INTRODUCTION

Hip fracture is one of the many medical conditions that are distinctive in elderly people. Because of the high rate of mortality and morbidity associated with hip fractures, the increasing incidence of hip fractures has become an important health care concern worldwide.\(^1,2\) Several factors are associated with functional prognosis after hip fracture, including the prefracture gait status, marital status, age, and cognitive impairment.\(^3\)–\(^6\) Even with appropriate postoperative care, not all patients reach their preinjury level of participation in activities of daily living (ADL).\(^7\) In fact, it has been reported that only about 50% of patients reach their preinjury independent walking ability at 1 year postfracture, with restriction in performing instrumental ADL being particularly notable among elderly individuals.\(^8\)–\(^10\) In their prospective evaluation of independent walking ability after hip fracture treatment among 753 patients in Japan, Tsuboi et al. reported a decrease in the proportion of individuals who were able to walk independently outdoors, with or without an assistive
Fracture-related pain is associated with lower functional status at discharge from the hospital and poor overall functional prognosis. Acute postoperative pain is associated with a delay in the initiation of walking during postoperative rehabilitation, a prolonged hospital stay, and greater disability at 6 months postfracture. Moreover, persistent pain on postoperative day 4 was found to be predictive of the development of postoperative chronic pain. However, the effects of acute postoperative pain on the recovery of walking ability after hip fracture remain to be fully clarified, particularly among patients who were independent in their ADL before hip fracture. The purpose of our study, therefore, was to investigate the association between acute postoperative pain and the recovery of functional gait among patients who had independent walking ability before hip fracture. Outcomes of our study will inform practice regarding the importance of effective postoperative management of acute pain in patients with hip fractures.

**METHODS**

The present study was conducted at the Nara Yukokai Hospital. This prospective study was performed according to the principles of the Declaration of Helsinki. The Institutional Review Board approved the study, and informed consent was obtained from all patients. Patients forming our study group were community dwelling elderly individuals who underwent operative treatment and rehabilitation for a traumatic hip fracture. For postoperative pain relief, all patients received oral loxoprofen sodium hydrate 60 mg every 8 h on postoperative day 1 through 3.

In the present study, patients fulfilling the following criteria were included: (1) lived independently prior to hip fracture, (2) ability to communicate, (3) stable internal fixation with no weight-bearing restrictions, and (4) gait ability became independent during hospitalization postsurgery. Patients with a cognitive and/or mental disorder, neurological disease, fractures at other sites of the lower limb, or severe cognitive impairment were excluded. Our rehabilitation protocol involved transfer training from a sitting position to a wheelchair on the second day postsurgery, standing and walking training on the fifth day postsurgery, and walking training after 2 weeks postsurgery. Overall, our goal was for patients to be able to walk independently 4 weeks postoperatively. The following demographic and clinical variables were extracted from medical records for analysis: age, sex, body mass index (BMI), type of fracture, operative treatment received, and relevant medical history. Patients’ functional levels prior to injury were obtained through interviews, either with the patient or with his or her family. Interviews were conducted by a nurse or physical therapist and supplemented, as needed, with information from the patient’s medical record.

**Acute Postoperative Pain Measures**

The intensity of postoperative pain was assessed using the Verbal Rating Scale (VRS). The VRS is an ordinal scale of 5 points, with pain intensity quantified as follows: 1, no pain; 2, slight pain; 3, moderate pain; 4, considerable pain; and 5, extreme pain. Previous research has shown the VRS to have a lower rate of noncompliance than the visual analog scale for the assessment of postoperative pain, including after hip fracture surgery. Using the recommended methods of Briggs and Closs, we presented the VRS on a sheet of A4 paper with the pain adjectives displayed in large print. Patients were asked to point to the printed adjective that most closely described their pain during ADL. Pain intensity was measured on six consecutive days postsurgery and summed as follows for analysis: (1) VRS for days 1 and 2, (2) VRS for days 3 and 4, and (3) VRS for days 5 and 6.

**Functional Ability Measures**

Independent walking was defined as a locomotion score ≥6 on the Functional Independence Measure (FIM). The time to recovery of independent walking was defined as the number of days required to achieve an FIM locomotion score ≥6 from the time of surgery. The locomotion FIM score was assessed by physical therapists.

**Muscle Strength Measures**

The isometric strength of knee extensor muscles was measured by hand-held dynamometry (µTas F-1, ANIMA, Co., Ltd., Tokyo, Japan) using the methods described by Bohannon. Knee extensor strength was measured on postoperative day 7. This time frame for strength assessment was based on the findings of Järvinen et al. who reported recovery of strength at 3–7 days after injury to a skeletal muscle, with infiltration of muscle satellite cells into the wound occurring by postinjury day 7. Two measurements were obtained with a 30 s rest interval between measurements. The mean of the two measurements in the bilateral lower limbs, normalized using body weight, was used for analysis.
Mental and Cognitive Measures

The Montgomery–Åsberg Depression Rating Scale (MADRS) was used to evaluate patients’ mental function. The MADRS was developed as a subscale of the Comprehensive Psychopathological Rating Scale and is widely used in research and practice. Cognitive function was assessed using the Mini Mental State Examination (MMSE). The MMSE, developed by Folstein et al. for the assessment of cognitive impairment, is the standard tool for cognitive testing worldwide. The MADRS and MMSE were assessed on postoperative day 7.

Statistical Analyses

The median time to recovery of independent walking among our study group was used as a cutoff to classify patients into an early independent walking group (EIW) and an independent walking group (IW). Between-group differences in age, sex, side of fracture, number of medical comorbidities, BMI, pain intensity (days 1–2, days 3–4, and days 5–6), muscle strength, MMSE, MADRS, and time to recovery of independent gait, were evaluated. Normality of distribution of the data was evaluated using the Shapiro–Wilk W-test and visual inspection of histograms of the residuals. For normally distributed variables, between-group differences were evaluated using the chi-square test for categorical variables and the unpaired Student’s t-test for continuous variables. For variables with a non-normal distribution, between-group differences were evaluated using the Wilcoxon test for continuous variables. Variables with a significant between-group difference (P <0.05) were included in a stepwise logistic regression analysis to predict time to recovery of independent walking. Variables with multicollinearity were eliminated, with only variables having a correlation coefficient ≥0.8 to the time to recovery of independent walking being entered into the regression analysis. Independent predictive factors were identified in a sequential fashion based on the entry criterion for univariate analysis of P <0.1. The adjusted odds ratio (OR) and corresponding 95% confidence interval (CI) for factors retained as independent predictors were calculated, adjusting for all variables entered in the model. All analyses were performed using SPSS ver. 20.0 (IBM Japan, Tokyo, Japan).

RESULTS

Among the 46 patients who met our inclusion criteria, the data for five patients were excluded because of restricted weight-bearing on the affected side. Relevant demographic and health characteristics of the 41 patients included in the analysis are summarized in Table 1. Notably, our study group was predominantly female (71%), with the majority of fractures treated using bipolar hip arthroplasty (68%). The remaining fractures were treated with either open or closed reduction and screw or pin fixation (proximal femoral nail anterotation, 6; compression hip screw, 4; others, 2).

The median time to recovery of independent gait was 24 days (range 7–50 days), with 20 patients classified to the EIW and 21 to the IW group. Results of univariate analyses are presented in Table 2, with the following between-group differences identified. Age, pain intensity (days 5 and 6), and BMI were lower among patients in the EIW than the IW group, with knee extensor strength being greater in the EIW group than the IW group.

No significant multicollinearity was identified among the measured variables and, therefore, all variables with a between-group P-value >0.1 were entered into the multivariate stepwise logistic regression analysis. The results are presented in Table 3. The following two variables were independent predictors of time to recovery of independent gait: pain intensity (OR=1.91, 95% CI=1.01–3.63) and knee extensor strength (OR=0.01, 95% CI=1.66–8.71).

DISCUSSION

The degree of recovery of gait function in patients surgically treated for hip fracture could be predicted by the pain intensity and knee extensor strength.
intensity measured during ADL and the knee extensor strength assessed in the acute phase.

Previous studies have demonstrated that the lower limb muscular strength on the operative side and the grip strength are important factors of functional prognosis. However, the results of the present study show that the ratio of bilateral knee extension muscle strength to body weight is a factor associated with independent walking after surgery for hip fracture. The gait pattern of a patient with femoral neck fracture is asymmetric, with more load placed on the nonoperative lower limb. The nonoperative lower limb muscular strength was important in patients with abnormal gait observed in the acute phase. For this reason, it was inferred that weakening of the muscle strength of both knee joints, i.e., both the operative and nonoperative sides, influenced the time to independent walking.

Of these predictive factors of functional prognosis, the specific effect of acute postoperative pain on recovery has been evaluated only in two previous studies, to our knowledge. Feldt and Oh identified the severity of acute postoperative pain among patients with hip fracture as being predictive of functional outcomes at 2 months postsurgery. Morrison et al. reported a significant association between postoperative pain at rest after hip fracture treatment among older individuals (411 patients, median age of 82 years) and prolonged length of hospital stay, delayed ambulation, and functional impairment at 6 months postsurgery. Our results extend these findings, indicating that the intensity of acute postoperative pain was predictive of the time to recovery of independent gait during the rehabilitation period after surgical hip fracture treatment. Our results suggest that pain prolonged until postoperative days 5 and 6 can predict a delay in the recovery of gait function. These findings imply that the period over which clinicians should evaluate pain is prolonged. The short follow-up duration of our study limited comparisons of the effects of acute pain on functional recovery identified in the current study with those described in previous studies.

Table 2. Between-group differences in clinical variables

|                      | EIW (n=20) | IW (n=21) | P-value |
|----------------------|------------|-----------|---------|
| Age                  | 76.9 ± 8.3 | 82.9 ± 8.5| 0.03    |
| Sex (female/male)    | 15/5       | 13/8      | 0.37    |
| Side (right/left)    | 12/8       | 10/11     | 0.43    |
| Number of medical comorbidities | 1.8±0.8 | 2.0±1.1 | 0.18    |
| BMI                  | 20.2±3.1   | 22.2±3.4  | 0.06    |
| Pain intensity       | 6.6±1.9    | 6.7±2.2   | 0.88    |
| Days 1–2             | 5.4±1.9    | 6.1±1.9   | 0.27    |
| Days 3–4             | 4.7±1.9    | 5.9±1.9   | 0.04    |
| Days 5–6             |            |           |         |
| Knee extensor strength (%Body weight) | 25.6 ± 0.9 | 16.0 ± 0.1 | 0.01 |
| MMSE score           | 26.3 ± 4.6 | 24.2 ± 4.8| 0.19    |
| MADRS score          | 5.4 ± 7.3  | 7.2 ± 5.1 | 0.16    |
| Time to recovery of independent gait (days) | 15.9 ± 4.8 | 34.2 ± 9.1 | 0.01 |

EIW, early independent walking; IW, independent walking.

Table 3. Results of the stepwise logistic analysis of variables predictive of time to recovery of independent gait

|                      | Partial regression coefficient | P-value | Odds ratio | 95% confidence interval |
|----------------------|--------------------------------|---------|------------|-------------------------|
|                      |                                |         |            | Lower limit | Upper limit |
| Pain intensity       | 0.65                           | 0.04    | 1.91       | 1.01        | 3.63        |
| Knee extensor strength | -6.7                          | 0.03    | 0.01       | 1.66        | 8.71        |

The model correctly predicted 85.4% of cases.
sitation has yet to be clearly evaluated. However, we do provide evidence that pain intensity during ADL reported on postoperative days 5–6 was predictive of the time to recovery of independent gait. Our findings challenge, to some extent, Brennan’s finding that moderate pain is expected up to 2–3 days after surgical hip treatment, with pain being largely ameliorated by postoperative day 7. In our study group, we identified significant prolongation of pain recovery among patients in the IW group, compared to that in patients in the EIW group. Interestingly, Herrick et al. reported an association between persistent postoperative pain after hip fracture treatment and muscle weakness. Future studies are needed to investigate plausible correlations between the prolongation of acute pain, central sensitization, and muscle weakness after surgical treatment of hip fractures. Regardless of the mechanisms underlying the prolongation of acute pain, we believe that our results provide support for the effective clinical management of acute postoperative pain among patients having undergone surgical hip fracture treatment.

Preemptive analgesic treatment and counseling are effective for the management of acute postoperative pain. Arinzon et al. reported that adequate acute pain control and family support were associated with better functional outcomes among hip fracture patients. A study on chronic pain has described the sense of helplessness and isolation reported by patients in whom pain is not well controlled. Therefore, adequate control of acute postoperative pain could also be important to prevent the development of chronic pain. Healthcare professionals are encouraged to promote recovery processes involving minimal pain during rehabilitation and care.

The limitations of our study should be acknowledged. Because we applied strict selection criteria, the number of patients meeting those criteria during the study period was small. Moreover, our findings may not hold true in patients with severe cognitive impairment and mental disorders, communication impairments, and multiple trauma. We did not collect data regarding hip pain prior to the fracture. Although the types of fracture and surgical techniques are factors affecting the postoperative gait ability, our study did not analyze these relationships. Therefore, it was not possible to determine the extent to which persistent pain was related to preexisting conditions. Similarly, because of the absence of prefracture pain information, the influence of referred pain from other tissues on the perceived intensity of acute postoperative pain could not be evaluated. Despite these limitations, our study provided new information on the possible importance of acute pain management in patients after surgical treatment of hip fracture. Further research is required to determine the effects of different durations of pain recovery on function. In addition, further knowledge is required regarding the specific etiologies of hip pain in this clinical population. Moreover, effective strategies for acute management and the barriers to optimal pain management should be identified.

To our knowledge, this is the first study to have determined that the intensity of postoperative acute pain in hip fracture patients who had independent walking ability prior to surgery predicts the time to recovery of independent walking postsurgery. In particular, the present study found that prolonged postoperative acute pain is associated with the delayed recovery of walking ability during hospitalization in hip-fracture patients with high cognitive function. Delayed recovery of pain may contribute to the development of chronic pain caused by central sensitization. Based on our findings, we propose that a comprehensive strategy for the management of acute postoperative pain is needed for patients with hip fractures.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

REFERENCES

1. Hagino H: Fragility fracture prevention: review from a Japanese perspective. Yonago Acta Med 2012;55:21–28. PMID:24031136
2. Neuman MD, Rosenbaum PR, Ludwig JM, Zubiagarreta JR, Silber JH: Anesthesia technique, mortality, and length of stay after hip fracture surgery. JAMA 2014;311:2508–2517. PMID:25058085, DOI:10.1001/jama.2014.6499
3. Lin PC, Chang SY: Functional recovery among elderly people one year after hip fracture surgery. J Nurs Res 2004;12:72–76. PMID:15136965, DOI:10.1097/01.JNR.0000387490.71062.4a
4. Koval KJ, Skovron ML, Aharonoff GB, Zuckerman JD: Predictors of functional recovery after hip fracture in the elderly. Clin Orthop Relat Res 1998;22–28. PMID:9553529

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5. Matsueda M, Ishii Y: The relationship between cognitive impairment score and ambulatory level after hip fracture in the elderly. Am J Orthop 2000;29:691–693. PMID:11008865

6. Martín-Martin LM, Arroyo-Morales M, Sánchez-Cruz JJ, Valenza-Demet G, Valenza MC, Jiménez-Molén JJ: Factors influencing performance-oriented mobility after hip fracture. J Aging Health 2015;27:827–842. PMID:25649676, DOI:10.1177/0898264315569451

7. Gialanella B, Ferlucci C, Monguzzi V, Prometti P: Determinants of functional outcome in hip fracture patients: the role of specific neuropsychiatric symptoms. Disabil Rehabil 2015;37:517–522. PMID:24963835, DOI:10.3109/09638288.2014.932446

8. Kyo T, Takaoka K, Ono K: Femoral neck fracture. Factors related to ambulation and prognosis. Clin Orthop Relat Res 1993;215–222. PMID:8519112

9. Kitamura S, Hasegawa Y, Suzuki S, Sasaki R, Iwata H, Wingstrand H, Thorngren KG: Functional outcome after hip fracture in Japan. Clin Orthop Relat Res 1998;29–36. PMID:9553530

10. Young Y, Brant L, German P, Kenzora J, Magaziner J: A longitudinal examination of functional recovery among older people with subcapital hip fractures. J Am Geriatr Soc 1997;45:288–294. PMID:9063273, DOI:10.1111/j.1532-5415.1997.tb00942.x

11. Tsuboi M, Hasegawa Y, Suzuki S, Wingstrand H, Thorngren KG: Mortality and mobility after hip fracture in Japan. J Bone Joint Surg Br 2007;89-B:461–466. PMID:17463112, DOI:10.1302/0301-620X.89B4.18552

12. Kristensen MT: Hip fracture-related pain strongly influences functional performance of patients with an intertrochanteric fracture upon discharge from the hospital. PM R 2013;5:135–141. PMID:23182336, DOI:10.1016/j.pmrj.2012.10.006

13. Morrison SR, Magaziner J, McLaughlin MA, Orosz G, Silberzweig SB, Koval KJ, Siu AL: The impact of postoperative pain on outcomes following hip fracture. Pain 2003;103:303–311. PMID:12791436, DOI:10.1016/S0304-3959(02)00458-X

14. Dubljajin-Raspopović E, Marković-Denić L, Zivkovic K, Nedeljković U, Tomanović S, Kadija M, Tulić G, Bumbasirević M: The impact of postoperative pain on early ambulation after hip fracture. Acta Chir Jugosl 2013;60:61–64. PMID:24669564, DOI:10.2298/ACIJ1301061D

15. Heruti RJ, Lusky A, Barell V, Ohry A, Adunsky A: Cognitive status at admission: Does it affect the rehabilitation outcome of elderly patients with hip fracture? Arch Phys Med Rehabil 1999;80:432–436. PMID:10206606, DOI:10.1016/S0003-9993(99)02821-2

16. Dasch B, Endres HG, Maier C, Lungenhausen M, Smektala R, Trampisch HJ, Pientka L: Fracture-related hip pain in elderly patients with proximal femoral fracture after discharge from stationary treatment. Eur J Pain 2008;12:149–156. PMID:17475523, DOI:10.1016/j.ejpain.2007.03.012

17. Briggs M, Closs JS: A descriptive study of the use of visual analogue scales and verbal rating scales for the assessment of postoperative pain in orthopedic patients. J Pain Symptom Manage 1999;18:438–446. PMID:10641470, DOI:10.1016/S0885-3924(99)00092-5

18. Leino KA, Kuusniemi KS, Lertola KK, Olkkola KT: Comparison of four pain scales in patients with hip fracture or other lower limb trauma. Acta Anaesthesiol Scand 2011;55:495–502. PMID:21288225, DOI:10.1111/j.1399-6576.2010.02373.x

19. Keith RA, Granger CV, Hamilton BB, Sherwin FS: The functional independence measure: a new tool for rehabilitation. Adv Clin Rehabil 1987;1:6–18. PMID:3503663

20. Bohannon RW: Test-retest reliability of hand-held dynamometry during a single session of strength assessment. Phys Ther 1986;66:206–209. PMID:3945674, DOI:10.1093/ptj/66.2.206

21. Järvinen TA, Järvinen TL, Kääriäinen M, Äärimaa V, Vahtinen S, Kalimo H, Järvinen M: Muscle injuries: optimising recovery. Best Pract Res Clin Rheumatol 2007;21:317–331. PMID:17512485, DOI:10.1016/j.berh.2006.12.004

22. Montgomery SA, Asberg M: A new depression scale designed to be sensitive to change. Br J Psychiatry 1979;134:382–389. PMID:444788, DOI:10.1192/bjp.134.4.382

23. Folstein MF, Folstein SE, McHugh PR: “Mini-mental state”. J Psychiatr Res 1975;12:189–198. PMID:1202204, DOI:10.1016/0022-3956(75)90026-6

24. Lamb SE, Morse RE, Evans JG: Mobility after proximal femoral fracture: the relevance of leg extensor power, postural sway and other factors. Age Ageing 1995;24:308–314. PMID:7484488, DOI:10.1093/ageing/24.4.308

25. Lemke KA: Understanding the pathophysiology of perioperative pain. Can Vet J 2004;45:405–413. PMID:15206589
26. Woolf CJ: Central sensitization: Implications for the diagnosis and treatment of pain. Pain 2011;152(Supplement):S2–S15. PMID:20961685, DOI:10.1016/j.pain.2010.09.030

27. Brennan TJ: Pathophysiology of postoperative pain. Pain 2011;152(Supplement):S33–S40. PMID:21232860, DOI:10.1016/j.pain.2010.11.005

28. Herrick C, Steger-May K, Sinacore DR, Brown M, Schechtman KB, Binder EF: Persistent pain in frail older adults after hip fracture repair. J Am Geriatr Soc 2004;52:2062–2068. PMID:15571543, DOI:10.1111/j.1532-5415.2004.52566.x

29. Woolf CJ, Chong MS: Preemptive analgesia – treating postoperative pain by preventing the establishment of central sensitization. Anesth Analg 1993;77:362–379. PMID:8346839, DOI:10.1213/00000539-199377020-00026

30. Ong CK, Lirk P, Seymour RA, Jenkins BJ: The efficacy of preemptive analgesia for acute postoperative pain management: a meta-analysis. Anesth Analg 2005;100:757–773. PMID:15728066, DOI:10.1213/01.ANE.0000144428.98767.0E

31. Nir RR, Nahman-Averbuch H, Moont R, Sprecher E, Yarnitsky D: Preoperative preemptive drug administration for acute postoperative pain: A systematic review and meta-analysis. Eur J Pain 2016;20:1025–1043. PMID:26991963, DOI:10.1002/ejp.842

32. Gambatesa M, D’Ambrosio A, D’Antini D, Mirabella L, De Capraris A, Iuso S, Bellomo A, Macchiarola A, Dambrosio M, Cinnella G: Counseling, quality of life, and acute postoperative pain in elderly patients with hip fracture. J Multidiscip Healthc 2013;6:335–346. PMID:24082786

33. Arinzon Z, Gepstein R, Shabat S, Berner Y: Pain perception during the rehabilitation phase following traumatic hip fracture in the elderly is an important prognostic factor and treatment tool. Disabil Rehabil 2007;29:651–658. PMID:17453986, DOI:10.1080/09638280600926470

34. Phillips J, Ogden J, Copland C: Using drawings of pain-related images to understand the experience of chronic pain: A qualitative study. Br J Occup Ther 2015;78:404–411. DOI:10.1177/0308022614562791