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Systematic Review

Non prosthetic peri-implant femur fracture classification system and treatment algorithm: a systematic review

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ABSTRACT

Non-prosthetic peri-implant femoral fractures (NP-PIFFs) are an increasingly recognised complication of fracture fixation, particularly in elderly and osteoporotic patients. These fractures occur in femora containing retained fixation hardware and present unique biomechanical and surgical challenges. Despite their growing prevalence, current literature lacks consensus on classification systems and optimal management. This systematic review aimed to summarise existing classification systems, treatment strategies, and reported outcomes in NP-PIFFs. This review was conducted in accordance with PRISMA guidelines and registered with PROSPERO (CRD420251102564). Searches of Medline and Google Scholar were performed using the keywords peri-implant fracture, femur, classification, and treatment algorithm. Studies were included if they reported on NP-PIFF classification, management, and at least one outcome measure (union rate, one-year mortality, or complications). Study quality was assessed using the National Heart, Lung, and Blood Institute (NHLBI) tool, and data were synthesised narratively due to heterogeneity. Nineteen studies published between 2016 and 2025 met inclusion criteria, encompassing 984 patients (mean age 82 years). Seven distinct classification systems were identified, with Videla-Cés et al and Chan (NPPIF) being most commonly used. Reported treatment strategies consistently emphasised constructs spanning the entire femur, minimisation of stress risers, and preservation of stable implants to reduce operative trauma. Union rates were high (95-100%), but one-year mortality ranged from 2.7% to 36%, largely reflecting patient frailty. Complications included mechanical failure, loss of fixation, varus collapse, and medical issues such as pneumonia, delirium, and thromboembolic events. NP-PIFFs are complex injuries that remain inconsistently classified and managed across studies. Although union rates are favourable when biological fixation principles are respected, patient outcomes are significantly influenced by age, comorbidity, and systemic complications. Future research should focus on standardising classification systems, validating treatment algorithms, and developing multidisciplinary strategies to optimise both surgical and medical care.

Keywords: Peri-implant fracture, Periimplant fracture, Femur fracture, Classification, Management, Surgical fixation, Osteosynthesis, Plate fixation, Intramedullary fixation

INTRODUCTION

Fragility fractures of the femur remain one of the most common causes of orthopaedic hospital admission worldwide. Between 2004 and 2014, 27% of all fractures requiring hospitalisation were hip fractures, accounting for 58% of orthopaedic bed occupancy in the UK National Health Services, with a further 10% attributed to femoral shaft and subtrochanteric fractures.[1] An increasingly recognised complication of fracture fixation is the NP-PIFF, with an incidence ranging from 0.5% to 2.7% and significant one-year mortality.[2-5]

NP-PIFFs represent a distinct clinical challenge, occurring in femora that contain retained osteosynthesis hardware following primary fixation or osteotomy.[6] Historically, these have been grouped under the broader category of "periprosthetic fractures," which occur around joint replacements; however, the biological and mechanical considerations of NP-PIFFs differ markedly.[4]

The main difficulty in treating NP-PIFFs arises from the presence of a pre-existing fixation device, which alters the mechanical environment of the bone, interferes with healing, and restricts options for further fixation.[6,7] Although principles derived from periprosthetic fracture management may be partially applicable, a dedicated classification and treatment algorithm is needed to address the specific challenges of NP-PIFFs.[2]

In recent years, several authors have proposed implant-specific classification systems and management strategies. This systematic review aims to evaluate the existing literature on NP-PIFFs, synthesise data on classification systems and treatment algorithms, and propose a novel integrated framework. Secondary objectives include assessing key outcomes, such as union rates, one-year mortality, and post-operative complications.

METHODS

This systematic review followed the PRISMA guidelines and was prospectively registered with PROSPERO (CRD420251102564).

Eligibility criteria

Included studies reported on NP-PIFFs, described a classification system and/or treatment algorithm, and documented at least one of the following outcomes: union rate, one-year mortality, or postoperative complications. Eligible study designs included retrospective or prospective cohort studies and case series published in English. Exclusion criteria were case reports, studies limited to periprosthetic fractures, reviews, editorials, or conference abstracts.

Search strategy

A comprehensive search was conducted in Medline and Google Scholar, with assistance from hospital librarians. Keywords and MeSH terms included peri-implant fracture, femur, classification, internal fixation, and treatment algorithm. The search included all literature published up to July 2025. Reference lists of included articles were manually screened to identify additional relevant studies.

Study selection and data extraction

Two independent reviewers screened titles and abstracts. Full texts were assessed for eligibility, with disagreements resolved by consensus or a third reviewer. Data was extracted using a standardised spreadsheet, capturing study characteristics, patient demographics, classification systems, treatment strategies, union and mortality rates, and postoperative complications.

Quality assessment and synthesis

Methodological quality was assessed using the National Heart, Lung and Blood Institute (NHLBI) Quality Assessment Tool for case series and cohort studies. Studies were rated as good, fair, or poor. Due to heterogeneity in study design and outcomes, a narrative synthesis was undertaken.

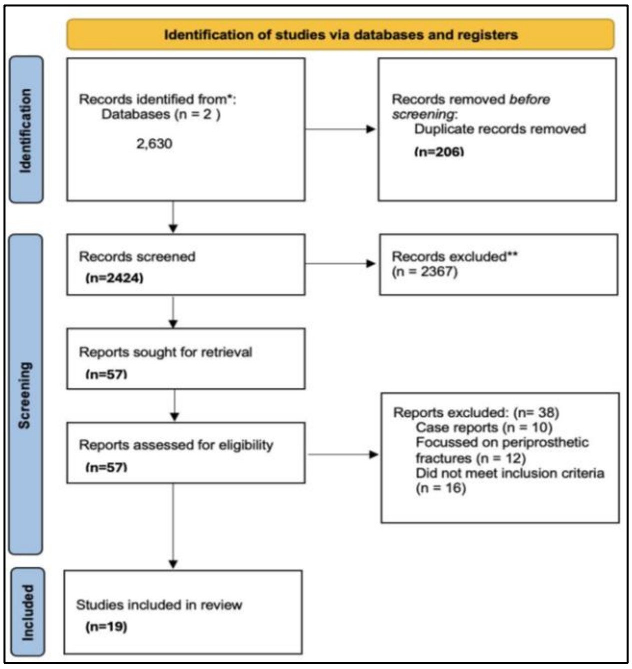

Figure 1: PRISMA flow chart.

Preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 flow diagram.

RESULTS

Study characteristics

The search yielded 2,424 unique articles; 19 studies met inclusion criteria after screening. These included 12 retrospective studies, five case series, one validation study, and one consensus review, comprising a total of 984 patients. Mean age was 82.2 years (range 22-105 years). The incidence of NP-PIFF ranged from 1.4% to 5.1% across studies.

Classifications identified

Seven distinct classification systems for NP-PIFF were identified, highlighting the lack of standardisation. The most frequently cited system was Videla-Cés et al used in five studies, categorising fractures by anatomical location and implant type.[8] Although comprehensive, it does not incorporate the healing status of the primary fracture.

Egol et al's classification simplifies fracture description to three main patterns but excludes distal implants and original fracture status.[9] The NPPIF/Chan classification adds a functional dimension by categorising primary fracture healing (A: healed, B: not healed, C: failing).[10,11] A modified version by Kruse et al expands this to include screws/pins and non-weightbearing fractures.[12]

The AO/OTA, Müller, and Skala-Rosenbaum systems provide varying degrees of anatomical detail but lack implant-specific parameters and biological context.[4,13-15] Four studies did not use any formal classification system.

The review suggests that an ideal classification should combine the structural specificity of Videla-Cés et al with the biological insight of the NPPIF/Chan framework, enabling clinicians to integrate fracture morphology with functional healing status.

Table 1: Characteristics of included studies.

Titles	Authors	Type of paper	Classification system	N	Treatment algorithm	NHLBI score
Risk factors for one-year mortality in 440 femoral peri-implant fractures: insights from the PIPPAS prospective, multicentre, observational study.[2]	Aguado	Case series study	Broggi classification	398	Yes	Good
Clinical and functional outcomes of peri-implant fractures associated with short proximal. Femur nails: prevention strategies and key insights[8]	Aguado-Maestro et al	Retrospective classification	Videla-Ces et al classification	33	-	Good
Peri-implant femoral fractures: Challenges, outcomes, and proposal of a treatment algorithm[9]	Bidolegui et al	Retrospective case series	NPPIF classification	33	Yes	Good
Non-prosthetic peri-implant fractures: classification, management and outcomes[10]	Chan et al	Retrospective case series	NPPIF classification	36	Yes	Fair
A comparison between nail-plate constructs and plate-on-plate technique in treatment of proximal femoral peri-implant fracture[11]	Chuang et al	Single centre retrospective cohort study	AO/OTA classification	37	Yes	Good
Previous implant fractures: a new descriptive classification system[12]	Egol et al	Retrospective classification	Egol et al classification	0	-	Good
Peri-implant femoral fractures in hip fracture patients treated with osteosynthesis: a retrospective cohort study of 1965 patients[13]	Kruse et al	Retrospective observational study	Modified NPPIF classification	41	-	Good
Peri-implant femoral fractures in elderly: Morbidity, mortality, treatment options and good practices[14]	Prevot et al	Retrospective	Videla-Ces et al classification	25	-	Good
Peri-implant fracture: a rare complication after intramedullary fixation of trochanteric femoral fracture[5]	Halonen et al	Retrospective	-	14	-	Good
Peri-implant femoral fractures: The risk is more than three times higher within PFN compared with DHS[4]	Muller et al	Retrospective study	Muller classification system	26	Yes	Good
Consensus review on peri-implant femur fracture treatment: Peri-implant Spanish consensus (PISCO) investigators' recommendations[6]	Castillón et al	Consensus review	-	0	Yes	Fair
Peri-implant fractures of the upper and lower extremities: a case series of 61 fractures[15]	Perskin et al	Retrospective case series	Egol et al classification	32	-	Good
A retrospective analysis of peri-implant fractures: insights from a large volume clinical study[7]	Poroh et al	Retrospective analysis	Egol et al classification	71	Yes	Good

Continued.

Titles	Authors	Type of paper	Classification system	N	Treatment algorithm	NHLBI score
Distal locking in short hip nails: Cause or prevention of peri-implant fractures?[16]	Skala-Rosenbaum et al	Retrospective analysis	Skala-Rosenbaum -their own classification system	17	-	Good
Peri-implant fractures distal to an antegrade femoral nail: a case series[17]	Jegathesan	Case series	AO/OTA classification	3	-	Good
A pilot agreement study of a new classification system for peri-implant femoral fractures[18]	Videla-Ces et al	Validation study	Videla-Ces et al classification	0	-	Good
Proposal for the classification of peri-implant femoral fractures: retrospective cohort study[19]	Videla-Ces et al	Retrospective	Videla-Ces et al classification	143	-	Good
Therapy aspects of peri-implant femoral fractures-a retrospective analysis of 64 patients[20]	Wulbrand et al	Retrospective study	-	64	Yes	Good
Peri-implant atypical femoral fracture after nail or plate osteosynthesis[21]	Kim et al	Retrospective study	-	11	Yes	Good

Table 2: Characteristics of classification system.

Classification system	No. of studies (n=19)	Structure	Advantages	Disadvantages
Videla-Ces et al's classification[2,8,14,18,19]	5	Fractures in relation to implant and anatomical location in femur	Detailed classification system that depict multiple fracture patterns in all implant types.	Does not consider original fracture healing status
Egol et al's classification[7,12,15]	3	Fracture in relation to implant	Depicts 3 fracture patterns in relation to proximal plates and nails.	Does not depict peri-implant fracture of distal implants and does not consider original fracture healing status
AO/OTA classification[11,17]	2	Fracture according to location in bone	Well-established and well-known	Not specific to NP-PIFF as it has no implant-specific classifications
NPPIF classification/ Chan classification[9,10]	2	Fracture in relation to implant	Depicts 2 fracture patterns in relation to proximal plates and nails. Considers original fracture healing status	Does not depict peri-implant fractures of distal implant.
Modified Chan classification (by Kruse et al)[13]	1	Fracture in relation to implant	Includes 3 fracture patterns in nail, plate and screw/ pins. Considers original fracture healing status.	Would benefit from inclusion of further fracture patterns
Muller et al.'s Classification system[4]	1	Fractures in relation to implant and anatomical location in femur	Provides a treatment algorithm. Includes 3 fracture patterns in all implant types	Does not consider original fracture healing status. Classification system is vague to encompass all implant types but does not offer specific treatment options based on implant type.
Skala-Rosenbaum et al's classification system[16]	1	Fractures in relation to implant and anatomical location in femur	Depicts 5 fracture patterns in relation to proximal nails	Does not depict peri-implant fracture of distal nails or plates. Does not consider original fracture healing status
No formal classification	4	-	-	-

Treatment strategies identified

Despite variability, management approaches shared consistent biomechanical principles. Most authors emphasised constructs spanning the entire femur, minimisation of stress risers, and retention of previous implants where feasible.[6,11,16,20]

For fractures distal to cephalomedullary nails, options included long-nail exchange or plate augmentation, particularly when the original fracture was unhealed.[2,10] Plate-related fractures were managed with nail-plate constructs or plate-on-plate fixation.[13] Distal femoral fractures were typically treated with locking plate osteosynthesis, such as LISS systems.[4]

Consensus guidelines, including the PISCO recommendations, reinforce the application of biological fixation principles-employing minimally invasive techniques, maintaining load-sharing constructs, and protecting the femoral neck.[6] Technical refinements, such as reconstruction nails for dual-segment protection and intentional valgus alignment to mitigate varus collapse, were also noted.[16,17]

Clinical outcomes and complications

One-year mortality was reported in 11 studies and ranged from 2.7% to 36%, highest in patients over 75 years with comorbidities. The most frequent causes of death were pneumonia, sepsis, and cardiovascular events.[2,18]

Union rates were consistently high-95-100% across 14 studies-with follow-up periods up to 43 months.[10,16,19] Reported complications included implant failure (plate breakage, screw pull-out, nail breakage), loss of fixation, and peri-implant fracture propagation.[5,17] Malalignment, including varus collapse and rotational malreduction, was observed in multiple series.

Medical complications such as pneumonia, delirium, urinary tract infections, and acute kidney injury were common, often prolonging hospital stay.[2,11,18] Thromboembolic events-notably deep vein thrombosis and pulmonary embolism-occurred predominantly in the early postoperative phase.[5,16,19]

These findings emphasise the dual importance of sound surgical technique and comprehensive perioperative care, requiring collaboration among orthopaedic, geriatric, and rehabilitation teams.

DISCUSSION

This systematic review synthesises the current literature on classification systems, treatment strategies, and clinical outcomes for NP-PIFFs-a challenging and increasingly recognised complication following fracture fixation in the elderly population.[3,20,21] The findings demonstrate marked heterogeneity in how NP-PIFFs are defined, classified, and managed, underscoring the absence of a universally accepted framework to guide clinical practice and research.

Classification systems: persistent heterogeneity

A consistent theme across the literature is the lack of a standardised, validated classification system for NP-PIFFs. Seven distinct classifications were identified among the 19 included studies, each addressing different aspects of fracture morphology, implant characteristics, or bone healing status. The most widely applied system-Videla-Cés et al's classification-categorises fractures by anatomical location and implant type; however, it omits consideration of the primary fracture's healing status, a key determinant of biomechanical stability and treatment planning.[3,8,22] In contrast, the NPPIF/Chan classification incorporates the healing status (healed, unhealed, or failing), which is clinically relevant but lacks comprehensiveness for distal and mixed-implant scenarios.[10,11]

The frequent omission of the original fracture's healing status-a factor with clear biomechanical and prognostic implications-represents a critical gap.[3,23-25] The coexistence of multiple systems limits the comparability of published data and obstructs the development of robust treatment algorithms. The trend toward hybrid or modified systems, such as the integration of Videla-Cés' structural classification with the NPPIF's functional component, reflects an evolving understanding that future classifications must integrate anatomical, mechanical, and biological dimensions. A unified, validated classification-incorporating implant type, fracture morphology, and healing status of original fracture-would provide a common language for the research, facilitate prognostic stratification, as well as the improve clinical decision-making.

Treatment strategies: convergence on core principles

Despite variations in fracture configuration and implant construct, treatment strategies across studies converged on several biomechanical principles. Authors consistently emphasised the importance of constructs spanning the entire femur, minimising stress risers, and retaining previous implants when feasible to avoid additional surgical trauma.[6,11,16,20] These tenets were reinforced by consensus recommendations from the PISCO group, which advocate biological fixation principles, implant overlap or bridging, and femoral neck protection.[6]

For fractures distal to a cephalomedullary nail, two dominant strategies emerged: long-nail exchange or supplementary plate fixation. For plate-related fractures, plate-on-plate fixation or combined nail-plate constructs were used to optimise load sharing. Distal femoral fractures were most often managed with long locking plate osteosynthesis, such as LISS systems, while retrograde nailing was reserved for select cases due to concerns of joint violation and implant interference.[4,10,16]

A recurring emphasis on biological fixation-using minimally invasive reduction, preservation of soft-tissue integrity, and respect for the healing environment-reflects a paradigm shift from rigid fixation to functional stability. The increasing use of overlapping constructs to protect the entire femur reflects growing awareness that stress concentration between implants predisposes to secondary fractures.[3,20]

Clinical outcomes and complications

Union rates were consistently high, often exceeding 95% across included studies, suggesting that predictable healing can be achieved when stable fixation and biological integrity are preserved.[10,16,19] Nonetheless, one-year mortality ranged widely from 2.7% to 36%, mirroring the frailty, multimorbidity, and advanced age typical of this patient group.[2,18]

Mortality was most frequently attributed to postoperative medical complications such as pneumonia, sepsis, and thromboembolic events.

Mechanical complications were also prominent, including implant failure (plate or nail breakage, screw pull-out), loss of fixation, and fracture propagation around existing implants.[5,17] Malalignment, particularly varus collapse and rotational malreduction, was described in several reports and may be associated with suboptimal construct length or inadequate overlap.

Equally significant were systemic complications-pneumonia, delirium, urinary tract infections, and acute kidney injury-which were strongly correlated with prolonged hospitalisation and delayed mobilisation.[2,11,16,18] The early postoperative period was also associated with a notable incidence of deep vein thrombosis and pulmonary embolism, highlighting the need for aggressive thromboprophylaxis and early mobilisation strategies.[5,16,19] Collectively, these data reinforce that NP-PIFF management requires a multidisciplinary approach integrating orthogeriatric, anaesthetic, and rehabilitation expertise to optimise outcomes and reduce systemic morbidity.

Evidence limitations and future directions

The current evidence base remains limited by methodological heterogeneity. Most studies were retrospective case series with small sample sizes, inconsistent follow-up durations, and variable outcome definitions. Only one prospective, multicentre study (the PIPPAS study) systematically evaluated mortality predictors in a large cohort, underscoring the need for higher-level evidence.[2] Furthermore, no randomised trials have directly compared fixation constructs or investigated the functional outcomes of differing surgical strategies.

Future research should prioritise the development of multicentre registries and prospective validation studies of unified classification systems. Standardised outcome measures-including functional recovery, health-related quality of life, and reoperation rates-are essential to advance the evidence base. Comparative biomechanical and clinical studies examining overlapping constructs, implant materials, and biological augmentation techniques will also be crucial in the defining optimal surgical strategies.

CONCLUSION

Non-prosthetic peri-implant femoral fractures represent a growing challenge in orthopaedic trauma, reflecting the increasing use of internal fixation devices and the aging population. This review highlights the heterogeneity in classification systems and treatment strategies and underscores the urgent need for a unified framework integrating implant type, fracture morphology, and original fracture status.

Despite limited high-level evidence, several consistent principles emerge: fixation constructs should span the entire femur, stress risers must be minimised, and existing implants should be preserved whenever possible to reduce surgical trauma. High union rates are achievable with these strategies, but the overall prognosis remains guarded due to patient frailty and systemic complications.

Future efforts should focus on prospective, multicentre validation of classification systems, comparative trials of fixation constructs, and integrated multidisciplinary care pathways aimed at optimising both surgical and systemic outcomes in this complex patient population.

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