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Functional Outcomes After Hip Fracture Rehabilitation Before and During the COVID-19 Pandemic: A Retrospective Comparative Study

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Abstract

Objectives: To compare functional recovery during inpatient rehabilitation, assessed by Functional Independence Measure (FIM) gain and FIM efficiency, between the pre-pandemic and COVID-19 pandemic periods in older adults after hip fracture. **Methods:** This retrospective observational study included patients aged ≥ 65 years who underwent hip fracture surgery between January 2016 and December 2022 and were admitted to a convalescent rehabilitation ward. Patients were categorized into the pre-pandemic (2016–2019) and pandemic (2020–2022) periods. Functional outcomes included total, motor, and cognitive FIM gain and FIM efficiency. Multiple linear regression analyses were performed to identify factors associated with rehabilitation outcomes. **Results:** A total of 650 patients were analyzed. Admission motor and total FIM scores were significantly lower during the pandemic, whereas cognitive FIM scores were similar between groups. After multivariable adjustment, total FIM gain and total FIM efficiency did not differ significantly between periods. Exploratory analyses showed no significant associations between the pandemic period and motor or cognitive FIM gain or efficiency. **Conclusions:** Although motor and total FIM scores at admission were lower during the pandemic period, no statistically significant differences in adjusted total FIM gain or total FIM efficiency were observed between the pre-pandemic and pandemic periods.

Keywords: activities of daily living; functional independence measure; older adults; physical function; post-acute inpatient rehabilitation



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1. Introduction

Hip fractures are among the most common injuries in older adults and are a major cause of functional decline and loss of independence [1,2]. In Japan, many older adults with hip fractures are admitted to convalescent rehabilitation wards after acute treatment to improve activities of daily living (ADLs) and facilitate discharge to home whenever possible. Functional recovery in these patients is commonly evaluated using the Functional Independence Measure (FIM) [3]. The FIM assesses functional independence across motor and cognitive domains and consists of 18 items (13 motor and 5 cognitive), including self-care, transfers, and locomotion for motor function, and communication and social

cognition for cognitive function. Because the FIM reflects patients' functional independence, it is widely used to evaluate rehabilitation outcomes and support discharge planning after hip fracture.

The coronavirus disease 2019 (COVID-19) pandemic substantially altered living environments worldwide, including in Japan. In the community setting, opportunities to leave home and engage in social activities decreased during the pandemic. In rehabilitation wards, visitor restrictions were implemented [4], and additional measures, such as restrictions on communal activities and shared spaces, modifications to rehabilitation practice, and limitations on discharge support and home assessment, were also introduced in many rehabilitation wards in Japan [5]. Such changes could potentially affect rehabilitation processes, opportunities for physical activity, family involvement, and discharge planning.

Previous studies have suggested that the COVID-19 pandemic adversely affected physical activity, functional capacity, cognitive function, and mental health among older adults [6,7].

Available evidence regarding rehabilitation outcomes during the pandemic has not consistently demonstrated deterioration in functional recovery. Leibovici-Weissman et al. reported that older adults with hip fractures admitted to a post-acute geriatric rehabilitation center during the first wave of the pandemic showed no significant differences in functional outcomes compared with patients treated before the pandemic, despite complete restrictions on family and caregiver visits [8]. In Japan, Kanazawa et al. examined inpatient rehabilitation during the initial phase of the pandemic and found that, although rehabilitation provision and care processes were affected, the overall impact on inpatient functional outcomes was limited [9]. In addition, a study of Japanese rehabilitation wards reported changes in rehabilitation provision and selected outcomes in association with visitor restrictions [4].

Japanese convalescent rehabilitation wards have distinctive organizational characteristics. They are interdisciplinary post-acute rehabilitation units in which relatively intensive rehabilitation can be provided over comparatively long inpatient periods, with rehabilitation therapy available for up to 3 h per day, 7 days per week [10]. This care model may be relevant when considering the effects of pandemic-related restrictions on rehabilitation processes and outcomes. During the COVID-19 pandemic, these wards implemented infection-control measures while continuing to provide inpatient rehabilitation, although the extent of restrictions and changes in care processes varied over time [5].

However, it remains unclear whether functional recovery after hip fracture, particularly FIM gain and FIM efficiency, differed between the pre-pandemic and pandemic periods in Japanese convalescent rehabilitation wards. Previous reports have mainly addressed selected periods of the pandemic, specific restrictions, or broader inpatient rehabilitation populations, and the effects of the pandemic across multiple years, while accounting for available baseline functional and clinical characteristics, have not been sufficiently examined.

The aim of this study was to compare functional recovery during inpatient rehabilitation, assessed using FIM gain and FIM efficiency, between the pre-pandemic and COVID-19 pandemic periods in older adults after hip fracture. Admission and discharge FIM scores were also compared between the pre-pandemic and pandemic periods to evaluate differences in functional status before and after inpatient rehabilitation.

2. Materials and Methods

2.1. Study Design and Setting

This retrospective observational study was conducted in a Japanese post-acute inpatient rehabilitation ward (convalescent rehabilitation ward). In our rehabilitation ward,

the target rehabilitation time was up to 3 h per day during the first 60 postoperative days and up to 2 h per day thereafter, in accordance with the standard rehabilitation program. This rehabilitation schedule remained unchanged throughout both the pre-pandemic and pandemic periods.

2.2. Participants

This study included patients aged ≥ 65 years who experienced a hip fracture between January 2016 and December 2022, underwent surgical treatment at an acute care hospital, and were subsequently admitted to our convalescent rehabilitation ward. The patients were drawn from the same source population as our previously reported cohort of older adults undergoing inpatient rehabilitation after hip fracture at the same institution during the same study period [11]. During the study period, 676 consecutive patients were screened for eligibility.

Patients requiring transfer from the rehabilitation ward to an acute care hospital for newly developed medical conditions unrelated to the index hip fracture were excluded. Twenty-six patients met this exclusion criterion, leaving 650 patients for the final analysis (Figure 1).

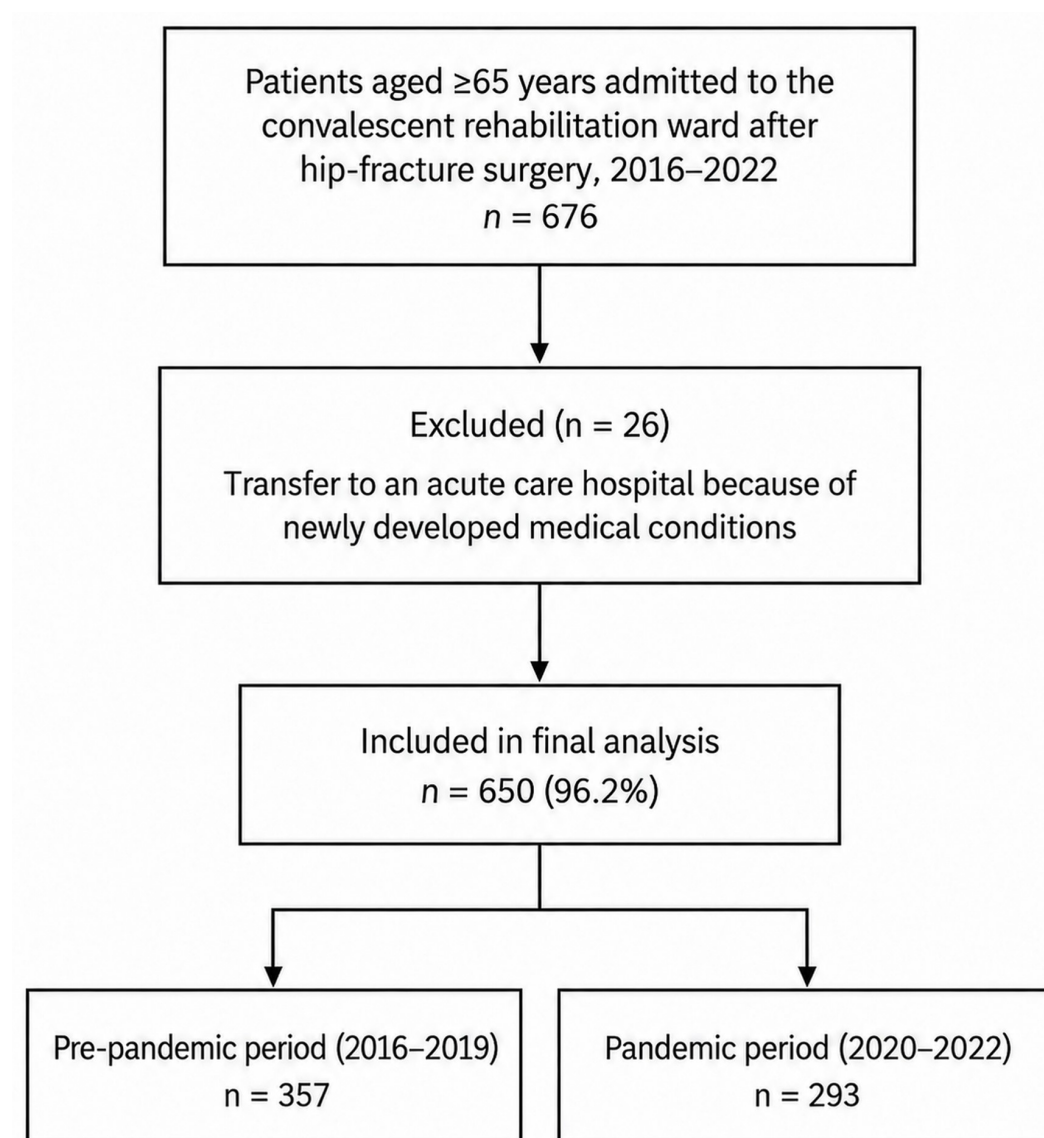


Figure 1. Flow diagram of patient selection.

Patients were categorized into two groups according to the timing of injury: a pre-pandemic group (2016–2019) and a pandemic group (2020–2022), defined according to the onset of the COVID-19 pandemic in Japan (early 2020).

2.3. Data Collection

Clinical data were retrospectively collected from electronic medical records. The following variables were extracted: patient characteristics (including age, sex, pre-injury residence, fracture type, surgical procedure, and time-related variables) and clinical outcomes (including discharge destination, length of stay, and Functional Independence Measure [FIM] scores at admission and discharge).

2.4. Outcome Measures

The primary outcomes were total FIM gain and total FIM efficiency. The Functional Independence Measure (FIM) consists of 18 items, including 13 motor and 5 cognitive items, with a total score ranging from 18 to 126, where higher scores indicate greater independence.

FIM gain was defined as the difference between FIM scores at discharge and admission. FIM efficiency was calculated as FIM gain divided by the length of stay in the rehabilitation ward and multiplied by 30 to represent the gain per 30 days.

In addition to total FIM outcomes, exploratory analyses were also conducted separately for motor and cognitive FIM gain and efficiency.

Discharge destination (facility or home) was recorded and included as a variable in the analyses.

2.5. Statistical Analysis

Continuous variables are presented as medians with interquartile ranges (Q1–Q3), and categorical variables are presented as counts and percentages. Comparisons between the pre-pandemic and pandemic groups were performed using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables.

Multiple linear regression analyses were performed to identify factors associated with the prespecified primary outcomes of total FIM gain and total FIM efficiency. Independent variables included the pandemic period (pre-pandemic vs. pandemic), demographic factors, clinical variables, discharge destination, and baseline FIM scores.

Exploratory regression analyses were subsequently performed using motor and cognitive FIM gain and FIM efficiency as the dependent variables. Additional exploratory subgroup analyses were conducted according to pre-injury living arrangement among patients discharged home.

Length of stay in the rehabilitation ward was included as a covariate in the FIM gain models but was excluded from the FIM efficiency models because length of stay is incorporated into the calculation of FIM efficiency.

The assumptions of multiple linear regression were assessed using residual diagnostic plots. Normality of residuals was evaluated using Q–Q plots, linearity and homoscedasticity were assessed using residual-versus-fitted plots, and influential observations were assessed using studentized residuals and Cook's distance.

Multicollinearity among the independent variables was assessed using variance inflation factors (VIFs). A two-tailed p value of <0.05 was considered statistically significant. No formal adjustment for multiple comparisons was applied. The analyses of motor and cognitive FIM outcomes and the subgroup analyses were considered exploratory and hypothesis-generating and were interpreted accordingly.

There were no missing values for the variables included in the regression analyses; therefore, no imputation of missing data was performed.

Sensitivity analyses were also performed to assess the robustness of the primary findings. First, an ANCOVA-type model was performed using total FIM score at discharge as the dependent variable and total FIM score at admission as a baseline covariate, together with the other covariates included in the primary total FIM gain model. Second, the primary outcomes were examined separately for 2020, 2021, and 2022, with the pre-pandemic period (2016–2019) serving as the reference. For each year-specific analysis, the same covariates as in the corresponding primary regression model were included. Third, because diagnostic assessment indicated departures from some linear regression assumptions, particularly for total FIM efficiency, robust linear regression using Huber M-estimation was performed for both primary outcomes using the same covariates as in the corresponding primary models.

Analyses other than the robust regression sensitivity analyses were performed using StatFlex version 7 (Artech Co., Ltd., Osaka, Japan). Robust regression analyses were performed using Python with statsmodels version 0.14.6.

2.6. Ethical Considerations

This study was approved by the Institutional Review Board of Rakuwakai Otowa Rehabilitation Hospital (Approval No. RAKUOTORI-RIN-19-001). In accordance with the approved protocol, the study was conducted using an opt-out approach by posting information on the hospital's website to ensure that patients had the opportunity to decline participation. The study was conducted in accordance with the principles of the Declaration of Helsinki.

3. Results

3.1. Patient Characteristics

Among 676 patients screened for eligibility, 26 were excluded because they required transfer to an acute care hospital during rehabilitation. The remaining 650 patients (96.2%) were included in the final analysis, with 357 in the pre-pandemic group and 293 in the pandemic group (Figure 1).

Baseline characteristics of the patients are shown in Table 1. There were no significant differences between the two groups in age, sex, pre-injury residence (facility vs. home), or fracture type and surgical procedure.

Table 1. Comparison of patient characteristics between the pre-pandemic and pandemic periods.

	Pre-Pandemic	Pandemic	<i>p</i> Value
Number of Patients	357	293	
Male	53 (14.8%)	46 (15.7%)	0.763
Female	304 (85.2%)	247 (84.3%)	
Age (years)	85 [78–88]	85 [79–89]	0.611
Pre-injury residence			
Facility *	62 (17.4%)	45 (15.4%)	0.492 †
Home	295 (82.6%)	248 (84.6%)	
Living alone	111 (31.1%)	68 (23.2%)	0.012 ‡
With family	184 (51.5%)	180 (61.4%)	
Fracture type and surgical procedure §			
FNF-BHA	141 (39.5%)	117 (39.9%)	0.842
FNF-IF	51 (14.3%)	46 (15.7%)	
TF-IF	165 (46.2%)	130 (44.4%)	
Time from injury to surgery (days)	4 [2–6]	3 [1–6]	0.009
Time from surgery to rehabilitation admission (days)	16 [13–23]	17 [13–21]	0.816

Table 1. *Cont.*

	Pre-Pandemic	Pandemic	<i>p</i> Value
FIM score at admission			
motor FIM score	49 [35–60]	43 [32–53]	<0.001
cognitive FIM score	25 [19–31]	27 [19–33]	0.117
total FIM score	73 [57–89]	70 [52–84]	0.010

Continuous variables are presented as median [Q1–Q3]. * “Facility” includes chronic care wards.

† Comparison between facility and home (chi-square test). ‡ Comparison between living alone and living with family within the home group (chi-square test). § Fracture type and surgical procedure: FNF-BHA = femoral neck fracture treated with bipolar hip arthroplasty; FNF-IF = femoral neck fracture treated with internal fixation; TF-IF = trochanteric fracture treated with internal fixation.

However, among patients who had lived at home before injury, the proportion of those living alone was significantly lower in the pandemic group, whereas the proportion of those living with family was higher ($p = 0.012$).

The time from injury to surgery was significantly shorter in the pandemic group ($p = 0.009$). In addition, motor and total FIM scores at admission were significantly lower in the pandemic group ($p < 0.001$ and $p = 0.010$, respectively).

During the pandemic period, several nosocomial COVID-19 outbreaks occurred in the rehabilitation ward. However, none of the patients included in this study developed COVID-19 during hospitalization. Two patients required temporary room isolation for approximately 10 days because they had been in close contact with infected roommates. Rehabilitation therapy was continued individually in patient rooms during the isolation period.

3.2. Clinical Outcomes

Clinical outcomes are shown in Table 2. There were no significant differences in discharge destination (facility vs. home) between the two groups. However, among patients discharged home, the proportion of those living alone was significantly lower in the pandemic group, whereas cohabitation was more common ($p = 0.011$).

Table 2. Comparison of clinical outcomes between the pre-pandemic and pandemic periods.

	Pre-Pandemic	Pandemic	<i>p</i> Value
Destination			
Facility *	105 (29.4%)	82 (28.0%)	0.690 †
Home	252 (70.6%)	211 (72.0%)	
Living alone	87 (34.5%)	50 (23.7%)	0.011 ‡
With family	165 (65.5%)	161 (76.3%)	
Length of stay in rehabilitation ward (days)	64 [45–82]	61 [45–77]	0.085
FIM score at discharge			
motor FIM score	75 [62–83]	71 [54–89]	0.018
cognitive FIM score	27 [20–32]	29 [20–34]	0.166
total FIM score	102 [82–115]	100 [76–114]	0.225
FIM gain			
motor FIM score	21 [15–31]	24 [16–32]	0.069
cognitive FIM score	0 [0–2]	0 [0–1]	0.191
total FIM score	22 [15–32]	25 [16–34]	0.098
FIM efficiency			
motor FIM score	12 [7–16]	12 [8–18]	0.017
cognitive FIM score	0 [0–1]	0 [0–1]	0.238
total FIM score	12 [7–17]	13 [8–19]	0.024

Continuous variables are presented as median [Q1–Q3]. * “Facility” includes chronic care wards.

† Comparison between facility and home (chi-square test). ‡ Comparison between living alone and living with family within the home group (chi-square test).

There were no significant differences in the length of stay in the rehabilitation ward between the two groups.

Regarding functional outcomes, motor FIM scores at discharge were significantly lower in the pandemic group ($p = 0.018$), whereas cognitive and total FIM scores at discharge did not differ significantly between groups.

No significant differences were observed in total, motor, or cognitive FIM gain between the groups, although motor and total FIM gain tended to be higher in the pandemic group. In the unadjusted analysis, total FIM efficiency and motor FIM efficiency were significantly higher in the pandemic group ($p = 0.024$ and $p = 0.017$, respectively), whereas cognitive FIM efficiency did not differ significantly between the groups.

3.3. Factors Associated with Total FIM Gain

The results of the multiple linear regression analysis for total FIM gain are shown in Table 3. The pandemic period was not independently associated with total FIM gain. No substantial multicollinearity was observed among the independent variables (all VIFs < 2.5). Discharge to home was significantly associated with greater total FIM gain compared with discharge to a facility ($p < 0.001$). A shorter time from surgery to rehabilitation admission was also associated with greater total FIM gain ($p = 0.011$), and a longer length of stay in the rehabilitation ward was associated with greater total FIM gain ($p = 0.014$).

Table 3. Multiple regression analysis for factors associated with total FIM gain.

	B (95% CI)	p Value
Pandemic *	−1.41 (−3.25, 0.43)	0.133
Sex †	−1.51 (−3.95, 0.92)	0.224
Age (years)	−0.07 (−0.21, 0.06)	0.293
Fracture type and surgical procedure (reference: FNF-BHA) ‡		
FNF-IF	1.31 (−1.39, 4.01)	0.340
TF-IF	−0.46 (−2.44, 1.51)	0.644
Living status at discharge (reference: facility) §	4.22 (2.00, 6.43)	<0.001
Time from injury to surgery (days)	0.00 (−0.06, 0.07)	0.906
Time from surgery to rehabilitation admission (days)	−0.12 (−0.21, −0.03)	0.011
Length of stay in rehabilitation ward (days)	0.05 (0.01, 0.10)	0.014
Motor FIM score at admission	−0.46 (−0.55, −0.37)	<0.001
Cognitive FIM score at admission	0.66 (0.50, 0.82)	<0.001

Values are presented as unstandardized regression coefficients (B) with 95% confidence intervals (CIs). Model fit: $R^2 = 0.218$; adjusted $R^2 = 0.204$. * Pandemic period: 0 = pre-pandemic, 1 = pandemic.

† Sex: male = 0, female = 1. ‡ Fracture type and surgical procedure (reference: FNF-BHA): FNF-BHA = femoral neck fracture treated with bipolar hip arthroplasty; FNF-IF = femoral neck fracture treated with internal fixation; TF-IF = trochanteric fracture treated with internal fixation.

§ Living status at discharge: “facility” includes chronic care wards; “home” includes both living alone and living with family.

Regarding baseline functional status, a lower motor FIM score at admission and a higher cognitive FIM score at admission were significantly associated with greater total FIM gain (both $p < 0.001$).

Age, sex, fracture type and surgical procedure, as well as time from injury to surgery, were not significantly associated with total FIM gain.

3.4. Factors Associated with Total FIM Efficiency

The results of the multiple linear regression analysis for total FIM efficiency are shown in Table 4. The pandemic period was not independently associated with total FIM efficiency ($p = 0.083$).

Table 4. Multiple regression analysis for factors associated with total FIM efficiency.

	B (95% CI)	p Value
Pandemic *	1.37 (−0.18, 2.92)	0.083
Sex †	−1.28 (−3.35, 0.80)	0.227
Age (years)	−0.24 (−0.35, −0.12)	<0.001
Fracture type and surgical procedure (reference: FNF-BHA) ‡		
FNF-IF	1.39 (−0.91, 3.68)	0.235
TF-IF	−1.24 (−2.91, 0.43)	0.145
Living status at discharge (reference: facility) §	2.03 (0.15, 3.91)	0.034
Time from injury to surgery (days)	−0.03 (−0.08, 0.03)	0.380
Time from surgery to rehabilitation admission (days)	−0.05 (−0.13, 0.03)	0.205
Motor FIM score at admission	−0.08 (−0.15, −0.01)	0.029
Cognitive FIM score at admission	0.22 (0.08, 0.35)	0.002

Values are presented as unstandardized regression coefficients (B) with 95% confidence intervals (CIs). $R^2 = 0.110$; adjusted $R^2 = 0.096$. * Pandemic period: 0 = pre-pandemic, 1 = pandemic. † Sex: male = 0, female = 1. ‡ Fracture type and surgical procedure (reference: FNF-BHA): FNF-BHA = femoral neck fracture treated with bipolar hip arthroplasty; FNF-IF = femoral neck fracture treated with internal fixation; TF-IF = trochanteric fracture treated with internal fixation. § Living status at discharge: “facility” includes chronic care wards; “home” includes both living alone and living with family.

Age was significantly associated with total FIM efficiency, with younger patients showing higher efficiency ($p < 0.001$). Discharge home was also significantly associated with higher total FIM efficiency compared with discharge to a facility ($p = 0.034$).

Regarding baseline functional status, a lower admission motor FIM score and a higher admission cognitive FIM score were associated with higher total FIM efficiency ($p = 0.029$ and $p = 0.002$, respectively). Other variables, including sex, fracture type and surgical procedure, and time-related variables, were not significantly associated with total FIM efficiency.

3.5. Sensitivity Analyses

As an additional sensitivity analysis, total FIM score at discharge was analyzed with adjustment for total FIM score at admission and the other covariates included in the primary total FIM gain model. The pandemic period was not significantly associated with total FIM score at discharge ($B = 1.11$, 95% CI [−0.78, 3.00], $p = 0.249$; $R^2 = 0.748$, adjusted $R^2 = 0.744$).

Year-specific sensitivity analyses showed no statistically significant associations between 2020, 2021, or 2022 and either total FIM gain or total FIM efficiency compared with the pre-pandemic period (Table 5). These findings were consistent with the primary analyses.

Table 5. Year-specific sensitivity analyses of total FIM gain and total FIM efficiency during the COVID-19 pandemic.

Pandemic Year	n	Total FIM Gain B (95% CI), p	Total FIM Efficiency B (95% CI), p
2020 vs. pre-pandemic	456	−1.53 (−4.15, 1.10), 0.254	1.96 (−0.07, 4.00), 0.059
2021 vs. pre-pandemic	453	−1.63 (−4.27, 1.01), 0.226	0.73 (−1.52, 2.99), 0.525
2022 vs. pre-pandemic	455	−1.75 (−4.38, 0.88), 0.191	0.56 (−1.49, 2.61), 0.591

Values are presented as unstandardized regression coefficients (B) with 95% confidence intervals (CIs) and p values. Each pandemic year (2020, 2021, and 2022) was analyzed separately in comparison with the pre-pandemic period (2016–2019), which served as the reference period. Models were adjusted for the same covariates as in the primary analyses (Tables 3 and 4). Length of stay in the rehabilitation ward was included as a covariate in the total FIM gain models but not in the total FIM efficiency models because length of stay is incorporated into the calculation of FIM efficiency. n indicates the total number of patients included in each year-specific regression model.

Diagnostic assessment showed only minor deviations from residual normality in the total FIM gain model, whereas the total FIM efficiency model showed a more pronounced right-skewed residual distribution. Residual-versus-fitted plots showed no clear systematic

nonlinear pattern, although some heteroscedasticity and influential observations were identified. In robust regression analyses using Huber M-estimation, the pandemic period was not significantly associated with either total FIM gain ($B = -1.52$, 95% CI $[-3.30, 0.25]$, $p = 0.092$) or total FIM efficiency ($B = 0.83$, 95% CI $[-0.33, 1.99]$, $p = 0.161$). Thus, the interpretation of the primary findings was unchanged.

3.6. Exploratory Analyses of Additional FIM Outcomes

The results of the exploratory regression analyses of additional FIM outcomes are shown in Table 6. The pandemic period was not significantly associated with motor FIM efficiency ($B = 1.26$, 95% CI $[-0.22, 2.74]$, $p = 0.094$), and no significant association was observed for motor FIM gain ($B = -1.47$, 95% CI $[-3.11, 0.17]$, $p = 0.078$). No significant associations were observed between the pandemic period and cognitive FIM gain or cognitive FIM efficiency.

Table 6. Multiple regression analyses for exploratory motor and cognitive FIM outcomes.

	Motor FIM Gain B (95% CI), p	Cognitive FIM Gain B (95% CI), p	Motor FIM Efficiency B (95% CI), p	Cognitive FIM Efficiency B (95% CI), p
Pandemic *	$-1.47 (-3.11, 0.17)$, 0.078	$-0.04 (-0.47, 0.38)$, 0.846	$1.26 (-0.22, 2.74)$, 0.094	$0.07 (-0.16, 0.30)$, 0.569
Sex †	$-1.63 (-3.80, 0.55)$, 0.142	$-0.33 (-0.89, 0.24)$, 0.254	$-1.24 (-3.21, 0.74)$, 0.220	$-0.23 (-0.54, 0.07)$, 0.135
Age (years)	$-0.08 (-0.20, 0.05)$, 0.231	$0.01 (-0.03, 0.04)$, 0.722	$-0.24 (-0.35, -0.13)$, <0.001	$0.00 (-0.01, 0.02)$, 0.700
Fracture type and surgical procedure (reference: FNF-BHA) ‡				
FNF-IF	$0.79 (-1.62, 3.20)$, 0.520	$0.56 (-0.06, 1.19)$, 0.076	$1.07 (-1.12, 3.26)$, 0.338	$0.34 (-0.005, 0.678)$, 0.053
TF-IF	$-0.15 (-1.91, 1.61)$, 0.867	$-0.17 (-0.63, 0.28)$, 0.459	$-1.09 (-2.68, 0.50)$, 0.179	$-0.09 (-0.34, 0.16)$, 0.490
Living status at discharge (reference: facility) §	$3.75 (1.78, 5.72)$, <0.001	$0.33 (-0.18, 0.84)$, 0.208	$1.87 (0.08, 3.66)$, 0.041	$0.10 (-0.18, 0.38)$, 0.473
Time from injury to surgery (days)	$0.00 (-0.06, 0.06)$, 0.917	$0.01 (-0.01, 0.02)$, 0.258	$-0.03 (-0.08, 0.03)$, 0.308	$0.00 (-0.01, 0.01)$, 0.422
Time from surgery to rehabilitation admission (days)	$-0.11 (-0.19, -0.03)$, 0.006	$-0.01 (-0.03, 0.01)$, 0.510	$-0.04 (-0.12, 0.03)$, 0.241	$-0.01 (-0.02, 0.00)$, 0.230
Length of stay in rehabilitation ward (days)	$0.04 (0.01, 0.08)$, 0.026	$0.01 (-0.001, 0.019)$, 0.067	—	—
Motor FIM score at admission	$-0.47 (-0.55, -0.40)$, <0.001	$0.01 (-0.01, 0.03)$, 0.242	$-0.09 (-0.16, -0.02)$, 0.008	$0.01 (0.00, 0.02)$, 0.013
Cognitive FIM score at admission	$0.76 (0.62, 0.90)$, <0.001	$-0.11 (-0.15, -0.07)$, <0.001	$0.28 (0.14, 0.41)$, <0.001	$-0.06 (-0.08, -0.04)$, <0.001
R ²	0.269	0.087	0.127	0.076
Adjusted R ²	0.256	0.072	0.113	0.062

Values are presented as unstandardized regression coefficients (B) with 95% confidence intervals (CIs). * Pandemic period: 0 = pre-pandemic, 1 = pandemic. † Sex: male = 0, female = 1. ‡ Fracture type and surgical procedure (reference: FNF-BHA): FNF-BHA = femoral neck fracture treated with bipolar hip arthroplasty; FNF-IF = femoral neck fracture treated with internal fixation; TF-IF = trochanteric fracture treated with internal fixation. § Living status at discharge (reference: facility): “facility” includes chronic care wards; “home” includes both living alone and living with family. Length of stay in the rehabilitation ward was included as a covariate in the FIM gain models but not in the FIM efficiency models because length of stay is incorporated into the calculation of FIM efficiency. These analyses were exploratory and hypothesis-generating, and no adjustment for multiple comparisons was applied.

3.7. Exploratory Subgroup Analyses

Exploratory subgroup analyses limited to patients discharged home showed no significant associations between the pandemic period and total, motor, or cognitive FIM gain or efficiency among either patients living alone or those living with family.

4. Discussion

4.1. Principal Findings

The principal finding of this study was that the COVID-19 pandemic period was not independently associated with total FIM gain or total FIM efficiency. Although motor and total FIM scores at admission were lower during the pandemic period, no statistically significant differences in these adjusted outcomes were observed between the pre-pandemic and pandemic periods.

The robustness of these findings was further supported by year-specific sensitivity analyses, in which neither total FIM gain nor total FIM efficiency differed significantly in 2020, 2021, or 2022 compared with the pre-pandemic period.

4.2. Lower Baseline Functional Status During the Pandemic

During the COVID-19 pandemic, opportunities for older adults to leave home and engage in social activities were substantially reduced. Previous studies have reported that the pandemic adversely affected physical activity, functional capacity, cognitive function, and mental health among community-dwelling older adults [6,7]. These findings raise the possibility that pre-injury physical function may have differed between the pre-pandemic and pandemic periods. However, pre-injury ADL and physical function were not directly measured in the present study, and their contribution to the lower admission FIM scores observed during the pandemic period cannot be determined.

Interestingly, cognitive FIM scores at admission did not significantly differ between the pre-pandemic and pandemic groups, despite concerns regarding cognitive decline during the pandemic. One possible explanation is that the cognitive FIM mainly reflects the minimum cognitive abilities necessary for daily living and may be less sensitive to mild cognitive decline. Previous studies have suggested that although the pandemic may accelerate cognitive decline in older adults, its clinical impact on basic ADL-related cognitive function may be limited [12].

In contrast, motor FIM scores at both admission and discharge were significantly lower during the pandemic period. One possible explanation is that reduced physical activity during the pandemic may have been associated with lower pre-injury physical function; however, pre-injury physical activity and functional status were not directly measured in this study. Previous studies have reported declines in muscle mass and muscle strength among older adults during the COVID-19 pandemic [7,13,14]. Mild muscle weakness may not immediately lead to overt disability in daily life [15], but it may contribute to lower physical reserve and poorer functional status at the time of hip fracture. These previous findings provide a possible context for the lower admission motor FIM scores observed during the pandemic period, although the underlying mechanism cannot be determined from the present data.

In the present study, the time from injury to surgery was significantly shorter during the pandemic period. The reason for this finding cannot be determined from the present data. A recent nationwide Japanese study reported that the mean waiting time for hip-fracture surgery decreased from 3.5 days in 2011 to 3.0 days in 2021, suggesting a secular trend toward earlier surgery in Japan [16]. Therefore, the shorter time from injury to surgery observed in the pandemic group may partly reflect temporal changes in hip-fracture care rather than a pandemic-specific effect. Changes in healthcare-resource availability during the pandemic may also have contributed, but this possibility could not be evaluated in the present study and remains hypothetical. Moreover, time from injury to surgery was not independently associated with either total FIM gain or total FIM efficiency in our multivariable analyses.

4.3. Comparison of Rehabilitation Outcomes Between Periods

Although several infection control measures were implemented during the pandemic, including visitor restrictions and limitations on communal activities, the pandemic period was not independently associated with total FIM gain or total FIM efficiency. Thus, after adjustment for measured covariates, no statistically significant differences in total FIM gain or total FIM efficiency were observed between the pre-pandemic and pandemic periods. These findings should not be interpreted as demonstrating equivalence or preservation of rehabilitation effectiveness. Because this study was not designed as a non-inferiority analysis, a mild clinically meaningful decline cannot be excluded.

4.4. Living Arrangement and Discharge During the Pandemic

Interestingly, although discharge destination (facility vs. home) did not significantly differ between the pre-pandemic and pandemic groups, the proportion of patients discharged home who lived alone was significantly lower during the pandemic period. Similarly, among patients who had lived at home before injury, the proportion living alone was lower during the pandemic period.

In Japan, the proportion of older adults living alone has generally increased over time; however, national survey data suggested a slight decrease during the COVID-19 pandemic period [17]. Specifically, the proportion of persons aged ≥ 65 years living alone decreased slightly from 19.6% in 2019 to 19.4% in 2021. A similar trend may also have occurred in the region investigated in the present study.

Although living with family may initially appear favorable for older adults compared with living alone, the increase in cohabitation during the pandemic may partly have reflected social and economic circumstances affecting younger family members, including employment-related changes. Previous studies have also suggested that cohabitation during the pandemic could itself become a source of psychological stress within households [18]. Therefore, increased cohabitation during the pandemic should not necessarily be interpreted as universally beneficial for older adults. Careful attention may be needed during discharge planning to assess family relationships, caregiving capacity, and the sustainability of the post-discharge living environment.

4.5. Factors Associated with Functional Recovery

The present study also demonstrated that lower motor FIM scores at admission were associated with greater total FIM gain and higher total FIM efficiency. One possible explanation is that patients with lower motor FIM scores at admission may have greater potential for measurable functional improvement during inpatient rehabilitation. In contrast, higher cognitive FIM scores at admission were associated with greater total FIM gain and efficiency, suggesting that preserved cognitive function may facilitate effective participation in rehabilitation programs. This finding is consistent with previous reports demonstrating that cognitive status is an important predictor of rehabilitation outcomes after hip fracture [19].

4.6. Limitations

This study has several limitations. First, this was a retrospective observational study conducted at a single rehabilitation ward in Japan, which may limit the generalizability of the findings. Second, pre-injury ADL function could not be directly evaluated. Therefore, differences in functional status before hip fracture between the pre-pandemic and pandemic periods could not be fully assessed. Third, patients who were not admitted to the rehabilitation ward after surgery were not included in the analysis. Thus, patients who died, remained medically unstable, or were otherwise considered unsuitable for transfer

to post-acute rehabilitation were not represented in this cohort. In addition, patients who required transfer back to an acute care hospital during rehabilitation were excluded. These selection processes may have resulted in underrepresentation of patients with greater medical severity, and selection bias therefore cannot be excluded. Fourth, potentially relevant confounders, including comorbidities, frailty, nutritional status, dementia or delirium, post-operative complications, pre-injury functional status, and the actual amount or intensity of rehabilitation, were not systematically available for the entire cohort and could not be included in the multivariable models. Residual confounding by these unmeasured factors therefore cannot be excluded.

Fifth, FIM efficiency is calculated using the length of stay as the denominator and therefore reflects the rate of functional gain during hospitalization rather than rehabilitation effectiveness alone. It may be influenced by discharge timing and other factors affecting length of stay, although discharge destination was included as a covariate in the multivariable models. Residual effects related to discharge timing therefore cannot be excluded.

In addition, because the exposure of interest was defined according to calendar period, the pandemic indicator may also capture secular changes in patient characteristics, surgical timing, and clinical practice that occurred over time. Although year-specific sensitivity analyses were performed for 2020, 2021, and 2022, detailed information on changes in infection-control measures, visitor restrictions, vaccination coverage, and healthcare-system pressures over time was not available. Residual confounding by such temporal trends therefore cannot be excluded.

Furthermore, because multiple exploratory analyses were performed, some of the observed associations may have been identified by chance.

Finally, because of the retrospective observational design, the present findings represent associations and should not be interpreted as establishing a causal effect, or the absence of a causal effect, of the COVID-19 pandemic period on rehabilitation outcomes.

Despite these limitations, the present study provides information regarding inpatient rehabilitation outcomes after hip fracture before and during the COVID-19 pandemic. These findings may contribute to understanding how rehabilitation outcomes varied during a major public health emergency.

5. Conclusions

The COVID-19 pandemic period was not independently associated with total FIM gain or total FIM efficiency in older adults undergoing inpatient rehabilitation after hip fracture. Although motor and total FIM scores at admission were lower during the pandemic period, no statistically significant differences in adjusted total FIM gain or total FIM efficiency were observed between the pre-pandemic and pandemic periods.

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Abbreviations

FIM Functional Independence Measure

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