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Original Research Article

Functional and Radiological Outcomes Following Surgical Management of Periprosthetic Femoral Fractures after Total Hip Arthroplasty

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Abstract

Background: Periprosthetic femoral fractures following total hip arthroplasty are challenging injuries requiring treatment according to fracture location, femoral stem stability, and available bone stock. This study evaluated functional and radiological outcomes following their surgical management.

Methods: This prospective observational study included 80 patients with periprosthetic femoral fractures following THA. Fractures were classified according to the Vancouver classification and treated using open reduction and internal fixation or revision arthroplasty as appropriate. Patients were followed for a minimum of 12 months. Outcomes included fracture union, time to union, implant stability, Harris Hip Score, ambulatory status, complications, and reoperation.

Results: Vancouver B2 fractures were most common (37.5%), followed by B1 (30.0%), C (17.5%), and B3 (15.0%). Overall fracture union was achieved in 93.8% of patients, with a mean union time of 18.2 ± 4.2 weeks. The union rates for B1, B2, B3, and C fractures were 95.8%, 93.3%, 83.3%, and 100%, respectively. The mean Harris Hip Score at 12 months was 81.7 ± 9.8, and 76.3% achieved excellent or good functional outcomes. Nonunion occurred in 6.3%, implant failure in 3.8%, and reoperation in 10.0% of patients.

Conclusion: Appropriate surgical management based on Vancouver fracture type, stem stability, and bone stock resulted in high union rates and satisfactory functional recovery. B3 fractures demonstrated comparatively less favorable outcomes because of their greater reconstructive complexity.

Keywords: Periprosthetic Femoral Fracture; Total Hip Arthroplasty; Vancouver Classification; ORIF; Revision Arthroplasty; Fracture Union; Harris Hip Score.

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Introduction

Periprosthetic femoral fractures (PFFs) following total hip arthroplasty (THA) are challenging complications associated with considerable morbidity, functional impairment, and technical difficulty in management. Their clinical importance has increased with the growing number of primary and revision hip arthroplasties and the increasing longevity of the elderly population. Management is influenced by fracture location, implant stability, bone stock, patient age, comorbidities, and pre-fracture functional status. [1]

Accurate classification is essential for planning appropriate treatment. The Vancouver classification is widely used because it incorporates the anatomical location of the fracture, stability of the femoral stem, and quality of the remaining bone stock. Its reliability and clinical utility have been demonstrated in previous studies.[2] The Unified Classification System subsequently extended these principles to provide a comprehensive framework for the assessment of periprosthetic fractures around different joint replacements. [3,4] Surgical treatment varies according to fracture characteristics and stem stability.

Fractures around a well-fixed femoral stem, particularly Vancouver B1 fractures, are commonly treated with open reduction and internal fixation (ORIF), whereas fractures associated with a loose stem, particularly Vancouver B2 and B3 fractures, generally require revision arthroplasty with or without supplementary fixation. Vancouver C fractures are usually managed by fixation according to standard fracture principles. [5] Despite advances in locking plates, cables, revision stems,

and surgical techniques, complications such as delayed union, nonunion, infection, implant failure, dislocation, and reoperation remain important concerns. Functional recovery may also be influenced by the patient's age, fracture pattern, implant stability, and pre-existing comorbidities. [6,7]

Therefore, the present study was undertaken to evaluate the functional and radiological outcomes following surgical management of periprosthetic femoral fractures after total hip arthroplasty, with particular emphasis on fracture union, implant stability, functional recovery, complications, and requirement for reoperation.

Materials and Methods

Study Design and Participants: This prospective observational study included 80 patients with periprosthetic femoral fractures following total hip arthroplasty who underwent surgical management. Patients fulfilling the eligibility criteria were enrolled consecutively during the study period and followed for a minimum period of 12 months.

Inclusion Criteria: Patients aged 18 years or older with a postoperative periprosthetic femoral fracture following primary or revision THA requiring surgical treatment were included. Vancouver type B1, B2, B3, and C fractures were eligible for inclusion.

Exclusion Criteria: Patients with intraoperative periprosthetic fractures, pathological fractures secondary to malignancy, active deep periprosthetic joint infection at presentation, fractures managed non-operatively, fractures following hemiarthroplasty, incomplete clinical or radiological records, or inability to complete the required follow-up were excluded.

Preoperative Assessment: A detailed history was obtained regarding age, sex, mechanism of injury, interval between primary THA and fracture, indication for primary arthroplasty, previous revision surgery, comorbidities, ambulatory status, and pre-fracture functional level.

Clinical examination included assessment of limb deformity, shortening, soft-tissue condition, neurovascular status, and associated injuries. Standard anteroposterior radiographs of the pelvis and anteroposterior and lateral radiographs of the entire femur were obtained. Computed tomography was performed where required to evaluate fracture morphology, bone stock, and implant stability.

Fracture Classification: All fractures were classified according to the Vancouver classification:

- **Type B1:** fracture around or immediately distal to a well-fixed femoral stem.
- **Type B2:** fracture around the stem with a loose femoral component but adequate bone stock.
- **Type B3:** fracture associated with a loose stem and inadequate proximal femoral bone stock.
- **Type C:** fracture well distal to the femoral stem.

Classification was based on preoperative radiographs, supplemented by CT findings where required. Femoral stem stability was confirmed intraoperatively when uncertainty remained.

Surgical Management: The surgical technique was selected according to Vancouver fracture type, femoral stem stability, bone quality, fracture configuration, and patient characteristics.

Vancouver B1 fractures were treated predominantly with open reduction and internal fixation using locking plates, cables, cerclage wires, and/or cortical strut grafts where required.

Vancouver B2 fractures were generally managed with revision of the loose femoral component using a long revision stem that bypassed the fracture, with supplementary fixation when necessary.

Vancouver B3 fractures were treated with revision arthroplasty using an appropriate long stem or other reconstructive technique according to the severity of proximal femoral bone loss. Structural graft augmentation was used when indicated.

Vancouver C fractures were treated with open reduction and internal fixation, generally using a locking plate construct with adequate proximal overlap of the femoral stem.

Postoperative Management: Postoperative management included analgesia, antibiotic prophylaxis, venous thromboembolism prophylaxis, wound care, and physiotherapy. Early mobilization was encouraged according to fixation stability and the patient's general condition.

Weight-bearing was individualized according to fracture type, fixation stability, bone quality, and surgical procedure. Patients progressed from protected or partial weight-bearing to full weight-bearing after clinical and radiological evidence of satisfactory fracture healing.

Follow-up and Outcome Assessment: Patients were evaluated at 6 weeks, 3 months, 6 months, and 12 months following surgery. At each follow-up, clinical and radiological assessments were performed.

Functional outcome was evaluated using the Harris Hip Score (HHS). The ability to return to pre-fracture ambulatory status and requirement for walking aids were also documented.

Radiological outcomes included:

- Time to fracture union
- Maintenance of fracture alignment
- Implant stability
- Stem subsidence or migration
- Loss of fixation
- Nonunion or delayed union
- Implant failure

Fracture union was defined by the presence of bridging callus or cortical continuity across the fracture site on serial radiographs together with absence of significant fracture-site pain during weight-bearing.

Complications: Postoperative complications including superficial and deep infection, dislocation, delayed union, nonunion, implant failure, stem subsidence, thromboembolic complications, and reoperation were recorded. Revision procedures performed during follow-up were also documented.

Statistical Analysis: Data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages.

Preoperative and postoperative functional scores were compared using the paired Student's t-test. Differences in outcomes according to Vancouver fracture type and surgical procedure were analyzed using the independent t-test, analysis of variance (ANOVA), Chi-square test, or Fisher's exact test, as appropriate.

Factors associated with poor functional outcome, nonunion, or reoperation were evaluated using univariate analysis, with multivariable regression performed where appropriate. A p-value <0.05 was considered statistically significant.

Results

A total of 80 patients with periprosthetic femoral fractures following total hip arthroplasty underwent surgical treatment and were evaluated during a minimum follow-up period of 12 months.

Vancouver B2 fractures were the most common fracture type. Overall, satisfactory fracture union and functional improvement were achieved in the majority of patients.

Table 1: Demographic, Clinical, and Fracture Characteristics

Variable	Number (n=80)	Percentage (%)
Age group (years)		
<60	10	12.5
60–69	22	27.5
70–79	32	40.0
≥80	16	20.0
Mean age (years)	72.1 ± 8.6	—
Sex		
Male	32	40.0
Female	48	60.0
Low-energy fall	66	82.5
High-energy trauma	14	17.5
Primary THA	67	83.8
Revision THA	13	16.2
Mean interval from THA to fracture (years)	7.4 ± 4.1	—
Vancouver classification		
B1	24	30.0
B2	30	37.5
B3	12	15.0
C	14	17.5

The mean age of the patients was 72.1 ± 8.6 years, and 60.0% were female. Low-energy falls accounted for 82.5% of fractures. Vancouver B2 was the most frequent fracture type (37.5%), followed by B1 (30.0%), C (17.5%), and B3 (15.0%).

Table 2: Surgical Management and Radiological Outcomes According to Vancouver Type

Vancouver Type	n	Predominant Surgical Treatment	Union, n (%)	Mean Time to Union (weeks)	Implant/Stem Stable at Final Follow-up, n (%)
B1	24	ORIF with locking plate ± cables	23 (95.8)	17.2 ± 3.6	23 (95.8)
B2	30	Revision long stem ± supplementary fixation	28 (93.3)	18.1 ± 4.0	28 (93.3)
B3	12	Revision arthroplasty ± graft/reconstruction	10 (83.3)	21.4 ± 4.8	10 (83.3)
C	14	ORIF with locking plate	14 (100.0)	16.8 ± 3.4	14 (100.0)
Overall	**80**	—	**75 (93.8)**	**18.2 ± 4.2**	**75 (93.8)**

Overall radiological union was achieved in 75 patients (93.8%), with a mean time to union of 18.2 ± 4.2 weeks. Vancouver C fractures demonstrated the highest union rate (100%), while B3 fractures had the lowest union rate (83.3%) and the longest mean time to union. At final follow-up, implant or stem stability was maintained in 93.8% of patients.

Table 3: Functional Outcomes Following Surgical Management

Functional Parameter	Pre-fracture/ Preoperative	6 Months	12 Months	p-value*
Harris Hip Score	74.8 ± 10.6	69.5 ± 11.2	81.7 ± 9.8	<0.001
Patients independently ambulatory, n (%)	58 (72.5)	41 (51.3)	52 (65.0)	0.018
Walking without aid, n (%)	44 (55.0)	27 (33.8)	38 (47.5)	0.021
Able to perform routine daily activities independently, n (%)	56 (70.0)	39 (48.8)	51 (63.8)	0.015

***Comparison of postoperative recovery across follow-up.**

The mean Harris Hip Score improved to 81.7 ± 9.8 at 12 months, demonstrating satisfactory functional recovery following surgery. At final follow-up, 65.0% of patients were independently ambulatory, while 47.5% were able to walk without an assistive device. Most patients showed progressive improvement between 6 and 12 months, although not all regained their pre-fracture level of mobility. At 12 months, excellent or good functional outcomes were observed in 61 patients (76.3%), while 19 patients (23.7%) had fair or poor outcomes. Patients with Vancouver B1 and C fractures generally demonstrated better functional recovery than those with B3 fractures.

Table 4: Postoperative Complications and Reoperations

Complication/Outcome	Number (n=80)	Percentage (%)
Delayed union	6	7.5
Nonunion	5	6.3
Stem subsidence/migration	4	5.0
Loss of fixation/implant failure	3	3.8
Superficial infection	3	3.8
Deep infection	2	2.5
Hip dislocation	4	5.0
Thromboembolic complication	2	2.5
Reoperation	8	10.0
Revision surgery	5	6.3

Radiological or implant-related complications were relatively uncommon. Nonunion occurred in 6.3% of patients, while implant failure was observed in 3.8%. Hip dislocation occurred in 5.0%, and deep infection in 2.5%. Eight patients (10.0%) required reoperation during follow-up, of whom five required revision surgery.

Discussion

The present study evaluated functional and radiological outcomes following surgical management of periprosthetic femoral fractures after total hip arthroplasty in 80 patients. Overall fracture union was achieved in 93.8% of patients, with a mean union time of 18.2 weeks. Functional recovery was satisfactory, with 76.3% achieving excellent or good outcomes at 12 months. However, outcomes varied according to fracture type, with Vancouver B3 fractures demonstrating slower union and comparatively poorer functional recovery. Vancouver B1 and C fractures treated predominantly with locking plate fixation demonstrated union rates of 95.8% and 100%, respectively. Froberg et al. [8] reported satisfactory

outcomes following locking-plate osteosynthesis for Vancouver B1 and C fractures and emphasized the importance of adequate fixation and appropriate plate overlap. Graham et al. [9] similarly demonstrated that locking plate fixation can provide reliable results in Vancouver B1 fractures, although fixation failure remains possible in unfavorable fracture patterns. The overall radiological union rate observed in the present study is also comparable with previous reports of locking plate fixation. Niikura et al. [10] demonstrated favorable clinical and radiological results following locking plate fixation of periprosthetic femoral fractures. Wood et al. [11] also reported satisfactory outcomes using locking compression plates around well-fixed arthroplasty components. These findings support stable fixation as an effective strategy when the femoral stem remains well fixed.

In the present study, Vancouver B2 fractures were generally managed with revision using a long femoral stem, whereas B3 fractures required more complex revision and reconstruction. B3 fractures demonstrated the lowest union rate (83.3%) and longest mean time to union (21.4 weeks), which may be related to poor proximal bone stock and greater reconstructive complexity. Hoffmann et al. [12] reported favorable outcomes with modern locking constructs in selected periprosthetic fractures, highlighting the importance of individualized treatment based on stem stability and fracture characteristics.

Although revision arthroplasty remains the traditional treatment for Vancouver B2 fractures, selected fractures may be suitable for fixation. Flury et al. [13] suggested that ORIF may represent a valuable alternative to stem revision in selected Vancouver B2 fractures. Similarly, Stoffel et al. [14] found that both fixation and revision strategies can achieve satisfactory results in appropriately selected B2 and B3 fractures, although the available evidence remains heterogeneous.

At 12 months, the mean Harris Hip Score was 81.7, and 65.0% of patients were independently ambulatory. Nevertheless, some patients did not regain their pre-fracture mobility, emphasizing the considerable functional impact of these injuries in an elderly population. Lewis et al. [15], in their systematic review and meta-analysis of Vancouver B2 fractures, also demonstrated that both ORIF and revision arthroplasty can be viable approaches, with treatment selection influenced by patient characteristics, fracture morphology, and implant stability.

The overall reoperation rate in our study was 10.0%. Nonunion occurred in 6.3%, while stem migration, implant failure, infection, and dislocation were relatively uncommon. Contemporary practice continues to demonstrate variation in the treatment of periprosthetic femoral fractures, particularly for Vancouver B2 injuries. Thaler et al. [16] highlighted differences in treatment preferences among hip surgeons, reflecting the need for individualized decision-making rather than a uniform approach for every fracture. Overall, successful management depends on accurate identification of femoral stem stability, fracture configuration, bone stock, and patient-related factors. Stable fixation is appropriate for fractures around well-fixed stems, whereas revision arthroplasty remains important when stem loosening or substantial bone loss is present.

Conclusion

Surgical management of periprosthetic femoral fractures following total hip arthroplasty resulted in satisfactory functional and radiological outcomes, with a 93.8% union rate and excellent or good functional outcomes in 76.3% of patients. Vancouver B1 and C fractures demonstrated favorable outcomes following fixation, whereas B3 fractures were associated with slower union and poorer functional recovery. Accurate fracture classification, assessment of stem stability and bone stock, and selection of an appropriate fixation or revision strategy are essential for achieving favorable outcomes.

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