO was performed in 68 consecutive knees in 55 cases by our senior surgeon (Y. K.). Seven patients died, 6 patients were unable to be evaluated due to the presence of other severe medical illnesses, and 2 patients were lost to follow-up. Three knees in 3 patients were converted to total knee arthroplasty (TKA) at 10 years, 12 years, and 15 years after HTO, respectively. Therefore, the remaining 48 knees in 37 cases were available for the present study, and the follow-up rate of the knee joint was 70.6%. There were 43 knees in 33 women and 5 knees in 4 men. The mean age at HTO was 59 years with a range from 40 to 69 years. The mean follow-up period was 17.1 years, but individual follow-up ranged from 14 to 24 years. The preoperative diagnosis was medial compartment knee OA in all the cases, and the preoperative Kellgren-Lawrence classification[21] showed grade II in 8 knees, grade III in 35 knees, and grade IV in 5 knees. All of the patients were evaluated initially in 1993, with a mean follow-up of 6.5 years, and evaluated at more than 10 years follow-up postoperatively. All of the patients were fully informed about the procedures and gave their informed consent.

Operative procedures and postoperative regimen

In all knees, the closing-wedge interlocking osteotomy through a lateral approach was performed according to the technique described by Ogata.[22] The correction angle was preoperatively determined to allow the mechanical axis, which is the line connecting the center of the femoral head and the ankle joint, to pass through the midpoint of the lateral compartment. The preoperative planning was performed using non-weight-bearing supine radiograph of the whole lower extremity according to Ogata et al.[23] Ogata mentioned that the relative angle of the articular surface (condylar-plateau angle) in the weight-bearing knee changed after osteotomy, and this might give unpredictable results postoperatively. He also found that the condylar-plateau angle in the postoperative standing radiograph was very similar to that seen in the non-weight-bearing supine condition, and recommended that a non-weight-bearing supine radiograph was better for preoperative planning. The femorotibial angle (FTA) that met this condition was around 165° to 168° in the majority of cases. The fibula was resected at the mid portion of the shaft. The osteotomy site was fixed with two threaded pins and a figure-of-eight wiring technique. First, two threaded pins, 2.4 or 3.0mm in diameter, were inserted from distal and lateral of the osteotomy site to the medial corner of the proximal tibia passing through the medial half of the osteotomy line. Next, figure-of-eight wiring, 0.8 to 1.0mm in diameter, was placed between the distal end of the pins and lateral wall of the proximal tibia. After the osteotomy site was fixed, leg alignment was checked by X-ray and cancellous bone fragments harvested from the resected bone wedge were grafted to the osteotomy site (Fig. 1). Postoperatively, the knee joint was immobilized with a cast for 6 weeks. Range-of-motion exercise was started after the cast was removed. Partial weight bearing was started 4 weeks after HTO and full weight bearing was allowed at 8 to 10 weeks postoperatively.

Clinical evaluation

All of the patients were directly interviewed and examined. The clinical result was evaluated using the Japanese Orthopedic Association knee rating score (JOA score).[24] The JOA score consisted of four categories and 100 points as full marks: pain and walking (30 points), pain and ascending or descending stairs (25 points), range of motion (35 points), and joint effusion (10 points). In this study, the preoperative JOA score was compared with the JOA score at the first evaluation in 1993 and at the most recent follow-up. Subsequently, the results of the JOA score were classified as excellent if the most recent score was 91 to 100, good if 81 to 90, fair if 71 to 80, and poor if the most recent score was less than 70 points. Furthermore, all knee joints were divided into two subgroups according to the result of the most recent follow-up. The patients who were classified as excellent and good were referred to as the satisfactory group, and the patients who were classified as fair and poor were referred to as the unsatisfactory a,b1  b2

c d

Fig. 1. Radiography of the knee joint before and after high tibial osteotomy (HTO) with two threaded pins and figure-of-eight wiring fixation technique. **a** Before HTO, **b** after HTO, **c** first evaluation, **d** most recent evaluation

group. Thirty-seven knees in 22 patients (1 male, 21 female) were included in the satisfactory group, with an average age at surgery of 57.9 ± 5.0 years and average follow-up period of 14.0 ± 2.9 years. On the other hand, 11 knees in 10 patients (3 male, 7 female) were included in the unsatisfactory group, with an average age at surgery of 60.1 ± 8.7 years and average follow-up period of 14.3 ± 3.1 years. No statistical difference was observed in the demographic data between the two groups.

Radiographic evaluation

The change of FTA and the grades of knee OA according to the Kellgren-Lawrence classification were analyzed with a standing whole-leg X-ray taken before surgery, at 1 to 3 weeks after HTO, and at each follow-up point.

Statistical analysis

The obtained data were expressed as the mean values ± standard deviation (SD). The relationships of analyzed parameters were determined using the paired *t*-test and the Wilcoxon signed rank test. In all analyses, a *P* value of less than 0.05 was considered to be significant.

Results

Clinical results

The mean JOA score of all patients improved significantly from 59.1 ± 7.6 before HTO to 86.3 ± 6.5 at the first evaluation (Table 1). At the most recent follow-up, the JOA score had slightly declined to 83.1 ± 9.3 but this change was not significant. In each category of JOA scores in all patients, the pain and walking score improved from 14.5 ± 5.2 before HTO to 26.6 ± 5.6 at the most recent evaluation, the pain and stairs score from 12.7 ± 6.6 to 20.2 ± 4.9, the score for range of motion from 25.6 ± 4.8 to 27.8 ± 4.6, and the score for joint effusion from 6.3 ± 5.7 to 8.5 ± 4.3. The mean range of motion was 9.3° ± 8.0° fixed flexion to 133.0° ± 18.1° of flexion before HTO, and 2.6° ± 4.3° to 132.5° ± 16.2° of flexion at the most recent evaluation. In comparing the satisfactory group and the unsatisfactory group, the mean JOA score was similar before HTO, but at the first and the most recent evaluation, the JOA score of the unsatisfactory group was significantly lower than that of the satisfactory group. Furthermore, in the unsatisfactory group, the JOA score had significantly declined from first evaluation to the most recent follow-up (Table 1). In the current study, there were two postoperative complications. One patient had peroneal nerve palsy and spontaneously recovered in 3 months after surgery. Another patient had delayed union and autologous iliac bone graft was performed. Final bone union was obtained at 7 months after HTO. These complications did not affect the clinical results.

Radiographic results

The mean FTA of all patients was corrected from 185.4° ± 4.4° before HTO to 168.2° ± 2.9° postoperatively, and this alignment was maintained at the most recent evaluation. In the satisfactory group, the change of FTA was almost same as the results of all patients. In contrast, the FTA of the unsatisfactory group changed from 185.3° ± 2.1° preoperatively to 170.2° ± 2.3° after HTO, and gradually increased at first evaluation and increased even more at the most recent follow-up. The FTA of the unsatisfactory group was the same as the satisfactory group preoperatively, but was significantly larger at each time of postoperative evaluation (Table 2). Seven of the unsatisfactory group (63.6%) had an FTA larger than 168° (170°: 3 cases, 172°: 3 cases, 173°: 1 case). The radiographic OA of all patients before HTO were classified as follows: 8 knees as Grade II, 35 knees as Grade III, and 5 knees as Grade IV. At the most recent evaluation, the distributions were 1 knee as Grade II, 18 knees as Grade III, and 29 knees as Grade IV. The number of Grade IV OA at the latest evaluation was significantly greater than that of before HTO (Table 3). In comparing the satisfactory group and the unsatisfactory group, no statistical difference was observed in the distribution of preoperative radiographic OA grade (Table 4). At the latest evaluation, the distributions of OA in the satisfactory group were 1 knee in Grade II, 18 knees in Grade III, and 18 knees in Grade IV. On the other hand, in unsatisfactory group, all knees were classified as Grade IV OA.

Table 1. Japanese Orthopaedic Association (JOA) score before high tibial osteotomy (HTO), at the first evaluation, and at the latest evaluation

Classification	Number of knees	JOA score: Before HTO	JOA score: First evaluation[a]	JOA score: Latest evaluation[b]
All Patients	48	59.1 ± 7.6	86.3 ± 6.5 (** vs. before HTO)	83.1 ± 9.3
Satisfactory group	37	59.1 ± 9.1	90.0 ± 5.4 (** vs. before HTO)	87.3 ± 4.3
Unsatisfactory group	11	59.1 ± 5.8	82.2 ± 7.2 (** vs. before HTO; * vs. satisfactory group)	69.1 ± 5.8 (* vs. first evaluation; ** vs. satisfactory group)

Data given as mean ± standard deviation
* $P < 0.05$; ** $P < 0.01$
[a] Mean follow-up 6.5 years
[b] Mean follow-up 17.1 years