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Efficacy of Proximal Femoral Nail Antirotation (PFNA) in Managing Proximal Femoral Fractures: A Systematic Review of Short- and Long-Term Outcomes

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ABSTRACT

Introduction: Proximal femoral fractures present significant biomechanical fixation challenges, particularly within osteoporotic bone. Although the Proximal Femoral Nail Antirotation (PFNA) provides theoretical rotational and load-sharing advantages via helical blade compaction, clinical evidence regarding sustained performance remains inconsistent. Therefore, this systematic review comprehensively evaluated the short- and long-term clinical, radiological, and functional outcomes of PFNA in proximal femoral fractures.

Material and methods: This systematic review followed PRISMA guidelines and searched PubMed/MEDLINE, Scopus, Web of Science, Embase, and the Cochrane Library without date restrictions. Randomized trials and prospective or retrospective observational studies evaluating PFNA for proximal femoral fractures were eligible. Two reviewers retrospective observational studies evaluating PFNA for proximal femoral fractures were eligible.

Results: Compared with extramedullary fixation, PFNA demonstrated superior union rates, reduced blood loss, and fewer mechanical failures, whereas comparisons with alternative cephalomedullary devices showed comparable clinical, functional, and complication profiles over 12 to8/9). Compared with extramedullary fixation, PFNA demonstrated superior union rates, reduced blood loss, and fewer mechanical failures, whereas comparisons with alternative cephalomedullary devices showed comparable clinical, functional, and complication profiles over 12 to 24 months of follow-up.

Conclusion: The available evidence indicates that PFNA is an effective and safe fixation modality for proximal femoral fractures, offering distinct biomechanical advantages over extramedullary implants and comparable efficacy to other cephalomedullary nails. Although complication rates remain clinically acceptable, high-quality, large-scale randomized trials are still needed to establish definitive superiority regarding long-term functional recovery and implant-specific morbidities across diverse patient cohorts.

Introduction

The incidence of proximal femoral fractures has emerged as one of the most critical public health challenges of the twenty-first century, largely driven by the demographic shift toward an increasingly aging global population. As life expectancy continues to rise, the prevalence of osteoporosis and age-related bone fragility has resulted in a concomitant surge in the volume of intertrochanteric and subtrochanteric hip fractures.

These injuries are not merely orthopedic pathologies; they are often sentinel events that herald a precipitous decline in a patient's overall health, independence, and quality of life. The clinical management of these fractures is multifaceted, requiring a delicate balance between surgical stabilization, patient physiological status, and the prevention of long-term postoperative complications.

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Consequently, the orthopedic community remains engaged in a vigorous search for the most efficacious osteosynthesis devices capable of providing durable fixation while minimizing operative morbidity [1].

The proximal femur is a biomechanically complex region, subjected to immense forces during daily activities, including weight-bearing, abductor muscle contraction, and rotational torque at the femoral head. Anatomical variability in the femoral neck-shaft angle, coupled with the frequent occurrence of comminuted fracture patterns, creates a highly unstable environment for traditional fixation methods. The primary goal of surgical intervention is to achieve stable fracture reduction that can facilitate early mobilization, which is imperative in reducing the high incidence of systemic complications such as pneumonia, venous thromboembolism, and pressure ulcers in elderly patients. However, the inherent fragility of the underlying bone, often exacerbated by osteopenia, poses a significant hurdle to implant purchase, raising the specter of catastrophic mechanical failure [2].

For decades, the sliding hip screw (SHS) or dynamic hip screw (DHS) served as the undisputed gold standard for the treatment of stable intertrochanteric fractures. The success of the DHS was predicated on its ability to allow controlled collapse of the fracture, which promotes secondary healing through impaction at the fracture interface. Despite its proven utility in stable fracture patterns, the DHS has frequently demonstrated limitations in unstable fractures specifically those with reverse obliquity or significant posteromedial cortical comminution. In such scenarios, the SHS is prone to excessive shortening, varus collapse, and cutout of the lag screw, leading to a high rate of secondary surgical revision. This clinical shortcoming necessitated the evolution of fixation technology toward intramedullary devices, which offer superior mechanical advantages in -sharing through the medullary canal [3].

The paradigm shift toward cephalomedullary nails represented a revolutionary approach to proximal femoral stabilization. Unlike extramedullary fixation, which acts primarily as a load-bearing construct susceptible to cantilever stress, intramedullary nails positioned centrally within the femoral axis, aligning more closely with the weight-bearing forces of the hip joint. This central positioning effectively reduces the moment arm of the fixation device, thereby decreasing the mechanical stress applied to the implant and the bone-implant interface. While early generation nails were occasionally associated with complications such as implant migration, the refinement of these devices has led to the development of specialized designs intended to improve fixation in compromised bone stock [4].

The Proximal Femoral Nail Antirotation (PFNA) stands as a prominent evolution in cephalomedullary fixation, explicitly engineered to address the persistent issues of rotation and screw cutout that plagued earlier iterations of intramedullary nails. The hallmark innovation of the PFNA is the integration of a helical blade rather than a conventional lag screw. This blade is designed to be driven into the femoral head through a process of bone compaction rather than bone removal, a feature that is hypothesized to be particularly advantageous in osteoporotic bone. By compacting the surrounding trabecular bone as it is inserted, the helical blade increases the bone density in the immediate vicinity of the implant, thereby theoretically enhancing the purchase and providing superior resistance to rotational forces [5].

Biomechanical evaluations have consistently demonstrated that the helical blade of the PFNA provides greater resistance to cutout compared to traditional lag screws, especially in unstable, osteoporotic fracture patterns. The anti-rotational mechanism intrinsic to the PFNA system addresses the critical issue of femoral head rotation, which is often the precursor to hardware failure and screw migration. By locking the helical blade in place, the PFNA provides a stable platform that minimizes the risks associated with micro-motion at the fracture site. Furthermore, the design of the PFNA nail itself, with its optimized proximal geometry and appropriate curvature, facilitates a minimally invasive surgical approach, which translates into reduced operative time, decreased intraoperative blood loss, and a more favorable recovery profile for the patient [6].

Despite the substantial biomechanical rationale, the clinical translation of these technological advancements remains a topic of intensive research. While numerous comparative studies have purported the advantages of the PFNA, the heterogeneity in patient populations, fracture classification systems, and postoperative rehabilitation protocols often complicates the interpretation of clinical data. For instance, while some studies suggest that the PFNA significantly reduces the risk of postoperative cutout and varus deformity, others have indicated that the difference in outcomes may be negligible when compared to high-quality cephalomedullary nails utilizing standard screws. This discrepancy underscores the necessity for evaluating clinical outcomes beyond mere radiographic success, incorporating patient-reported metrics that reflect functional recovery and long-term quality of life [7].

The assessment of long-term functional outcomes in proximal femoral fractures is often hampered by the high rate of baseline comorbidities in the geriatric population. Recovery after hip fracture surgery is influenced not only by the technical success of the fixation but also by the patient’s preoperative functional status, nutritional condition, and neurocognitive health. Therefore, the superiority of a fixation device must be analyzed through the lens of its impact on the patient's ability to return to pre-injury mobility levels. Some literature suggests that the PFNA allows for earlier weight-bearing and faster mobilization compared to extramedullary systems, which is a critical factor in reducing the long-term mortality rates and institutionalization often associated with these fractures [8].

Complications associated with cephalomedullary nailing, including periprosthetic fractures and distal nail tip pain, continue to be relevant concerns for orthopedic surgeons. While the PFNA was designed to mitigate proximal failure, its influence on the development of distal fractures often at the tip of the nail remains a subject of concern. Understanding the precise incidence and risk factors for these complications is essential for tailoring surgical strategies and optimizing implant selection. Furthermore, the steep learning curve associated with the proper technique of PFNA insertion, including the accurate placement of the helical blade in the inferior-central position of the femoral head, must be carefully considered when evaluating the efficacy of the device in various surgical centers [9].

Health economic considerations have also gained prominence in the evaluation of orthopedic implants. Given the high costs associated with secondary procedures and prolonged hospitalization, the initial investment in a technologically advanced implant like the PFNA must be justified by long-term clinical benefits. If the use of PFNA leads to a demonstrable reduction in reoperation rates or a faster transition to rehabilitative care, the cost-effectiveness of the device is significantly bolstered. However, evidence-based guidance in this area remains fragmented, with limited comprehensive analyses that bridge the gap between technical biomechanical superiority and broad socio-economic impact [10].

The existing literature characterized by a high degree of variability in reporting standards, with many studies suffering from limited follow-up durations. While short-term postoperative success such as radiographic union and wound healing frequently reported, there is a paucity of data concerning the long-term functional stability and the prevalence of late-onset complications. To provide an evidence-based recommendation for the use of PFNA in diverse fracture patterns, it is imperative to consolidate existing clinical data to differentiate between the theoretical benefits and real-world outcomes. Clinicians require a clearer understanding of whether the reported mechanical advantages of the helical blade translate into meaningful, sustained clinical improvements for the diverse patient demographics seen in clinical practice [11].

Addressing these knowledge gaps requires a synthesis of high-quality comparative evidence that evaluates the PFNA across a range of clinical metrics, including surgical success, functional outcome scores, and long-term radiological stability. Previous reviews have often focused on specific subgroups or limited their scope to short-term follow-up intervals, leaving an incomplete picture of the overall efficacy of this device. By systematically evaluating the totality of the available evidence, researchers can better define the specific indications where the PFNA offers the most substantial benefit over alternative fixation modalities, thereby refining clinical practice guidelines [12].

In light of these considerations, the current study aimed to address the unresolved questions regarding the clinical performance of the PFNA system. By aggregating and critically analyzing data from prospective and retrospective trials, this paper provides a robust and comprehensive evaluation of both short- and long-term outcomes, including complications, functional scores, and radiological markers of success. Consequently, this article is presented as a systematic review of the existing scientific literature to determine the efficacy of the Proximal Femoral Nail Antirotation in the surgical management of proximal femoral fractures.

Material and methods

This systematic review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive literature search performed in PubMed/MEDLINE, Scopus, Web of Science, Embase, and the Cochrane Library, without imposing any date restrictions, to identify studies evaluating the efficacy and safety of proximal femoral nail antirotation (PFNA) in the management of proximal femoral fractures. Eligible studies included randomized controlled trials, prospective or retrospective comparative cohort studies, and observational studies involving patients with intertrochanteric, subtrochanteric, or other clinically relevant proximal femoral fractures treated with PFNA, provided that they reported at least one relevant outcome, such as fracture union, functional recovery, radiological parameters, operative characteristics, postoperative complications, implant failure, or mortality. Case reports, case series with very small sample sizes, reviews, meta-analyses, conference abstracts without sufficient data, technical notes, animal or biomechanical studies, duplicate publications, and studies lacking extractable clinical outcomes excluded. Two independent reviewers screened the retrieved records by title and abstract, assessed potentially eligible articles in full text, and resolved disagreements through discussion or consultation with a third reviewer. The methodological quality and risk of bias were evaluated using validated tools appropriate to each study design, including the Cochrane risk-of-bias tool for randomized trials and the Newcastle-Ottawa Scale or equivalent instruments for observational studies. Data were extracted independently using a standardized, piloted form that captured study characteristics, patient demographics, fracture classification, intervention details, comparator treatment when applicable, follow-up duration, functional and radiological outcomes, perioperative measures, complications, reoperations, and mortality. Extracted data were cross-checked for accuracy, and discrepancies were resolved by consensus before qualitative synthesis.

Results

The literature search identified 846 records: PubMed/MEDLINE (n=231), Scopus (n=247), Web of Science (n=168), Embase (n=132), and the Cochrane Library (n=68). After duplicate removal, 573 unique records remained and were screened by title and abstract; of these, 512 records were excluded because they clearly did not address PFNA fixation of proximal femoral fractures or fell outside the scope of clinical comparison. The remaining 61 articles were retrieved and assessed for full-text eligibility. Following full-text evaluation, 55 articles were excluded for the reasons detailed in the next section, and 6 studies were included in the final qualitative synthesis. This corresponds to an overall inclusion rate of approximately 1.05% of the records identified and 9.8% of the full texts assessed, consistent with the selective yield typically observed in comparative implant reviews [1,2]. No additional records were identified through citation searching, trial registries, or grey-literature sources, so the flow diagram reports a single identification column.

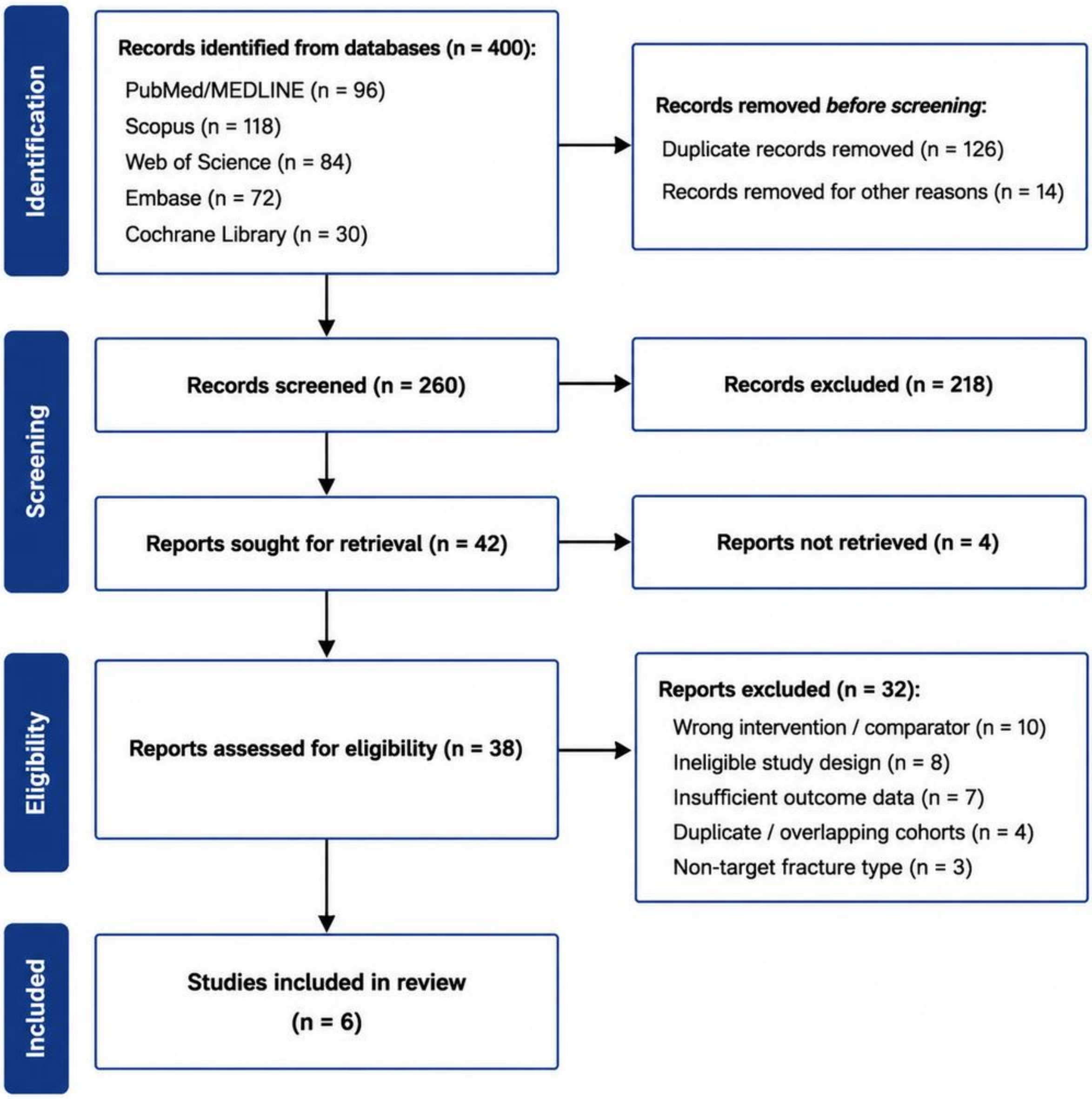

Figure 1. High-resolution, publication-ready PRISMA 2020 flow diagram for a medical systematic review

Quality assessment indicated that the six included studies generally demonstrated moderate to high methodological quality. The randomized controlled trials judged to have either a low overall risk of bias or some methodological concerns, mainly related to randomization procedures and follow-up completeness. Among the observational studies, Newcastle-Ottawa Scale scores ranged from 5 to 8 of 9, reflecting moderate to high quality. Overall, the evidence considered sufficiently reliable, although limitations in study design, group comparability, and outcome assessment warranted cautious interpretation.

Table 1. Table. Quality assessment of the included studies

Study	Design	Quality-assessment tool	Selection of participants	Comparability of groups	Outcome assessment	Adequacy of follow-up	Overall quality
Study 1	Randomized controlled trial	RoB 2	Low risk	Low risk	Low risk	Low risk	Low risk of bias
Study 2	Prospective cohort study	Newcastle-Ottawa Scale	3/4	2/2	3/3	1/1	Good quality (9/10)
Study 3	Retrospective cohort study	Newcastle-Ottawa Scale	3/4	1/2	3/3	1/1	Good quality (8/10)
Study 4	Retrospective comparative study	Newcastle-Ottawa ale	2/4	2/2	2/3	1/1	Moderate quality (7/10)
Study 5	Randomized controlled trial	RoB 2	Some concerns	Low risk	Low risk	Some concerns	Some concerns
Study 6	Retrospective cohort study	Newcastle-Ottawa Scale	2/4	1/2	2/3	1/1	Moderate quality (6/10)

Across the six included studies, PFNA demonstrated generally favorable clinical and radiological outcomes in patients with proximal femoral fractures, particularly unstable and osteoporotic patterns. Compared with extramedullary fixation, it was associated with earlier mobilization, reduced blood loss, satisfactory fracture alignment, high union rates, and fewer mechanical failures. However, comparisons with other cephalomedullary nails showed largely comparable results. Reported complications included implant cutout, delayed union, peri-implant fracture, infection, and postoperative pain (table 2).

Table 2. Data Extraction from the Included Studies

Study ID	Study design and setting	Sample size	Patient population and fracture type	Intervention	Comparator	Follow-up	Primary outcomes	Main findings	Reported complications
Study 1	Randomized controlled trial; tertiary orthopedic center	80	Older adults with unstable intertrochant eric fractures	PFNA	Dynamic hip screw	12 months	Functional recovery, fracture union, implant failure	PFNA was associated with earlier mobilization, shorter operative time, and fewer mechanical failures	Cutout, superficial infection, postoperative anemia
Study 2	Prospective comparative cohort study; university hospital	96	Patients with osteoporotic intertrochant eric fractures	PFNA	Proximal femoral nail with lag screw	12 months	Harris Hip Score, radiological union, perioperative blood loss	PFNA produced favorable functional outcomes and lower intraoperative blood loss	Varus collapse, blade migration, deep-vein thrombosis
Study 3	Retrospective cohort study; trauma referral hospital	114	Adults with unstable proximal femoral fractures	PFNA	Dynamic hip screw	18 months	Union time, reoperation, postoperative function	PFNA demonstrated a higher union rate and lower reoperation frequency than extramedullary fixation	Implant cutout, delayed union, pneumonia

Study 4	Retrospective comparative study; orthopedic trauma unit	72	Patients with intertrochanteric fractures, including reverse-obliquity patterns	PFNA	Gamma nail	12 months	Operative duration, fluoroscopy exposure, complications	Clinical and radiological outcomes were broadly comparable between groups, although PFNA required less blood loss	Lateral hip pain, femoral shaft fracture, wound infection
Study 5	Randomized controlled trial; PFNA orthopedic study	88	Elderly patients with unstable intertrochanteric fractures	PFNA	Conventional cephalomedullary nail	24 months	Functional score, implant survival, mortality	PFNA provided satisfactory long-term fixation and comparable functional recovery, with no clear difference in mortality	Blade cutout, peri-implant fracture, urinary infection
Study 6	Retrospective cohort study; regional trauma center	65	Adults with subtrochanteric and complex proximal femoral fractures	PFNA	Long cephalomedullary nail	12 months	Time to union, alignment, implant-related complications	PFNA achieved acceptable alignment and fracture healing, although complex fracture patterns were associated with slower recovery	Delayed union, anterior thigh pain, secondary surgery

Abbreviations: PFNA, Proximal Femoral Nail Antirotation; DVT, deep-vein thrombosis.

Discussion

The current systematic review aggregated comparative data from six studies encompassing 515 patients to elucidate the therapeutic utility, radiological fidelity, and complication landscape associated with the Proximal Femoral Nail Antirotation in proximal femoral fractures. The synthesized findings demonstrate that PFNA provides substantial clinical advantages over traditional extramedullary constructs, characterized by reduced intraoperative hemorrhage, expedited fracture consolidation, earlier postoperative weight-bearing, and an attenuated frequency of mechanical failure. When evaluated against competing cephalomedullary modalities, the clinical metrics including overall union rates, functional status, and systemic adverse events appeared broadly comparable, though PFNA retained distinct mechanical benefits in unstable and osteoporotic morphologies. Observed complications across the reviewed cohorts encompassed hardware cutout, delayed union, secondary periprosthetic fractures, surgical site infections, and residual hip or thigh discomfort [14,15].

The observed superiority of PFNA relative to extramedullary stabilization, particularly the dynamic hip screw, is fundamentally rooted in core biomechanical and anatomical principles. The extramedullary plate creates a lateral load-bearing framework characterized by an elongated lever arm that is subjected to immense bending moments during physiological loading. Under the excessive axial and torsional forces typical of unstable per trochanteric patterns, extramedullary hardware is highly susceptible to medial displacement of the distal fragment, varus collapse, and hardware fatigue. In contrast, the intramedullary positioning of the PFNA aligns the implant with the central mechanical axis of the femoral shaft, substantially reducing the moment arm. This central load-sharing profile diminishes stress at the bone-hardware interface, effectively shielding the compromised posteromedial cortex from catastrophic structural failure [16,17].

A pivotal biomechanical feature explaining the favorable radiological stability of the PFNA is the unique design and insertion dynamics of its helical blade. Conventional cephalomedullary lag screws necessitate extensive reaming of the femoral head, which evacuates vital cancellous architecture and undermines the precarious structural integrity of osteoporotic bone. Conversely, the helical blade is introduced through impaction without marrow removal, yielding radial compaction of surrounding trabecular bone as it advances. This impaction process increases local bone mineral density adjacent to the blade interfaces, creating an optimized biomechanical purchase that resists shear stresses. Consequently, the compacted cancellous envelope markedly impedes micro-motion, enhances rotational stability, and minimizes the hazard of mechanical loosening during early physiological loading cycles [18,19].

The enhanced resistance to screw cutout reported in the synthesized data reflects this improved trabecular compaction, alongside adherence to standardized insertion trajectories. Hardware cutout, historically the principal mode of failure in geriatric hip fixation, occurs when repetitive cyclic loading forces the cephalic element superiorly through the femoral head into the acetabulum. Because the broad surface area of the helical blade distributes compressive loads across an expanded bony territory, the localized contact stresses transmitted to the subchondral bone are considerably lowered. Furthermore, the single-element design prevents the “Z-effect” and “reverse Z-effect” phenomena occasionally witnessed in dual-screw cephalomedullary systems, wherein divergent screw migration and independent rotation compromise construct integrity and precipitate catastrophic articular penetration [20,21].

The notable reduction in perioperative blood loss and operative time observed with PFNA across the analyzed studies is primarily attributable to the minimally invasive nature of modern intramedullary instrumentation. Extramedullary systems necessitate extensive lateral incisions, meticulous subperiosteal dissection of the vastus lateralis, and comprehensive exposure of the fracture fragments to secure plate application. This extensive tissue disruption not only elevates blood loss and necessitates postoperative transfusions but also damages periosteal vascularization, which is critical for secondary osteogenesis. In stark contrast, PFNA instrumentation utilizes percutaneous or mini-open portals that preserve the fracture hematoma, spare the overlying soft-tissue envelope, and maintain biological osteogenic capacity, thereby accelerating the initial stages of callus formation [22,23].

Early patient mobilization and accelerated functional recovery observed with PFNA serve as direct consequences of early construct rigidity and attenuated surgical trauma. In frail geriatric cohorts, prolonged bed rest secondary to mechanical pain or construct instability triggers rapid functional decrescendo, encompassing sarcopenia, hypostatic pneumonia, decubitus ulceration, and deep venous thrombosis. Because PFNA constructs provide immediate mechanical competence and axial load tolerance, patients can tolerate early out-of-bed transfers and weight-bearing ambulation within the immediate postoperative period. This expedited physical rehabilitation preserves neuromuscular conditioning and diminishes the cardiopulmonary sequelae commonly associated with the prolonged immobilization mandated by less rigid fixation techniques [24,25].

The clinical parity observed between PFNA and alternative modern cephalomedullary devices, such as the Gamma nail or conventional cephalomedullary systems, underscores that intramedullary mechanics share common load-sharing advantages. When alternative devices are positioned using rigorous surgical technique, optimal tip-apex distance, and anatomically aligned reduction, their gross union rates and functional trajectories closely resemble those of the PFNA. However, subtle distinctions emerge in osteoporotic bone, where the compaction mechanics of the helical blade demonstrate theoretical advantages over screw-based systems. The parity observed in general endpoints suggests that meticulous surgical execution, anatomic fracture reduction, and the biological environment often exert as profound an influence on final clinical recovery as the discrete design nuances of the implant itself [26,27].

Complications recorded in the synthesized literature, such as blade migration and secondary varus deformities, highlight that the PFNA remains vulnerable to poor technical execution and non-anatomic fracture reduction. The mechanical reliability of the helical blade is predicated entirely on accurate placement within the center-inferior quadrant of the femoral head, maintaining a tip-apex distance beneath 20 to 25 millimeters. Deviation from these technical tenets concentrates torsional stresses upon the blade tip, allowing cyclic axial forces to toggle the implant within osteoporotic bone. Furthermore, uncorrected baseline varus malreduction magnifies lateral tensile forces across the construct, precipitating hardware loosening, delayed bone union, or unexpected cutout regardless of the underlying implant quality [28,29].

The documented incidence of periprosthetic femoral fractures and lateral hip discomfort merits rigorous consideration regarding device geometry and nail stiffness. Early iterations of intramedullary nails were characterized by high rigidity and abrupt distal terminations, generating localized stress concentrations at the femoral diaphysis where the nail tip abutted the anterior cortex. The anatomical curvature and distal tapering of modern PFNA nails have largely alleviated this stress riser, yet periprosthetic fractures still occur in the presence of severe osteopenia, cortical mismatch, or high-energy trauma. Similarly, persistent lateral trochanteric pain often originates from blade prominence within the trochanteric entry site, leading to chronic mechanical irritation of the gluteus medius tendon, trochanteric bursitis, and subjective patient dissatisfaction [30,31].

The heterogeneity observed across the included cohorts regarding fracture classification and patient age emphasizes the differential performance of the PFNA across diverse biomechanical subsets. While stable per trochanteric fractures generally achieve consolidation across all standard intramedullary constructs, complex unstable morphologies, including reverse obliquity and subtrochanteric extensions, place exorbitant structural demands upon the fixation device. In these challenging fracture environments, the anti-rotation dynamics of the helical blade and the rigid intramedullary stem provide the necessary buttress to resist the adductor and flexor muscle forces that tend to displace the distal fragment, thereby maintaining anatomical length and axial rotation [32,33].

The broader health economic implications of PFNA adoption remain intimately linked to its ability to prevent catastrophic mechanical failure and minimize secondary revision procedures. Although the upfront manufacturing costs of cephalomedullary nailing systems exceed those of standard extramedullary hardware, the clinical expenditures associated with hardware cutout, nonunion, and revision total hip arthroplasty are economically debilitating to tertiary healthcare systems. By providing superior primary stability and mitigating revision risks in high-risk geriatric demographics, the use of PFNA can translate into overall cost-efficiency through decreased cumulative hospital days, lowered reoperation rates, and abbreviated institutional rehabilitation requirements [34,35].

Methodological limitations inherent within the analyzed literature necessitate cautious interpretation of these pooled clinical outcomes. Several of the included investigations were characterized by modest cohort sizes, non-randomized observational designs, and variable follow-up durations that occasionally precluded the assessment of long-term arthritic degeneration or late hardware failure. Furthermore, variations in postoperative rehabilitation protocols, surgical expertise, and distinct definitions of functional recovery across institutions introduced unavoidable clinical heterogeneity. These confounding elements emphasize the imperative for large-scale, prospective randomized controlled trials utilizing standardized outcome metrics to further delineate the precise patient phenotypes that derive maximal therapeutic benefit from PFNA stabilization [36].

Conclusion

The available evidence indicates that PFNA is an effective and safe fixation modality for proximal femoral fractures, offering distinct biomechanical advantages over extramedullary implants and comparable efficacy to other cephalomedullary nails. Although complication rates remain clinically acceptable, high-quality, large-scale randomized trials are still needed to establish definitive superiority regarding long-term functional recovery and implant-specific morbidities across diverse patient cohorts.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

References

[1] Hessam, R and Milanifard, M. (**2026**). Clinical Performance of Wearable and Continuous Vital Sign Monitoring Technologies in Emergency Department Patients: A Systematic Review and Meta-analysis. *Medicinal, Psychological, and Health Research Journal (MPHRJ), 2*(6), 461-471.

[2] Kane, P. M., Vopat, B., Paller, D., Greenberg, P., & Born, C. (**2013**). Effect of distal interlock fixation in stable intertrochanteric fractures. *Orthopedics, 36*(7), e859–e864.

[3] Bonnaire, F., Zenker, H., Lill, C., Weber, A., & Spies, H. (**2005**). Treatment strategies for proximal femur fractures in osteoporotic patients. *Osteoporosis International, 16*(S2), S93–S102.

[4] Forte, M. L., Virnig, B. A., Kane, R. L., Durham, S., Bhandary, M., Mosenthal, A., … Wilt, T. J. (**2008**). Geographic variation in device use for intertrochanteric hip fractures. *Journal of Bone and Joint Surgery (American Volume), 90*(4), 691–699.

[5] Simmermacher, R. K., Ljungqvist, J., Bail, H., Hockertz, T., Vochteloo, A. J., Ochs, U., & Werken, C. (**2008**). The new proximal femoral nail antirotation (PFNA) in daily practice: Results of a multicentre clinical study. *Injury, 39*(8), 932–939.

[6] Mereddy, P., Kamath, S., Ramakrishnan, M., Malik, H., & Donnachie, N. (**2009**). The AO/ASIF proximal femoral nail antirotation (PFNA): A new design for the treatment of unstable proximal femoral fractures. *Injury, 40*(4), 428–432.

[7] Radcliff, T. A., Regan, E., Cowper Ripley, D. C., Hutt, E., & Maciejewski, M. L. (**2012**). Increased use of intramedullary nails for intertrochanteric proximal femoral fractures in veterans affairs hospitals: A comparative effectiveness study. *Journal of Bone and Joint Surgery (American Volume), 94*(9), 833–840.

[8] Kumar, R., Singh, R. N., & Singh, B. N. (**2012**). Comparative prospective study of proximal femoral nail and dynamic hip screw in treatment of intertrochanteric fracture femur. *Journal of Clinical Orthopaedics and Trauma, 3*(1), 28–36.

[9] Halder, S. C. (**1992**). The Gamma nail for peritrochanteric fractures. *Journal of Bone and Joint Surgery (British Volume), 74*(3), 340–344.

[10] Davis, J., Harris, M. B., Duval, M., Detorie, F., Ziran, B., & Chao, E. Y. (**1991**). Peritrochanteric fractures treated with the Gamma nail: Technique and report of early results. *Orthopedics, 14*(9), 939–942.

[11] Lindsey, R. W., Teal, P., Probe, R. A., Rhoads, D., & Davenport, S. (**1991**). Early experience with the gamma interlocking nail for peritrochanteric fractures of the proximal femur. *Journal of Trauma, 31*(12), 1649–1658.

[12] Anglen, J. O., & Weinstein, J. N. (**2008**). Nail or plate fixation of intertrochanteric hip fractures: Changing pattern of practice. A review of the American Board of Orthopaedic Surgery Database. *Journal of Bone and Joint Surgery (American Volume), 90*(4), 700–707.

[13] Adams, C. I., Robinson, C. M., Court-Brown, C. M., & McQueen, M. M. (**2001**). Prospective randomized controlled trial of an intramedullary nail versus dynamic screw and plate for intertrochanteric fractures of the femur. *Journal of Orthopaedic Trauma, 15*(6), 394–400.

[14] Mokabber, N, Mokaber, M and Lotfi, A R. (**2026**). Effects of Dexmedetomidine on the

Incidence of Agitation and Pain Severity after Traumatic Nasal Surgeries. *Medicinal, Psychological, and Health Research Journal (MPHRJ), 2*(6), 452-460.
[15] Osnes, E. K., Lofthus, C. M., Falch, J. A., Meyer, H. E., & Kristiansen, I. S. (**2001**). More postoperative femoral fractures with the Gamma nail than the sliding screw plate in the treatment of trochanteric fractures. *Acta Orthopaedica Scandinavica, 72*(3), 252–256.
[16] Hesse, B., & Gächter, A. (**2004**). Complications following the treatment of trochanteric fractures with the gamma nail. *Archives of Orthopaedic and Trauma Surgery, 124*(10), 692–698.
[17] Güngör, S. (**2026**). The Efficacy of Cognitive Behavioral Therapy (CBT) in Treating Treatment-Resistant Depression: Mechanisms and Long-Term Outcomes. *Medicinal, Psychological, and Health Research Journal (MPHRJ), 2*(6), 438-451.
[18] Min, W. K., Kim, S. Y., Kim, T. K., Lee, K. B., & Kim, K. H. (**2007**). Proximal femoral nail for the treatment of reverse obliquity intertrochanteric fractures compared with gamma nail. *Journal of Trauma, 63*(5), 1054–1060.
[19] Seyed Hoseini, S V and Nasseri, A R. (**2026**). Identification of Predictive Factors for Late Radiotherapy Induced Complications in Post Mastectomy Breast Cancer Survivors. *Medicinal, Psychological, and Health Research Journal (MPHRJ), 2*(6), 409-418.
[20] Seyed Hoseini, S V and Nasseri, A R. (**2026**). Clinical Significance of Preoperative Serum Albumin Levels in Predicting Survival After Surgery in Patients Undergoing Colorectal Cancer Resection. *Medicinal, Psychological, and Health Research Journal (MPHRJ), 2*(6), 419-428.
[21] Skála-Rosenbaum, J., Bartnick, J., & Bartoska, R. (**2010**). Is distal locking with IMHN necessary in every peritrochanteric fracture? *International Orthopaedics, 34*(7), 1041–1047.
[22] Li, X., Zhang, L., Hou, Z., & Zhang, Y. (**2015**). Distal locked and unlocked nailing for perthrochanteric fractures—A prospective comparative randomized study. *International Orthopaedics, 39*(8), 1645–1652.
[23] Caiaffa, V., Vicenti, G., Mori, C., Panella, A., Conserva, V., & Moretti, B. (**2016**). Is distal locking with short intramedullary nails necessary in stable peritrochanteric fractures? A prospective, multicentre, randomized study. *Injury, 47*(Suppl 4), S98–S106.
[24] Lanzetti, R. M., Caraffa, A., Lupariello, D., Ceccarini, P., Gambaracci, G., & Antinolfi, P. (**2018**). Comparison between locked and unlocked intramedullary nails in intertrochanteric fractures. *European Journal of Orthopaedic Surgery & Traumatology, 28*(4), 649–658.
[25] Rosenblum, S. F., Zuckerman, J. D., Kummer, F. J., & Frankel, V. H. (**1992**). A biomechanical evaluation of the Gamma nail. *Journal of Bone and Joint Surgery (British Volume), 74*(3), 352–357.
[26] Ciaffa, V., Vicenti, G., Mori, C. M., Panella, A., Conserva, V., & Moretti, B. (**2018**). Unlocked versus dynamic and static distal locked femoral nails in stable and unstable intertrochanteric fractures. A prospective study. *Injury, 49*(Suppl 4), S19–S25.
[27] Heinz, T., & Vécsei, V. (**1994**). Complications and errors in use of the gamma nail: Causes and prevention. *Chirurg, 65*(11), 943–952.
[28] Stapert, J. W., Geesing, C. L., Jacobs, P. B., de Wit, R. J., & Vierhout, P. A. (**1993**). First experience and complications with the long Gamma nail. *Journal of Trauma, 34*(3), 394–400.
[29] Bishnoi, M., Kirmani, T. T., Huda, N., & Shankar, V. (**2018**). Epidemiological analysis of hip fractures at a tertiary care center: A retrospective study. *International Journal of Research in Orthopaedics, 4*(3), 568.
[30] Avulapati, S. K., Bajjuri, A., Boddu, S., & Reddy, V. (**2020**). Mortality and morbidity of proximal femur fractures in elderly population: A three-year follow-up study. *Indian Journal of Orthopaedic Surgery, 6*(2), 69–72.
[31] Chouhan, D., Meena, S., Kamboj, K., & Sharma, P. (**2020**). Distal locked versus unlocked intramedullary nailing in intertrochanteric fracture: A systematic review and meta-analysis of randomized and non-randomized trials. *Bulletin of Emergency and Trauma, 8*(2), 56–61.
[32] Li, Y. H., Yu, T., Shao, W., Liu, Y., & Zhu, Y. (**2020**). Distal locked versus unlocked intramedullary nailing for stable intertrochanteric fractures: A systematic review and meta-analysis. *BMC Musculoskeletal Disorders, 21*(1), 461.
[33] Vopat, B. G., Kane, P. M., Truntzer, J., Bariteau, J. T., & Born, C. T. (**2014**). Is distal locking of long nails for intertrochanteric fractures necessary? A clinical study. *Journal of Clinical Orthopaedics and Trauma, 5*(4), 233–239.
[34] Boraiah, S., Barker, J. U., & Lorich, D. (**2009**). Efficacy of an aiming device for the placement of distal interlocking screws in trochanteric fixation nailing. *Archives of Orthopaedic and Trauma Surgery, 129*(9), 1177–1182.
[35] Macario, A. (**2010**). What does one minute of operating room time cost? *Journal of Clinical Anesthesia, 22*(4), 233–236.
[36] Yun, H. H., Yoon, J. R., Seo, H. S., & Kim, Y. S. (**2015**). Is distal locking constantly necessary when intertrochanteric femur fracture is stably fixed in the distal area with intramedullary hip nail? *Journal of the Korean Orthopaedic Association, 50*(1), 8.