Determinants of Functional Outcomes Using Clinical Pathways for Rehabilitation After Hip Fracture Surgery

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Background: This study evaluated functional outcomes using newly established clinical pathways after hip fracture surgery in older adults and analyzed the major determinants of successful functional outcomes in rehabilitation programs using standardized clinical pathways. Methods: This was a retrospective cohort study performed in a tertiary rehabilitation facility. A total of 220 patients who had received unilateral hip fracture surgery were followed up from immediately after surgery to 6 months postoperatively. Clinical pathways for rehabilitation included early, individualized rehabilitation, education for activities of daily living, review of general medical conditions, and arrangement of discharge settings. One rehabilitation specialist consecutively checked ambulatory function using 3-level grading, and patients were classified into good recovery and poor recovery groups based on ambulatory function at 6 months postoperatively. Logistic regression analysis was performed using 7 representative variables (age, sex, bone mineral density, Mini-Mental Status Examination [MMSE], Berg Balance Scale [BBS], premorbid ambulatory function, and length of hospital stay). Results: A total of 86.8% of patients could walk with or without assistance at 6 months after surgery and 75.5% of patients involved in the rehabilitation program were classified into the good recovery group in this study. The good recovery group showed higher MMSE and BBS scores compared with the poor recovery group. The factors in the model most strongly correlated with recovery were MMSE and BBS. Conclusion: This study showed that a well-designed rehabilitation program could improve ambulatory function in older patients after hip fracture surgery and that cognitive impairment and poor balance control may inhibit the recovery of ambulatory function.

INTRODUCTION

Hip fracture is a geriatric disease with multiple predisposing factors that may lead to falls, such as osteoporosis, weakness, and dizziness. The incidence of hip fracture differs by country. In South Korea, the age-standardized annual incidence rate of hip fractures in 2003 was 104.06 per 100,000, including 146.38 per 100,000 for women and 61.72 per 100,000 for men.1,2 Older people have a 5- to 8-fold increased risk of mortality during the first 3 months after hip fracture, and increased annual mortality persisted over time in both women and men following hip fracture.3 Likewise, hip fractures, which mostly result from falls related to multiple predisposing risk factors in geriatric populations, are a major public health problem.

To achieve ambulatory function after surgical treatment, multidisciplinary rehabilitation has been emphasized by geriatric and inpatient rehabilitation units. Multidisciplinary rehabilitation for hip fractures includes early mobility and self-care training, postoperative management monitored by a geriatrician, high-frequency additional occupational therapy combined with physical therapy, and accelerated discharge. Furthermore, home-based rehabilitation is required to decrease complications, reduce transfers to intensive care units or nursing homes, and improve walking ability. Halbert et al.,4 in their review of randomized trials, reported that multidisciplinary rehabilitation decreased the likelihood that patients with hip fracture would have a poor outcome, including death or admission to a nursing home, by an additional 16% compared...
with traditional rehabilitation. Recently, effective clinical pathways have been introduced in rehabilitation programs for many types of geriatric disease.\(^5\) Many studies have explored the effects of postoperative rehabilitation in hip fracture, and several clinical pathways for postoperative rehabilitation of hip fracture have been proposed.\(^2\) However, clinical pathways for the rehabilitation of acute hip fracture in Korea have not been well established due to the limited integration of care among orthopedic, geriatric, and rehabilitation specialties. Therefore, specialized inpatient rehabilitation services are not properly provided for patients with acute hip fracture in most general hospitals. For this reason, we developed clinical pathways for the rehabilitation of acute hip fracture, and patients with acute hip fracture have been involved since the program’s inception.

The purpose of the study was to evaluate the functional outcomes of newly established clinical pathways after hip fracture surgery in older adults, and to analyze the major determinants of successful functional outcomes using standardized clinical pathways.

**MATERIALS AND METHODS**

1. **Subjects**

This was a retrospective cohort study performed in a tertiary rehabilitation facility. Between November 2009 and December 2015, 883 patients who had received fracture surgery and were transferred to the Department of Rehabilitation Medicine, and who agreed to be enrolled in the study were registered. We recruited 220 patients who met the following inclusion criteria: (1) hospitalization period between November 2009 and December 2015; (2) duration of inpatient rehabilitation >1 week; (3) age \(\geq\) 65 years; (4) acute unilateral hip fracture (femur neck, intertrochanteric, subtrochanteric); and (5) time interval between onset of injury and operation \(\leq\) 2 weeks. Surgical treatments included bipolar hemiarthroplasty, total hip arthroplasty, and open reduction and internal fixation (Fig. 1). Patients who had hip surgery due to osteoarthritis, infected hip, or avascular necrosis, and those who were readmitted due to periprosthetic fracture or prosthetic loosening were excluded. After patients were transferred to the Department of Rehabilitation Medicine, they participated in the Rehabilitation program for Hip fracture Functional Outcome Study (ReHipFOS) (Fig. 1).

2. **Clinical Rehabilitation Pathway**

ReHipFOS, the clinical pathway for rehabilitation evaluated in this study, includes early individualized rehabilitation, education for activities of daily living (ADLs), review of general medical conditions, appropriate management, establishment of further plans, and arrangement for discharge settings.

(Fig. 2). The rehabilitation and education elements of this clinical pathway included transfer and gait training with an assistive device, education about hip precautions in ADLs, functional training for independent ADL, strengthening exercises for the hip girdle muscles, stretching exercises to increase flexibility of the lower extremities including the hip muscles, and fall-prevention education. Specifically, patients were involved in physical therapy twice a day and occupational therapy once a day for at least 20 minutes per session during the hospital day. Patients who were unable to walk before surgery received physical therapy on the tilt table, standing frame, and parallel bars, and patients who were able to walk before surgery employed increased weight-bearing according to the type of surgery and began walking with assistive devices at an early stage. When ambulatory function improved, increased gait endurance was encouraged and lower extremity strengthening exercises were performed using isotonic exercise equipment and elastic bands. Patients were also trained using balance equipment. The study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval number: B-1101-119-110).

3. **Functional Evaluation**

To evaluate ambulatory function, one geriatric rehabilitation specialist consecutively assessed patient ambulatory function during the premorbid stage, after transfer to rehabilitation medicine, at discharge, and at the 6-month follow-up using 3-level grading of ambulatory function modified from the Functional Ambulation Category or Classification, as fol-
flows, Level 3: Ambulation is independent and without supervision or physical assistance from another person. Except for parallel bars, the patient may use assistive devices, orthoses, and prostheses, Level 2: The individual is able to walk at least 10 feet outside the parallel bars with physical assistance from only one person. Except for parallel bars, mechanical assistance from any device or ambulation aid may be used, Level 1: Individual ambulatory function does not advance. Comorbidity status, dual-energy X-ray absorptiometry for bone densitometry, and length of hospital stay were recorded after transfer to rehabilitation medicine and at discharge. In addition, data for the following scales were used to evaluate functional and cognitive status.

1) Modified Barthel Index (MBI)

The MBI measures individual performance for 10 ADLs. The scores for each item in the MBI are based on the amount of physical assistance required to perform the task, and the items are summed to give a score ranging from 0 to 100.

2) Mini-Mental Status Examination (MMSE)

This screening test is a brief, objective measure of cognitive functioning. The MMSE has a maximum score of 30 points, and the questions are grouped into 7 categories, each representing a different cognitive domain or function.

3) Geriatric Depression Scale (GDS)

The GDS is the most commonly used depression self-report scale and consists of 30 items. The items, which have yes or no answers, have been useful in distinguishing depressed from normal subjects based on characteristics of depression in older people.

4) The 10-m walk test

This test is a simple gait assessment that can be used to determine walking speed. For the test, the time taken to walk 10 m is measured using a stopwatch, and walking speed is calculated by dividing the distance covered by the time (m/sec).

5) Berg Balance Scale (BBS)

The BBS was developed as a performance-oriented measure of balance in older adults. The items include simple mobility tasks and more difficult tasks. The BBS consists of 14 items scored on a scale of 0 to 4; the maximum total score is 56.

4. Data Analysis

We compared ambulatory function during the premorbid

![Flow chart of subject recruitment. CP, clinical pathway; PTx, physical therapy; W/U, work up; OPD, outpatient department; F/U, follow-up.](image-url)
Functional Outcomes After Hip Fracture

Table 1. Patient demographics (n=220)

| Variable                        | Value        |
|---------------------------------|--------------|
| Age (yr)                        | 80.6±7.4     |
| Sex                             |              |
| Male                            | 61           |
| Female                          | 159          |
| Laterality                      |              |
| Right                           | 108          |
| Left                            | 112          |
| Body mass index (kg/m²)         | 21.4±3.9     |
| BMD (T-score)                   | -3.1±1.2     |
| Osteoporosis                    | 175          |
| Osteopenia                      | 45           |
| MMSE                            | 19.4±7.2     |
| MBI                             | 33.1±20.1    |
| BBS                             | 18.7±15.3    |
| GDS                             | 11.2±7.6     |
| Time taken to walk 10 m (sec)   | 59.9±52.5    |
| Previous hip surgery            | 27           |
| Level of fracture               |              |
| Intertrochanter                 | 114          |
| Femur neck                      | 102          |
| Subtrochanter                   | 4            |
| Type of operation               |              |
| Bipolar hemiarthroplasty        | 157          |
| Total hip replacement arthroplasty | 7          |
| Open reduction and internal fixation | 56       |
| Time interval (day)             |              |
| Onset of injury to operation    | 5.6±7.3      |
| Operation to start of physical therapy | 7.8±6.1     |
| Admission to discharge          | 27.8±36.0    |
| Discharge setting               |              |
| Home                            | 109          |
| Secondary rehabilitation hospital | 95         |
| Nursing home                    | 16           |

Values are presented as the mean±standard deviation or number. BMD, bone mineral density; MMSE, Mini-Mental State Examination; CDR, Clinical Dementia Rating; MBI, Modified Barthel Index; BBS, Berg Balance Scale; GDS, Geriatric Depression Scale.

Table 2. Recovery of ambulatory function after hip fracture surgery

| Ambulatory Function | Premorbid | Transfer | Discharge | 6-Month follow-up |
|---------------------|-----------|----------|-----------|-------------------|
| Independent ambulation (3) | 180 (81.8) | 4 (1.8)   | 77 (35.0) | 156 (70.9)        |
| Assisted ambulation (2)    | 26 (11.8)  | 155 (70.5)| 111 (50.5)| 35 (15.9)         |
| Nonambulatory (1)          | 14 (6.4)   | 61 (27.7) | 32 (14.5) | 29 (13.2)         |

Values are presented as number (%).

RESULTS

1. Demographic Data

The demographic characteristics of patients are listed in Table 1. Of the 220 patients (mean age, 80.6±7.4 years; 61 male and 159 female patients), 108 had fractures on their right side, and 112 on the left. A total of 114 patients had previous hip surgery. The mean body mass index (BMI) was 21.4±3.9, and mean T-score of bone mineral density was -3.1±1.2. With regard to cognitive functioning, the mean MMSE score was 19.4±7.2. The mean BBS score was 18.7±15.3, and the mean time taken to walk 10 m was 59.9±52.5 seconds. In addition, the mean GDS score was 11.2±7.6. The patients were classified into 3 groups based on each of the following characteristics: level of fracture (114 intertrochanteric; 102 femur neck; 4 subtrochanteric); type of operation (157 bipolar hemiarthroplasty; 7 total hip replacement arthroplasty; 56 open reduction and internal fixation); and discharge setting (109 home; 95 secondary rehabilitation hospital; 16 nursing home).

2. Recovery of Ambulatory Function After Hip Fracture

Ambulatory function at each time point is listed in Table 2. Although 93.6% of patients could walk with or without assistance (independent ambulation: 81.8%; assisted ambulation: 11.8%) in the premorbid state, only 72.3% were able to walk (independent ambulation: 1.8%; assisted ambulation: 70.5%) when they were transferred to rehabilitation medicine. A total of 85.5% of patients could walk with or without assistance (independent ambulation: 1.8%; assisted ambulation: 70.5%) at discharge, and 86.8% were able to walk (independent ambulation: 70.9%; assisted ambulation: 15.9%) at 6 months after surgery. Premorbid ambulatory function,
the type of fracture, and the type of surgery did not have significant effects on the prognosis for ambulatory function after hip fracture.

3. Comparison Between Premorbid and 6-Month Postoperative Ambulatory Function

Of the 220 patients, 166 were in the good recovery group, and 54 were in the poor recovery group (Fig. 3). Of 180 patients whose ambulatory function was level 3 before surgery, 136 (75.6%) remained at level 3 after surgery. Of 26 patients whose ambulatory function was at level 2 before surgery, 21 (80.8%) improved from level 2 to 3 or remained at level 2. In addition, of the 14 patients whose ambulatory function was level 1 before surgery, 9 (64.3%) improved to level 2 or 3, i.e., good recovery.

Of the 180 patients whose ambulatory function was level 3 before surgery, ambulatory function deteriorated to level 1 or 2 in 44 (24.4%) after surgery. Of the 26 patients whose ambulatory function was level 2 before surgery, ambulatory function in 5 (19.2%), decreased to level 1, five patients whose ambulatory function was at level 1 before and after surgery were in the poor recovery group.

The demographic characteristics of each group are listed in Table 3. There was no significant difference in the proportion of those with poor recovery according to sex, laterality, BMI, etc. The good recovery group showed higher MMSE and BBS, but lower CDR than the poor recovery group. There were no significant differences between the 2 groups except in MMSE, BBS, and CDR.

4. Factors Influencing Ambulatory Function at the 6-Month Follow-up

The results of stepwise multiple regression analysis for am-

Table 3. Differences between the good recovery and poor recovery groups

| Variable                        | Good recovery (n=166) | Poor recovery (n=54) |
|---------------------------------|-----------------------|----------------------|
| Age (yr)                        | 80.2±7.4              | 81.9±7.2             |
| Sex                             |                       |                      |
| Male                            | 46 (27.7)             | 15 (27.8)            |
| Female                          | 120 (72.3)            | 39 (72.2)            |
| Laterality                      |                       |                      |
| Right                           | 83 (50.0)             | 25 (46.3)            |
| Left                            | 83 (50.0)             | 29 (53.7)            |
| Body mass index (kg/m²)         | 21.2±3.8              | 21.7±4.4             |
| T-score of bone mineral density | -3.1±1.2              | -3.0±1.2             |
| MMSE                            | 20.6±6.7**            | 15.5±7.1             |
| MBI                             | 35.2±19.7             | 26.5±19.6            |
| BBS                             | 21.4±15.3**           | 10.9±12.1            |
| GDS                             | 10.6±7.3              | 13.4±8.2             |
| 10-m walk test (sec)            | 58.5±44.7             | 64.6±72.7            |
| Previous hip surgery            | 21                    | 6                    |
| Level of fracture               |                       |                      |
| Intertrochanteric               | 89 (53.7)             | 25 (46.3)            |
| Femur neck                      | 73 (43.9)             | 29 (53.7)            |
| Subtrochanteric                 | 4 (2.4)               | 0                    |
| Type of operation               |                       |                      |
| Bipolar hemiarthroplasty        | 117 (70.5)            | 40 (74.1)            |
| Total hip replacement arthroplasty | 6 (3.6)           | 1 (1.9)              |
| Open reduction and internal fixation | 43 (25.9)       | 13 (24.0)            |
| Time interval (day)             |                       |                      |
| Onset of injury to operation    | 5.4±8.0               | 6.3±4.3              |
| Operation to start of physical therapy | 7.6±5.6      | 8.3±7.3              |
| Admission to discharge          | 32.4±46.9             | 36.5±22.0            |
| Discharge setting               |                       |                      |
| Home                            | 87 (52.4)             | 22 (40.7)            |
| Secondary rehabilitation hospital | 67 (40.4)       | 28 (51.9)            |
| Nursing home                    | 12 (7.2)              | 4 (7.4)              |

Values are presented as mean±standard deviation or numbe (%). MMSE, Mini-Mental State Examination; MBI, Modified Barthel Index; BBS, Berg Balance Scale; GDS, Geriatric Depression Scale. **p<0.01.
bulatory function after hip fracture are summarized in Table 4. We used the backward elimination method with 7 independent variables (age, sex, bone mineral density, MMSE, BBS, premorbid ambulatory function, and length of hospital stay). The highest proportion of explained variance in ambulatory function after hip fracture was seen for the model that included MMSE and BBS ($R^2=0.180$). The model factors most predictive of recovery were MMSE ($\beta=0.344$, $p<0.001$) and BBS ($\beta=0.190$, $p=0.023$).

**DISCUSSION**

Only 72.3% of hip fracture patients could walk with or without assistance (independent ambulation: 1.8%; assisted ambulation: 70.5%) when they were transferred to rehabilitation medicine, but 86.8% could walk (independent ambulation: 70.9%; assisted ambulation: 15.9%) at 6 months after surgery.

In our study, 75.5% of patients involved in the ReHipFOS program achieved good ambulatory function. In other studies, hip fracture patients had difficulty achieving functional ambulatory recovery. Koot et al.\(^{16}\) reported that 64 of 177 patients (36%) had regained the level of mobility that they had before the injury at 4 months of follow-up. Of patients hospitalized for hip fractures, only 60% had recovered their pre-fracture walking ability 6 months later.\(^{17}\) Kitamura et al.\(^{18}\) reported that at 1-year follow-up in Japan, 67% of hip fracture patients who underwent ambulation training after surgery, but who were not involved in a postoperative rehabilitation protocol specific to hip fracture, recovered to presurgery ambulatory status. In the present study, the prognosis for functional recovery in hip fracture patients was better than that in other studies.

According to several guidelines, patients should receive a coordinated multidisciplinary rehabilitation program after hip fracture surgery; furthermore, it is important that rehabilitation start from the time of admission.\(^{19,20}\) However, current clinical pathways operating in countries other than Korea are mostly developed and maintained by orthopedic surgeons and physicians, and the focus is on reducing mortality, the length of hospital stay, and medical complications.\(^{21-24}\) Furthermore, there are no proper and systematic rehabilitation protocols for hip fracture patients in Korea. In our clinical pathway, rehabilitation is systematically organized and managed by a geriatric rehabilitation specialist, with a focus on recovery of ambulatory function. In this study, we established clinical pathways by considering various aspects of hip fracture, and these resulted in significantly improved ambulatory function at 6 months after surgery.

In previous studies, patients who were older, had cognitive impairment, or had poor ambulatory function prior to hip fracture exhibited poor functional recovery. In this study, functional recovery in hip fracture patients was associated with cognitive function and balance control upon transfer to rehabilitation.\(^{16,25-27}\) The mean age of our poor recovery group was not statistically different from that of the good recovery group, although it tended to be somewhat higher. Of the 220 patients, 26 (11.8%) had level 2, and 14 (6.4%) had level 1 preoperative ambulatory function at the initial classification. This imbalance in the number of patients in these groups may explain why significant results were not obtained for improvement relative to the premorbid state.

There are several limitations to this study. First, we initially evaluated 883 patients, but only 220 (57.4%) visited the outpatient clinic of the Department of Rehabilitation for follow-up 6 months after surgery. The reason for the relatively low follow-up rate may be that patients with either improved or poor ambulatory function did not wish to return to the outpatient clinic. Therefore, it is possible that prognosis was over- or underestimated for these patients. Second, ambulatory function was evaluated using a 3-level grading system modified from the Functional Ambulation Category. The reason for using the 3-level scale was that the prefracture status had to be judged by referring to the premorbid function record during history-taking from the patient or caregivers. The grading criteria were very clear, and all patients enrolled in this study were assessed by one geriatric rehabilitation specialist. Third, the difference between the good and poor recovery groups was arbitrary, and the cutoff value was not clear. Finally, we did not assess ambulatory function of patients who were not involved in the ReHipFOS program after hip fracture and surgery. In this study, all patients enrolled were transferred to the Department of Rehabilitation Medicine, and all were involved in a proper rehabilitation program. Therefore, we could not directly compare the effects of ReHipFOS with the results of no treatment. For this reason, prospective comparative studies are required.

In conclusion, this study showed that a well-designed clinical pathway for hip fracture could restore ambulatory independence in most older patients. Furthermore, based on our results, the major determinants of poor ambulatory function after hip fracture include cognitive impairment and poor balance.
Conflicts of Interest Disclosures: The researchers claim no conflicts of interest.

Acknowledgments

This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HC15C1234).

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