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Original Article

Multidisciplinary Approach to Reduce Postoperative Complications and Improve the Activity of Patients with Hip Fracture: A 24-month Follow-up Survey

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Multidisciplinary approaches such as fracture liaison services (FLS) have been introduced in some countries to reduce medical complications and secondary fractures in patients with fragility hip fracture. We aimed to investigate outcomes in patients with fragility hip fracture following the introduction of FLS. Patients > 50 years old who experienced fragility hip fractures between January 1, 2015 and December 31, 2017 were enrolled, and divided into a control group (without FLS; 94 patients) and FLS group (373 patients). We found that the time from injury to surgery decreased significantly from 2.42 to 1.83 days ($p = 0.003$), the proportion of patients who underwent surgery within 36 h of injury increased significantly ($p = 0.014$), and the number of cases with complications after admission decreased significantly ($p = 0.004$) in the FLS group. Patients with a Barthel index ≥ 80 were more common in the FLS than the control group at 6, 12, and 24 months following injury ($p = 0.046$, 0.018, and 0.048, respectively). Multiple logistic regression analysis revealed the factors associated with postoperative complications and death within 12 or 24 months after injury. Our results indicate that FLS contributed to earlier recovery, rehabilitation following surgery and rehabilitation of medical complications following admission; improved patient activity; and decreased secondary hip fractures.

Key words: postoperative complications, fracture liaison services, hip fractures, multidisciplinary approaches

In Japan, the number of fragility hip fractures is increasing due to a continuous increase in the number of older adults [1]. Takusari *et al.* reported that the estimated number of patients with new hip fractures was 193,400 in 2012 and 193,400 in 2017, representing a 10% increase over 5 years [1]. A previous study indicated that the average age of patients with hip fracture in Niigata Prefecture, Japan in 2015 was 81.4 years in men and 84.9 years in women, and 80% of the patients had more than one comorbidity at the time of their fracture [2]. Moreover, 25% of patients with hip fracture in our previous study developed medical complications following hospitalization [3]; in the same study, such complications were shown to delay rehabilitation progress, decrease patient activity, and cause the patient to be bedridden and/or die prematurely. Therefore, there is need of a more comprehensive approach to the treatment of fragility hip fractures in the elderly.

Fracture liaison services (FLS) that have been introduced in the United Kingdom [4-9] and Japan [10] have reduced the rate of medical complications and secondary fractures and improved the cost-effectiveness of the treatment of hip fractures [11-13].

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At our institution, we introduced an FLS as a multidisciplinary approach based on the methods implemented for the treatment of hip fracture in elderly in Toyama City Hospital, in Toyama, Japan in 2019 [10]. In the present study, because data on hip fracture outcomes following FLS introduction are scarce in Japan, we investigated improvements in the following parameters after the introduction of FLS: time to surgery, daily activity, the rate of medical complications after admission, and the rate of secondary hip fractures.

Materials and Methods

Study design and characteristics of the participants. This study was conducted in accordance with the principles of the Declaration of Helsinki (1964) and was approved by the institutional review board of the Niigata Prefectural Shibata Hospital (No. 167). The need for written informed consent was waived by the institutional review board owing to the retrospective cohort design of this study. Licenses to access the data used in this study were acquired by the corresponding author and coauthors, who alone had administrative permission regarding this research.

Patients who were treated at our institution for a fragility hip fracture, including a femoral neck or trochanteric fracture, between January 1, 2015 and December 31, 2017 and were older than 50 years at the time of injury were retrospectively enrolled in this study. We excluded patients with pathological and periprosthetic fractures, high-energy injuries (*e.g.*, those due to traffic accidents), and falls from heights. We assigned the remaining patients to 2 groups: patients who were injured between January 1 and June 30, 2015 who had not received FLS (control group; n = 122), and those who were injured between July 1, 2015 and December 31, 2017 and received FLS (FLS group; n = 507). Additionally, we excluded patients who were lost to follow-up at less than 3 months after the injury. The final analysis included 94 and 373 patients in the control and FLS groups, respectively (Fig. 1).

FLS outline. To reduce the burden of consultation with internists, we based the consultation criteria on a report by Shigemoto *et al.* [10] as well as the information provided in Table 1. As recommended by several hip fracture management guidelines, we consulted with various specialists regarding early surgery (36 h after the injury) based on the patient status, as shown in Table 1 [14-16]. A dedicated nephrologist from the Japan Osteoporosis Society ensured cooperation between orthopedic surgeons and internists. In addition, an anesthesiologist arranged surgery as early as possible if the patient's condition was amenable to surgery.

To prevent secondary fracture, we introduced anti-osteoporosis outpatient medications, such as bisphos-

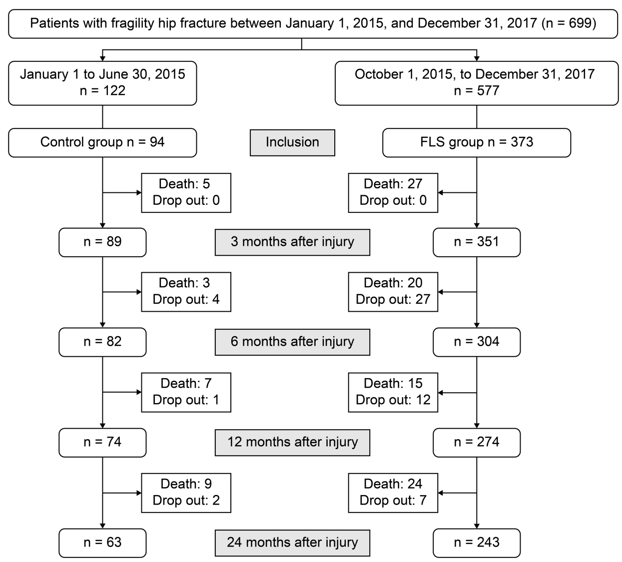

Fig. 1 Flow diagram of eligibility criteria.

Table 1 Consultation criteria by internist subspecialty

Subspecialty	Target disease or physical condition
Cardiologist	History of cardiovascular disease Abnormal findings on electrocardiogram at admission
Pulmonologist	History of bronchial asthma, home oxygen therapy Arterial oxygen saturation less than 90% in room air Pneumonia at admission
Nephrologist	Patients on hemodialysis Chronic kidney disease with eGFR less than 40 mL/min
Neurologist	History of neurogenic disease, such as Parkinson's disease or cerebral infarction
Endocrinologist	Casual blood glucose greater than 200 ng/dL History of diabetes mellitus, including type 1
Gastroenterologist	History of liver failure, including liver cirrhosis

phonate, at 1-3 months after the injury.

Survey components. Patient information, including age (years), sex, days from injury to surgery, the rate at which surgery occurred within 36 h of injury, the number and proportion of patients who underwent surgery, and the average length of hospital stay (days), were collected using surveys. Data on comorbidities at the time of surgery (as classified in our previous study [3]: hypertension, cardiovascular disease, pulmonary disease, renal disease, urinary tract infection, diabetes, cerebrovascular disease, digestive disease, and delirium); complications following admission, including worsening of a comorbidity; and hip fracture on the opposite side within 12 and 24 months after the first hip fracture were also collected. We also examined the rate of anti-osteoporosis medication compliance, daily activity as evaluated by the Barthel index (BI), and the rate of patients whose BI was ≥80 (*i.e.*, patients considered independent) [17]. Most parameters were evaluated at admission and at 3, 6, 12, and 24 months after the injury. Moreover, mortality was examined within 1, 12, and 24 months after the injury. When evaluating anti-osteoporosis medication compliance and daily activities, deceased patients and those lost to follow-up were excluded from the analyses at 3, 6, 12, and 24 months (Fig. 1). The data were obtained from medical records via telephone calls or via surveys mailed to patients or their families by a specialized liaison nurse certified by the Japan Osteoporosis Society.

Statistical analysis. SPSS statistical software (version 24; SPSS, Chicago, IL, USA) was used for the data analyses. The normality of distribution of continuous variables was assessed by the Kolmogorov-Smirnov test. Fisher's exact test was employed to compare qualitative data; *e.g.*, the number of men and women. The unpaired Student's *t*-test was used to analyze quantitative data, such as age. To determine mortality, Kaplan-Meier analysis and a log-rank test were conducted. We also performed a post-hoc analysis to evaluate statistical power (type II [β] error). We defined the effect size (d) as 0.5 and type I (α) error as 0.05 for the *t*-test, and the effect size (d) as 0.3 and type I (α) error as 0.05 for Fisher's exact test. A multiple logistic regression analysis was used to determine which of the following factors contributed to postoperative complications: age, sex, FLS intervention, BI at injury, and surgery within 36 h of injury. An additional multiple logistic regression analysis was used to examine which of the following factors contributed to death within 12 and 24 months after injury: age, sex, FLS intervention, BI at injury, surgery within 36 h of injury, and occurrence of postoperative complications. Two-tailed *p*-values of <0.05 were considered statistically significant in all analyses.

Results

Among the 467 patients, the cause of injury was a fall from a standing position in 369 (79.0%), a missed step in 14 (3.0%), a fall from a sitting position in 18 (3.9%), a fall from bed in 19 (4.1%), lying down or turning in 5 (1.1%), other in 9 (1.9%), and unknown in 33 (7.1%) patients. Table 2 shows the detailed participant characteristics. The number of days between injury and surgery decreased significantly from 2.42 days to 1.83 days after FLS introduction ($p=0.003$; Table 2). Moreover, the proportion of patients who were able to undergo surgery within 36 h of injury increased significantly in the FLS group ($p=0.014$; Table 2). The hospital length of stay was similar in both groups, while the proportion of patients who underwent surgery after the injury also increased significantly, from 86.2% to 93.8% ($p=0.018$; Table 2).

A significant decrease was observed in the total number of patients who developed complications following admission ($p=0.004$) and in the number of patients with cardiovascular (heart failure in all 17 patients) ($p=0.010$), pulmonary ($p=0.043$), and cerebrovascular (cerebral infarction in all 11 patients) ($p=0.049$) disease in the FLS group. The rate of comorbidities at the time of the injury was similar in both groups (Table 2).

The rate of anti-osteoporosis medication compliance was significantly higher in the FLS group than in the control group at 3, 6, 12, and 24 months after injury (Table 3). Daily activities of patients were similar at all time points examined. However, the proportion of patients with a BI of ≥80 was significantly higher in the FLS group at 6, 12, and 24 months after injury ($p=0.046$, 0018, and 0.048, respectively; Table 3). The mortality rate was slightly but not significantly lower in the FLS group throughout the study period (Fig. 2). Based on multiple logistic regression analysis, FLS intervention (odds ratio: 0.372; $p=0.004$) and BI at the time of injury (odds ratio: 0.978; $p=0.004$) significantly affected the occurrence of postoperative complications. BI at the time of injury (odds ratio: 0.975 and

Table 2 Characteristics of the study participants

	Control group	FLS group	*P*-value
Patients	94	373	
Age (years)	83.3 ± 8.8	83.3 ± 10.3	0.950[a]
Sex (Men/women)	21/73 (women: 77.7%)	69/304 (women: 81.6%)	0.384[b]
Delay in surgery (days from injury)	2.42 ± 2.19	1.83 ± 1.45	0.003[a]
Cases that underwent any surgery	81 (86.2%)	350 (93.8%)	0.018[b]
Surgery performed within 36 hours of injury	52 (55.3%)	259 (69.4%)	0.014[b]
Hospital stay (days)	22.6 ± 10.7	20.8 ± 8.2	0.346[a]
Comorbidity at injury			
n[#] (%)	82 (87.2%)	325 (87.1%)	0.871[b]
Hypertension	37 (39.3%)	193 (51.7%)	0.038[b]
Cardiovascular disease	25 (26.6%)	95 (25.4%)	0.895[b]
Pulmonary disease	6 (6.4%)	31 (8.3%)	0.671[b]
Renal disease	9 (9.6%)	42 (11.3%)	0.715[b]
Diabetes	8 (8.5%)	54 (14.5%)	0.172[b]
Cerebrovascular disease	18 (19.1%)	83 (22.3%)	0.577[b]
Digestive disease	32 (34.0%)	124 (33.2%)	0.902[b]
Complications after admission,			
n[#] (%)	27 (27.7%)	58 (15.5%)	0.004[b]
Cardiovascular disease	8 (8.5%)	9 (2.4%)	0.010[b]
Pulmonary disease	10 (10.6%)	17 (4.6%)	0.043[b]
Renal disease	3 (3.2%)	5 (1.3%)	0.205[b]
Urinary tract infection	8 (8.5%)	18 (4.8%)	0.205[b]
Cerebrovascular disease	5 (5.3%)	6 (1.6%)	0.049[b]
Digestive disease	2 (2.1%)	6 (1.6%)	0.665[b]
Delirium	5 (5.3%)	12 (3.2%)	0.355[b]

[#]: including duplicate cases, [a]: Student's *t*-test, [b]: Fisher's exact test.
FLS fracture liaison services.

Table 3 Comparison of outcomes following injury

	Control group	FLS group	*P*-value
Rate of medication for osteoporosis			
At injury	7/94 (7.2%)	31/373 (8.3%)	0.784[b]
3 months after injury	17/89 (19.1%)	168/351 (47.8%)	<0.001[b]
6 months after injury	28/82 (34.1%)	166/304 (54.6%)	0.001[b]
12 months after injury	23/74 (31.1%)	160/274 (58.4%)	<0.001[b]
24 months after injury	17/63 (27.0%)	148/243 (60.9%)	<0.001[b]
Barthel index (BI)			
At injury	84.9 ± 19.1	86.7 ± 17.7	0.375[a]
BI ≥ 80	68/94 (72.3%)	265/373 (71.0%)	0.899[b]
3 months after injury	60.4 ± 29.5	66.6 ± 30.2	0.222[a]
BI ≥ 80	30/89 (33.7%)	152/351 (43.3%)	0.118[b]
6 months after injury	64.5 ± 30.2	70.6 ± 29.5	0.129[a]
BI ≥ 80	34/82 (41.5%)	165/304 (54.3%)	0.046[b]
12 months after injury	66.5 ± 30.7	71.6 ± 28.8	0.228[a]
BI ≥ 80	31/74 (41.9%)	158/274 (57.7%)	0.018[b]
24 months after injury	65.3 ± 32.8	71.9 ± 28.5	0.190[a]
BI ≥ 80	27/63 (42.9%)	138/243 (56.8%)	0.048[b]
Opposite-side fracture within 1 year after first hip fracture	3/74 (4.1%)	7/274 (2.5%)	0.449[b]
Opposite-side fracture within 2 years after first hip fracture	5/63 (7.9%)	12/243 (4.9%)	0.359[b]

[a]: Student *t*-test, [b]: Fisher's exact test.
FLS fracture liaison services.

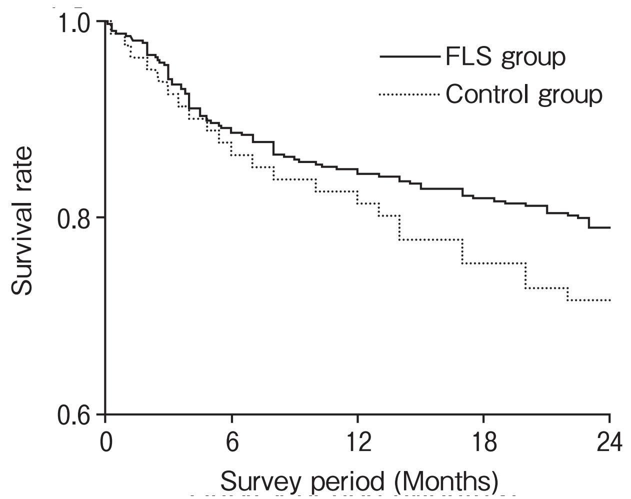

Fig. 2 Kaplan-Meier survival estimates. The mortality rate was slightly but not significantly lower in the fraction liaison service group.

0.977; $p = 0.002$ and 0.001), surgery within 36 h of injury (odds ratio: 0.406 and 0.453; $p = 0.013$ and 0.004), and postoperative complications (odds ratio: 4.396 and 2.389; $p = 0.001$ and 0.021) were significantly associated with patient death within 12 or 24 months. The post-hoc analysis revealed that the power of the *t*-test and the Fisher's exact test was 0. 941 and 0. 999, respectively.

Discussion

In this study, we observed that 23.4% of the patients in the control group experienced complications after admission, which was similar to the rates reported in the previous researches [3, 10]. In the FLS group, however, complications decreased following admission. Based on the logistic regression analysis, the lower rate of complications in the FLS group may have been due to the more prompt surgery and the internist intervention for comorbidities at the time of injury in that group, which decreased the occurrence of new complications after admission and prevented existing comorbidities from worsening. Similar results have been observed in previous studies [10, 18-20]. We believe that early intervention by the internist led to prompt approval and scheduling of the surgery. In addition, the internist was able to intervene before the exacerbation of the patients' general condition or hemodynamics, which also seemed to contribute to the decrease in complications.

In addition, more patients were able to undergo hip surgery after FLS introduction at our hospital, possibly due to cooperation between orthopedic surgeons and internists. Furthermore, the number of complications after admission and before surgery decreased, as mentioned above, and cooperation with anesthesiologists was associated with more prompt surgery. In this study, hospital length of stay was similar in both groups. In a meta-analysis of 18 studies by Grigoryan *et al.*, the hospital lengths of stay decreased following FLS intervention [15]. In our hospital, many patients are transferred to the inpatient rehabilitation facility at 1 to 2 weeks after admission or surgery; therefore, no difference in the hospital length of stay could be observed between the two groups.

Regarding the daily living activities evaluated by the BI, the proportion of patients thought to be independent was significantly higher in the FLS group at each of 6, 12, and 24 months after injury. Earlier recovery after rehabilitation, more prompt surgery, as well as a decrease in delaying rehabilitation due to medical complications after admission, may explain this finding.

A notable exception to the improvements associated with FLS was the incidence of opposite-side hip fractures within 1 and 2 years of the first hip fracture; this parameter was not significantly decreased by the introduction of liaison services. However, the rate of anti-osteoporosis medication use was higher in the FLS group than in the control group. Axelsson *et al.* described that their FLS did not decrease the incidence of recurrent hip fracture; however, the risk of recurrent fragility fractures, including hip fractures, was decreased in their Swedish cohort study, which reported results similar to ours were over the age of 80 years, the mortality rate for this cohort could have been high even without hip fractures; therefore, our FLS might not bring a significant effect on mortality.

This study has several limitations. First, the sample size was small at approximately 600 patients. Therefore, while the statistical power was sufficient, it may be difficult to compare the rates of complications due to the low incidence rates. Second, this was a retrospective cohort study, which may have affected the interpretation of the results. However, we acquired our data from a robust prospective database that was accurately constructed by trained staff. Third, only approximately 70% of the patients were carefully followed up. Although our hospital serves patients from a wide area, they are generally transferred to inpatient rehabilitation facilities closer to their area of residence; consequently, many patients did not visit our institution. To overcome this limitation, we attempted to track patients using medical records, telephone calls, and mail; nevertheless, we were unable to monitor several patients. Additional prospective studies examining a large sample are warranted.

In conclusion, following FLS introduction at our institution, we observed more frequent prompt surgery in addition to a decrease in the rate of complications following admission, which may improve patient independence in performing daily activities. Therefore, the FLS intervention presented herein is expected to improve patient activity and may possibly decrease the rate of secondary hip fractures following hip surgery.

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