Predictive factors for mortality after distal femoral fractures in the elderly: A retrospective multicenter (TRON group) study

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Abstract

Purpose: This retrospective multicenter study aimed to assess the 1-year mortality rate in elderly patients with distal femoral fractures (DFFs) and identify potential risk factors for mortality.

Methods: We analyzed 321 patients aged 65 years and older with DFFs treated surgically between 2012 and 2019 in 13 hospitals. Patient demographics and surgical characteristics were extracted from medical records and radiographs. We used univariable and multivariable Cox regression analyses to identify the factors affecting mortality.

Results: The mortality rate for DFFs in elderly patients at 1 year was 9.0%. Multivariable Cox regression analysis revealed older age, male sex, underweight (body mass index [BMI] <18.5 kg/m^2), bedridden status, and nursing home residency to be independent predictors for mortality (older age: hazard ratio [HR] 1.07, 95% confidence interval [CI] 1.03–1.11, P<0.001; male sex: HR 3.08, 95% CI 1.23–7.71, P=0.015; underweight: HR 1.93, 95% CI 1.01–3.68, P=0.045; bedridden status: HR 4.59, 95% CI 1.61–13.07, P=0.0042; and nursing home residency: HR 2.63, 95% CI 1.18–5.83, P=0.017). None of the factors associated with surgery including types of fixation, time from initial visit to surgery, blood loss during operation, and operation time was an independent predictor for mortality.

Conclusion: The 1-year mortality rate in elderly patients with DFFs was relatively low at 9.0%. Older age, lower BMI, and nursing home residency were associated with mortality after surgery for DFFs. Factors associated with the surgical procedure were not significant predictors.

Introduction

In elderly patients, distal femoral fractures (DFFs) are the second most frequently occurring fragility fractures of the femur following those of the hip [1-3]. The mortality rate after 1 year in elderly patients with DFFs has been reported to range from 13% to 38% [4-7]. In recent years, intramedullary nailing and locking plate techniques have been used as minimally invasive surgical treatments for DFFs. These surgical methods may also affect life expectancy [8]. Several studies have shown that mortality after DFFs in the elderly improved with surgical intervention [6,9].

Elderly patients who suffer DFFs may have some medical comorbidities that could be associated with the risk of life-threatening postoperative complications [10]. Several risk factors including older age, male sex, and higher Charlson Comorbidity Index (CCI) were associated with higher mortality after DFFs [7,11]. Surgical delay was also a risk factor for mortality [5,7,12]. However, it is still unclear which independent factors are associated with mortality in the elderly who have undergone surgery for DFFs.

We aimed to determine 1-year mortality and to identify predictors associated with mortality in elderly patients with DFFs who underwent surgery in a multicenter study.

Patients and methods

Study design and setting

The ethics committee of each participating hospital approved this multicenter retrospective study (Ref 2020-564). All patients provided informed consent to participate in the study. We established a trauma database called TRON, which has registered orthopedic trauma cases annually since 2012. All participating hospitals are located in central Japan and are associated with the Department of Orthopedic Surgery of our university. We collected cases of DFFs from this database.

Subjects

We collected 501 cases of DFFs treated in our 13 hospitals between January 2012 and December 2019. At one of the 13 hospitals, we could not access the medical records before July 2017 and thus collected the data after that. Inclusion criteria were age of 65 years or older, non-periprosthetic and periprosthetic fractures after total knee arthroplasty, and closed DFFs treated surgically. We excluded the following patients: 112 who were less than 65 years old, 58 who were treated conservatively, 9 who had open fractures, and one treated with external fixation. To confirming the patients’ health, we phoned all patients' homes or nursing-home to ask if they were alive and well. If they did not answer the phone, we sent them a letter. Even then, if the patient was still unidentified, we checked the electronic medical record for the last time they visit each hospital. Ultimately, 321 patients were included in the final analysis (Fig. 1).

Clinical evaluation

The data collected from the electronic medical records were patient age at the time of fracture, sex, body mass index (BMI), residence (home or nursing home), mechanism of injury, pre-injury mobility level (graded as independent, cane ambulation, front-walker or frame ambulation, wheelchair, and bedridden) [13], and date of death or the date of last follow-up. Patients were classified into three groups according to the World Health Organization BMI categories [14]: underweight (BMI <18.5 kg/m^2), normal weight (BMI 18.5 to <25 kg/m^2), and overweight (BMI ≥25 kg/m^2). We also recorded the presence or absence of previous fragility fractures, which were defined as the following fractures occurring before the actual DFF: fracture of vertebra, proximal femur, distal radius, and proximal humerus. Additionally, patient comorbidities present at the time of injury were collected from the electronic medical record to allow calculation of the CCI [15,16]. The CCI is calculated by assigning one point each to myocardial infarction, congestive heart failure, peripheral vascular disease, dementia, chronic pulmonary disease, connective tissue disease, peptic ulcer disease, mild liver disease, and uncomplicated diabetes. Two points each are assigned to hemiplegia, moderate to severe renal disease, complicated diabetes, malignancy within five years of diagnosis, leukemia, or lymphoma. Three points are assigned for moderate to severe liver disease, and six points each are assigned to AIDS (not HIV) and metastatic solid tumor. Then, we divided our population into normal (CCI 0), mild (CCI 1), moderate (CCI 2), and severely ill (CCI ≥3) cohorts

[17]. We also extracted the information associated with the surgical procedure such as operation time, blood loss during operation, waiting time from initial visit to surgery, and type of fixation. To determine whether an optimum time to surgery existed, we divided our population into early (<48 hours to surgery) and late (≥48 hours to surgery) treatment groups.

Radiographic evaluation

We classified the fracture type according to the AO-OTA system [18] on each patient's anteroposterior and lateral radiographs. Two observers (Y.Y., K.K.) retrospectively evaluated these radiographs independently. Interobserver reliability was measured using Fleiss' kappa value. Interobserver reliability was found to be at a good level (Fleiss' kappa = 0.89, 95% confidence interval [CI]: = 0.84–0.93).

Surgical treatment

Of the 321 patients, 168 were treated with retrograde intramedullary nailing, 135 with open reduction and plate fixation, and 18 with screw fixation only. Of the nails used, 160 (96.4%) were T2 supracondylar nails (Stryker, Mahwah, NJ, USA), 5 (3.0%) were TRIGEN (Smith＆Nephew, Memphis, USA), and one (0.6%) was DFN (Synthes GmbH, Oberdorf, Switzerland). All 135 plates used were locking plates for distal femur and 70 (51.8%) were LCP Distal Femur Plate(Synthes), 38

(28.1%) were NCB distal femur system (Zimmer Biomet, Warsaw, Indiana, USA), 18 (13.3%) were AxSOS 3 Ti Distal Lateral Femur (Stryker) , and 2 (1.4%) were Targeter System for 4.5mm Distal Femur Locking Plate(Smith & Nephew),and 7 (5.1%) were unknown.These surgical methods were chosen according to each surgeon's preference. After discharge from hospital, most patients were transferred to a nearby rehabilitation center with convalescent rehabilitation wards [19] and were subsequently referred to the outpatient clinic of each hospital.

Statistical analysis

We performed univariable and multivariable Cox regression analyses to identify the factors associated with mortality. Then we used the Kaplan-Meier method to create survival curves and the log-rank test to compare survival between various groups. The threshold for statistical significance was set at a P value <0.05. The statistical analysis was performed using EZR software version 1.40 (Saitama Medical Center, Jichi Medical University) [20].

Results

The patients' baseline characteristics and mortality rates are shown in Table 1. The mean patient age at time of the fracture was 80.59 ± 8.59 years, and the mean follow-up period was 23.55 (range 0–99) months. The mortality rate at 1 year after the initial visit was 9.0%. The Kaplan-Meier plot of overall survival is shown in Fig. 2.

Factors associated with patients' characteristics

Kaplan-Meier plots showed that underweight (BMI <18.5 kg/m^2) patients, nursing home residents, and patients with previous fragility fractures were significantly more likely to have shorter survival (Fig. 3A-C). Fracture type according to the AO-OTA system was not associated with mortality (Fig. 3D).

Univariable and multivariable Cox regression analyses are shown in Table 2. Older age, male sex, underweight, bedridden status, and nursing home residency were identified as independent risk factors for mortality (older age: hazard ratio [HR] 1.07, 95% CI 1.03–1.11, P<0.001; male sex: HR 3.08, 95% CI 1.23–7.71, P=0.015; underweight: HR 1.93, 95% CI 1.01–3.68, P=0.045; bedridden status: HR 4.59, 95% CI 1.61–13.07, P=0.0042; and nursing home residency: HR 2.63, 95% CI 1.18–5.83, P=0.017). The presence of previous fragility fractures was not an independent predictor for mortality in this analysis (HR 1.11, 95% CI 0.56–2.20, P=0.74).

Factors associated with surgery

Kaplan-Meier plots showed that neither type of fixation nor delay of surgery were associated with mortality (Fig. 4A, 4B). Cox regression analysis revealed that type of fixation, operation time, blood loss during operation, and time from initial visit to surgery were not significantly associated with mortality after adjustment for age, sex, BMI, CCI, and fracture types (Table 3).

Discussion

This multicenter study showed the 1-year mortality rate for DFFs in elderly patients to be 9.0% and identified the following patient characteristics as independent predictors for mortality after DFFs: older age, male sex, underweight (BMI <18.5 kg/m^2), bedridden status, and nursing home residency. None of the factors associated with surgery, including types of fixation, time from initial visit to surgery, blood loss during operation, and operation time, was an independent predictor for mortality.

The mortality rate in our study population was similar to that of previous studies reporting 1-year mortality rates between 13.4% and 18% [4,13]. Other studies also reported that mortality after DFFs is equivalent to that of hip fractures [12,21].

Our study showed that the patients admitted from nursing homes had a significantly higher mortality rate than those who lived at their own home. Bedridden status was also an independent predictor for mortality. A previous retrospective study on hip fracture patients showed that nursing home residents had significantly higher mortality rates and lower functional outcome scores [22]. Kammerlander et al. [9] reported that DFF patients admitted from nursing homes also showed a lower survival rate. This suggested that nursing home residents were prone to having more comorbidities than patients who lived at their own home and that this resulted in higher mortality. A retrospective study reported that among elderly nursing home residents, sarcopenia is highly prevalent and is associated with a significantly increased risk of all-cause death regardless of age, sex, and other confounding factors [23]. This may be one reason for the shorter survival of nursing home residents in our study population.

Our study showed lower BMI to be an independent predictor for mortality. This is consistent with a previous population-based cohort study that assessed patients aged 40 years and older with hip and non-hip fracture and reported higher mortality in individuals with low BMI (<18.5 kg/m^2) [24]. Lower BMI reflects poor nutritional status, which may have resulted in higher mortality rates after DFFs in our study population.

Three types of fixation (intramedullary nail, open reduction and plate fixation, and screw fixation) were used in the study patients, and no significant difference was found between these surgical methods and mortality. Furthermore, no other factors including operation time, blood loss during operation, and time to surgery were associated with mortality. A previous study reported that fixation type (intramedullary nail or open reduction internal fixation) had no effect on mortality after DFFs [4]. Another study confirmed these results in a retrospective series of 115 fractures comparing retrograde nailing (n = 59) and mini-invasive locking plate use (n = 56) [25]. Several studies also reported no association between time to surgery and mortality after DFFs [9,11]. These results suggest that clinical outcomes after DFFs do not depend on the choice of implant and that it is important for surgeons to plan the surgical techniques carefully and wait until the patient's general condition become acceptable for surgery.

Our study has several limitations. First, this is a retrospective study and data collection is limited to that routinely recorded in patient notes. Second, some patients could not be followed for a long enough period, and their data were censored.

Conclusion

We showed that the 1-year mortality rate for DFFs in elderly patients was 9.0%. Older age, male sex, underweight (BMI <18.5 kg/m^2), bedridden status, and nursing home residency were the independent predictors for mortality. Surgical methods and timing were not associated with mortality, so surgeons should plan the treatment carefully according to each patient's condition.

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Table

Table 1

Patient characteristics and mortality rates (n=321)

Variable	Value
Age, years (SD)	80.59 (8.59)
Sex, n (%)	
Males	37 (11.5)
Females	284 (88.5)
BMI, kg/m^2 (SD)	21.26 (4.36)
Pre-injury mobility, n (%)	
Independent	153 (47.7)
One aid	50 (15.6)
Walker or frame	46 (14.3)
Wheelchair	53 (16.5)
Bedridden	19 (5.9)
CCI, n (%)	
0	78 (24.3)
1	105 (32.7)
2	72 (22.4)
≥3	66 (20.6)
Residential status, n (%)	
Own home	261 (81.3)
Nursing home	60 (18.7)
Presence of a TKA, n (%)	55 (17.1%)
OTA/AO classification, n (%)	
33-A1	114 (35.5)
33-A2	77 (24.0)
33-A3	42 (13.1)
33-B1	12 (3.7)
33-B2	24 (7.5)
33-B3	2 (0.6)
33-C1	18 (5.6)
33-C2	29 (9.0)
33-C3	3 (0.9)
Mechanism of injury, n (%)	
Fall from a standing height	219 (68.2)
Care-related	49 (15.3)
Fall from a height	23 (7.2)
Traffic accident	30 (9.3)

Type of fixation, n (%)	
Intramedullary nail	168 (52.3)
ORIF with plate	135 (42.1)
Screws alone	18 (5.6)
Time to surgery, hrs, median [range]	95.26 [4.05, 1624.10]
30-Day mortality (%)	1.0
6-Month mortality (%)	3.9
1-Year mortality (%)	9.0

SD = standard deviation, BMI = body mass index, CCI = Charlson Comorbidity Index, TKA = total knee arthroplasty, ORIF = open reduction internal fixation.

Table 2

Hazard ratios for overall mortality by Cox regression model in patient background

Variables	Univariable analysis		Multivariable analysis	
	Hazard ratio (95% CI)	P value	Hazard ratio (95% CI)	P value
Age	1.09 (1.05-1.12)	0.000000083	1.07 (1.03-1.11)	0.00051
Male sex	1.78 (0.83-3.79)	0.13	3.08 (1.23-7.71)	0.015
Normal (18.5≤BMI<25)	Reference		Reference	
Underweight (BMI <18.5)	2.38 (1.32-4.28)	0.0038	1.93 (1.01-3.68)	0.045
Overweight (BMI ≥25)	0.45 (0.17-1.19)	0.10	0.59 (0.20-1.69)	0.32
Pre-injury mobility				
Independent	Reference		Reference	
One aid	1.10 (0.40-3.03)	0.83	1.08 (0.37-3.09)	0.88
Walker or frame	2.36 (1.00-5.54)	0.048	2.08 (0.85-5.09)	0.10
Wheelchair	4.53 (2.16-9.51)	0.000063	2.12 (0.84-5.33)	0.10
Bedridden	7.84 (3.38-18.18)	0.0000015	4.59 (1.61-13.07)	0.0042
Residential status				
Own home	Reference		Reference	
Nursing home	4.05 (2.26-7.25)	0.0000023	2.63 (1.18-5.83)	0.017
OTA/AO classification				
33-A	Reference		Reference	
33-B	0.71 (0.28-1.82)	0.48	1.06 (0.39-2.85)	0.90
33-C	0.53 (0.22-1.26)	0.15	1.26 (0.49-3.20)	0.62
CCI 0	Reference		Reference	
CCI 1	1.20 (0.57-2.51)	0.62	1.04 (0.45-2.38)	0.92
CCI 2	0.94 (0.41-2.14)	0.88	0.62 (0.25-1.52)	0.29
CCI ≥3	0.81 (0.33-1.98)	0.65	0.47 (0.17-1.31)	0.15
Previous fragility fractures	2.45 (1.36-4.42)	0.0026	1.11 (0.56-2.20)	0.74

CI = confidence interval, BMI = body mass index, CCI = Charlson Comorbidity Index.

Table 3

Hazard ratios for overall mortality by Cox regression model in surgical factors

Variables	Univariable analysis		Multivariable analysis*	
	Hazard ratio (95% CI)	P value	Hazard ratio (95% CI)	P value
Type of fixation				
Intramedullary nail	Reference		Reference	
ORIF with plate	0.73 (0.41-1.30)	0.28	0.85 (0.44-1.64)	0.64
Screws alone	0.58 (0.13-2.45)	0.46	1.41 (0.25-7.74)	0.68
Operation time	0.99 (0.99-1.00)	0.20	Reference	
Blood loss during operation	0.99 (0.99-1.00)	0.38	0.99 (0.99-1.00)	0.29
Time to surgery	0.99 (0.99-0.99)	0.03	0.99 (0.99-1.00)	0.091

CI = confidence interval, ORIF = open reduction internal fixation.

*Adjusted for age, sex, body mass index, Charlson Comorbidity Index, and fracture types.

Figure legends

Figure 1 Flowchart

Figure 2 A Kaplan-Meier curve for overall survival

Figure 3 Kaplan-Meier curves for patients according to (A) body mass index, (B) residency, (C) presence or absence of previous fragility fractures, (D) OTA/AO classification

Figure 4 Kaplan-Meier curves for patients according to (A) type of fixation (intramedullary nailing, open reduction and plate fixation, and screw fixation), (B) time from initial visit to surgery

Figure1

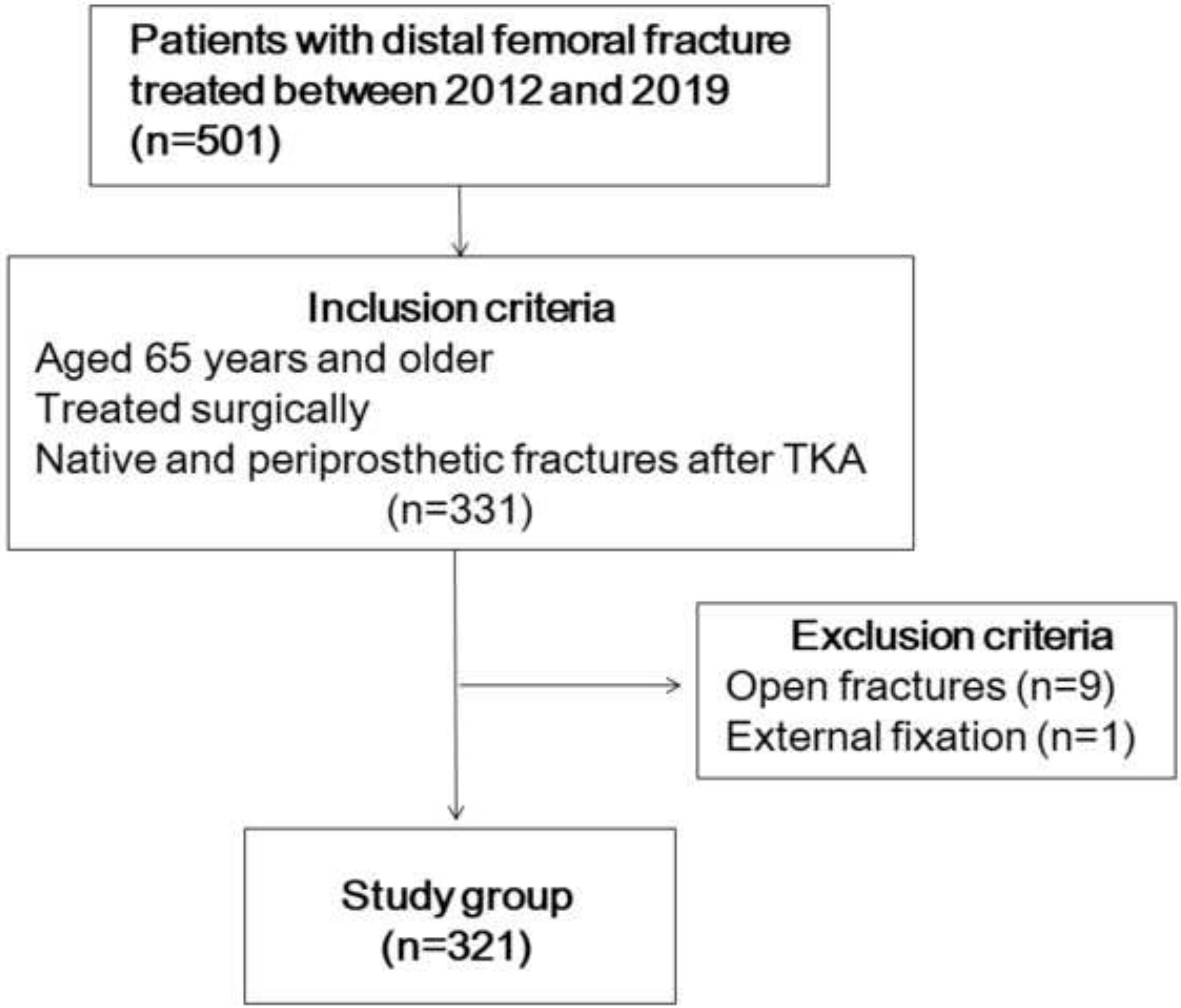
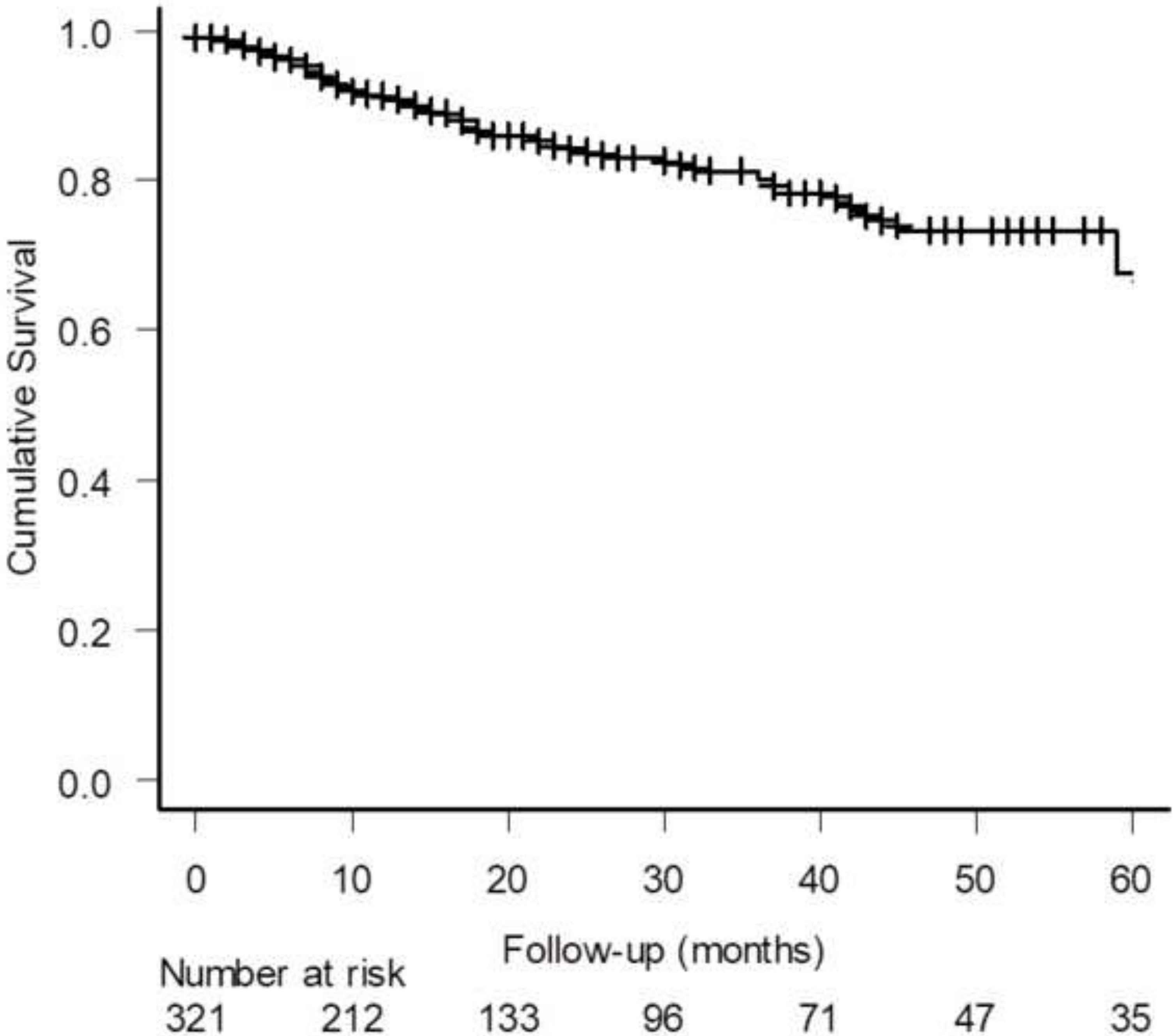

Patients with distal femoral fracture treated between 2012 and 2019 (n=501)
Inclusion criteria
Aged 65 years and older
Treated surgically
Native and periprosthetic fractures after TKA
(n=331)
Exclusion criteria
Open fractures (n=9)
External fixation (n=1)
Study group
(n=321)

Figure2



Cumulative Survival
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
Follow-up (months)
Number at risk
321
212
133
96
71
47
35

Figure3

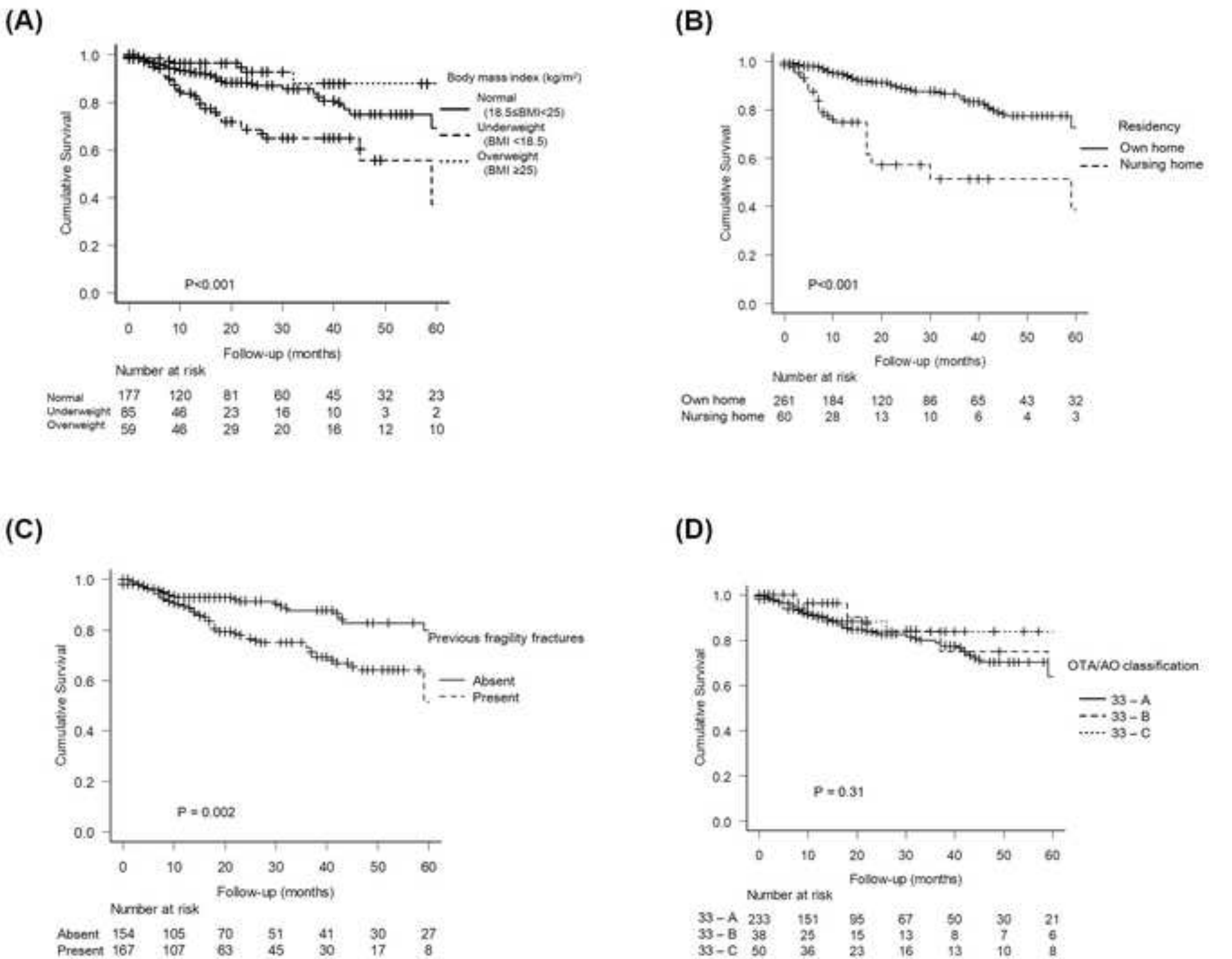
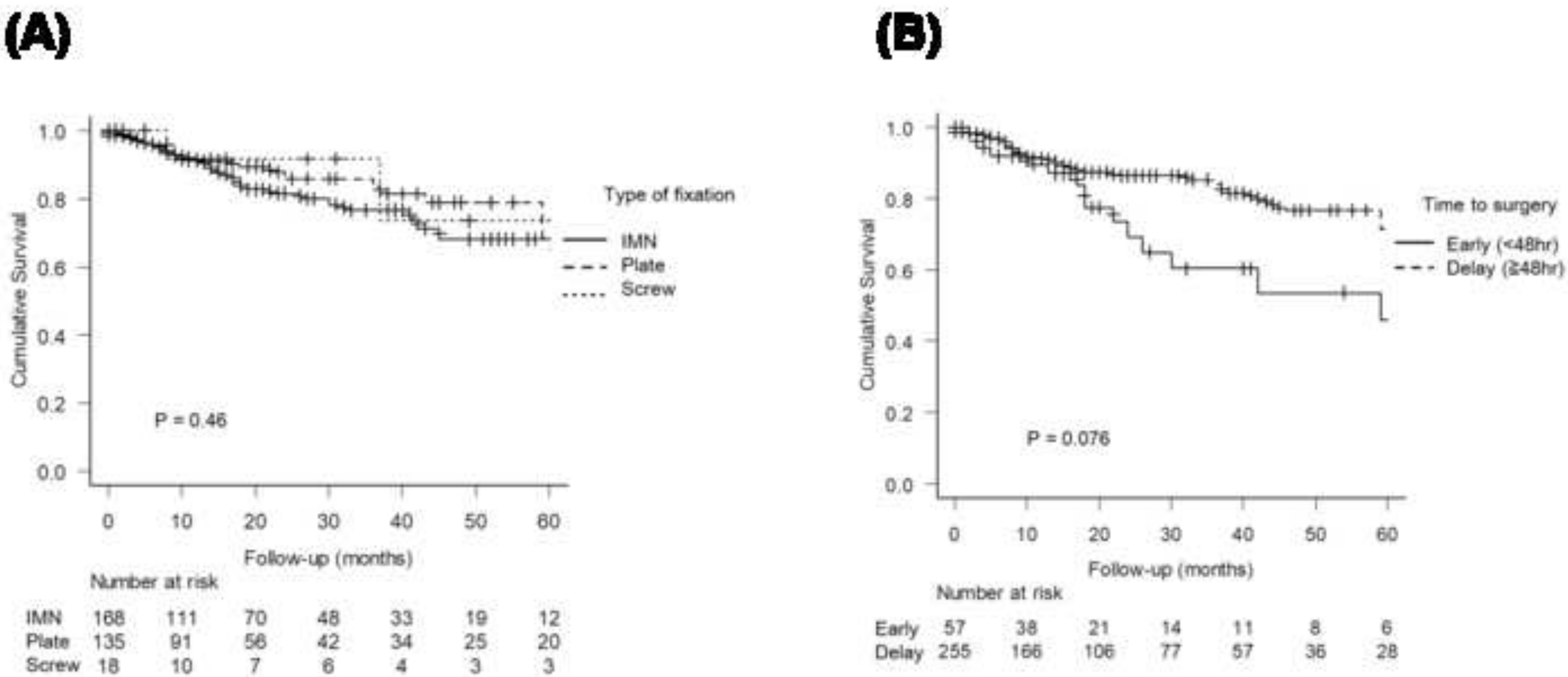

(A)
Cumulative Survival
Body mass index (kg/m²)
Normal (18.5≤BMI<25)
Underweight (BMI <18.5)
Overweight (BMI ≥25)
P<0.001
Follow-up (months)
Number at risk
Normal 177 120 81 60 45 32 23
Underweight 65 46 23 16 10 3 2
Overweight 59 46 29 20 16 12 10
(B)
Cumulative Survival
Residency
Own home
Nursing home
P<0.001
Follow-up (months)
Number at risk
Own home 261 184 120 86 65 43 32
Nursing home 60 28 13 10 6 4 3
(C)
Cumulative Survival
Previous fragility fractures
Absent
Present
P = 0.002
Follow-up (months)
Number at risk
Absent 154 105 70 51 41 30 27
Present 167 107 63 45 30 17 8
(D)
Cumulative Survival
OTA/AO classification
33 – A
33 – B
33 – C
P = 0.31
Follow-up (months)
Number at risk
33 – A 233 151 95 67 50 30 21
33 – B 38 25 15 13 8 7 6
33 – C 50 36 23 16 13 10 8

Figure4


(A)
1.0
0.8
0.6
0.4
0.2
0.0
Cumulative Survival
P = 0.46
Type of fixation
IMN
Plate
Screw
0
10
20
30
40
50
60
Follow-up (months)
Number at risk
IMN 168 111 70 48 33 19 12
Plate 135 91 56 42 34 25 20
Screw 18 10 7 6 4 3 3
(B)
1.0
0.8
0.6
0.4
0.2
0.0
Cumulative Survival
P = 0.076
Time to surgery
Early (<48hr)
Delay (≥48hr)
0
10
20
30
40
50
60
Follow-up (months)
Number at risk
Early 57 38 21 14 11 8 6
Delay 255 166 106 77 57 36 28

Highlights

We conducted a multicenter study to identify the 1-year mortality rate and predictors for mortality after distal femoral fractures in the elderly.

We assessed factors associated with patients' characteristics and surgical procedures with Cox regression analysis.

The 1-year mortality rate was 9.0%. Older age, underweight (body mass index<18.5 kg/m^2), and nursing home residency were independent predictors for mortality. Factors associated with the surgical procedure were not significant predictors.