

Outcomes of the Femoral Neck System for Intracapsular Femoral Neck Fractures: A Single-Centre, Single-Surgeon Experience of 69 Consecutive Cases

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Method Article

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Abstract

Purpose

To evaluate clinical and radiological outcomes of Femoral Neck System (FNS) fixation for intracapsular femoral neck fractures in a single-surgeon consecutive series, and to examine the relationship between reduction quality and outcome.

Methods

A retrospective review of 69 consecutive intracapsular femoral neck fractures treated with FNS at a single centre (October 2020–June 2024) was performed. Fractures were classified using the Garden and Pauwels systems. Primary outcomes were union, avascular necrosis (AVN), and conversion to arthroplasty, assessed at a minimum of 12 months' follow-up. Reduction quality was graded using the Garden Alignment Index, neck-shaft angle, cortical continuity, and neck station.

Results

Mean age was 40.2 ± 15.4 years; 81.2% were male. Displaced fractures (Garden III–IV) comprised 69.6% and Pauwels type III fractures 55.1%. Union was achieved in 63 fractures (91.3%); 6 (8.7%) developed non-union and 6 (8.7%) developed AVN. No implant-specific mechanical failures occurred. Sub-group analysis showed that 5 of 6 non-union cases and 5 of 6 AVN cases occurred despite satisfactory reduction.

Conclusion

FNS achieved reliable union with a low mechanical failure rate across a demanding case mix of displaced, high-shear-angle fractures. Most adverse outcomes occurred despite satisfactory reduction, suggesting the initial vascular insult at injury, rather than reduction quality alone, may be the dominant determinant of outcome — a hypothesis warranting confirmation in larger comparative series.

Introduction

Femoral neck fractures (FNF) are a major and growing orthopaedic burden, with global incidence projected to reach 6.3–8.2 million cases annually by 2050 [1, 2]. While predominantly affecting the elderly, FNF also occur in younger patients after high-energy trauma, comprising approximately 2% of fractures in patients under 50 years [3, 4], with higher rates of AVN (14.3%) and non-union (9.3%) reported in this group [5, 6]. Preservation of the native femoral head requires stable fixation and union [7]; the precarious blood supply via the medial femoral circumflex artery renders these fractures vulnerable to AVN, with reported rates of 9–18% after internal fixation [8, 9].

Multiple cannulated screws (MCS) preserve blood supply but offer limited shear resistance, particularly in Pauwels type III fractures [10]. The dynamic hip screw (DHS) provides greater fixed-angle stability but requires more extensive exposure; the FAITH trial reported a higher AVN incidence with DHS, possibly related to femoral head rotation during screw insertion [11]. The Femoral Neck System (FNS; DePuy Synthes), introduced in 2018 [12], combines percutaneous insertion with fixed-angle stability; biomechanical testing shows superior resistance to varus collapse compared with both MCS and DHS [13].

Clinical data remain limited, and many published series are multi-surgeon with relatively short follow-up [14, 15]. We report outcomes of FNS in a single-surgeon consecutive series, focusing on union, AVN, and the influence of reduction quality on outcome.

Methods

A retrospective review of all consecutive patients with intracapsular femoral neck fractures (AO/OTA 31-B1:3) treated with FNS by a single surgeon at one tertiary centre between October 2020 and June 2024 was conducted, with a minimum follow-up of 12 months or until documented union, non-union, or revision. Pathological fractures amenable to preservation were included; patients undergoing primary arthroplasty or lost to follow-up before a radiological outcome was established were excluded. Institutional ethical approval was obtained.

Fractures were classified using the Garden (types I–IV) and Pauwels (type I < 30°, II 30–50°, III > 50°) systems [16, 17]. All procedures were performed with the patient supine on a fracture table under spinal or general anaesthesia. Closed reduction was attempted under fluoroscopic guidance; open reduction (Smith-Petersen approach) was used when closed reduction was unsatisfactory. FNS was inserted through a lateral 3–4 cm incision, with implant position assessed using the Cleveland index and tip-apex distance. Postoperative protocol comprised protected weight-bearing for 6 weeks before progression to full weight-bearing.

Reduction quality was assessed on postoperative AP and lateral radiographs by an observer independent of the operating surgeon, using cortical continuity, fragment overlap, translation/retroversion, angulation, the Garden Alignment Index (acceptable range 160–180° AP, 180° lateral) [18], and neck station; each case was graded satisfactory or unsatisfactory overall.

Union was defined as radiographic bridging callus with pain-free weight-bearing; non-union as absent radiographic healing at 6 months with persistent symptoms or hardware failure; AVN was diagnosed radiographically (collapse, sclerosis, subchondral lucency) [19], without routine CT/MRI confirmation. All patients were followed for a minimum of 12 months to allow ascertainment of delayed complications beyond the original 6-month window. Continuous variables are expressed as mean $\pm$ SD or median (IQR); categorical variables as frequencies and percentages.

Results

Sixty-nine patients were included, with no losses to follow-up. Mean age was 40.2 ± 15.4 years (range 16–89); 56 (81.2%) were male. The predominant mechanism was fall (52.2%) or road traffic accident (43.5%); 20.3% had polytrauma. Displaced fractures (Garden III–IV) comprised 69.6% of the cohort; by Pauwels classification ($n = 66$), 57.6% were type III. Demographics and fracture characteristics are summarised in Table 1.

Variable	Value
Age (years), mean $\pm$ SD (range)	40.2 ± 15.4 (16–89)
Male sex, n (%)	56 (81.2%)
Mechanism – Fall / RTA / Other	36 (52.2%) / 30 (43.5%) / 3 (4.3%)
Polytrauma, n (%)	14 (20.3%)
Garden I / II / III / IV / Pathological	3 (4.3%) / 15 (21.7%) / 21 (30.4%) / 27 (39.1%) / 3 (4.3%)
Pauwels I / II / III ($n = 66$)	12 (18.2%) / 16 (24.2%) / 38 (57.6%)

Thirty-three patients (47.8%) were operated within 1–2 days; mean operative duration was 43.2 minutes. Closed reduction was successful in 63 (91.3%); overall reduction quality was satisfactory in 63 (91.3%) and unsatisfactory in 6 (8.7%). Mean neck-shaft angle at follow-up was $129.7^\circ \pm 4.8^\circ$ and mean lateral Garden Alignment Index was $170.7^\circ \pm 10.6^\circ$. Operative and reduction parameters are shown in Table 2.

Parameter	Value
Time to surgery – 1–2 d / 3–7 d / >7 d	33 (47.8%) / 29 (42.0%) / 7 (10.1%)
Operative duration, mean (range)	43.2 min (35–55 min)
Reduction – Closed / Open	63 (91.3%) / 6 (8.7%)
Angulation – Neutral / Valgus / Varus	55 (79.7%) / 11 (15.9%) / 3 (4.3%)
Overall reduction – Satisfactory / Unsatisfactory	63 (91.3%) / 6 (8.7%)
Neck-shaft angle ($^\circ$), mean $\pm$ SD	129.7 ± 4.8
Garden Alignment Index – lateral ($^\circ$), mean $\pm$ SD	170.7 ± 10.6

Union was achieved in 63 fractures (91.3%) at a mean of 4.3 months; 6 (8.7%) developed non-union and 6 (8.7%) developed AVN. Four patients (5.8%) required conversion to arthroplasty; one developed a superficial wound infection; no implant-specific mechanical failures occurred. All patients reached a minimum of 12 months' follow-up, with no additional adverse events identified beyond the initial 6-month assessment.

Sub-group analysis of the 6 non-union cases showed 5 (83%) had satisfactory reduction and 1 (17%) unsatisfactory reduction; of the 6 AVN cases, 5 (83%) had satisfactory and 1 (17%) unsatisfactory reduction. AVN occurred in 2 cases each of Garden II, III, and IV. Clinical outcomes and this sub-group analysis are summarised in Table 3.

Outcome	Value
Union, n (%)	63 (91.3%)
Non-union, n (%) – of which satisfactory / unsatisfactory reduction	6 (8.7%) – 5 (83%) / 1 (17%)
AVN, n (%) – of which satisfactory / unsatisfactory reduction	6 (8.7%) – 5 (83%) / 1 (17%)
AVN by Garden type – II / III / IV	2 / 2 / 2
Time to union, mean (range)	4.3 months (2.5–8 months)
Revision to arthroplasty, n (%)	4 (5.8%)
Wound infection, n (%)	1 (1.4%)
Implant-related mechanical failure	0 (0%)
Minimum follow-up achieved (all patients)	12 months

Discussion

This series of 69 consecutive FNS fixations achieved union in 91.3% with an AVN rate of 8.7% and no implant-specific mechanical failures, sustained to a minimum of 12 months. These results are consistent with published FNS series, including a multicentre comparison with DHS at 2-year follow-up [14, 15, 20, 22]. Our cohort was younger (mean 40.2 years) than typical European and North American series (> 60 years) [20], with a high proportion of road traffic trauma, and a demanding case mix (69.6% displaced, 55.1% Pauwels III) traditionally considered a relative contraindication to cannulated screws [21]; union in this subgroup was consistent with the proposed biomechanical advantages of FNS [13].

Our non-union rate (8.7%) compares favourably with published series: Kim et al. reported 9.3% at a mean follow-up of 12.5 months [20], and a systematic review of 380 patients reported rates of 8.8–21% [23]. Our AVN rate (8.7%) falls within the reported 9–18% range for internally fixed FNF [8], which is reasonable given the younger, more displaced cohort.

Anatomic reduction is widely regarded as a key modifiable determinant of outcome [24], and it remains biomechanically plausible that unsatisfactory reduction contributes to failure. However, our sub-group data showed that most non-union (83%) and AVN (83%) occurred despite satisfactory reduction, indicating that reduction quality alone does not account for most adverse outcomes in this series. Since AVN results primarily from disruption of the retinacular blood supply at the moment of injury rather than from the technical adequacy of subsequent fixation [8, 9], we propose that the initial vascular insult –

itself a function of fracture displacement and energy — was the more likely dominant driver of non-union and AVN, with reduction quality playing at most a secondary role. This is consistent with AVN occurring across all Garden subtypes rather than being confined to the most displaced fractures. This is a hypothesis generated from descriptive sub-group data in a small number of adverse events, not a formally tested statistical association, and requires confirmation in a larger, adequately powered comparative study.

Limitations include the retrospective, single-surgeon, single-centre design without a comparator group; reliance on plain radiographic criteria for union/AVN without routine CT/MRI; and the small numbers underlying the sub-group analysis. Very late AVN beyond 12 months, reported up to 8 years post-fixation in some series [25], cannot be excluded by the present follow-up. Radiological assessment by an observer independent of the operating surgeon reduced, but did not eliminate, potential assessment bias.

Conclusion

FNS achieved reliable union with a low mechanical failure rate across a demanding case mix of displaced, high Pauwels-grade femoral neck fractures, sustained to 12 months' follow-up. Most non-union and AVN occurred despite satisfactory reduction, suggesting the initial vascular insult at injury — rather than reduction quality alone — is the more likely dominant determinant of outcome, a hypothesis warranting confirmation in larger comparative series. FNS was technically straightforward with a manageable learning curve, supporting its use as a practical fixation option for this challenging fracture pattern.

Declarations

Author Contribution

Study conception and design: Nikita Bedi. Data acquisition: Nikita Bedi and Pratyaksha Jain. Primary Surgeon: Mukesh Jain. Radiological assessment: Nikita Bedi and Gurinder Bedi. Data analysis and interpretation: Nikita Bedi and Gurinder Bedi. Drafting of the manuscript: Nikita Bedi. Critical revision for important intellectual content: all authors. All authors read and approved the final manuscript.

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Figures

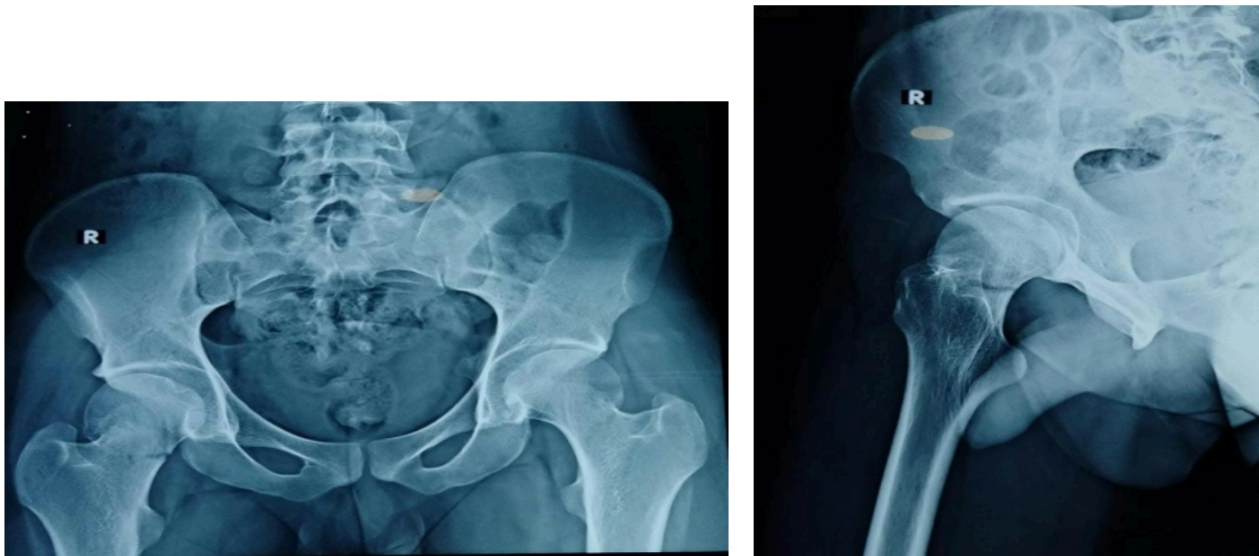


Figure 1

Preoperative AP and lateral radiographs of a representative displaced Pauwels type III femoral neck fracture, showing the vertically oriented fracture line and degree of displacement (Garden type III/IV).

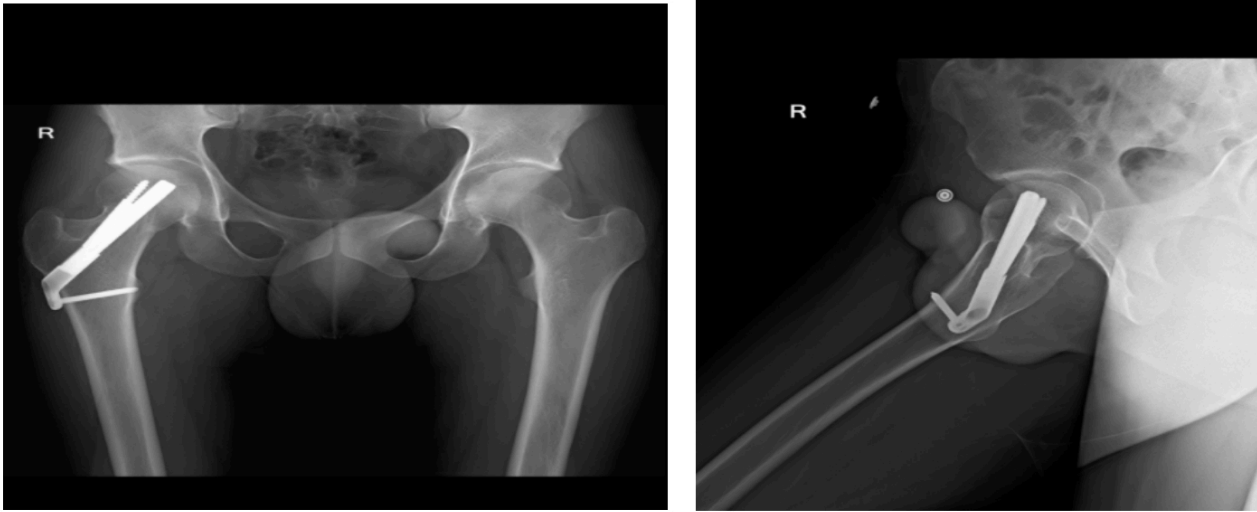


Figure 2

Postoperative AP and lateral radiographs demonstrating satisfactory FNS fixation with central bolt placement, acceptable tip-apex distance, and neutral neck-shaft alignment.



Figure 3

Radiograph of a 46-year-old patient after a fall on the stairs, showing a vertically oriented fracture line (Pauwels type III, complete displacement Garden IV).



Figure 4

Follow-up radiographs at 4–5 months demonstrating fracture union with obliteration of the fracture line and bridging callus, with the FNS construct intact and no evidence of implant failure, cut-out, or varus colla

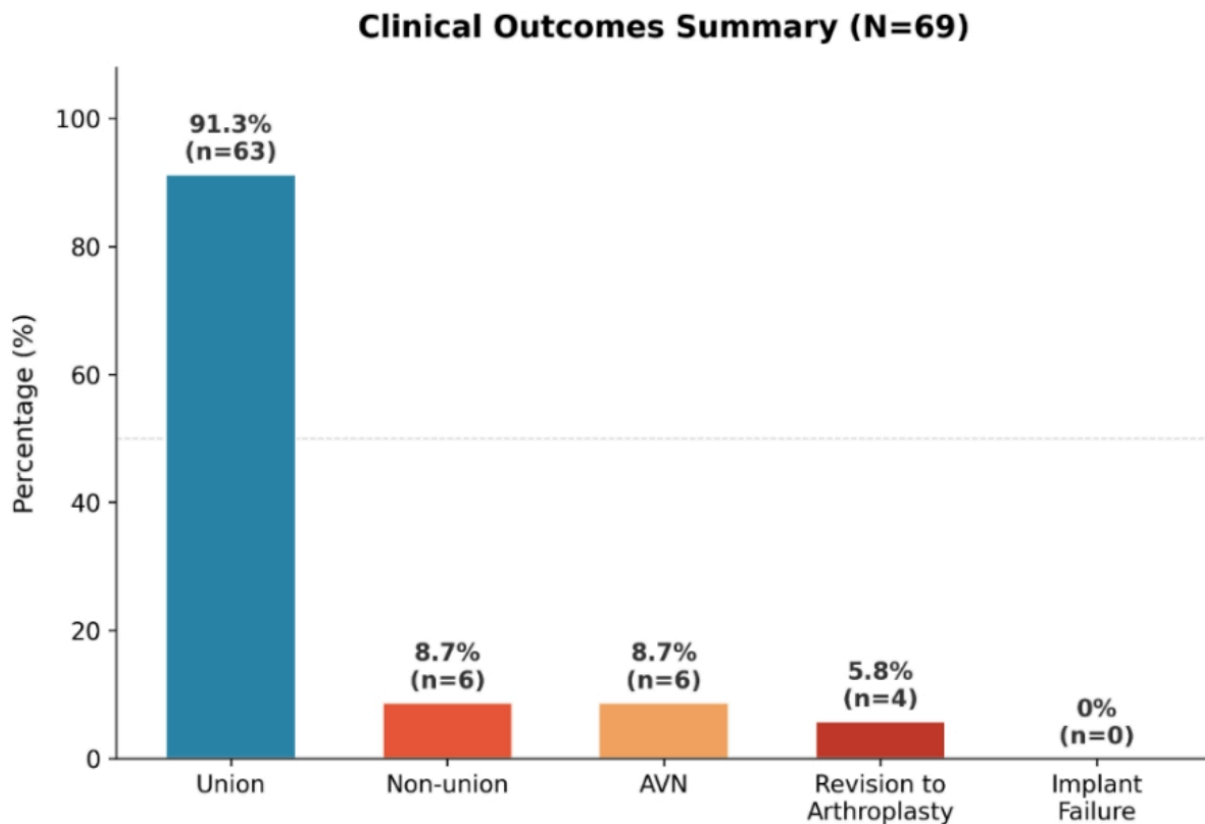


Figure 5

Bar chart summarising clinical outcomes for 69 consecutive femoral neck fractures treated with FNS: union 91.3%, non-union 8.7%, AVN 8.7%, revision to arthroplasty 5.8%, wound infection 1.4%, implant-related mechanical failure 0%.