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Mortality and clinical outcomes of Vancouver type B periprosthetic femoral fractures

A MULTICENTRE RETROSPECTIVE STUDY

H. Takami,
Y. Takegami,
K. Tokutake,
H. Kurokawa,
M. Iwata,
S. Terasawa,
T. Oguchi,
S. Imagama

From Nagoya University, Nagoya, Aichi, Japan

Aims
The objectives of this study were to investigate the patient characteristics and mortality of Vancouver type B periprosthetic femoral fractures (PFF) subgroups divided into two groups according to femoral component stability and to compare postoperative clinical outcomes according to treatment in Vancouver type B2 and B3 fractures.

Methods
A total of 126 Vancouver type B fractures were analyzed from 2010 to 2019 in 11 associated centres' database (named TRON). We divided the patients into two Vancouver type B subtypes according to implant stability. Patient demographics and functional scores were assessed in the Vancouver type B subtypes. We estimated the mortality according to various patient characteristics and clinical outcomes between the open reduction internal fixation (ORIF) and revision arthroplasty (revision) groups in patients with unstable subtype.

Results
The one-year mortality rate of the stable and unstable subtype of Vancouver type B was 9.4% and 16.4%. Patient demographic factors, including residential status and pre-injury mobility were associated with mortality. There was no significant difference in mortality between patients treated with ORIF and Revision in either Vancouver B subtype. Patients treated with revision had significantly higher Parker Mobility Score (PMS) values (5.48 vs 3.43; p = 0.00461) and a significantly lower visual analogue scale (VAS) values (1.06 vs 1.94; p = 0.0399) for pain than ORIF in the unstable subtype.

Conclusion
Among patients with Vancouver type B fractures, frail patients, such as those with worse scores for residential status and pre-injury mobility, had a high mortality rate. There was no significant difference in mortality between patients treated with ORIF and those treated with revision. However, in the unstable subtype, the PMS and VAS values at the final follow-up examination were significantly better in patients who received revision. Based on post-operative activities of daily life, we therefore recommend evision in instances when either treatment option is feasible.

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Keywords: periprosthetic femoral fractures, Vancouver type B, open reduction internal fixation, revision arthroplasty

Correspondence should be sent to Yasuhiko Takegami; email: takegami@med.nagoya-u.ac.jp

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Introduction
In recent years, the demand for total hip arthroplasty (THA) has increased. In the USA, the performance of THA is expected to increase by 137% between 2005 and 2030.[1] As the number of THA operations increases, the incidence of periprosthetic femoral fractures (PFF) around THA is naturally expected to rise. It is predicted that there the incidence of PFF will increase 1.5 times over

the next 30 years.[2,3] According to the UK National Joint Registry, the incidence of revision arthroplasty for PFF has increased, and PFF is the third most common cause of revision arthroplasty.[4] The COMPOSE cohort study demonstrated over 80% of PFFs involve the femoral diaphysis close to a hip prosthesis,[5] and are classified as Vancouver type B. These are further divided into three subtypes: B1, B2, and B3.[6] This category determined based on the stem stability and quality of the remaining proximal femoral bone stock. In type B1 fractures, the stem remains well fixed, and in type B2 fractures, the stem is loose. In type B3 fractures, the stem is loose and the bone stock is poor.[6] Therefore, in terms of implant stability, Vancouver type B1 is 'stable' and Vancouver type B2 and B3 fractures are 'unstable' implant subtypes. Although it has been reported that type B1 fractures are best treated using open reduction internal fixation (ORIF) and type B2 and B3 fractures are best treated using revision arthroplasty,[6] several authors have recently argued that type B2 or B3 fractures treated with ORIF resulted in equivalent, if not better, outcomes.[7-11] A large-scale retrospective study of 1,381 type B fractures showed that the type of fixation was not a significant factor for reoperation for type B2 or B3 fractures.[8] Another retrospective study, which reviewed 203 type B PFFs, reported that there was no difference in survival or reoperation rates between patients treated with ORIF or revision arthroplasty.[7] However, few studies have investigated the clinical outcomes according to subtype in patients with Vancouver type B PPF, and the clinical outcomes of the different treatment approaches for Vancouver type B2 and B3 fractures are not yet fully known. In the present study, we aimed to investigate the patient characteristics and mortality of patients with Vancouver type B PPF with patients divided into two groups according to femoral component stability, and to compare the postoperative clinical outcomes according to treatment in patients with Vancouver type B2 and B3 fractures.

Methods

Patient selection. This multicentre, retrospective study was approved by the ethics commission at each participating hospital. All patients provided their informed consent to participate in the study. Hospitals of the Trauma research group (TRON) have registered orthopaedic trauma surgery cases in the TRON database annually since 2010.[12] The hospitals participating in the database are all associated with the department of orthopaedic surgery of our university, and orthopaedic surgeons perform surgical operations at these hospitals located in Central Japan. We collected cases of PFF from this database.

Between 2010 and 2019, a total of 249 patients with PFF were treated in all hospitals, including 153 with Vancouver type B fractures. We excluded the following patients: patients with Vancouver type A or C fractures, patients aged younger than 59 years, patients with fractures caused by malignancy and high-energy mechanism, and patients who were lost to follow-up. Finally, we analyzed 126 patients (Figure 1).

We divided the patients into two Vancouver type B subtypes according to femoral component stability (type B1 was deemed 'stable' and types B2 and B3 were deemed 'loose'). Fracture classification was performed by two orthopaedic surgeons. Interobserver reliability was measured using Fleiss' kappa value. Interobserver reliability was found to be good (Fleiss' kappa 0.8; 95% confidence interval 0.84 to 0.93).

Treatment overview. With the exception of one case, Vancouver type B1 fractures were primarily treated with ORIF. In 18 patients with type B2 or B3 fractures, ORIF was performed because patients were not able to tolerate revision arthroplasty due to medical comorbidities. Revision arthroplasty was performed in 35 patients with type B2 or B3 fractures. Proximal femoral arthroplasty was performed in one patient with a type B2 fracture. One type B1 fracture was also treated with revision arthroplasty as it was a short transverse fracture.

Surgical treatment. In fractures treated with ORIF, cable/cerclage wiring or locking compression plates were used. In fractures treated with revision arthroplasty, uncemented stems were used with a Wagner femoral cone (Zimmer, USA) and Delta-LOCK stem (Teijin Nakashima Medical, Japan), and cemented stem was used with the Exeter system (Stryker Orthopedics, USA). The treatment option also included proximal femoral arthroplasty using the Stryker Global Modular Arthroplasty System (GMRS; Stryker) in one type B2 case. Fractures with poor bone stock were treated with allograft struts. In addition, fractures were fixed either by cerclage wiring or by greater trochanter reattachment with a cable-plate system (GTR; Zimmer).

Conservative treatment. Conservative treatment was chosen for patients who were unable to tolerate surgery due to a poor general condition or who declined surgery. We used basically the same protocol among our hospitals. On the day after admission, the patient started non-weightbearing rehabilitation. We checked the progress of fracture displacement on radiographs; no patients required an additional operation due to progression of displacement. Mobilization was started according to the patient's pre-injured walking ability and degree of pain. Weightbearing was only started after pain relief and checking for callus formation or cortical bridging on radiographs. Such treatment decisions should be made by a multidisciplinary team, including orthopaedic surgeons, nurses, and physiotherapists.

Data collection. We obtained patient demographic data, including age, sex, and BMI, pre-injury mobility level (graded as independent, cane ambulation, front-walker or frame ambulation, wheelchair, and bedridden),[13]

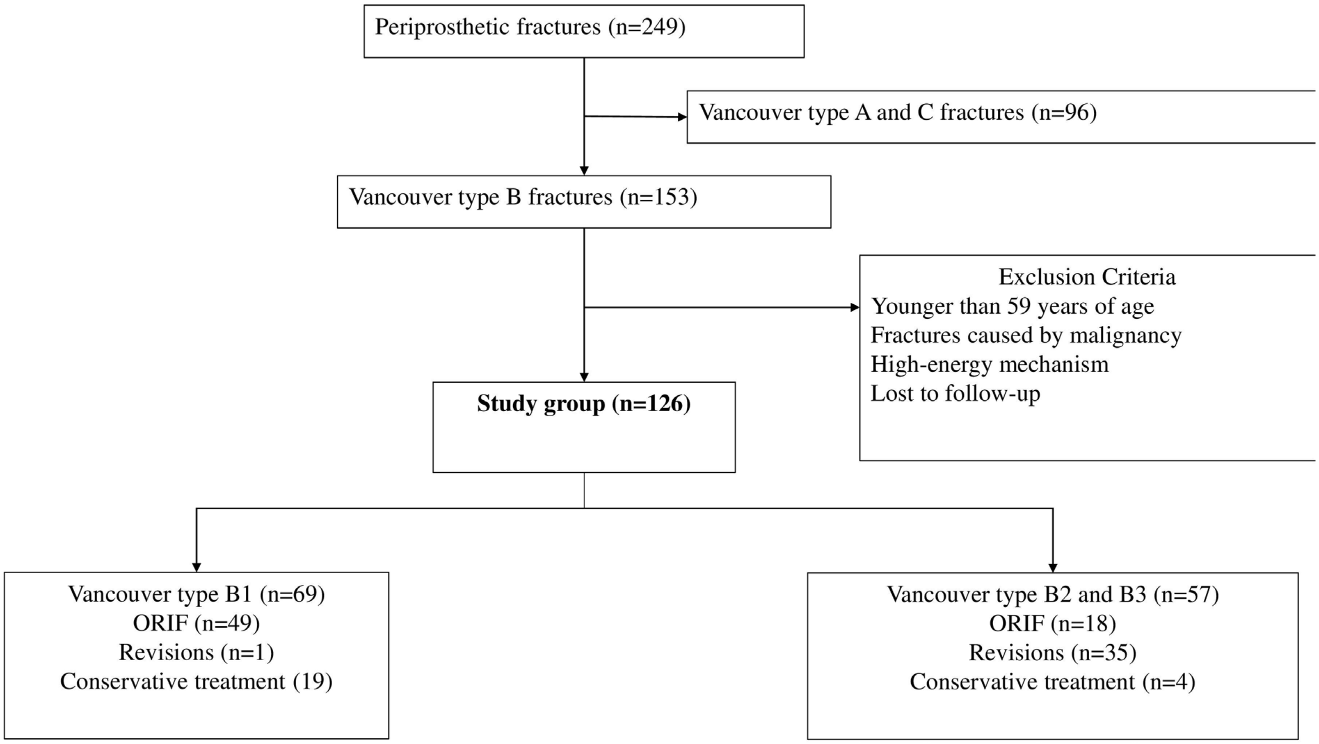

Fig. 1

Patient flowchart

residence (home, nursing home or other), femoral component type (cementless or cemented) from electronic medical records in each hospital. The "other" category in the "residence" factor included patients who were admitted to hospitals for treatment of other diseases or those who were admitted psychiatric hospitals at the time of injury. We also recorded the Parker Mobility Score (PMS)[14] before injury. The PMS was used to assess each patient's ambulatory status and walking ability, which was rated on a scale of 0 to 9. We recorded the medical comorbidities of patients when they were admitted according to the Charlson Comorbidity Index (CCI).[15] The CCI is an index for scoring and evaluating medical comorbidities and is calculated by adding 1 to 6 points for each item. We evaluated patients according to the total score, which ranges from 0 to 33 depending on the presence of certain diseases with assigned values. Then, we divided our population into CCI 0, CCI one, and CCI ≥ two cohorts.[16] We phoned all patients' homes or nursing homes to ask if they were alive and well. If the patient was unidentified, we checked the electronic medical record for the last time that they visited their hospital.

Clinical evaluation. We used the PMS and a visual analogue scale (VAS) to assess treatment outcomes at the final follow-up examination. Patients rated their own pain on the VAS between 0 (no pain) and 10 (worst pain imaginable).

Statistical analysis. We used independent samples *t*-test for continuous variables to compare patient characteristics between the stable subtype and the unstable subtype in patients with Vancouver type B PPFs. Categorical variables were compared using Fisher's exact test.

We estimated mortality for the subtypes of Vancouver type B PFF, various patient characteristics, and treatment methods in the Vancouver B subtypes using Kaplan-Meier curves. Differences in survival were compared using a log-rank test. In patients with Vancouver type B2 and B3 fractures, clinical outcomes were compared between the ORIF and revision arthroplasty groups using an independent-samples *t*-test, because the data of the clinical outcomes were normally distributed, and p-values < 0.05 were considered to indicate statistical significance. All statistical analyses were performed using EZR (version 1.4; Jichi Medical School, Japan).[17]

Results

The study population included 126 patients (39 male, 87 female) with a mean age of 79.81 years (63 to 98; standard deviation (SD) 8.04); the mean follow-up period was 32.26 months (0 to 105; SD 25.49). The baseline characteristics of the patients with stable or unstable subtypes of Vancouver B fractures are shown in Table I. There was a significant difference between the treatment methods.

Table I. Patient demographics

Variable	Vancouver type B1	Vancouver type B2 and B3	p-value
Patients, n	69	57	
Mean age, yrs (SD)	80.74 (8.10)	78.68 (7.97)	0.156†
Sex, n (%)			
Male	21 (30.4)	15 (30.0)	0.813†
Female	48 (69.6)	35 (70.0)	
Mean BMI, kg/m² (SD)	20.26 (3.82)	20.22 (3.84)	0.959†
Pre-injury mobility, n (%)			
Independent	28 (40.6)	19 (33.3)	0.900*
One aid	17 (24.6)	17 (29.8)	
Walker or frame	11 (15.9)	11 (19.3)	
Wheelchair	11 (15.9)	9 (15.8)	
Bedridden	2 (2.9)	1 (1.8)	
Mean PMS (SD)	5.94 (2.54)	5.96 (2.38)	0.959*
CCI, n (%)			
0	23 (33.3)	15 (26.3)	0.711
1	21 (30.4)	20 (35.1)	
≥ 2	25 (36.2)	22 (38.6)	
Residential status, n (%)			
Own home	49 (71.0)	39 (68.4)	1.000*
Nursing home	18 (26.1)	14 (24.6)	
Others	2 (2.90)	4 (7.0)	
Femoral component, n (%)			
Cementless	62 (89.9)	50 (87.7)	0.780*
Cemented	7 (10.1)	7 (12.3)	
Treatment, n (%)			
ORIF	49 (71.0)	18 (31.6)	< 0.001*
Revision	1 (1.4)	35 (61.4)	
Conservation	19 (27.5)	4 (7.0)	

*Independent-samples *t*-test.
†Fisher's exact test.
CCI, Charlson Comorbidity Index; ORIF, open reduction internal fixation; PMS, Parker Mobility Score; SD, standard deviation.

The Kaplan-Meier plots for survival according to the Vancouver B subtypes are shown in Figure 2. Log-rank tests showed no difference between the two subtypes. The one-year mortality rate of patients with Vancouver type B1 fractures was 9.4%, while that of patients with type B2 and B3 fractures was 16.4%.

The Kaplan-Meier plots for survival according to patient characteristics in the Vancouver B subtypes are shown in Figure 3. The log-rank test revealed significant differences in residential status and pre-injury mobility in both subtypes. There was also significant difference in CCI in Vancouver types B2 and B3.

The Kaplan-Meier plots for survival according to the Vancouver type B subtypes are shown in Figure 4. The log-rank test revealed that in patients with stable Vancouver type B PFF, there were no differences between ORIF, revision arthroplasty, or conservation. On the other hand, in patients with unstable Vancouver type B PFF, conservative treatment was associated with high mortality in comparison to surgical treatment, although there was no difference between ORIF and revision arthroplasty. In addition, in the unstable Vancouver type B PFF, the clinical outcomes, including the PMS and VAS at the final follow-up examination, were significantly better in comparison to the revision arthroplasty group (Table II). In the ORIF and revision groups, the mean PMS was 3.43 and 5.48, respectively (p = 0.006), while the mean VAS was 1.94 and 1.06, respectively (p = 0.040).

Discussion

This multicentre study showed that in patients with Vancouver type B PFF, the one-year mortality rate of the stable subtype was 9.4%, while that of the unstable subtype was 16.4%. The log-rank test revealed that patient demographic factors, including residential status and pre-injury mobility, were associated with mortality in both Vancouver subtypes. In addition, CCI was associated with mortality in the unstable subtype. According to the log-rank test results, conservative treatment was associated with a higher mortality rate in comparison to surgical treatment in the unstable subtype. In addition, there was no significant difference in mortality between patients treated with ORIF and those treated with revision arthroplasty in either Vancouver B subtype. In the

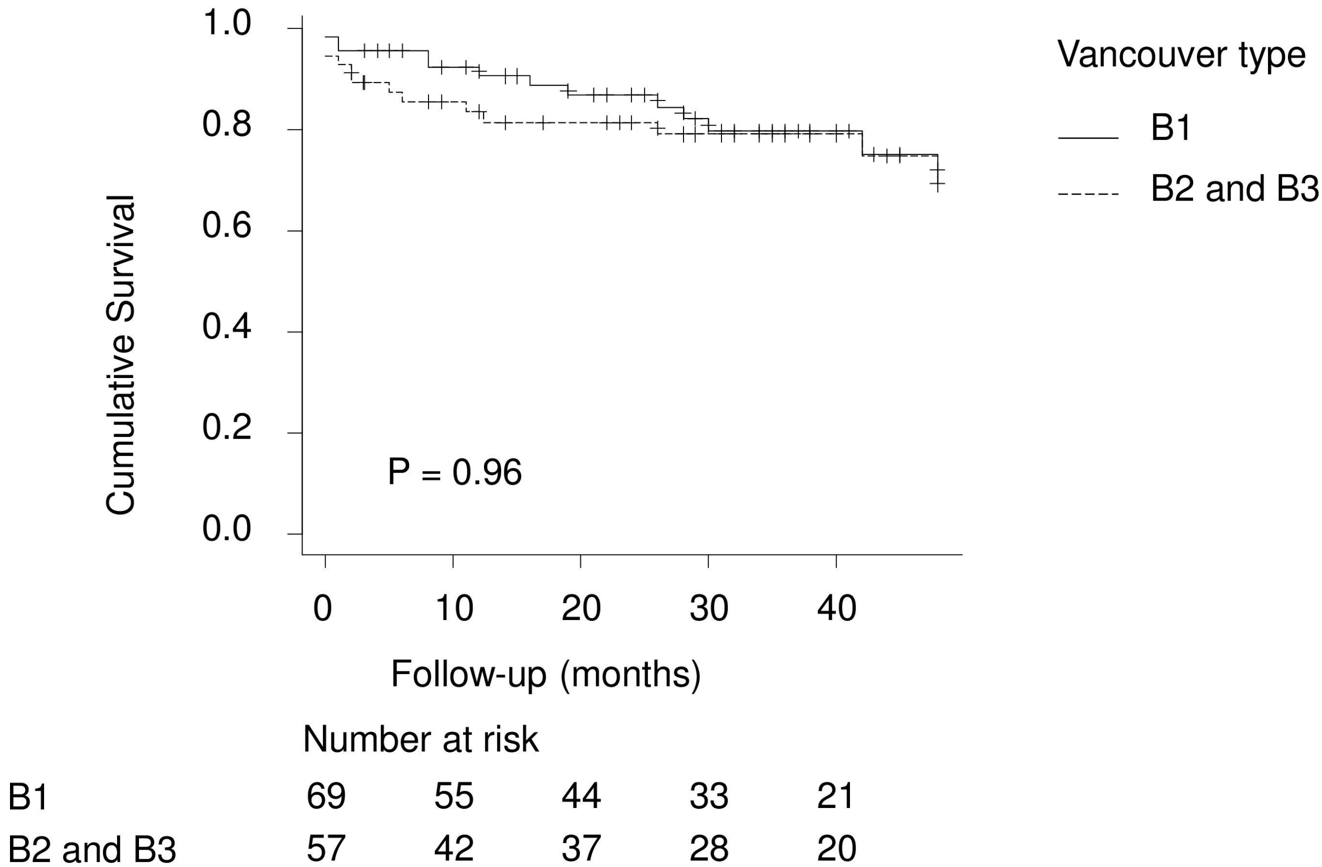

Fig. 2

Kaplan-Meier survival curve for patients with Vancouver type B by fracture subtype.

unstable subtype, the clinical outcomes, including the PMS and VAS values at the final follow-up examination, were significantly better in patients who received revision arthroplasty than in those who received ORIF.

In this study, the one-year mortality rates for the stable and unstable subtypes were 9.4% and 16.4%, respectively, and the log-rank tests showed that the difference was not statistically significant. The COMPOSE cohort study demonstrated that the one-year mortality rates for B1, B2, and B3 were 19.5%, 19.2%, and 38.5%, respectively.[18] A study of 203 patients with type B PFF reported that the one-year mortality rate was 13% and the five-year mortality rate was 46%.[7] Similarly, in another study of 121 patients with PFF, the one-year mortality rate of PFF was 13.2%.[19] The one-year mortality rate of this study was similar to these previous studies.

In the present study, frail patients who had worse scores for residential status and pre-injury mobility, showed a high mortality rate in both Vancouver B subtypes. In Vancouver type B2 and B3, CCI was also associated with mortality. The COMPOSE study also showed that older age and residential care were associated with the mortality.[18] A retrospective study of 60 patients with PPF demonstrated that increased age, increased ASA, and increased CCI are significant risk factors for one-year mortality.[20] Another retrospective study of 124 patients with PPF of the hip and knee found that sex, type of fixation, surgical delay, BMI, and age at surgery were not associated with increased mortality.[21] Few studies have analyzed mortality according to patient characteristics in patients with Vancouver type B fractures.

This study showed that there was no significant difference in mortality between patients treated with ORIF and those treated with revision arthroplasty. The mainstay of treatment for type B1 fractures has been internal plate fixation and locking cable-plate and cable-grip systems have recently been introduced. Because unstable fracture patterns (e.g. transverse or short oblique fractures) tend to be associated with high rates of nonunion in patients with B1 fractures, this type of fracture should be treated with revision arthroplasty.[22] The choice between ORIF and revision arthroplasty can occasionally be controversial in type B2 and B3 fractures. In cases involving loose implants, revision arthroplasty is considered, but internal fixation is an option when patients have severe comorbidities that make surgery

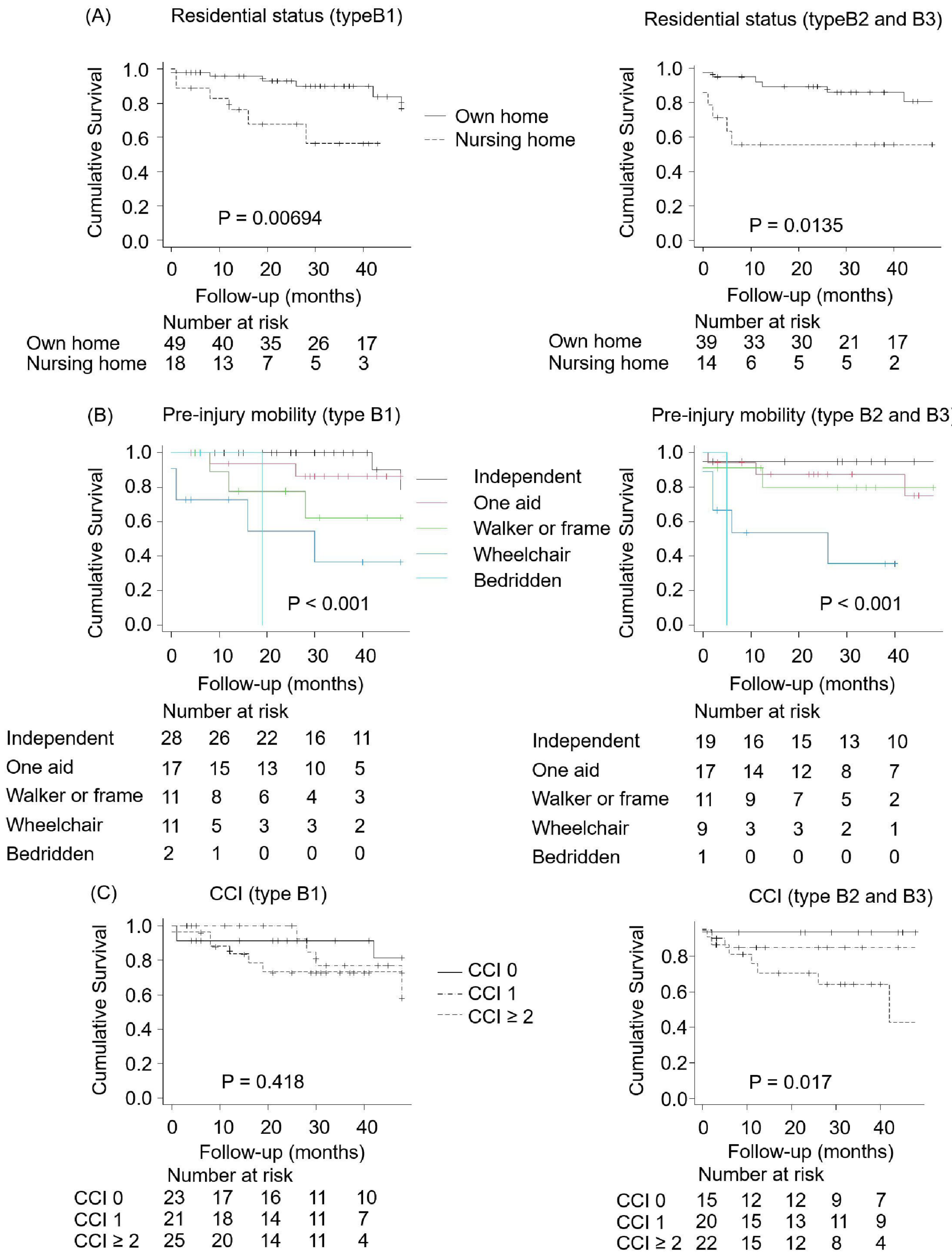

Fig. 3

Kaplan-Meier survival curves for patients with Vancouver type B subtypes according to a) residential status, b) pre-injury mobility, and c) Charlson Comorbidity Index (CCI).

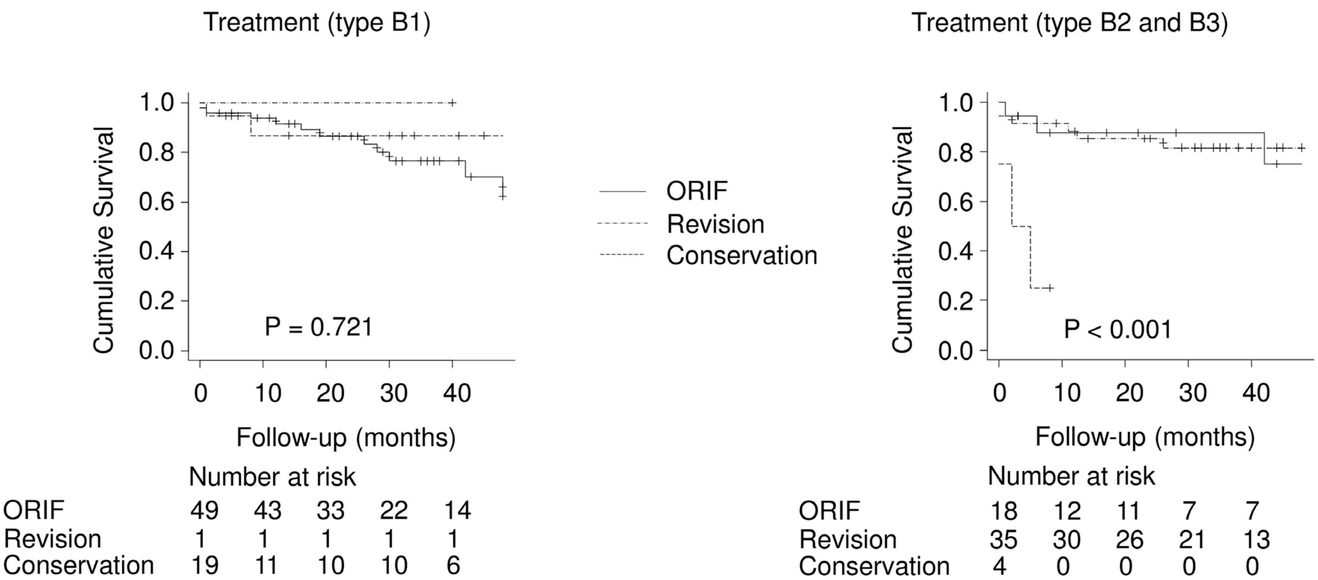

Fig. 4

Kaplan–Meier survival curve for patients with Vancouver type B subtypes by type of treatment (open reduction internal fixation (ORIF), revision, and conservation).

Table II. Clinical outcomes of 53 patients with surgically-treated Vancouver type B2 and B3 periprosthetic fractures.

Variable	ORIF (n = 18)	Revision (n = 35)	p-value*
Mean pre-injury PMS (range; SD)	5.39 (0 to 9; 2.43)	6.54 (2 to 9; 2.21)	0.0881
Mean PMS (range; SD)	3.43 (0 to 9 to 1.82);	5.48 (2 to 9; 2.41)	0.00461
Mean VAS (range; SD)	1.94 (0 to 6;1.48)	1.06 (0 to 4;1.26)	0.0399

*Independent-samples *t*-test.
ORIF, open reduction internal fixation; PMS, Parker Mobility Score; SD, standard deviation; VAS, visual analogue scale of pain.

inappropriate or when the patient has low functional demands.

In our study, postoperative the PMS and VAS values of patients with Vancouver type B2 and B3 fractures treated with revision arthroplasty were significantly better in comparison to those treated with ORIF. A retrospective study of 97 type B fractures found that among type B2 and B3 fractures, patients treated with internal fixation had significantly lower PMS values in comparison to patients who received revision arthroplasty, and the VAS scores showed no difference between patients who received internal fixation and those who received revision arthroplasty.[23] Joestl et al[9] retrospectively reviewed 36 type B2 PPFs and reported that there was no difference in the postoperative PMS values of patients who received ORIF and those who received revision arthroplasty. However, the problem in the study was the relatively small number of samples. Because few studies have compared clinical outcomes (e.g. PMS or VAS) between ORIF and revision arthroplasty, these represent very valuable results when considering the treatment of B2 and B3 fractures. According to Gitajn et al,[7] who retrospectively reviewed 203 type B PFFs, there were no differences in the survival or reoperation rates between patients treated with ORIF and those treated with revision arthroplasty. The authors suggested that the orthopaedic surgeon should feel comfortable performing the type of intervention that they are most proficient in performing when treating Vancouver type B fractures. Our study showed the same result with respect to mortality. Some authors have shown other results in relation to the reoperation rate for type B2 or B3 fractures. The COMPOSE study showed the one-year reoperation rate in the revision group was higher than that in the fixation group.[18] In contrast, a systematic review of 22 studies, including 343 type B2 fractures and 167 B3 fractures, demonstrated that 13.3% of B2 and 28.6% of B3 fractures with internal fixation required reoperation; this rate was higher in comparison to that in patients who received revision arthroplasty.[24] In a retrospective study including 1,064 B2 and B3 fractures, fractures treated with ORIF alone showed a significantly greater reoperation rate in comparison to those treated with revision arthroplasty (22% vs 13.5%, respectively).[8] From a biomechanical perspective, Moazen et al[25] found that the plating method was three times less stiff than the long stem revision method. In the treatment of type B2 or B3 fractures, based on the postoperative activites of daily life (ADL), we recommend revision arthroplasty in instances when either treatment option is feasible.

The present study was associated with some limitations. First, this was a retrospective study using a clinical database; thus, the possibility of a selection bias must be considered and the evidence level is low. Second, this was a mid-term follow-up study. The follow-up period would benefit from longer-term assessment in the future. Third, the sample size was relatively small. Fourth, the study population was Asian cohort only. The homogenous background of patients receiving THA may differ from other studies, which may lead to different clinical outcomes. Fifth, the clinical outcomes of this study did not include the reoperation rate, postoperative complications, or the period of fracture healing. Finally, various ORIF systems and revision arthroplasties were used, which may have confounded our results.

In conclusion, this study showed that in patients with Vancouver type B fractures, the one-year mortality rate of patients with the stable subtype was 9.4%, while that of patients with the unstable subtype was 16.4%. Among patients with Vancouver type B fractures, frail patients, such as those with worse scores for residential status or pre-injury mobility, had a high mortality rate. There was no significant difference in mortality between patients treated with ORIF and those treated revision arthroplasty in either Vancouver B subtype. However, among patients with the unstable subtype, the PMS and VAS values at the final follow-up examination were significantly better patients who received revision arthroplasty than in those who received ORIF. Therefore, based on postoperative ADL, we recommend revision arthroplasty in instances when either treatment option is feasible. Further studies with a larger sample size and longer-term follow-up are needed.

Take home message

- Among patients with Vancouver type B fractures, frail patients, such as those with worse scores for residential status or pre-injury mobility, had a high mortality rate.
- For type B2 or B3 fractures, the pain and gait ablity were significantly better patients who received revision arthroplasty than in those who received open reduction internal fixation.

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Author information:
- H. Takami, MD, Fellow
- Y. Takegami, MD, PhD, Lecturer
- H. Kurokawa, MD, Fellow
- M. Iwata, MD, Fellow
- S. Terasawa, MD, Fellow
- S. Imagama, MD, PhD, Professor
Department of Orthopaedic Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan.
- K. Tokutake, MD, PhD, Assistant Professor, Department of Hand Surgery, Nagoya University, Nagoya, Japan.
- T. Oguchi, MD, PhD, Director, Department of Orhopedic Surgery, Anjo Kosei Hospital, Anjo, Japan.

Author contributions:

- H. Takami: Visualization, Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.
- Y. Takegami: Conceptualization, Methodology, Writing – original draft, Writing – review & editing.
- K. Tokutake: Conceptualization, Writing – original draft, Writing – review & editing.
- H. Kurokawa: Data curation, Formal analysis, Writing – original draft, Writing – review & editing.
- M. Iwata: Data curation, Writing – original draft, Writing – review & editing.
- S. Terasawa: Data curation, Writing – original draft, Writing – review & editing.
- T. Oguchi: Writing – original draft, Writing – review & editing.
- S. Imagama: Conceptualization, Validation.

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