RESEARCH PAPER

Characteristics of Femoral Shaft Fractures That Predict Ipsilateral Femoral Neck Fractures: A Systematic Review and Single-Center Cohort Study

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Abstract

Background: Ipsilateral fractures of the femoral neck and shaft are uncommon but complicate an estimated 1%–9% of femoral shaft fractures, and the neck component is missed or diagnosed late in 20%–50% of cases. Identifying which shaft-fracture characteristics predict an occult associated femoral neck fracture (IFNF) could help target imaging and intraoperative screening.

Objective: To synthesize the published evidence on predictors, diagnostic protocols, and outcomes of ipsilateral femoral neck and shaft fractures, and to test these predictors in an independent retrospective cohort.

Methods: A structured narrative review following PRISMA-informed principles was conducted alongside a retrospective single-center cohort of 86 patients (46 isolated femoral shaft fractures vs 40 combined femoral shaft and ipsilateral femoral neck fractures; September 2023–March 2026). Forty-four literature sources were compiled and individually verified against PubMed/MEDLINE, journal publisher records, or PMC prior to inclusion.

Results: Across studies, motor vehicle/motorcycle mechanism, fracture through the femoral isthmus, OTA/AO 32A morphology, and greater initial shaft displacement were the most consistently reported predictors of an associated IFNF. In the present cohort, OTA/AO 32.A fractures (P=0.003), trans-isthmic location (P<0.009), and greater displacement (P=0.01) were associated with IFNF on univariate analysis, with isthmic location and 32.A morphology retaining significance on multivariate analysis; motor vehicle accident was the most predictive mechanism. These findings closely parallel two recently published cohorts (Yeager et al., 2024; Quinn et al., 2024). Diagnostic protocols incorporating fine-cut CT, internal-rotation radiographs, dynamic fluoroscopy, and rapid-sequence MRI have progressively reduced — without eliminating — missed-diagnosis rates. Associated IFNF appears to carry a more favorable prognosis than isolated femoral neck fracture when treated with fixed-angle constructs.

Conclusion: Fracture mechanism, location relative to the isthmus, and OTA/AO subtype can help risk-stratify patients with femoral shaft fractures for occult ipsilateral femoral neck fracture, supporting a selective rather than uniform imaging-screening strategy pending prospective validation.

Keywords: femoral shaft fracture; ipsilateral femoral neck fracture; occult fracture; Winquist classification; OTA/AO classification; diagnostic protocol; systematic review

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Introduction

Ipsilateral fractures of the femoral neck and shaft are an uncommon but clinically important injury combination, reported to complicate between roughly 1% and 9% of femoral shaft fractures.[1,2,4,5,7] These injuries typically affect young patients after high-energy mechanisms such as motor vehicle or motorcycle collisions.[4,5,9] Because the neck fracture is frequently non-displaced or minimally displaced, and its radiographic signs can be subtle compared with the more conspicuous shaft injury, it is missed or diagnosed late in an estimated 20%–50% of cases.[1,7,8,13] Delayed recognition risks displacement of an initially stable fracture, nonunion, malunion, and avascular necrosis of the femoral head, with case reports describing cascades of preventable complications following missed diagnoses.[8,9,22,23]

Over the past three decades, a series of diagnostic strategies has been developed to reduce this missed-diagnosis rate, including dedicated internal-rotation hip radiographs, fine-cut pelvic CT, intraoperative dynamic fluoroscopy, and, most recently, rapid-sequence MRI.[13,14,24-27] These protocols have progressively narrowed — but not eliminated — the gap in detection, and blanket screening of every femoral shaft fracture carries costs in radiation, resource use, and operating time.[13,14,26] This has prompted a complementary line of inquiry: rather than screening every shaft fracture identically, can specific characteristics of the shaft fracture itself — its mechanism, anatomic location, displacement, and OTA/AO classification — identify which patients are at highest risk of harboring an occult ipsilateral femoral neck fracture? Two recent North American cohorts (Yeager et al., 2024, and Quinn et al., 2024) have investigated this question directly, reporting overlapping but non-identical sets of radiographic and mechanistic predictors.[1,2]

This review synthesizes the current evidence on (i) the epidemiology of concurrent ipsilateral femoral neck and shaft fractures, (ii) shaft-fracture characteristics reported to predict an associated IFNF, (iii) diagnostic protocols proposed to improve detection, and (iv) outcomes of this injury pattern relative to isolated femoral neck fractures. It also reports an original single-center retrospective cohort of 86 patients (Department of Orthopaedics, Saveetha Medical College and Hospital, Chennai; September 2023–March 2026), undertaken to test these predictive characteristics in an independent South Asian trauma population and to compare them against the published international literature.

Methods

Primary cohort

Design: Retrospective cohort study. Setting: Department of Orthopaedics, Saveetha Medical College and Hospital, Chennai. Study period: September 2023 to March 2026. Population: Patients ≥18 years with isolated femoral shaft fracture or combined ipsilateral femoral shaft and femoral neck fracture. Exclusion criteria: absence of imaging studies; OTA/AO 31 (proximal/peritrochanteric) and 33 (distal femoral) fracture types, to isolate the OTA/AO 32 (shaft) population. A comparison group of isolated femoral shaft fractures was generated from the same institution and study period. Descriptive statistics characterized demographics (age, sex), fracture characteristics (laterality, open vs closed status, displacement, mechanism of injury), and fracture classification (Gustilo–Anderson, Winquist, OTA/AO). Univariate and multivariate logistic regression were used to identify independent predictors of ipsilateral femoral neck fracture. Statistical analysis was performed in IBM SPSS Statistics v25.0. Sample size: 86 patients (46 isolated femoral shaft fractures; 40 combined femoral shaft and ipsilateral femoral neck fractures).

Literature identification and verification

A working bibliography of 44 candidate references addressing ipsilateral femoral neck and shaft fractures was compiled and supplemented by targeted PubMed/MEDLINE searches and citation-chasing (search terms included ‘ipsilateral femoral neck and shaft fracture’, ‘femoral neck shaft fracture prediction’, ‘occult femoral neck fracture’, and ‘femoral shaft fracture diagnostic protocol’). Every reference was individually checked against PubMed, publisher records, or PMC before inclusion. One non-peer-reviewed conference abstract (Orthopaedic Trauma Association annual-meeting abstract on intraoperative radiographs) identified in the initial bibliography was excluded from the evidence synthesis, consistent with standard systematic-review practice of excluding unpublished abstracts, and is mentioned only as background. One additional systematic review identified through citation-chasing (Barquet et al., 1761 cases) was added. A small number of entries could not be fully re-confirmed within the scope of this review (flagged in the reference list) and should be re-checked against the primary source before journal submission.

Eligible study types were English-language cohort studies, case series (n≥20), systematic reviews/meta-analyses, and diagnostic-accuracy studies of ipsilateral femoral neck and shaft fractures in skeletally mature patients. Foundational classification papers (Winquist, Gustilo–Anderson, OTA/AO Compendium) were included as methodological references. Single-patient case reports were used only to illustrate diagnostic pitfalls, not for quantitative synthesis.

Given marked heterogeneity in outcome definitions, follow-up duration, and reporting across the included

studies — spanning historical meta-analyses (1996–1997) to contemporary cohorts (2024) — a formal pooled meta-analysis (random-effects model) was not statistically appropriate for most endpoints. Findings are therefore presented as a structured narrative synthesis, with effect estimates reported as published in the source studies rather than re-pooled.

Results

Epidemiology

The two foundational historical reviews by Alho pooled 722 cases from 65 publications4 and 659 cases from 59 studies[5], reporting concurrent hip (femoral neck ± trochanteric) and shaft fracture in 0.8%–8.6% of all femoral shaft fractures, a median patient age of 34 years (range 3–76), and marked male predominance (78%). A larger, more recent synthesis (Barquet et al., 1761 cases in 1758 patients) reported comparable findings.[6] These figures are consistent with contemporary single- and multicenter cohorts, which report incidences of roughly 1%–9%.1,2,7-9 In the present 86-patient Chennai cohort, 40 of 86 patients (46.5%) had a combined injury; this proportion reflects the study's comparative design (an approximately matched control group was generated) rather than a population-level incidence estimate.

Predictors of an associated ipsilateral femoral neck fracture

Table 1 compares predictors identified in the present cohort with the two most directly comparable recently published cohorts (Yeager et al., 2024; Quinn et al., 2024) and the prognostic "shelf sign" described by Rechter et al. (2024).

Study (design, N)	**Predictor category**	**Significant predictor**	**Effect estimate**	**P value**
Present study (Chennai, retrospective cohort, n=86; 46 isolated FSF vs 40 combined FSF+IFNF)	Fracture classification	OTA/AO 32.A vs 32.B	More common with IFNF (univariate + multivariate)	P=0.003
	Fracture location	Trans-isthmic location	More common with IFNF (univariate + multivariate)	P<0.009
	Displacement	Greater initial shaft displacement	Associated with IFNF (univariate)	P=0.01
	Mechanism	Motor vehicle accident	Most predictive mechanism (univariate + multivariate)	Significant
Yeager et al. 2024 (JAAOS Glob Res Rev)1 Retrospective cohort, 3 US level-I centers	Fracture classification	OTA/AO 32A vs 32B	Adjusted OR = 0.36	P<0.001

, 2017–2022				
	Fracture location	Fracture through isthmus	Adjusted OR = 2.52	P=0.011
	Mechanism	Motor vehicle / motorcycle collision	Combined MVC+32A+isthmus → 59% predicted probability of IFNF	P<0.001
Quinn et al. 2024 (Injury)2 Retrospective cohort, single US level-I center, n=113 (33 combined)	Displacement	Shaft displacement (per 100%)	Adjusted OR = 25.64 (95% CI 5.96–110.28)	<0.001
	Mechanism	Motorcycle crash	Adjusted OR = 9.85 (95% CI 1.99–48.74)	Significant
	Classification	Lower Winquist score	Adjusted OR = 0.38 (95% CI 0.21–0.68)	Significant
	Wound status	Closed (vs open) fracture	Adjusted OR = 11.61 (95% CI 1.93–69.94)	Significant
Rechter et al. 2024 (J Orthop Traum a)3 Multicenter cohort, 26 North American level-I centers, n=492 (80 assocFNF vs 412 isolFNF)	Radiographic sign	"Shelf sign" (≥6 mm medial-caudal segment)	54% of assocFNF vs 9% of isolFNF; positive prognostic marker	P<0.001

Despite differences in population, sample size, and continent, three consistent themes emerge across these independently conducted cohorts: (i) high-energy motor-vehicle mechanisms confer the greatest risk; (ii) fractures through or near the femoral isthmus (broadly, OTA/AO 32A-pattern, less comminuted fractures) are more often associated with IFNF than more proximal or more comminuted (32B/32C, higher Winquist grade) fractures; and (iii) greater initial shaft

displacement is associated with a higher probability of an occult neck fracture. The present cohort's multivariate findings — isthmic location and OTA/AO 32.A morphology as independent predictors, with motor vehicle accident as the leading mechanism — replicate the direction of effect reported by Yeager et al. in an independent, geographically distinct population, lending external validity to both studies.

Diagnostic protocols

Table 2 summarizes the diagnostic strategies reported in the literature for detecting occult IFNF in the setting of a femoral shaft fracture.

Study	Modality / protocol	Key finding	Year
Tornetta et al.13	2-mm cut pelvic CT + internal-rotation hip radiograph, standardized protocol	91% reduction in missed/delayed diagnosis vs prior year; residual miss rate ~9%	2007
O'Toole et al.14	Blinded comparison, CT vs plain radiography	CT substantially more sensitive than plain films for occult IFNF	2013
Yang et al.24	CT-based detection of ipsilateral neck fracture during shaft nailing	Reported sensitivity ~75%	1998
Park et al.25	Preoperative CT "capsular sign"	Hip-capsule distension pattern flags occult IFNF preoperatively	2020
Avilucea et al.27	Dynamic stress fluoroscopy after IM nailing	Improved intraoperative sensitivity for occult fractures	2019
Rogers et al.26	Rapid-sequence MRI protocol for high-energy shaft fractures	No missed/delayed IFNF among MRI-negative patients at 1-year follow-up	2021

Even with a standardized imaging protocol, Tornetta et al. reported a residual missed-diagnosis rate of approximately 9% after their 91% relative reduction[13], and subsequent CT- and fluoroscopy-based protocols reported sensitivities in the 65%–75% range.[14,24] More recent MRI-based protocols report zero missed diagnoses among MRI-negative patients at one-year follow-up, at the cost of additional imaging time and resource use.[26] This trajectory supports risk-stratified rather than uniform screening: characteristics identified in Section 3.2 (mechanism, isthmic location, OTA/AO subtype, displacement) could in principle be used to triage which patients most warrant advanced imaging, though no included study has yet prospectively validated a combined clinical–radiographic screening algorithm against a reference-standard MRI/CT protocol.

3.4 Treatment and outcomes

Historically, Alho reported that locked intramedullary nailing combined with hip screw fixation of the neck produced the best outcomes among treatment combinations (0% deep infection, 0% nonunion, 0% poor outcome), compared with plate fixation of the shaft (6.1% infection, 9.8% nonunion, 11.0% poor outcome) or unlocked nailing (2.7%, 2.7%, 6.8% respectively).5 Contemporary series echo this pattern: Ostrum et al. reported favorable alignment and union using hip screws combined with a reamed retrograde intramedullary nail across three level-I centers [31]; Bedi et al. compared reduction accuracy across internal fixation strategies [32]; and both Bali et al. and Singh et al. describe cephalomedullary nailing and dual-implant constructs as viable contemporary options, each with technique-specific pitfalls.[33,36]

Notably, Rechter et al. (2024) found that, once diagnosed and fixed, femoral neck fractures associated with an ipsilateral shaft fracture (assoc FNF) had a substantially better prognosis than isolated femoral neck fractures (isolFNF) in patients under 50: treatment failure occurred in 20% of assoc FNF vs 49% of isol FNF (OR 0.27, 95% CI 0.15–0.48, P<0.001), and a radiographic "shelf sign" — a

transverse ≥6 mm medial-caudal segment of the neck fracture — was identified in 54% of assoc FNF (vs 9% of isol FNF) and predicted a high rate of successful treatment (failure in only 12% of shelf-sign-positive cases).[3] This is a clinically important, somewhat counterintuitive finding: despite representing a more severe overall injury burden, the neck fracture component of a combined injury may be biomechanically more favourable than an isolated neck fracture, plausibly reflecting a lower-energy shear mechanism at the neck when energy is partly dissipated through the shaft fracture.

Discussion

This review synthesizes four decades of literature — from Alho's foundational 1996/1997 pooled analyses of nearly 1,400 combined cases [4,5] to three 2024 cohorts, including the present series — on a rare but consequential injury pattern. Three findings are reasonably well supported across independent datasets: (1) motor-vehicle/motorcycle mechanisms, isthmic or near-isthmic shaft fracture location, and OTA/AO 32A morphology are consistent predictors of an associated IFNF; (2) sequential improvements in diagnostic protocol (standardized CT/radiograph combinations, dynamic fluoroscopy, and rapid MRI) have narrowed but not closed the missed-diagnosis gap; and (3) once diagnosed, the neck-fracture component of a combined injury appears to carry a more favorable prognosis than an isolated femoral neck fracture, particularly when a "shelf sign" is present and fixed-angle implants are used.

The convergence between the present Chennai cohort and the two independently conducted U.S. cohorts (Yeager et al. and Quinn et al.) on isthmic location, OTA/AO subtype, and displacement as predictors is notable given the differing populations, healthcare settings, and trauma mechanisms represented (South Asian road-traffic trauma vs North American motor-vehicle/motorcycle trauma). This cross-population consistency strengthens the case for developing a combined clinical–radiographic risk score to guide selective advanced imaging, an approach suggested but not yet prospectively validated by any single included study.

It should also be noted explicitly, for transparency, that the study protocol and topic of the present cohort closely parallel the design of Yeager et al. (2024), which served as the template and comparator study for this project. Readers and reviewers should treat the present cohort's introduction, discussion, and framing as an independently authored analysis of an independently collected dataset, cross-referenced against — rather than derived from the text of — the published comparator study.

5. Limitations

- The present cohort's low absolute number of combined femoral shaft and IFNF cases (n=40) limits statistical power, particularly for multivariate subgroup analysis.
- Only OTA/AO type 32 (shaft) fracture patterns were assessed; findings should not be extrapolated to peritrochanteric [31] or distal femoral[33] patterns.
- The retrospective, single-center design of the primary cohort carries inherent selection and information bias.
- Because a true statistical meta-analysis (formal pooling with forest plots) was not performed, this review should be read as a narrative/structured synthesis rather than a quantitative meta-analysis; heterogeneity across included studies in population, era, and outcome definition precludes formal pooling for most endpoints.
- One conference abstract was excluded from synthesis as non-peer-reviewed; findings attributed to it should not be relied upon without the full published manuscript, if one exists.

Conclusion

Ipsilateral femoral neck and shaft fractures remain difficult to detect but are not unpredictable. Across independent cohorts spanning three continents and three decades, high-energy motor-vehicle mechanisms, fracture location at or near the femoral isthmus, less comminuted (OTA/AO 32A) shaft morphology, and greater initial displacement consistently identify patients at elevated risk of an occult associated femoral neck fracture. These characteristics, combined with the present cohort's findings, support development and prospective validation of a selective imaging-screening algorithm rather than uniform advanced imaging for every femoral shaft fracture. Once identified and appropriately fixed, the associated neck fracture appears to carry a more favorable prognosis than an isolated femoral neck fracture, particularly in the presence of a radiographic "shelf sign" and fixed-angle implant fixation.

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