

Effect of continuous nursing based on “Internet + nursing service” on prognosis of elderly patients with hip fracture after PFNA surgery

Efecto de la enfermería continua basada en «Internet + servicio de enfermería» en el pronóstico de pacientes ancianos

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Abstract

Objective: The aim of this study was to evaluate if “Internet + nursing service”-based continuous nursing improves hip function, self-management efficacy, and quality of life in elderly hip fracture patients post-PFNA surgery. **Methods:** This prospective, non-randomized controlled study with a non-concurrent control group used consecutive sampling to enroll 88 elderly patients (April 2024–September 2025): 44 patients in the control group received routine discharge guidance and telephone follow-up, and 44 patients in the intervention group received routine care plus the “Internet + nursing” intervention. General self-efficacy scale (GSES), rehabilitation compliance, Harris hip score, ADL, SF-36, nursing satisfaction, complications, and first ambulation time were compared. **Results:** No baseline differences ($p > 0.05$). At 1 month, study group had higher GSES, better compliance, and shorter ambulation time ($p < 0.05$). At 3/6 months, higher Harris, ADL, and SF-36 scores ($p < 0.05$). Complication rate: 8.18% (study) versus 27.27% (control); nursing satisfaction: 95.45% versus 79.55% ($p < 0.05$). **Conclusions:** “Internet + nursing service” in post-proximal femoral nail anti-rotation care accelerates mobilization, functional recovery, reduces complications, and improves adherence/satisfaction, with strong clinical applicability.

Keywords: Internet+nursing service. Continuous nursing. Elderly. Hip fracture. Proximal femoral nail anti-rotation internal fixation. Post-operative prognosis.

Resumen

Objetivo: Evaluar si la enfermería continua basada en «Internet + servicio de enfermería» mejora la función de cadera, la autoeficacia en el autocuidado y la calidad de vida en pacientes ancianos con fractura de cadera tras cirugía PFNA. **Métodos:** Estudio prospectivo, controlado y no aleatorizado, con muestreo consecutivo para incluir 88 pacientes ancianos (abril de 2024 a septiembre de 2025), de los cuales 44 del grupo control recibieron orientación rutinaria al alta y seguimiento telefónico y 44 del grupo de intervención recibieron atención rutinaria más la intervención «Internet + enfermería». Se compararon GSES, adherencia rehabilitatoria, puntuación Harris, IADL, SF-36, satisfacción, complicaciones y tiempo hasta la primera deambulacion. **Resultados:** No hubo diferencias basales ($p > 0.05$). A 1 mes, el grupo de estudio tuvo mayor GSES, más adherencia y menor tiempo hasta la deambulacion ($p < 0.05$). A 3 y 6 meses hubo mayores puntuaciones Harris, IADL y SF-36 ($p < 0.05$). La tasa de complicaciones fue del 8.18% en el grupo de estudio y el 27.27% en el control, y la satisfacción del 95.45% y el 79.55%, respectivamente ($p < 0.05$). **Conclusiones:** «Internet + servicio de enfermería» en el cuidado

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post-PFNA acelera la movilización y la recuperación funcional, reduce las complicaciones y mejora la adherencia y la satisfacción, con alta aplicabilidad clínica.

Palabras clave: Internet + servicio de enfermería. Enfermería continua. Ancianos. Fractura de cadera. Fijación interna PFNA. Pronóstico postoperatorio.

Introduction

As a major orthopedic condition in the geriatric demographic, hip fracture is notable for its high incidence, substantial disability burden, and significant mortality risk. With the deepening of global aging, the number of patients suffering from this disease is increasing year by year.^{1,2} The proximal femoral nail anti-rotation (PFNA) procedure, with its advantages such as stable fixation, minimal trauma, and short post-operative recovery period, has become the preferred surgical method for treating elderly hip fractures in clinical practice.^{3,4} However, elderly patients generally have problems such as decreased body functions and numerous underlying complications. Moreover, after undergoing PFNA surgery, they need to undergo long-term rehabilitation training at home. If they lack professional and continuous nursing supervision after discharge, it is very likely that their rehabilitation compliance will be low, and the recovery of hip joint function will be slow. Even worse, patients under such circumstances face a heightened susceptibility to adverse events, particularly falls, loosening of internal fixation, and pressure injuries, which will directly affect the post-operative rehabilitation effect and quality of life of the patients.⁵ “Internet + Nursing Services” is a new type of nursing model based on internet information technology,⁶ centered on “online appointment and offline delivery”.⁷ It can break through the barriers of time and space, extend professional in-hospital nursing services to the home environment, and provide personalized and continuous care intervention for post-operative patients at home.^{8,9} This model has now been put into practical use in areas such as chronic disease management and stoma wound care, and has achieved satisfactory results.^{10,11} However, research specifically targeting elderly hip fracture patients after PFNA surgery remains scarce, particularly regarding tailored nursing interventions delivered through digital platforms. Accordingly, the objective of this study was to evaluate the effects of integrating “Internet + Nursing Services” into post-operative continuous care on self-efficacy, rehabilitation compliance, hip function, activities of daily living (ADL),

quality of life, complications, and nursing satisfaction in elderly patients after PFNA surgery, thereby providing empirical evidence for optimizing post-operative continuous care after PFNA.

Methods

General information

This prospective, non-randomized controlled study with a non-concurrent control group included 88 elderly patients with hip fractures who underwent PFNA surgery in the Department of Traumatic Orthopedics between April 2024 and September 2025. Consecutive sampling was used to enroll all eligible patients during the predefined recruitment periods; thus, the control and intervention groups were recruited sequentially rather than concurrently. Both groups were treated at the same institution under the same eligibility criteria and outcome-assessment schedule. Baseline characteristics were compared between groups to assess comparability, while the possibility of residual temporal confounding was acknowledged in the limitations. The sample size was calculated a priori for the primary continuous outcome (general self-efficacy scale [GSES] score at 1 month) using a two-sided independent-samples *t* test. With a prespecified standardized effect size of 0.65, an alpha level of 0.05, 80% statistical power, and a 1:1 allocation ratio, at least 39 participants were required per group. Allowing for an approximately 10% loss to follow-up, the target sample size was 44 participants per group (88 participants in total). The control group comprised 44 patients admitted from April to December 2024 who received routine continuous nursing care, and the intervention group comprised 44 patients admitted from January to September 2025 who received continuous nursing based on “Internet + Nursing Services.” All 88 enrolled participants completed the 6-month follow-up, and no participant was lost to follow-up. To minimize attrition, the research team verified patient and caregiver contact details before discharge, used scheduled telephone and online reminders, maintained contact through the rehabilitation communication group, provided home visits when

scheduled, and offered flexible follow-up arrangements. This study was approved by the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University, with the ethical approval number XYFY2025-KL118-01.

Inclusion criteria

(1) Age ≥ 60 years, the diagnosis of intertrochanteric femoral fracture was confirmed through imaging examinations; (2) PFNA surgery performed by the same medical team, with successful operation and stable post-operative vital signs; (3) clear consciousness with normal communication and comprehension abilities, voluntary signing of informed consent form, and cooperation with full follow-up; and (4) at least one caregiver who is proficient in using a smart phone should live together with the patient.

Exclusion criteria

(1) Patients with concurrent failure of vital organs such as heart, lung, or kidney, patients with severe deterioration of the underlying condition; (2) patients with fluctuating vital signs or persistent deterioration of condition; (3) patients with psychiatric disorders or cognitive impairment who are unable to cooperate with rehabilitation training and follow-up; (4) patients who experience severe post-operative complications requiring secondary surgery; and (5) patients who refuse to participate in the study or are unable to complete the 6-month follow-up.

The control group average age: (81.59 ± 7.32) years old. Fracture types included 44 intertrochanteric femoral fractures. Underlying disease was as follows: hypertension in 24 cases, diabetes in six cases, coronary heart diseases (CHD) in seven cases, and history of cerebral infarction in 13 cases. The study group average age: (80.16 ± 7.41) years old. Fracture types included 44 intertrochanteric femoral fractures. Underlying diseases included hypertension in 20 cases, diabetes in 11 cases, CHD in four cases, and history of cerebral infarction in 15 cases. Baseline characteristics such as gender, age, fracture type, and basic comorbidities were statistically comparable across the two arms ($p > 0.05$); there is comparability between the groups (Fig. 1).

Intervention methods

All patients underwent PFNA surgery performed by the same medical team. After surgery, patients

received routine anti-infective, analgesic, and anticoagulant treatment, together with basic rehabilitation guidance. Patients were discharged 7-10 days after surgery once their clinical condition was stable. The intervention period was 6 months after surgery.

Control group

Participants assigned to the control group received standard continuous orthopedic nursing care. Before discharge, individualized health education was provided according to each patient's rehabilitation needs. Rehabilitation manuals and videos were supplied, a WeChat communication group was established, and rehabilitation information was regularly updated through the hospital's official website. Education covered diet, medication use, rehabilitation exercises, and precautions for home care. After discharge, patient and caregiver questions were answered through the WeChat group. Telephone follow-up was conducted weekly, and patients were reminded to attend hospital assessments at 1, 3, and 6 months after surgery.

Study group

In addition to the standard continuous nursing protocol provided to the control group, the intervention group received a continuous nursing program based on "Internet + Nursing Services." Using the Pengcheng Home Internet Nursing Platform, the program integrated online monitoring with offline home visits. The multidisciplinary intervention team consisted of attending physicians, rehabilitation therapists, dietitians, and specially trained orthopedic nurses. The head nurse was responsible for overall coordination and quality control, while an orthopedic specialist nurse supervised implementation and outcome evaluation. The intervention procedures were as follows:

INPATIENT BASIC INTERVENTION (FACE-TO-FACE, 20-30 MIN)

Specialist nurses, rehabilitation physicians, and attending physicians jointly collect patients' baseline data and assess post-operative hip joint function; explain the "Internet + Nursing Service" model to patients and their families, guide platform operation methods, and inform available home-based service options; complete routine discharge education,

Study Flow & Enrollment Diagram

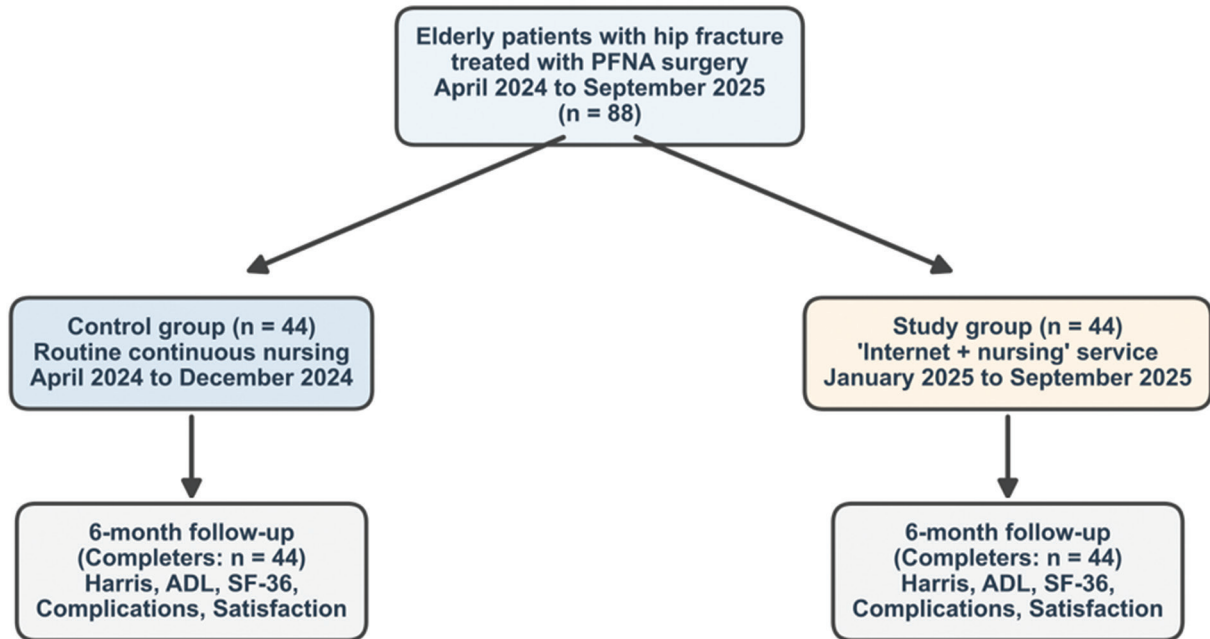


Figure 1. Study flowchart.

establish a dedicated rehabilitation communication group, instruct family members to follow the WeChat service account, distribute personalized rehabilitation manuals, and deliver customized functional exercise videos.

Simultaneously establish comprehensive service emergency response plans, covering disposal procedures for scenarios such as sudden medical condition changes (e.g., falls and breathing difficulties), nursing procedure risks (e.g., Pipeline slippage and infections), platform technical failures, and information security incidents. Develop nursing quality evaluation indicators, including risk assessment implementation rate, adverse event incidence rate, nurse-patient dispute rate, patient satisfaction rate, and nurse occupational injury rate, to enhance service quality through continuous quality improvement.

TWO WEEKS POSTOPERATION (HOME VISIT SERVICE, 0.5-1 H)

A specialized nurse provides home-based specialized care, including urinary catheter replacement, perineum care, health guidance for indwelling urinary

catheters, wound healing assessment, and infection risk screening; on-site demonstration of rehabilitation movements such as slight hip flexion and abduction; targeted guidance on complication prevention and control, including repositioning and back patting techniques, effective coughing to prevent pulmonary infections, explanation of key points for deep vein thrombosis (DVT) prevention and medication protocols, reminders to increase fluid intake and maintain perineum hygiene to prevent urinary tract infections, implementation of skin care and pressure ulcer prevention measures, dissemination of home safety and fall prevention knowledge, and on-site guidance for initial ambulation.

WITHIN 2 WEEKS POSTOPERATION (ONLINE INTERVENTION, ONCE EVERY 3 DAYS)

The intervention team monitored rehabilitation progress through the online platform, supervised completion of ankle-pump exercises and isometric quadriceps contractions, reviewed uploaded records, and answered nursing and rehabilitation questions from patients and caregivers in real time.

ONE MONTH POSTOPERATION (HOME VISIT SERVICE, 0.5-1 H)

The specialized nurse, based on follow-up examination results and patient condition, demonstrates post-bed mobility activities including hip joint movement, walking, and sitting/lying postures, explains and demonstrates the use of walkers and stair-climbing techniques; assesses potential safety hazards in the home environment, and provides targeted improvement recommendations to reduce fall risk.

FROM 2 WEEKS TO 1 MONTH POSTOPERATION (ONLINE INTERVENTION, ONCE EVERY 3 DAYS)

Online follow-up continued to track recovery and completion of the prescribed rehabilitation plan. Training intensity was adjusted according to recovery status, and online questions were answered promptly.

POST-OPERATIVE 2-6 MONTHS (TELEPHONE + ONLINE FOLLOW-UP, ONCE EVERY 2 WEEKS)

The intervention team conducts joint follow-up to evaluate the efficacy of rehabilitation training and self-care abilities; provides psychological counseling to alleviate negative emotions and enhance patients' confidence in recovery; guides patients to gradually reintegrate into social life; and reminds them of scheduled follow-up visits at the hospital.

PLATFORM USE, ACTIVITY VERIFICATION, AND SUPERVISION

Before discharge, a specialist nurse registered the patient and caregiver on the Pengcheng Home Internet Nursing Platform and demonstrated how to log in, view the individualized rehabilitation schedule, receive reminders, mark assigned tasks as completed, upload photographs or short videos, and submit questions. For example, during the first 2 weeks, ankle-pump and isometric quadriceps exercises appeared as scheduled tasks every 3 days; the patient or caregiver confirmed completion and uploaded a short video for review. The wound-care module prompted caregivers to upload a wound photograph and complete a symptom checklist covering redness, drainage, pain, and body temperature. The platform generated time-stamped task-completion records, upload histories,

and nurse-feedback logs. The specialist nurse reviewed these records at least every 3 days during the 1st month and every 2 weeks from months 2 to 6. Missed tasks, abnormal symptoms, or inconsistent records triggered telephone contact within 24 h and, when necessary, escalation to the attending physician or rehabilitation therapist. During home visits at 2 weeks and 1 month, the nurse directly observed exercise technique, assessed the wound and medication use, checked walking-aid use and home safety, and compared these findings with platform logs and caregiver reports. Any discrepancy was corrected on site and documented in the visit record. The head nurse conducted weekly audits of task completion, response times, adverse events, and home-visit documentation, and the multidisciplinary team reviewed complex cases. This combined digital and face-to-face verification provided the high level of supervision required for safe implementation.

Observation indicators**SELF-EFFICACY AND REHABILITATION COMPLIANCE**

One month after the surgery, the GSES was used to assess the self-management efficacy. The scale consists of 10 items, with individual scores ranging from 1 to 4.¹² Rehabilitation compliance was categorized as non-compliance (failure to follow the training plan), partial compliance (completion of 50%-90% of the plan), and full compliance (complete adherence to the training plan).

QUALITY OF LIFE

Post-operative quality of life was assessed using the SF-36 Brief Health Survey at 3 and 6 months after surgery. Eight dimensions were selected: Scored on a 0-100 scale for each of its eight dimensions (physiological function, physiological competence, somatic pain, general health, vitality, social functioning, emotional competence, and mental health), the instrument yields higher values indicative of superior quality of life.⁶

HIP JOINT FUNCTION AND SELF-CARE ABILITY

Post-operative hip joint function was assessed using the Harris hip function scale. The scale includes four dimensions: pain, function, deformity, and range

of motion, where higher scores indicate better functional outcomes.⁹ Self-care ability was evaluated using the ADL Scale, covering dimensions such as eating, mobility, and toileting, with higher scores indicating stronger self-care capacity.¹³

OTHER INDICATORS

Recorded the first post-operative ambulation time in both groups and the incidence of complications within 6 months post-operation (pressure ulcers, DVT et al.). Satisfaction was evaluated using an in-house developed nursing satisfaction scale, which included three dimensions: nursing skills, professional competence, and service attitude, with a 5-point scoring system.

Statistical methods

All inferential statistics were computed with the Statistical Package for the Social Sciences 26.0, and data visualization was implemented in R. Normality of continuous variables was assessed separately in the control group ($n = 44$) and the intervention group ($n = 44$) using the Shapiro-Wilk test. Because each group-specific normality assessment involved 44 participants, the Shapiro-Wilk test was retained despite the total sample size of 88. Normally distributed continuous data are presented as mean $\pm$ standard deviation $\bar{X} \pm s$ and were compared between groups using the independent-samples t test; categorical data are presented as frequencies (n) and percentage (%), and the comparison between groups is conducted using the χ^2 test; for ranked data, the rank sum test (Z) is employed. Exploratory Pearson correlation analysis (two-sided $p < 0.05$) examined associations of age, sex, length of stay, first ambulation day, comorbidity count, and complications with 6-month functional and quality-of-life outcomes; no missing values were present. An exploratory random forest using these variables plus discharge Harris and ADL scores ranked predictors by mean decrease in Gini impurity. $p < 0.05$ indicates a statistically significant difference.

Results

Comparison of GSES scores, rehabilitation compliance, and first ambulation time between the two groups

At the 1-month post-operative follow-up, the study group demonstrated significantly higher GSES scores

and rehabilitation training compliance compared to the control group, with a significantly earlier first ambulation time than the control group ($p < 0.05$) (Table 1).

Comparison of Harris hip function score and ADL scores

Across the 1-, 3-, and 6-month follow-up assessments, both Harris hip function score and ADL scale values were markedly elevated in the study group relative to the control group ($p < 0.05$) (Table 2 and Fig. 2).

Comparison of SF-36 quality of life scale scores

During the 3- and 6-month post-operative assessments, statistically significant elevations were observed across all SF-36 dimensions in the study group relative to the control group (all $p < 0.05$), as detailed in table 3 and depicted in figure 3.

Comparison of post-operative complication incidence rates

During the 6-month post-operative period, the complication incidence rate was recorded as 8.18% in the study group versus 27.27% in the control group, with the between-group difference attaining statistical significance ($p < 0.05$) (Table 4 and Fig. 4).

Comparison of nursing satisfaction

During the evaluation, nursing satisfaction was recorded as 95.45% in the study group versus 79.55% in the control group, with the inter-group difference reaching statistical significance ($p < 0.05$) (Table 5 and Fig. 5).

Baseline factors associated with 6-month prognosis after PFNA surgery

We further explored whether readily available baseline and early post-operative variables could help explain the divergent recovery trajectories between the two groups. As shown in fig. 6A, first ambulation time carried the strongest inverse correlations with 6-month Harris hip score ($r = -0.49$), ADL score ($r = -0.49$), and SF-36 vitality ($r = -0.61$); complications also tracked negatively with later function (Harris:

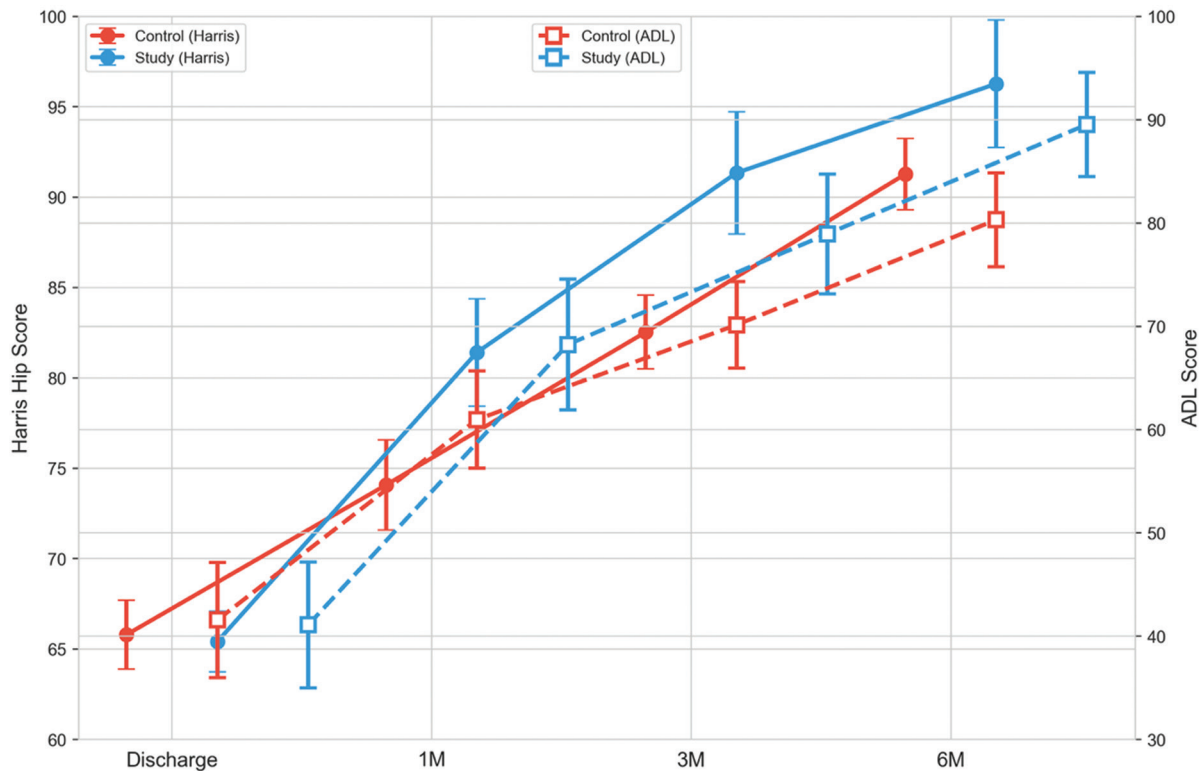


Figure 2. Longitudinal recovery trajectory of Harris hip score and activities of daily living score from discharge to 6 months postoperatively.

Table 1. Comparison of GSES scores, rehabilitation compliance $\bar{x} \pm s$, and first ambulation time $\bar{x} \pm s$, $n = 44$

Group	GSES score (points)	Compliance with rehabilitation training (%)	First ambulation time (d)
Control group	27.52 $\pm$ 4.18	65.91	19.00 $\pm$ 1.40
Study group	34.86 $\pm$ 4.35	93.18	15.00 $\pm$ 1.99
t	7.892	8.765	10.917
p-value	< 0.001	< 0.001	< 0.001

GSES: general self-efficacy scale.

$r = -0.30$; ADL: $r = -0.31$). When these variables were entered into a random forest model (Fig. 6B), first ambulation time emerged as the most influential predictor of 6-month outcomes (Gini importance = 0.20), ahead of discharge Harris score (0.18), length of stay (0.18), and age (0.17). Because the Internet + nursing service intervention had already shortened the median time to first ambulation by roughly 4 days in the study group, the present correlation and machine-learning analyses point to early mobilization as a likely critical mediator of the model's long-term clinical benefit, see fig. 6.

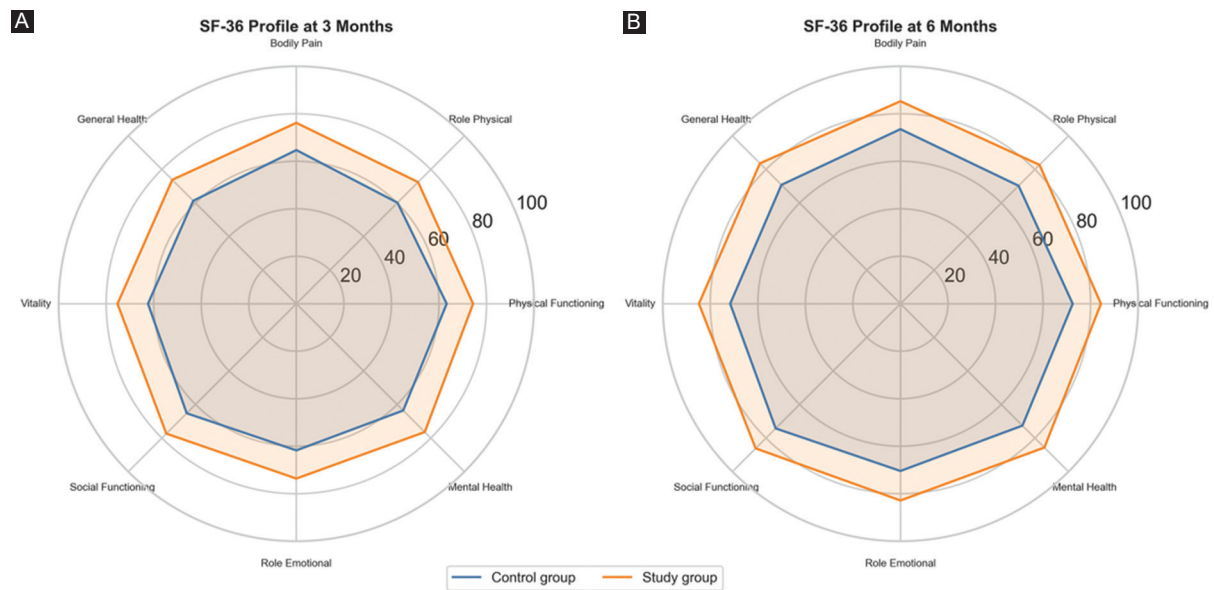
Discussion

Rehabilitation after PFNA surgery for hip fractures in the elderly is characterized by a long duration, high professional requirements, and complexity.¹⁴ Moreover, these patients are mostly elderly with multiple underlying diseases and weak recovery capabilities, thus having a high demand for long-term standardized home care after discharge.¹⁵ In addition, the quality of care directly determines the surgical outcome and long-term prognosis. This study strictly controlled the baseline conditions.¹⁶ The homogeneity of research subjects was ensured, laying a reliable foundation for the subsequent comparative analysis of intervention effects. It also eliminated the interference of baseline differences on the research results.

Conventional continuous care mainly relies on oral education, paper manuals, and telephone follow-ups. This approach has shortcomings such as delayed information transmission, monotonous supervision methods, and lack of targeted guidance.^{17,18} Moreover, elderly patients have poor memory and family caregivers lack professional skills, which can easily lead to decreased rehabilitation compliance, improper

Table 2. Comparison of Harris hip function score and ADL scale $\bar{x} \pm s$ scores

Group	Harris Hip Function Score				ADL Scale Score			
	At discharge	Post-operative 1 month	Post-operative 3-month	Post-operative 6-month	At discharge	Post-operative 1 month	Post-operative 3-month	Post-operative 6-month
Control Group	65.77 $\pm$ 1.87	73.93 $\pm$ 2.54	82.36 $\pm$ 2.14	91.14 $\pm$ 2.02	41.36 $\pm$ 5.54	61.02 $\pm$ 4.65	70.23 $\pm$ 4.17	80.27 $\pm$ 4.45
Study Group	65.39 $\pm$ 1.65	81.32 $\pm$ 2.14	91.20 $\pm$ 3.36	96.23 $\pm$ 3.44	40.91 $\pm$ 6.03	68.41 $\pm$ 6.27	79.09 $\pm$ 5.73	89.66 $\pm$ 4.99
t	1.030	12.637	14.732	8.461	0.368	6.280	8.293	9.316
p	0.306	< 0.001	< 0.001	< 0.001	0.714	< 0.001	< 0.001	< 0.001

**Figure 3. A and B:** Radar charts of SF-36 quality of life dimensions at 3 months and 6 months postoperatively.

training movements, and thus delay hip joint function recovery and increase the risk of complications.^{19,20} In this study, the “Internet + Nursing Service” continuous care model was adopted. This model precisely intervened based on the rehabilitation characteristics. By combining the results of various observation indicators, the clinical advantages of this model can be specifically analyzed from the following aspects based on the data.

First, this intervention model can effectively enhance patients’ self-efficacy and their compliance with rehabilitation training, facilitating their early ambulation for rehabilitation and promoting subsequent functional recovery. At the 1-month post-operative assessment, the study group exhibited elevated GSES scores and improved compliance with rehabilitation training

relative to the control group, alongside an earlier time to first ambulation. This result is consistent with the conclusion of the related research on FLS combined with online home care. This model, relying on the convenience of mobile internet, breaks through the time and space limitations of traditional follow-up, and realizes the real-time interaction between medical staff and patients. Online real-time Q&A and problem-solving, regular rehabilitation, and medication reminders, combined with on-site guidance by specialized nurses, can promptly correct patients’ non-standard training movements, ensuring the professionalism of the rehabilitation process.²¹ At the same time, early post-operative guidance on getting out of bed is effective in alleviating patients’ fear, helping them build confidence in recovery, and reducing the occurrence

Table 3. Comparison of SF-36 quality of life scale $\bar{x} \pm s$ scores

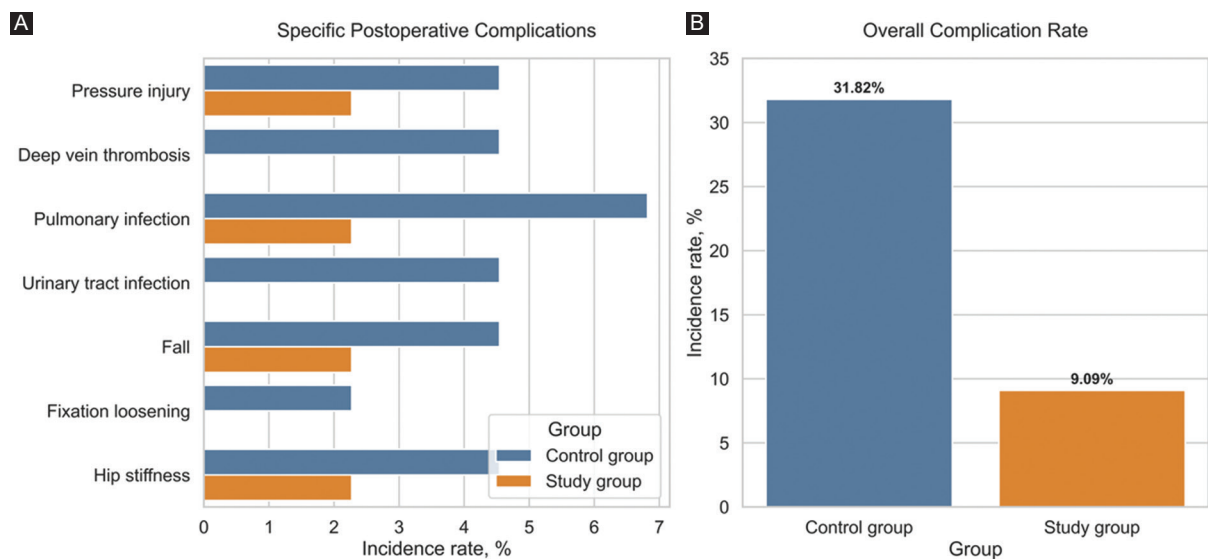
Group	Physical Functioning			Role-Physical			Bodily Pain		
	At discharge	Post-operative 3-month	Post-operative 6-month	At discharge	Post-operative 3-month	Post-operative 6-month	At discharge	Post-operative 3-month	Postoperative 6-month
Control Group	33.27 $\pm$ 1.99	60.23 $\pm$ 5.27	66.95 $\pm$ 3.07	24.05 $\pm$ 1.78	59.27 $\pm$ 3.49	64.45 $\pm$ 3.65	35.41 $\pm$ 4.03	61.52 $\pm$ 2.66	72.73 $\pm$ 4.36
Study Group	33.55 $\pm$ 2.14	70.70 $\pm$ 3.35	69.80 $\pm$ 5.40	24.68 $\pm$ 2.03	68.36 $\pm$ 3.57	72.52 $\pm$ 4.05	36.05 $\pm$ 4.37	69.68 $\pm$ 3.67	79.80 $\pm$ 3.30
t	0.619	11.129	3.036	1.563	12.245	9.810	0.711	11.933	8.567
p	0.538	< 0.005	< 0.001	0.122	< 0.001	< 0.001	0.479	< 0.001	< 0.001
Group	General Health			Vitality			Social Functioning		
	At discharge	Post-operative 3-month	Post-operative 6-month	At discharge	Post-operative 3-month	Post-operative 6-month	At discharge	Post-operative 3-month	Post-operative 6-month
Control Group	40.86 $\pm$ 4.50	42.64 $\pm$ 2.99	46.25 $\pm$ 3.26	31.55 $\pm$ 2.50	49.41 $\pm$ 3.01	58.64 $\pm$ 2.60	32.41 $\pm$ 1.92	54.11 $\pm$ 3.16	65.50 $\pm$ 1.93
Study Group	42.52 $\pm$ 3.71	48.59 $\pm$ 3.71	52.89 $\pm$ 3.95	32.36 $\pm$ 1.77	56.18 $\pm$ 2.98	65.66 $\pm$ 4.87	32.52 $\pm$ 1.75	61.30 $\pm$ 2.81	71.89 $\pm$ 6.58
t	1.889	8.287	8.585	1.773	10.595	8.440	0.290	11.261	10.901
p	0.062	< 0.001	< 0.001	0.080	< 0.001	< 0.001	0.772	< 0.001	< 0.001
Group	Role-Emotional			Mental Health					
	At discharge	Post-operative 3-month	Post-operative 6-month	At discharge	Post-operative 3-month	Post-operative 6-month			
Control Group	34.09 $\pm$ 1.57	56.14 $\pm$ 3.51	65.80 $\pm$ 4.04	36.98 $\pm$ 1.36	55.48 $\pm$ 6.07	63.36 $\pm$ 4.15			
Study Group	34.64 $\pm$ 2.25	63.73 $\pm$ 3.40	73.16 $\pm$ 3.12	38.18 $\pm$ 4.14	61.50 $\pm$ 3.80	73.30 $\pm$ 6.58			
t	1.318	10.309	9.566	1.835	5.580	8.470			
p	0.191	< 0.001	< 0.001	0.072	< 0.001	< 0.001			

Table 4. Comparison of post-operative complication incidence rates

Group	Pressure injury	Deep vein thrombosis	Pulmonary infection	Urinary tract infection	Fall	Loosening of internal fixation	Hip joint stiffness	Overall incidence rate
Control Group	2 (4.55)	2 (4.55)	3 (6.82)	2 (4.55)	2 (4.55)	1 (2.27)	2 (4.55)	12 (27.27)
Study Group	1 (2.27)	0 (0.00)	1 (2.27)	0 (0.00)	1 (2.27)	0 (0.00)	1 (2.27)	4 (8.18)
	-	-	-	-	-	-	-	4.865
p	-	-	-	-	-	-	-	0.028

Table 5. Comparison of nursing satisfaction

Group	Highly satisfied	Moderately satisfied	Neutral	Moderately dissatisfied	Highly dissatisfied	Satisfaction degree
Control Group	12 (27.27)	23 (52.28)	6 (13.64)	2 (4.55)	1 (2.27)	35 (79.55)
Study Group	25 (56.82)	17 (38.64)	2 (4.55)	0 (0.00)	0 (0.00)	42 (95.45)
	-	-	-	-	-	5.045
p	-	-	-	-	-	0.025

**Figure 4.** Comparison of post-operative complications between the two groups within 6 months. **A:** incidence rates of specific complications. **B:** overall complication rate.

of interruptions in rehabilitation training.^{22,23} This is also the core reason for the research group's improvement in rehabilitation compliance and self-efficacy, as well as the earlier onset of getting out of bed. Early activities of getting up can further promote blood circulation, creating favorable conditions for the subsequent recovery of hip joint function.

Second, hip joint function and daily living ability improved progressively under this intervention model, with the treatment effect becoming more discernible at later follow-up visits. Evaluations conducted at 1, 3, and 6 months postoperatively confirmed that the study group achieved higher Harris hip function and ADL scores than the control group at each assessment.

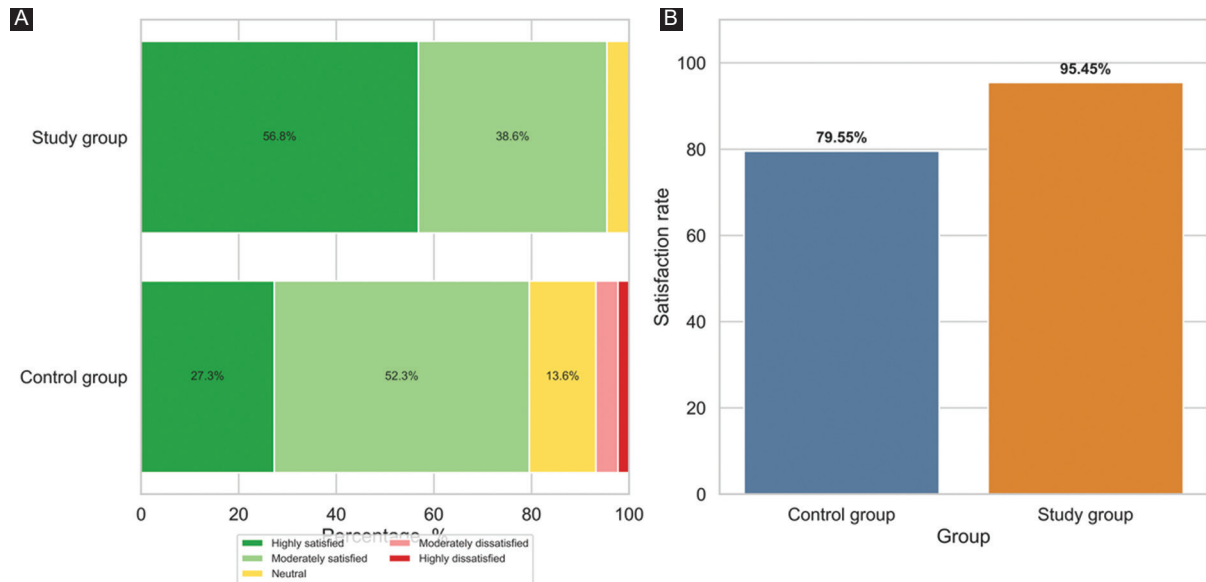


Figure 5. Analysis of nursing satisfaction. **A:** distribution of nursing satisfaction levels. **B:** overall nursing satisfaction rate.

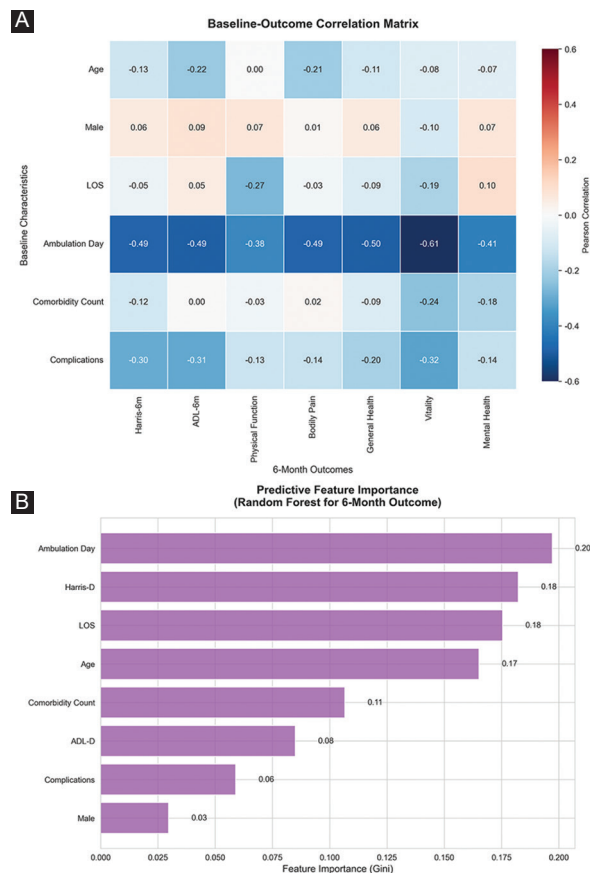


Figure 6. Baseline-outcome correlation and predictive feature importance analysis. **A:** Pearson correlation matrix between baseline characteristics and 6-month post-operative outcomes. **B:** predictive feature importance for 6-month outcomes based on Random Forest.

This result is highly similar to the existing research findings, indicating that the hierarchical and personalized online and offline collaborative intervention can achieve the scientific implementation of rehabilitation training.^{24,25} The intervention team, in combination with the patient's post-operative recovery process, formulated a phased rehabilitation plan, from early post-operative muscle contraction training, to mid-stage guidance on getting out of bed for walking, to late-stage functional strengthening training.²⁶ Throughout the process, the recovery status of the patients was dynamically evaluated through the online platform, the rehabilitation plan was adjusted accordingly, and combined with offline practical demonstrations, with muscular strength around the hip joint being progressively augmented, the joint range of motion was improved, and thus, the patients' ability to take care of themselves in daily life was steadily improved.²⁷

Furthermore, this intervention model was associated with a substantial reduction in post-operative complications, alongside marked improvements in both patient quality of life and nursing service satisfaction and achieve dual improvements in both physical and psychological aspects. The incidence of post-operative complications (specifically falls, infections, internal fixation loosening, hip joint stiffness, and pressure injuries) was recorded as 8.18% in the study group, a rate considerably below the 27.27%

observed in the control group. Similarly, nursing satisfaction was substantially elevated in the intervention cohort (95.45%) relative to controls (79.55%). At 3 and 6 months after the surgery, the scores of each dimension of the SF-36 scale in the study group were significantly higher than those in the control group ($p < 0.05$). On the one hand, specialized nurses provide on-site wound care, catheter care, skin care, and home environment fall risk screening, targeting the prevention of various complications. This particularly reduces the occurrence risks of common adverse events such as falls and pressure ulcers in elderly patients, aligning with published evidence that integrated FLS and online home care protocols mitigate falls and re-fractures. On the other hand, regular online health monitoring, personalized nutritional guidance, and continuous psychological counseling can accelerate the body's recovery of patients, attenuating post-operative anxiety, depression, and other negative emotional states, while concurrently promoting holistic patient improvement across physiological and psychological domains, ultimately translating into enhanced quality of life and nursing satisfaction.

These observed decreases in complications and gains in quality-of-life scores led us to examine whether baseline and early post-operative variables could account for the divergent recovery trajectories. Correlation analysis identified a significant inverse association between time to first ambulation and long-term hip function, ADL, and vitality, whereas post-operative complications were also negatively associated with later functional outcomes. Random forest modeling further confirmed that time to first ambulation was the most influential predictor of 6-month prognosis, outperforming discharge functional scores, length of stay, and age. These findings are consistent with recently published large cohort studies: Nakamura et al.²⁸ observed that patients achieving early mobilization following hip fracture surgery were significantly more likely to walk independently at discharge and had briefer hospitalizations; Ta et al.²⁹ reported that walking at least 5 feet within 72 hours predicted a substantially higher probability of independent ambulation than delayed mobilization; and a systematic review similarly concluded that early mobilization improves functional recovery and reduces complications.³⁰ The present study extends these observations by demonstrating that time to first ambulation remains a dominant predictor of long-term function and quality of life after PFNA fixation, and that the continuous nursing intervention based on “Internet

+ nursing service” significantly advanced this interval, thereby favorably altering a key modifiable determinant of prognosis. The underlying mechanism likely involves improved circulation and pulmonary ventilation, which lower the risk of DVT, pulmonary infection, and pressure injury – events that themselves predicted poorer long-term function in this analysis – while the integrated online and offline nursing model enabled real-time identification and resolution of barriers to early activity, including inadequate analgesia, caregiver anxiety, and home environmental hazards. Machine learning methods such as random forest have been increasingly applied to prognostication after hip fracture, including prediction of 1-year functional recovery and prolonged hospitalization;^{31,32} however, the present analysis indicates that a simple perioperative variable – time to first ambulation – outperformed more complex baseline characteristics in predicting long-term outcomes. Because this analysis was exploratory and the non-concurrent control design limits causal inference, these mechanistic interpretations require confirmation in prospective randomized trials.

Two recent studies provide important context for these findings. In a 2024 multicenter randomized controlled trial of 105 older adults with hip fracture, Prieto-Moreno et al. reported that the 12-week ActiveHip + mHealth education and telerehabilitation program improved physical performance at 3 months, although the between-group benefit was not maintained at 1 year.³³ This short-term functional benefit is consistent with the higher Harris hip and ADL scores observed in our intervention group at 3 and 6 months. However, our apparent benefit at 6 months should not be interpreted as evidence of greater durability, because the studies used different outcome instruments and designs, and our follow-up did not extend to 1 year. In addition, a 2025 meta-analysis of 17 randomized trials involving 1,577 patients by Xiao et al. found that telerehabilitation improved Harris hip scores, functional independence, rehabilitation adherence, and quality of life, but did not significantly improve Timed Up and Go performance or anxiety.³⁴ Our improvements in hip function, adherence, and SF-36 scores are concordant with those pooled findings, whereas the earlier first ambulation time in our study differs from the non-significant walking result in the meta-analysis. This difference may reflect the use of distinct mobility outcomes, the inclusion of in-person home visits alongside online monitoring in our program, and variation in patient characteristics and

follow-up schedules. Collectively, these comparisons support digitally enabled post-operative rehabilitation while indicating that its long-term and mobility-specific effects remain heterogeneous.

Several limitations should be acknowledged. First, although the sample size met the a priori calculation, only 88 participants from a single center were included; this modest sample limits estimate precision, precludes robust subgroup analyses, and may restrict generalizability. Second, follow-up ended at 6 months, so the persistence of benefit and clinically important outcomes beyond this period – including 1-year hip function, refracture, and medication adherence – could not be evaluated. Third, the non-randomized, non-concurrent group allocation may have introduced selection bias and temporal confounding, and residual differences in care could not be fully excluded. Fourth, the absence of blinding and the use of some self-reported outcomes may have introduced performance and response bias. Larger multicenter randomized trials with standardized outcomes and follow-up of at least 12 months are needed to confirm the durability, safety, and generalizability of these findings.

Conclusions

The “Internet + nursing service” model, which continues the nursing approach, is beneficial for the rehabilitation of elderly patients after PFNA surgery. The results of various observation indicators in this study confirm that this model can effectively enhance patients’ self-efficacy and compliance with rehabilitation training, shorten the time for the first time getting out of bed, continuously improve hip joint function and daily living ability, a marked reduction in the incidence of post-operative complications, improve patients’ quality of life and nursing satisfaction, and has stable and replicable intervention effects. As a new type of safe, efficient, economical, and convenient continuation care solution, it is worthy of being deeply applied and widely promoted in clinical orthopedic nursing.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of human subjects and animals. The authors declare that the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the World Medical Association and the Declaration of Helsinki. The procedures were authorized by the Institutional Ethics Committee.

Confidentiality, informed consent, and ethical approval. The authors have followed their institution’s confidentiality protocols, obtained informed consent from all patients, and secured approval from the Ethics Committee. SAGER guidelines have been followed as applicable to the nature of the study.

This study was approved by the Ethics Committee of The Affiliated Hospital of Xuzhou Medical University, with the ethical approval number XYFY2025-KL118-01.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing or creation of the content of this manuscript.

References

1. Sing CW, Lin TC, Bartholomew S, Bell JS, Bennett C, Beyene K, et al. Global epidemiology of hip fractures: secular trends in incidence rate, post-fracture treatment, and all-cause mortality. *J Bone Miner Res.* 2023;38:1064-75.
2. Tai TW, Hwang JS, Li CC, Hsu JC, Chang CW, Wu CH. The impact of various anti-osteoporosis drugs on all-cause mortality after hip fractures: a nationwide population study. *J Bone Miner Res.* 2022;37:1520-6.
3. Xu X, Hu X, Fei L, Shen S. Analysis of elderly patients with inter-trochanteric fracture and failure of postoperative internal fixation. *Technol Health Care.* 2025;33:1917-25.
4. Brorson S. Imaging-based assessment of fracture stability does not reliably predict outcomes in patients with two-part proximal humeral fractures and may lead to unnecessary surgeries. *EFORT Open Rev.* 2026;11:437-45.
5. Yang C, Fu Y, Du D, Li X, Zhou Q, Yang Y, et al. Application of telerehabilitation in home care for older adult patients with postoperative hip fractures: a scoping review. *PLoS One.* 2026;21:e0342110.
6. Lai H, Fan J, Liu H, Wu X, Wang L, Gao L, et al. Fracture liaison services combined with online home nursing care in fragility hip fracture: a comparative effectiveness pilot study. *Arch Osteoporos.* 2023;18:33.
7. Pliannuom S, Pinyopornpanish K, Buawangpong N, Wiwatkunupakarn N, Mallinson PAC, Jiraporncharoen W, et al. Characteristics and effects of home-based digital health interventions on functional outcomes in older patients with hip fractures after surgery: systematic review and meta-analysis. *J Med Internet Res.* 2024;26:e49482.
8. Castro AR, Chougui K, Bilodeau C, Tsimicalis A. Exploring the views of osteogenesis imperfecta caregivers on internet-based technologies: qualitative descriptive study. *J Med Internet Res.* 2019;21:e15924.
9. Yuan S, Liu M, Peng Y, Hu J, Li B, Ding X, et al. “Internet+nursing service” mobile apps in China app stores: functionality and quality assessment study. *JMIR Mhealth Uhealth.* 2024;12:e52169.
10. Zhang X, Guo Z, Duan Y, Sun C, Luo J. Effectiveness of telemedicine on wound-related and patient-reported outcomes in patients with chronic wounds: systematic review and meta-analysis. *JMIR Mhealth Uhealth.* 2025;13:e58553.
11. Hao J, Xu Y, Li H. The value of applying a continuous nursing model based on virtual platforms for patients with colostomy or ileostomy. *Adv Skin Wound Care.* 2023;36:206-12.
12. Yuan W, Zhou X, Meng X, Zhu Y. Anterior cervical discectomy and fusion training with virtual reality: enhance cognition, attitudes, self-efficacy and performance in residents. *Eur Spine J.* 2025;34:2227-38.

13. Khalifa AA, Kostadinov LJ, Hauri DD, Zhu TY. Health-related quality-of-life, complications, and mortality rates after geriatric acetabular fracture, non-operative compared to operative management: a systematic review and meta-analysis. *Int J Surg.* 2025;111:7181-201.
14. Jiang WZ. Construction and validation of a nomogram prediction model for factors affecting hip functional recovery after PFNA internal fixation of intertrochanteric femur fractures in the elderly. *Medicine (Baltimore).* 2024;103:e41043.
15. McGilton K, Campitelli M, Bethell J, Guan J, Vellani S, Krassikova A, et al. Impact of dementia on patterns of home care following inpatient rehabilitation discharge for older adults after hip fractures. *Arch Phys Med Rehabil.* 2021;102:1972-81.
16. Ríos-Germán PP, Gutierrez-Misis A, Queipo R, Ojeda-Thies C, Sáez-López P, Alarcón T, et al. Differences in the baseline characteristics, management and outcomes of patients with hip fractures depending on their pre-fracture place of residence: the Spanish national hip fracture registry (RNFC) cohort. *Eur Geriatr Med.* 2021;12:1021-9.
17. Pedrosa AR, Ferreira ÓR, Baixinho CR. Transitional rehabilitation care and patient care continuity as an advanced nursing practice. *Rev Bras Enferm.* 2022;75:e20210399.
18. Berdal G, Sand-Svartrud AL, Linge AD, Aasvold AM, Tennebo K, Eppeland SG, et al. Does follow-up really matter? A convergent mixed methods study exploring follow-up across levels of care in rehabilitation of patients with rheumatic and musculoskeletal diseases. *Disabil Rehabil.* 2024;46:5531-44.
19. Cheng KC, Lau KM, Cheng AS, Lau TS, Lau FO, Lau MC, et al. Use of mobile app to enhance functional outcomes and adherence of home-based rehabilitation program for elderly with hip fracture: a randomized controlled trial. *Hong Kong Physiother J.* 2022;42:99-110.
20. Kuo WY, Chen MC, Lin YC, Yan SF, Shyu YL. Trajectory of adherence to home rehabilitation among older adults with hip fractures and cognitive impairment. *Geriatr Nurs.* 2021;42:1569-76.
21. Phuphanich ME, Sinha KR, Truong M, Pham QG. Telemedicine for musculoskeletal rehabilitation and orthopedic postoperative rehabilitation. *Phys Med Rehabil Clin N. Am* 2021;32:319-53.
22. Alsawaylihi A, O'Connor D, Joshi GP, Kehlet H, Lobo DN. Importance of early postoperative mobilization: comprehensive review. *BJS Open.* 2025;10:zrag016.
23. Tobiesen Pedersen L, Ipsen JA, Egebaek HK, Bruun IH, Viberg B, Andersen PT. From fear to control: older adults' thoughts and feelings about empowerment-oriented rehabilitation after a hip fracture. *Int J Orthop Trauma Nurs.* 2024;53:101061.
24. Sheehan KJ, Guerra S, Ayis S, Goubar A, Foster NE, Martin FC, et al. Structured tailored rehabilitation after hip fragility fracture: the 'stratify' feasibility and pilot randomised controlled trial protocol. *PLoS One.* 2024;19:e0306870.
25. Cui L, Tong Z, Wang R, Fang X, Liu L. Using an internet-based platform to provide online and offline healthcare services for discharged patients. *BMC Nurs.* 2024;23:486.
26. Røpke A, Morville AL, Møller TE, Delkus EC, Juhl CB. HIP fracture rehabilitation program for older adults with hip fracture (HIP-REP) based on activity of daily living: a feasibility study. *BMC Geriatr.* 2022;22:370.
27. Coyle PC, Knox PJ, Pohlig RT, Pugliese JM, Sions JM, Hicks GE. Hip range of motion and strength predict 12-month physical function outcomes in older adults with chronic low back pain: the Delaware Spine studies. *ACR Open Rheumatol.* 2021;3:850-9.
28. Nakamura K, Kurobe Y, Sue K, Sakurai S, Sasaki T, Yamamoto S, et al. Impact of early postoperative ambulation on gait recovery after hip fracture surgery: a multicenter cohort study. *Sci Rep.* 2025;15:12893.
29. Ta CN, Lurie B, Mitchell B, Howard R, Onodera K, Harkin W, et al. Ambulation distance within 72 hours after surgical management is a predictor of 90-day ambulatory capacity in elderly patients with hip fracture. *J Am Acad Orthop Surg Glob Res Rev.* 2023;7:e23.00079.
30. Mazarello Paes V, Ting A, Masters J, Paes MV, Graham SM, Costa ML, et al. A systematic review of evidence regarding the association between time to mobilization following hip fracture surgery and patient outcomes. *Bone Jt Open.* 2025;6:741-7.
31. Lin C, Liang Z, Liu J, Sun W. A machine learning-based prediction model pre-operatively for functional recovery after 1-year of hip fracture surgery in older people. *Front Surg.* 2023;10:1160085.
32. Liu H, Xing F, Jiang J, Chen Z, Xiang Z, Duan X. Random forest predictive modeling of prolonged hospital length of stay in elderly hip fracture patients. *Front Med (Lausanne).* 2024;11:1362153.
33. Prieto-Moreno R, Mora-Traverso M, Estévez-López F, Molina-García P, Ortiz-Piña M, Salazar-Graván S, et al. Effects of the ActiveHip+ mHealth intervention on the recovery of older adults with hip fracture and their family caregivers: a multicentre open-label randomised controlled trial. *EClinicalMedicine.* 2024;73:102677.
34. Xiao H, Zeng W, Lu L, Yuan J, Yan oZ, Wang J. Effectiveness of tele-rehabilitation in postoperative outcomes in patients on hip fracture surgery: a meta-analysis of randomized controlled trials. *BMC Sports Sci Med Rehabil.* 2025;17:130.