# Effect of PDCA Cycle-Based Orthopedic Rehabilitation Nursing on Perioperative Pain and Functional Recovery in Patients With Femoral Fractures

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AIM: To investigate the effects of orthopedic rehabilitation nursing based on the Plan–Do–Check–Act (PDCA) cycle model on perioperative pain and postoperative functional recovery in patients undergoing surgical treatment for femoral fractures.

METHODS: This retrospective single-center study included 120 patients who underwent surgical treatment for femoral fractures at The 964th Hospital of Chinese People's Liberation Army Joint Logistics Support Force between May 2023 and May 2025. Based on the nursing interventions documented in medical records, patients were assigned to a control group (n = 58) and a study group (n = 62). The control group received routine perioperative orthopedic nursing care, while the study group received PDCA cycle-based orthopedic rehabilitation nursing. Clinical outcomes compared between the two groups included time to first ambulation, length of hospital stay, perioperative pain intensity assessed using the numerical rating scale (NRS), comfort level evaluated using the general comfort questionnaire (GCQ), hip joint function assessed using the Harris Hip Score (HHS) and Functional Independence Measure (FIM), and quality of life and health-promoting lifestyle level assessed using the World Health Organization Quality of Life-BREF (WHOQOL-BREF) and Health-Promoting Lifestyle Profile II (HPLP-II).

RESULTS: Compared with the control group, the study group demonstrated a significantly shorter time to first ambulation and reduced length of hospital stay ($p < 0.001$). Following the nursing intervention, both groups showed lower NRS scores and higher GCQ scores compared with baseline values. Furthermore, post-intervention NRS scores were significantly lower, and GCQ scores were significantly higher in the study group than the control group ($p < 0.001$). HHS and FIM scores improved in both groups after nursing compared with pre-nursing values, with significantly greater post-intervention scores observed in the study group ($p < 0.001$). Similarly, WHOQOL-BREF and HPLP-II scores increased in both groups compared with pre-nursing values, and the study group achieved significantly higher BREF and HPLP-II scores than the control group ($p < 0.001$).

CONCLUSIONS: PDCA cycle-based orthopedic rehabilitation nursing was associated with reduced perioperative pain, improved patient comfort, earlier postoperative ambulation, and enhanced functional recovery in patients with femoral fractures. However, given the retrospective single-center design and potential selection bias, the findings should be interpreted cautiously. Prospective multicenter, randomized controlled studies with larger sample sizes are warranted to validate these observations.

**Keywords:** femoral fractures; Plan–Do–Check–Act cycle model; orthopedic rehabilitation nursing; functional recovery

## Introduction

Femoral fracture is one of the most common and severe orthopedic injuries encountered in clinical practice, particularly among elderly patients, and is often associated with multiple comorbidities and a high perioperative risk [1,2]. Surgical intervention remains the primary treatment approach for restoring the anatomical integrity and functional capacity of the affected limb [3,4]. However, during the perioperative period, patients often experience significant pain, limited mobility, delayed functional recovery, and impaired quality of life, all of which may adversely affect postoperative rehabilitation and long-term prognosis [5,6]. Therefore, optimizing perioperative nursing strategies to alleviate pain and promote early mobilization and functional recovery has become an important focus in the field of orthopedic nursing.

Traditional perioperative orthopedic nursing primarily emphasizes basic vital sign monitoring, routine analgesic management, and guidance on functional exercises. Although these interventions can ensure patient safety to a certain extent, they still have limitations in alleviating perioperative stress responses, promoting rapid rehabilitation, and improving the overall patient experience. Consequently, establishing a systematic nursing management model capable of standardizing perioperative nursing procedures and con-

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tinuously improving nursing quality has become an important direction in contemporary orthopedic nursing practice. The Plan–Do–Check–Act (PDCA) cycle is a widely recognized quality management model that emphasizes continuous improvement through a cycle of planning, implementation, evaluation, and optimization [7,8]. In recent years, the PDCA cycle has been progressively introduced into clinical nursing management to standardize nursing procedures, strengthen quality control, and improve the effectiveness of nursing interventions [9,10]. By incorporating the PDCA cycle into perioperative orthopedic rehabilitation nursing, individualized nursing plans can be formulated according to patients' clinical conditions, nursing measures can be dynamically monitored and evaluated, and the nursing process can be continuously refined, thereby promoting early rehabilitation and improving patient outcomes.

Orthopedic rehabilitation nursing, as an essential component of perioperative care, emphasizes patient-centered functional recovery. Through early ambulation, progressive functional training, and psychological support, it aims to facilitate restoration of affected limb function and recovery of activities of daily living. Specifically, "early ambulation" in the present study refers to initiating bedside sitting and active or passive lower-limb exercises within 24 hours postoperatively, followed by assisted standing and partial weight-bearing within 48–72 hours, depending on the patient's clinical condition and surgical procedure. Progressive full weight-bearing was subsequently introduced based on clinical evaluation and physician guidance. Integration of the PDCA cycle model into orthopedic rehabilitation nursing may further enhance the scientific rigor, continuity, and standardization of nursing interventions, improve patients' compliance with rehabilitation training, and facilitate postoperative functional recovery [11].

However, studies investigating the application of PDCA cycle-based orthopedic rehabilitation nursing in the perioperative management of patients with femoral fractures remain limited, and its effects on perioperative pain relief and postoperative functional recovery require further clinical validation.

Accordingly, the present study adopted a retrospective design to compare the effects of conventional perioperative orthopedic nursing and PDCA cycle-based orthopedic rehabilitation nursing in patients undergoing surgery for femoral fractures. The study primarily evaluated their impacts on perioperative pain and postoperative functional recovery, to provide evidence-based support for optimizing perioperative nursing strategies in patients with femoral fractures.

## Methods

### *General Information*

This retrospective single-center study included 120 patients who underwent surgical treatment for femoral fractures at The 964th Hospital of Chinese People's Liberation Army Joint Logistics Support Force between May 2023 and May 2025. Based on the type of nursing intervention documented in the medical records, patients were divided into a control group (n = 58) and a study group (n = 62).

Different surgical procedures were selected according to fracture location and clinical condition. Femoral head fractures were mainly treated with open reduction and internal fixation (ORIF) or hip arthroplasty. Femoral neck fractures were commonly managed using cannulated screw fixation, dynamic hip screw (DHS) fixation, or hip arthroplasty. Intertrochanteric and subtrochanteric femoral fractures were primarily treated with proximal femoral nail antirotation (PFNA) or other intramedullary fixation techniques. Femoral shaft fractures were generally managed with interlocking intramedullary nail fixation. Distal femoral fractures were mainly treated using locking plate fixation or retrograde intramedullary nailing, while joint arthroplasty was performed in selected severe cases.

This study was approved by the Ethics Committee of The 964th Hospital of Chinese People's Liberation Army Joint Logistics Support Force (Approval No. Y-20260211-002), and all included patients provided informed consent. This study was conducted in strict adherence to the principles of the Declaration of Helsinki.

### *Inclusion Criteria*

1. Patients with a definitive diagnosis of femoral fracture confirmed by clinical manifestations and imaging examinations who underwent surgical treatment at The 964th Hospital of Chinese People's Liberation Army Joint Logistics Support Force;
2. Availability of complete medical records, nursing records, and perioperative clinical data available for retrospective analysis;
3. Receipt of either conventional perioperative orthopedic nursing care or PDCA cycle-based orthopedic rehabilitation nursing during the perioperative period;
4. Clear consciousness and the ability to cooperate with pain assessment and functional rehabilitation training.

### *Exclusion Criteria*

1. Patients with pathological fractures, including fractures caused by tumors or severe metabolic bone diseases;
2. Patients with multiple fractures or severe concomitant organ injuries;
3. Patients with preexisting severe dysfunction of the affected lower limb or a history of related lower-extremity surgery;
4. Patients with severe cognitive impairment, psychiatric disorders, or communication difficulties that prevented completion of relevant assessments;
5. Patients who developed severe perioperative complications or had incomplete medical records that could influence outcome evaluation.

*Nursing Methods*

Control Group

Patients in the control group received conventional perioperative orthopedic nursing care provided by ward nurses with ≥3 years of clinical experience in orthopedic nursing. The control group was managed in the same ward during an earlier time period (May 2023–June 2024), prior to implementation of the PDCA-based nursing program. Routine nursing care included standardized preoperative preparation and general health education, perioperative monitoring of vital signs, and medication administration as prescribed by the physician.

Postoperative analgesia was administered according to institutional protocols, consisting primarily of nonsteroidal anti-inflammatory drugs (NSAIDs) as first-line therapy. In contrast, opioid analgesics were administered when necessary for moderate to severe pain. Routine incision care and postoperative complication monitoring were also performed. Functional rehabilitation guidance included bedside limb movement within 24–48 hours after surgery and gradual progression to assisted ambulation, as recommended by the physician. However, no structured individualized rehabilitation program or continuous evaluation mechanism was implemented.

Study Group

Patients in the study group were managed in the same ward after implementation of the PDCA-based nursing model (July 2024–May 2025). Nursing care was delivered by a trained multidisciplinary team composed of orthopedic nurses, a rehabilitation therapist, and a supervising physician. Prior to study initiation, all staff members received standardized training on PDCA cycle implementation and perioperative rehabilitation management.

Plan: A comprehensive preoperative assessment was conducted, including evaluation of pain intensity using the numerical rating scale (NRS), limb function, and general clinical condition. Based on standardized institutional protocols, an individualized nursing plan was developed for each patient, including analgesic strategies (scheduled NSAIDs and, when appropriate, patient-controlled analgesia), early mobilization schedules (e.g., bedside sitting within 24 hours and assisted standing within 48–72 hours), and structured functional rehabilitation programs. Targeted health education and psychological support interventions were also incorporated into the nursing plan.

Do: The individualized nursing plan was implemented throughout the perioperative period. In addition to routine care, patients received structured rehabilitation training under the supervision of rehabilitation personnel, with clearly defined daily rehabilitation goals. Pain management adopted a proactive and dynamic approach involving scheduled assessments and timely adjustment of analgesic regimens. Specifically, regular evaluations were conducted at predefined postoperative time points, including postoperative day 1, day 3, and day 7. Pain intensity was assessed using the NRS at least twice daily (morning and evening), and whenever patients reported significant pain. Functional recovery and adherence to rehabilitation training were evaluated at the same time points using standardized assessment scales. Early mobilization and progressive weight-bearing exercises were actively supervised and documented.

Check: The nursing team performed regular and standardized evaluations of pain intensity (NRS), functional recovery (Harris Hip Score (HHS) and Functional Independence Measure (FIM)), and patient adherence to rehabilitation protocols. Clinical data were recorded using unified assessment forms, and weekly multidisciplinary meetings were conducted to review patient progress, identify existing problems, and evaluate the effectiveness of nursing interventions.

Act: Based on the evaluation results, the nursing care plan was adjusted in a timely manner. Targeted interventions were implemented to address identified problems, including optimizing analgesic regimens, adjusting rehabilitation intensity, and reinforcing preventive strategies to reduce the risk of complications such as deep vein thrombosis and pressure injuries. Continuous feedback and iterative quality improvement constituted essential components of the PDCA-based nursing process.

All included patients underwent surgical treatment and received standardized perioperative management within the same clinical pathway, thereby providing a consistent basis for intergroup comparison. The duration of nursing intervention in both groups was 10 days.

*Outcome Measures*

Postoperative recovery outcomes included time to first ambulation and length of hospital stay. Relevant clinical indicators in both groups were evaluated before and after the intervention. Perioperative pain intensity was assessed using the NRS [12]. The NRS is a unidimensional pain assessment tool scored from 0 to 10, where 0 indicates no pain and 10 indicates unbearable severe pain. Higher scores represent greater pain intensity.

Patient comfort level was evaluated using the general comfort questionnaire (GCQ) [13]. The GCQ consists of 28 items covering four dimensions: physical, psychological, social, and environmental comfort. Each item is scored on a 4-point Likert scale (1–4), yielding a total score of 28–112. Higher scores indicate a higher level of patient comfort.

Hip joint functional recovery was assessed using the Harris Hip Score (HHS) [14]. The HHS has a maximum total score of 100 points and primarily includes four domains: pain, function, deformity, and range of motion. Pain and function account for 44 and 47 points, respectively, while the remaining points are allocated to deformity and range of motion. Higher scores indicate better hip joint functional recovery. Due to the retrospective design and the availability of standardized clinical records, the HHS was retained

as one of the few standardized functional outcome measures consistently available across all patients.

Patients' activities of daily living and functional independence were evaluated using the Functional Independence Measure (FIM) [15]. The FIM consists of 18 items encompassing two domains: motor function and cognitive function. Each item is rated on a 7-point scale, with total scores ranging from 18 to 126. Higher scores indicate greater self-care ability and functional independence.

Quality of life was assessed using the World Health Organization Quality of Life-BREF (WHOQOL-BREF) [16]. This instrument contains 26 items covering four domains: physical health, psychological health, social relationships, and environment. Each item is rated on a 5-point Likert scale, with higher scores indicating better quality of life.

Health-promoting lifestyle behavior was evaluated using the Health-Promoting Lifestyle Profile II (HPLP-II) [17]. This scale comprises 52 items covering six dimensions: health responsibility, physical activity, nutrition, interpersonal relations, spiritual growth, and stress management. Each item is scored on a 4-point Likert scale (1–4), yielding a total score of 52–208. Higher scores indicate a higher level of health-promoting lifestyle behavior.

### *Statistical Analysis*

All data obtained in this study were analyzed using SPSS version 27.0 statistical software (IBM Corp., Armonk, NY, USA). Categorical variables are presented as counts (n) and percentages (%) and were compared using the chi-square ($\chi^2$) test. The normality of continuous variables was assessed using the Shapiro–Wilk test, and all variables were found to conform to a normal distribution. Continuous variables with normal distribution are expressed as mean ± standard deviation ($\bar{x} \pm SD$) and were compared using the independent-samples *t*-test. A two-sided *p*-value $< 0.05$ was considered statistically significant.

## Results

### *Comparison of General Characteristics Between the Two Groups*

According to the nursing intervention received, patients were divided into a control group and a study group. No statistically significant differences were observed between the two groups in age, sex, body mass index (BMI), disease duration, fracture type, surgical procedure, American Society of Anesthesiologists (ASA) classification, operative time, or intraoperative blood loss ($p > 0.05$) (Table 1), indicating good baseline comparability between the groups.

### *Comparison of Time to First Ambulation and Length of Hospital Stay Between the Two Groups*

The study group demonstrated a significantly shorter time to first ambulation and a significantly reduced length of hospital stay compared with the control group, and the differences were statistically significant ($p < 0.001$) (Table 2).

### *Comparison of Perioperative Pain Intensity and Comfort Levels Before and After Nursing Between the Two Groups*

Before nursing, no statistically significant differences in NRS or GCQ scores were observed between the control and study groups ($p > 0.05$). Following nursing intervention, NRS scores were lower, and GCQ scores were higher in both groups compared with their respective pre-nursing values. Comparisons of within-group scores before and after the intervention should be interpreted descriptively only, as the current statistical analysis does not permit formal inference regarding within-group changes. After nursing intervention, the NRS score in the study group was significantly lower than that in the control group ($p < 0.001$). Additionally, the GCQ score in the study group was significantly higher than that in the control group ($p < 0.001$) (Table 3), suggesting superior pain management and patient comfort under the PDCA cycle-based orthopedic rehabilitation nursing model.

### *Comparison of HHS and FIM Scores Before and After the Nursing Intervention Between the Two Groups*

Before the nursing intervention, no statistically significant differences in HHS or FIM scores were observed between the two groups ($p > 0.05$). Following the nursing intervention, both HHS and FIM scores were higher in both groups than at baseline. Comparisons of within-group scores before and after intervention should be interpreted descriptively only, as the current statistical analysis cannot establish statistically significant within-group changes. Moreover, post-intervention HHS and FIM scores in the study group were significantly higher than those in the control group, with a statistically significant difference between groups ($p < 0.001$) (Table 4), indicating better postoperative hip function recovery and greater functional independence among patients receiving PDCA cycle-based orthopedic rehabilitation nursing.

### *Comparison of Quality of Life and Health-Promoting Lifestyle Scores Before and After Nursing Between the Two Groups*

Before nursing, no statistically significant differences in WHOQOL-BREF and HPLP-II scores were observed between the two groups ($p > 0.05$). Following nursing intervention, WHOQOL-BREF and HPLP-II scores were higher in both groups than their corresponding pre-nursing values. Comparisons of within-group scores before and after intervention should be interpreted descriptively only, as the current statistical analysis does not permit formal inference regarding within-group changes. Moreover, post-intervention WHOQOL-BREF and HPLP-II scores in the study group were significantly higher than those in the control group ($p < 0.001$) (Table 5). These findings suggest that PDCA cycle-based orthopedic rehabilitation nursing was associated with better quality of life and more favorable health-promoting lifestyle outcomes than conventional perioperative orthopedic nursing.

**Table 1. Baseline characteristics of patients in the control and study groups**.

| Variable | Control group (n = 58) | Study group (n = 62) | $t/\chi^2$ | *p*-value |
|---|---|---|---|---|
| Age (years), mean ± SD | 64.55 ± 2.77 | 64.28 ± 2.84 | 0.537 | 0.592 |
| Sex, n (%) | | | | |
| Male | 30 (51.72) | 34 (54.84) | 0.061 | 0.805 |
| Female | 28 (48.28) | 28 (45.16) | | |
| BMI (kg/m$^2$), mean ± SD | 22.57 ± 0.37 | 22.61 ± 0.35 | 0.663 | 0.509 |
| Disease duration (days), mean ± SD | 3.85 ± 0.70 | 3.96 ± 0.68 | 0.824 | 0.411 |
| Fracture type, n (%) | | | | |
| Femoral head fracture | 1 (1.72) | 1 (1.61) | 0.400 | 0.995 |
| Femoral neck fracture | 26 (44.83) | 27 (43.55) | | |
| Intertrochanteric femoral fracture | 23 (39.66) | 23 (37.10) | | |
| Subtrochanteric femoral fracture | 4 (6.90) | 5 (8.06) | | |
| Femoral shaft fracture | 2 (3.45) | 3 (4.84) | | |
| Distal femoral fracture | 2 (3.45) | 3 (4.84) | | |
| Surgical procedure, n (%) | | | | |
| Hip arthroplasty | 23 (39.66) | 25 (40.32) | 0.891 | 0.996 |
| Cannulated screw fixation | 2 (3.45) | 3 (4.84) | | |
| DHS fixation | 1 (1.72) | 1 (1.61) | | |
| PFNA fixation | 22 (37.93) | 24 (38.71) | | |
| Intramedullary nail fixation | 5 (8.62) | 4 (6.45) | | |
| Interlocking intramedullary nail fixation | 2 (3.45) | 3 (4.84) | | |
| Locking plate fixation | 1 (1.72) | 1 (1.61) | | |
| Retrograde intramedullary nailing | 2 (3.45) | 1 (1.61) | | |
| ASA classification, n (%) | | | | |
| I | 27 (46.55) | 32 (51.61) | 0.307 | 0.579 |
| II | 31 (53.45) | 30 (48.39) | | |
| Operative time (min), mean ± SD | 130.28 ± 7.07 | 132.08 ± 7.19 | 1.384 | 0.169 |
| Intraoperative blood loss (mL), mean ± SD | 272.08 ± 7.35 | 273.20 ± 7.22 | 0.842 | 0.402 |

Abbreviations: BMI, body mass index; DHS, dynamic hip screw; PFNA, proximal femoral nail antirotation; ASA, American Society of Anesthesiologists.

**Table 2. Comparison of time to first ambulation and length of hospital stay between the two groups**.

| Variable | Control group (n = 58) | Study group (n = 62) | $t/\chi^2$ | *p*-value |
|---|---|---|---|---|
| Time to first ambulation (days), mean ± SD | 8.38 ± 0.75 | 6.25 ± 0.68 | 16.330 | <0.001 |
| Length of hospital stay (days), mean ± SD | 13.86 ± 1.37 | 11.83 ± 1.39 | 8.052 | <0.001 |

**Table 3. Comparison of perioperative pain intensity and comfort levels between the two groups before and after nursing intervention**.

| Variable | Control group (n = 58) | Study group (n = 62) | $t/\chi^2$ | *p*-value |
|---|---|---|---|---|
| Pre-nursing NRS score, mean ± SD | 8.30 ± 0.78 | 8.35 ± 0.71 | 0.371 | 0.712 |
| Post-nursing NRS score, mean ± SD | 3.53 ± 0.17 | 2.61 ± 0.17 | 22.971 | <0.001 |
| Pre-nursing GCQ score, mean ± SD | 46.27 ± 0.91 | 46.39 ± 1.04 | 0.698 | 0.487 |
| Post-nursing GCQ score, mean ± SD | 83.08 ± 1.59 | 94.14 ± 1.57 | 38.305 | <0.001 |

Abbreviations: NRS, numerical rating scale; GCQ, general comfort questionnaire.

**Table 4. Comparison of HHS and FIM scores before and after the nursing intervention between the two groups**.

| Variable | Control groups (n = 58) | Study groups (n = 62) | $t/\chi^2$ | *p*-value |
|---|---|---|---|---|
| Pre-nursing HHS score, mean ± SD | 55.84 ± 4.04 | 55.57 ± 4.22 | 0.360 | 0.720 |
| Post-nursing HHS score, mean ± SD | 63.92 ± 3.85 | 72.79 ± 4.78 | 11.158 | <0.001 |
| Pre-nursing FIM score, mean ± SD | 40.32 ± 3.19 | 41.19 ± 3.13 | 1.513 | 0.133 |
| Post-nursing FIM score, mean ± SD | 59.56 ± 4.32 | 71.54 ± 4.48 | 14.886 | <0.001 |

Abbreviations: HHS, Harris Hip Score; FIM, Functional Independence Measure.

**Table 5. Comparison of the quality of life and health-promoting lifestyle scores between the two groups before and after nursing intervention.**

| Variable | Control group (n = 58) | Study group (n = 62) | $t/\chi^2$ | *p*-value |
|---|---|---|---|---|
| Pre-nursing WHOQOL-BREF score, mean ± SD | 60.66 ± 4.00 | 60.55 ± 3.92 | 0.144 | 0.886 |
| Post-nursing WHOQOL-BREF score, mean ± SD | 93.57 ± 5.08 | 108.72 ± 4.81 | 16.778 | <0.001 |
| Pre-nursing HPLP-II score, mean ± SD | 76.84 ± 4.27 | 77.27 ± 4.20 | 0.553 | 0.581 |
| Post-nursing HPLP-II score, mean ± SD | 155.15 ± 7.76 | 171.71 ± 7.70 | 11.733 | <0.001 |

Abbreviations: WHOQOL-BREF, World Health Organization Quality of Life-BREF; HPLP-II, Health-Promoting Lifestyle Profile II.

## Discussion

This retrospective study evaluated the application of orthopedic rehabilitation nursing within the PDCA cycle model in the perioperative management of patients undergoing surgical treatment for femoral fractures. The findings demonstrated that, compared with conventional perioperative orthopedic nursing, PDCA cycle-based orthopedic rehabilitation nursing was associated with a shorter time to first ambulation, reduced length of hospital stay, lower perioperative pain intensity, improved patient comfort, better hip joint function, and higher quality-of-life and health-promoting lifestyle scores. These findings suggest that integrating the PDCA cycle model into perioperative nursing management may optimize the nursing process and improve rehabilitation-related outcomes in patients with femoral fractures. However, given the retrospective observational design, the observed associations should be interpreted cautiously, and causal relationships cannot be definitively established.

Pain control is a critical factor influencing early postoperative mobilization and rehabilitation in patients with femoral fractures. In the present study, NRS scores in the study group were significantly lower than those in the control group, suggesting that the PDCA cycle-based nursing management model may offer advantages in postoperative pain management through systematic planning, implementation, evaluation, and continuous refinement of nursing interventions. Within the PDCA framework, individualized pain management strategies can be developed based on patient needs, while dynamic pain assessment facilitates timely adjustment of analgesic regimens, thereby potentially enhancing pain control [18]. These findings are consistent with previous reports indicating that structured nursing management and continuous quality improvement strategies can reduce postoperative stress responses and decrease the incidence of analgesia-related adverse events, thereby improving patient comfort [19,20]. Furthermore, GCQ scores in the study group were significantly higher than those in the control group, further suggesting that PDCA cycle-based nursing interventions may enhance overall perioperative comfort through continuous evaluation and optimization of nursing care.

Functional recovery is an important outcome indicator for evaluating the effectiveness of surgical treatment for femoral fractures [21]. In the present study, the study group demonstrated significantly higher HHS and FIM scores than the control group. This improvement may be attributed to the PDCA cycle model, which emphasizes individualized rehabilitation planning, continuous monitoring of rehabilitation progress, and timely adjustment of nursing interventions according to patient needs. Through the iterative process of planning, implementation, evaluation, and improvement, the PDCA model may facilitate effective implementation of early mobilization and progressive functional rehabilitation training. A previous study has similarly reported that PDCA cycle-based management can help prevent muscle atrophy and joint stiffness, improve activities of daily living, and thereby promote the overall postoperative functional recovery [22].

In terms of quality of life and health-related behaviors, this study found that, after nursing intervention, WHOQOL-BREF and HPLP-II scores in the study group were significantly higher than those in the control group, suggesting that PDCA cycle-based orthopedic rehabilitation nursing may positively influence patients' quality of life and health-promoting behaviors during the perioperative period. Within the PDCA framework, health education, psychological support, and rehabilitation guidance can be continuously optimized according to patients' recovery status, thereby enhancing self-management awareness and encouraging the adoption of healthier lifestyle behaviors. Previous research has suggested that nursing management based on the PDCA cycle can facilitate patient rehabilitation, as the continuous planning, implementation, evaluation, and improvement process optimizes nursing interventions and improves recovery outcomes, findings consistent with those of the present study [23].

Although the findings of this study suggest potential advantages of PDCA cycle-based orthopedic rehabilitation nursing, several limitations should be acknowledged. First, this was a single-center retrospective study with a relatively small sample size, which may have introduced selection bias and limited the external validity and generalizability of the findings. In addition, potential unmeasured clinical heterogeneity, including variations in surgical management and perioperative care, could not be fully controlled. Second, the control and study groups were enrolled at different times, before and after implementation of the PDCA-

based protocol, which may have introduced temporal bias and secular trends in perioperative management that could not be fully distinguished from the effects of the intervention. Third, the study group received care from a multidisciplinary team comprising orthopedic nurses, rehabilitation therapists, and supervising physicians, whereas the control group primarily received routine nursing care from ward nurses. Therefore, the observed benefits may not be attributable solely to the PDCA framework. Fourth, follow-up was largely limited to the hospitalization period, and long-term functional recovery and quality of life were not systematically evaluated. Moreover, several outcome measures, including NRS, GCQ, WHOQOL-BREF, and HPLP-II scores, were derived from self-reported assessments and may therefore be susceptible to reporting bias, social desirability bias, and interindividual differences in perception. In addition, stratified analyses by fracture subtype and surgical approach were not performed, limiting the ability to assess potential subgroup-specific effects. Furthermore, although the Harris Hip Score (HHS) was adopted as a standardized functional assessment tool in this retrospective study, it may not fully capture functional recovery characteristics specific to all femoral fracture subtypes, particularly non-hip femoral fractures. Future multicenter, prospective randomized controlled studies with larger sample sizes and extended follow-up periods are warranted to further validate these findings.

## Conclusions

In conclusion, orthopedic rehabilitation nursing based on the PDCA cycle model was associated with improved perioperative outcomes in patients undergoing surgery for femoral fractures, including reduced pain intensity, earlier postoperative mobilization, and better functional recovery, as well as improved quality of life and health-promoting lifestyle behaviors. As a structured, continuous quality improvement framework encompassing planning, implementation, evaluation, and optimization, the PDCA cycle model may enhance the effectiveness, consistency, and standardization of perioperative nursing management. However, given the single-center, retrospective design of this study, these findings should be interpreted with caution. Further multicenter prospective studies are required to confirm the effectiveness and clinical applicability of this nursing model.

## Availability of Data and Materials

The data analyzed are available from the corresponding authors upon reasonable request.

## Author Contributions

ZYC and XS designed the research study and drafted the manuscript. ZYC, XS, HPZ, PZ, YDL, and YYG performed the research. YDL and YYG analyzed the data. All authors have been involved in revising the manuscript critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

## Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of The 964th Hospital of Chinese People's Liberation Army Joint Logistics Support Force (Approval NO. Y-20260211-002), and all included patients provided informed consent. This study was conducted in strict adherence to the principles of the Declaration of Helsinki.

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## Conflict of interest

The authors declare no conflict of interest.

## References

[1] Tong YYF, Holmes S, Sefton A. Early bisphosphonate therapy post proximal femoral fracture fixation does not impact fracture healing: a systematic review and meta-analysis. ANZ Journal of Surgery. 2022; 92: 2840–2848. https://doi.org/10.1111/ans.17792

[2] Walter N, Szymski D, Kurtz S, Alt V, Lowenberg DW, Lau E, et al. Factors associated with mortality after proximal femoral fracture. Journal of Orthopaedics and Traumatology : Official Journal of the Italian Society of Orthopaedics and Traumatology. 2023; 24: 31. https://doi.org/10.1186/s10195-023-00715-5

[3] Kim CH, Yoon YC, Kang KT. The effect of cerclage wiring with intramedullary nail surgery in proximal femoral fracture: a systematic review and meta-analysis. European Journal of Trauma and Emergency Surgery : Official Publication of the European Trauma Society. 2022; 48: 4761–4774. https://doi.org/10.1007/s00068-022-02003-z

[4] Farhan-Alanie MM, Jonas SC, Gallacher D, Whitehouse MR, Chesser TJ. Fewer native and periprosthetic femoral fracture patients receive an orthogeriatric review and expedited surgery compared to hip fracture patients. Hip International : the Journal of Clinical and Experimental Research on Hip Pathology and Therapy. 2024; 34: 281–289. https://doi.org/10.1177/11207000231198459

[5] Sarkies MN, Testa L, Carrigan A, Roberts N, Gray R, Sherrington C, et al. Perioperative interventions to improve early mobilisation and physical function after hip fracture: a systematic review and meta-analysis. Age and Ageing. 2023; 52: afad154. https://doi.org/10.1093/ageing/afad154

[6] Liu J, Chen L, Long C, Zhang X, Gao F, Duan X, et al. Effect of a preoperative mobilization program on perioperative complications and function recovery in older adults with femoral neck fracture. Geriatric Nursing (New York, N.Y.). 2022; 44: 69–75. https://doi.org/10.1016/j.gerinurse.2022.01.003

[7] He YH, Wang F. PDCA nursing in improving quality management efficacy in endoscopic submucosal dissection. World Journal

of Clinical Cases. 2022; 10: 9611–9618. https://doi.org/10.12998/wjcc.v10.i27.9611

[8] Chen J, Cai W, Lin F, Chen X, Chen R, Ruan Z. Application of the PDCA Cycle for Managing Hyperglycemia in Critically Ill Patients. Diabetes Therapy : Research, Treatment and Education of Diabetes and Related Disorders. 2022; 1–9. https://doi.org/10.1007/s13300-022-01334-9

[9] Bai L, Yang L, Shi X, Huang W. Effect of PDCA circulation nursing intervention on prognosis of patients with severe pneumonia. American Journal of Translational Research. 2022; 14: 252–263.

[10] Huang L, Lu C, Pang M, Li L, Zhang Y, Su A, et al. Effect of PDCA-based nursing intervention on activities of daily living, neurological function and self-management in acute cerebral stroke. American Journal of Translational Research. 2021; 13: 5315–5321.

[11] Zhao L, Hu L, Li Z, Deng F. Plan-Do-Check-Action Circulation Combined with Accelerated Rehabilitation Nursing under Computed Tomography in Prevention and Control of Hospital Infection in Elderly Patients Undergoing Elective Orthopedic Surgery. Contrast Media & Molecular Imaging. 2022; 2022: 4574730. https://doi.org/10.1155/2022/4574730

[12] Hartrick CT, Kovan JP, Shapiro S. The numeric rating scale for clinical pain measurement: a ratio measure? Pain Practice : the Official Journal of World Institute of Pain. 2003; 3: 310–316. https://doi.org/10.1111/j.1530-7085.2003.03034.x

[13] Kolcaba KY. A theory of holistic comfort for nursing. Journal of Advanced Nursing. 1994; 19: 1178–1184. https://doi.org/10.1111/j.1365-2648.1994.tb01202.x

[14] Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. The Journal of Bone and Joint Surgery. American Volume. 1969; 51: 737–755.

[15] Keith RA, Granger CV, Hamilton BB, Sherwin FS. The functional independence measure: a new tool for rehabilitation. Advances in Clinical Rehabilitation. 1987; 1: 6–18.

[16] Development of the World Health Organization WHOQOL-BREF quality of life assessment. The WHOQOL Group. Psychological Medicine. 1998; 28: 551–558. https://doi.org/10.1017/s0033291798006667

[17] Walker SN, Sechrist KR, Pender NJ. The Health-Promoting Lifestyle Profile: development and psychometric characteristics. Nursing Research. 1987; 36: 76–81.

[18] Cai H, Wang Y, Tang W, Lu Y, Ji J, Chen L. Effects of the application of combined plan-do-check-action and enhanced recovery by nurses on patients undergoing cesarean section. African Journal of Reproductive Health. 2024; 28: 165–174. https://doi.org/10.29063/ajrh2024/v28i12.17

[19] Pavelescu D, Mirea L, Păduraru M, Beuran M, Chiotoroiu A, Grinţescu I. The role of multimodal analgesia in the decrease of postoperative surgical stress response in major neoplastic thoracoabdominal surgery. Chirurgia (Bucharest, Romania : 1990). 2011; 106: 723–728.

[20] An B, Dong W. Effects of multimodal analgesia of flurbiprofen axetil, nalbuphine and patient controlled intravenous analgesia on inflammatory factor levels and stress response in patients after laparoscopic radical gynecological malignancy surgery. Pakistan Journal of Pharmaceutical Sciences. 2022; 35: 641–647.

[21] Xiao M, Wang Q, Liu T, Ma C, Yang L, Liu F, et al. Effect of Otago exercise programme on limb function recovery in elderly patients with hip arthroplasty for femoral neck fracture. Zhong Nan Da Xue Xue Bao. Yi Xue Ban = Journal of Central South University. Medical Sciences. 2022; 47: 1244–1252. https://doi.org/10.11817/j.issn.1672-7347.2022.220307

[22] Roll C, Tittel S, Schäfer M, Burkhardt J, Kinner B. Continuous improvement process: ortho-geriatric co-management of proximal femoral fractures. Archives of Orthopaedic and Trauma Surgery. 2019; 139: 347–354. https://doi.org/10.1007/s00402-018-3086-7

[23] Zhao M, Li H, Wang J, Chu L, Huang L, Li H. The effectiveness of motivation-guided PDCA cycle nursing for self-management ability and outcomes of patients with gestational diabetes mellitus. Nursing Open. 2023; 10: 6509–6516. https://doi.org/10.1002/nop2.1903