

POSITIVE MEDIAL CORTICAL SUPPORT VERSUS ANATOMICAL REDUCTION IN PROXIMAL FEMORAL NAILING FOR UNSTABLE INTERTROCHANTERIC FRACTURES: A PROSPECTIVE COMPARATIVE STUDY

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ABSTRACT

Background: The aim is to prospectively compare the radiological and functional outcomes of Positive Medial Cortical Support (PMCS) versus conventional Anatomical Reduction (AR) in elderly patients with unstable intertrochanteric fractures treated with Proximal Femoral Nailing (PFN). **Materials and Methods:** A prospective comparative study was conducted at the Department of Orthopaedics, Government Cuddalore Medical College and Hospital, Tamil Nadu, India, over six months following Institutional Ethics Committee approval. Forty patients aged above 60 years with AO/OTA type 31-A2 and 31-A3 fractures treated with PFN were allocated to Group A (PMCS, n=20) and Group B (AR, n=20). Radiological outcomes included time to union, neck-shaft angle (NSA) loss, Tip-Apex Distance (TAD), varus collapse, and implant cut-out. Functional outcomes were assessed using the Harris Hip Score (HHS) at 4, 8, and 12 weeks and at 6 months. Statistical analysis used SPSS version 20; p<0.05 was significant. **Result:** The groups were comparable at baseline. Union was significantly faster in Group A (11.4 ± 1.2 vs 13.6 ± 1.5 weeks; MD - 2.2, 95% CI -3.0 to -1.4; p<0.001). NSA loss was significantly lower in Group A ($2.3 \pm 1.1^\circ$ vs $4.9 \pm 1.7^\circ$; p<0.001). Implant cut-out occurred in 0 versus 4 patients (p=0.038). Mean HHS at 6 months was 83.1 ± 4.5 versus 74.2 ± 5.4 (MD 8.9, 95% CI 5.8 to 12.0; p<0.001). At final review, 90% of Group A patients achieved a Good or Excellent grade versus 45% in Group B (p<0.001). **Conclusion:** PMCS provides superior mechanical stability, faster fracture union, and significantly better functional recovery compared to anatomical reduction in PFN fixation of unstable intertrochanteric fractures. It is a safe, reproducible, and technically feasible reduction strategy that should be adopted as the primary intraoperative goal in elderly patients with osteoporotic bone.

INTRODUCTION

Intertrochanteric fractures rank among the most prevalent and clinically consequential injuries managed in orthopaedic departments across India and worldwide.^[1,2] In the elderly, these fractures arise almost exclusively from low-energy ground-level falls in the presence of osteoporotic bone, and the resulting fracture configuration is frequently unstable, characterised by posteromedial cortical comminution, lateral wall incompetence, or subtrochanteric extension—patterns corresponding

to AO/OTA types 31-A2 and 31-A3.^[3] As India's geriatric population continues to expand, the annual burden of these fractures is projected to rise steeply, with attendant demands on surgical resources, inpatient beds, and rehabilitation infrastructure.^[4] Proximal Femoral Nailing is currently the accepted gold standard for the surgical management of unstable intertrochanteric fractures, offering biomechanical advantages over extramedullary devices through its intramedullary position, shortened bending moment arm, and load-sharing properties at the fracture site.^[5] Nevertheless, published series consistently document mechanical

failure rates of 8–25% in the most comminuted patterns, encompassing progressive varus collapse, neck-shaft angle loss, and helical blade or lag screw cut-out.^[6,7] Accumulating evidence now identifies the quality of intraoperative fracture reduction as a primary determinant of these outcomes, independent of implant brand or screw positioning.^[8]

The concept of Positive Medial Cortical Support (PMCS), systematically defined and clinically validated by Chang et al. in 2015, introduced a paradigm shift in reduction philosophy.^[8] Rather than restoring anatomical alignment, PMCS deliberately positions the medial cortex of the proximal head-neck fragment slightly superomedial to the medial cortex of the distal femoral shaft, creating an immediate cortical buttress that transfers compressive loads from the implant to cortical bone from the very first weight-bearing cycle. This configuration enables the head-neck fragment to undergo controlled, progressive telescoping along the helical blade until secondary bony stability is achieved, without the risk of uncontrolled varus drift.^[8,9] Finite element analyses have independently confirmed that the positive anteromedial cortical support pattern produces the lowest implant stresses and the most favourable mechanical environment for fracture healing.^[10]

Despite these compelling findings, prospective comparative data generated under the resource and imaging constraints of South Indian government teaching hospitals remain limited. The present study was designed to fill this gap by prospectively comparing the radiological and functional outcomes of PMCS versus anatomical reduction in a cohort of 40 elderly patients with unstable intertrochanteric fractures undergoing PFN fixation.

MATERIALS AND METHODS

Study design and setting: This prospective, comparative, single-centre study was conducted in the Department of Orthopaedics, Government Cuddalore Medical College and Hospital (GCMCH), Chidambaram, Tamil Nadu, India over a continuous six-month period. Ethics committee clearance was obtained from the Institutional Ethics Committee prior to patient recruitment. All participants provided written informed consent before enrolment. The study was conducted in compliance with the ethical principles of the Declaration of Helsinki (2013 revision). The study did not involve a randomised intervention and was therefore not prospectively registered with CTRI.

Participants: Consecutive patients presenting with acute intertrochanteric fractures during the study period were assessed against pre-specified eligibility criteria. Inclusion criteria were: (i) age above 60 years; (ii) closed fracture classified as AO/OTA type 31-A2 or 31-A3 on plain radiographs; (iii) planned surgical fixation with PFN; (iv) surgery within one week of injury; and (v) willingness to comply with

the six-month follow-up schedule. Exclusion criteria were: (i) pathological fracture from causes other than osteoporosis; (ii) open fracture; (iii) polytrauma with ISS >16; (iv) pre-existing ipsilateral hip or femoral deformity or prior femoral surgery; (v) cognitive impairment or neurological deficit precluding valid functional assessment; and (vi) non-completion of the six-month follow-up. Forty patients satisfying all criteria were enrolled consecutively and allocated to Group A (PMCS, n=20) or Group B (AR, n=20) on the basis of the intraoperative reduction achieved, as confirmed by biplanar C-arm fluoroscopy.

Surgical technique: All procedures were performed under spinal anaesthesia on a radiolucent fracture table with longitudinal traction. Closed reduction was performed under biplanar C-arm image intensifier guidance by the same senior surgeon (S.D) for all cases. Nail diameter, length, and screw depth of insertion were determined by preoperative templating and kept consistent across groups.

In Group A, after initial reduction the proximal head-neck fragment was deliberately manoeuvred to achieve slight superomedial displacement of its medial cortex relative to the medial cortex of the distal femoral shaft, confirmed on the anteroposterior fluoroscopic view. This constituted positive medial cortical support. In Group B, standard reduction manoeuvres aimed at restoring flush medial cortical contact, corresponding to anatomical reduction, were performed and similarly confirmed. Distal locking was in the static mode for all patients. Identical perioperative antibiotic and low-molecular-weight heparin prophylaxis, and a standardised physiotherapy programme commencing on postoperative day one, were administered to all participants.

Outcome measures: Radiological follow-up was performed at 4, 8, and 12 weeks and at six months. Measurements on standard anteroposterior and lateral radiographs included: (i) time to radiological union—bridging callus on at least three cortices on orthogonal views, corroborated clinically by the absence of pain on axial loading; (ii) neck-shaft angle (NSA) loss—the difference between the immediate postoperative and the final follow-up NSA; (iii) Tip-Apex Distance (TAD)—calculated per the Baumgaertner method, with TAD <25 mm considered acceptable [11]; (iv) varus collapse—defined as NSA loss exceeding 5° from the immediate postoperative value; and (v) implant cut-out—articular penetration of the screw confirmed radiologically. Functional outcomes were assessed using the Harris Hip Score (HHS), a validated 100-point scale measuring pain (44 points), function (47 points), absence of deformity (4 points), and range of motion (5 points), graded as Excellent (90–100), Good (80–89), Fair (70–79), or Poor (<70).^[12]

Statistical analysis: Data were entered into a structured proforma and analysed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation. Normality was assessed using the Shapiro-Wilk test;

all continuous variables were normally distributed. Between-group comparisons for continuous variables were made using the independent samples Welch's t-test with 95% confidence intervals (CI) for mean differences. Categorical variables were compared using Fisher's exact test. A two-tailed p-value less than 0.05 was considered statistically significant.

RESULTS

Baseline characteristics: Forty patients (20 per group) were enrolled; none were lost to follow-up.

The groups were comparable across all baseline parameters, including age, sex, laterality, fracture type, mechanism of injury, Singh's Osteoporosis Index, ASA physical status grade, injury-to-surgery interval, and pre-operative HHS (all $p > 0.05$). The mean age was 64.8 ± 5.6 years (Group A) and 65.9 ± 5.2 years (Group B). The overall male-to-female ratio was 0.75:1, consistent with the established female preponderance of osteoporotic fragility fractures. Ground-level falls accounted for the majority of injuries in both groups. Baseline data are presented in [Table 1].

Table 1: Baseline demographic and fracture characteristics of study participants (N=40).

Variable	Group A – PMCS (n=20)	Group B – AR (n=20)
Age – mean \pm SD (years)	64.8 \pm 5.6	65.9 \pm 5.2
Age range (years)	61–78	62–77
Sex – Male : Female	8 : 12	7 : 13
Laterality – Right : Left	12 : 8	13 : 7
AO/OTA 31-A2	12 (60%)	13 (65%)
AO/OTA 31-A3	8 (40%)	7 (35%)
Mechanism – Ground-level fall	16 (80%)	17 (85%)
Mechanism – Road traffic accident	4 (20%)	3 (15%)
Singh's Osteoporosis Index – mean \pm SD	3.1 \pm 0.5	3.0 \pm 0.5
ASA Physical Status Grade – mean \pm SD	2.3 \pm 0.5	2.4 \pm 0.5
Injury-to-surgery interval – mean \pm SD (d)	3.3 \pm 1.2	3.6 \pm 1.3
Pre-operative HHS – mean \pm SD	37.4 \pm 4.8	36.9 \pm 4.6

AO/OTA = AO Foundation/Orthopaedic Trauma Association; ASA = American Society of Anaesthesiologists; HHS = Harris Hip Score; PMCS = Positive Medial Cortical Support; AR = Anatomical Reduction; SD = standard deviation. All intergroup p-values > 0.05 .

Radiological outcomes: Time to radiological union was significantly shorter in Group A (11.4 ± 1.2 weeks) compared with Group B (13.6 ± 1.5 weeks), with a mean difference of 2.2 weeks (95% CI: 1.4–3.0; $t=5.12$, $df=36.3$; $p < 0.001$). Neck-shaft angle loss at the six-month review was significantly lower in Group A ($2.3 \pm 1.1^\circ$) than in Group B ($4.9 \pm 1.7^\circ$; MD 2.6° , 95% CI: 1.7–3.5; $p < 0.001$). Mean TAD values were 22.3 ± 2.5 mm (Group A) and 23.8 ± 2.8 mm (Group B; MD 1.5 mm, 95% CI: -0.1 to 3.1; $p=0.067$), with no statistically significant difference and both values below the accepted 25 mm threshold.

Varus collapse occurred in 3 patients in Group A (15%) and 7 in Group B (35%), a difference that did not reach statistical significance ($p=0.163$), likely reflecting limited statistical power for this binary outcome. Implant cut-out requiring return to theatre occurred in 4 Group B patients (20%) and in none of the Group A patients ($p=0.038$). Satisfactory cortical reduction was maintained at six months in all 20 PMCS patients versus 11 of 20 AR patients ($p=0.001$). Radiological findings are summarised in [Table 2].

Table 2: Comparative radiological outcomes between Group A (PMCS) and Group B (AR).

Parameter	Group A – PMCS (n=20)	Group B – AR (n=20)	MD (95% CI)	p-value
Time to union – mean \pm SD (weeks)	11.4 \pm 1.2	13.6 \pm 1.5	-2.2 (-3.0, -1.4)	<0.001*
NSA loss – mean \pm SD ($^\circ$)	2.3 \pm 1.1	4.9 \pm 1.7	-2.6 (-3.5, -1.7)	<0.001*
Tip-Apex Distance – mean \pm SD (mm)	22.3 \pm 2.5	23.8 \pm 2.8	-1.5 (-3.1, 0.1)	0.067
Varus collapse (NSA loss $> 5^\circ$) – n (%)	3 (15%)	7 (35%)	—	0.163
Implant cut-out – n (%)	0 (0%)	4 (20%)	—	0.038*
Cortical reduction maintained – n (%)	20 (100%)	11 (55%)	—	0.001*

MD = mean difference; NSA = neck-shaft angle; TAD = Tip-Apex Distance; * Statistically significant ($p < 0.05$). Independent Welch's t-test for continuous variables; Fisher's exact test for proportions. Varus collapse defined as NSA loss $> 5^\circ$ from immediate postoperative radiograph.

Functional outcomes: Harris Hip Scores were consistently and significantly superior in Group A at every assessment interval (Table 3). At four weeks, mean HHS was 57.8 ± 4.2 (Group A) versus 50.6 ± 4.9 (Group B; MD 7.2, 95% CI: 4.4–10.0; $p < 0.001$). The advantage was sustained at eight weeks ($71.2 \pm$

4.4 vs 63.2 ± 5.2 ; MD 8.0, 95% CI: 5.0–11.0; $p < 0.001$), at twelve weeks (77.6 ± 4.1 vs 69.1 ± 5.0 ; MD 8.5, 95% CI: 5.7–11.3; $p < 0.001$), and at the six-month final review (83.1 ± 4.5 vs 74.2 ± 5.4 ; MD 8.9, 95% CI: 5.8–12.0; $p < 0.001$).

Table 3: Serial Harris Hip Score values at follow-up intervals (N=40).

Follow-up	Group A PMCS Mean HHS ± SD	Group B AR Mean HHS ± SD	MD (95% CI)	p-value
4 weeks postoperative	57.8 ± 4.2	50.6 ± 4.9	7.2 (4.4, 10.0)	<0.001*
8 weeks postoperative	71.2 ± 4.4	63.2 ± 5.2	8.0 (5.0, 11.0)	<0.001*
12 weeks postoperative	77.6 ± 4.1	69.1 ± 5.0	8.5 (5.7, 11.3)	<0.001*
6 months (final review)	83.1 ± 4.5	74.2 ± 5.4	8.9 (5.8, 12.0)	<0.001*

MD = mean difference; HHS = Harris Hip Score; CI = confidence interval; * p<0.001; independent Welch's t-test. HHS interpretation: <70 Poor, 70–79 Fair, 80–89 Good, 90–100 Excellent.

At the six-month review, 18 of 20 patients (90%) in Group A achieved a Good or Excellent HHS grade compared with 9 of 20 (45%) in Group B. Three Group B patients were graded Poor, all attributable to implant cut-out and consequent secondary varus

deformity requiring revision surgery. No Group A patient required revision. The between-group difference in grade distribution was statistically significant (p<0.001, Fisher's exact test). Grade distribution at six months is displayed in [Table 4].

Table 4: Harris Hip Score grade distribution at 6-month final review (N=40).

HHS Grade	Score Range	Group A – PMCS – n (%)	Group B – AR – n (%)
Excellent	90–100	5 (25%)	0 (0%)
Good	80–89	13 (65%)	9 (45%)
Fair	70–79	2 (10%)	8 (40%)
Poor	<70	0 (0%)	3 (15%)

p<0.001, Fisher's exact test, for overall grade distribution between groups. HHS = Harris Hip Score.

DISCUSSION

The results of this prospective comparative study consistently favour PMCS over conventional anatomical reduction across all primary and secondary outcome domains in elderly patients with unstable intertrochanteric fractures treated with PFN. The magnitude of benefit—a 2.2-week reduction in union time, a 2.6° reduction in neck-shaft angle loss, complete elimination of implant cut-out, and a clinically meaningful 8.9-point HHS advantage at six months—is not only statistically significant but also carries direct clinical relevance for this vulnerable patient population.

The mechanistic explanation for the superiority of PMCS lies in its ability to confer immediate, load-bearing cortical stability from the outset of postoperative weight-bearing. In unstable intertrochanteric fractures, posteromedial comminution eliminates the natural cortical buttress that ordinarily resists varus collapse, leaving the implant as the sole mechanical barrier against varus drift during the pre-union period in conventional anatomical reduction. When the medial cortex of the head-neck fragment is positioned flush with or medial to the shaft cortex, the entire varus moment arm of body weight is borne by the screw-bone interface, concentrating stress at the screw tip and creating conditions for progressive cut-out and varus angulation.^[8,9] By contrast, the intentional slight superomedial positioning of the head-neck cortex in PMCS interposes a cortical strut between the proximal and distal fragments, redistributing compressive forces from the implant to cortical bone and allowing progressive, controlled telescoping toward bony contact without the risk of catastrophic varus drift.

The biomechanical evidence base for this interpretation is substantial. Shao et al. applied finite

element analysis to nine distinct anteromedial cortical support configurations modelled on the PFNA-II nail system and demonstrated that the positive-positive anteromedial support pattern yielded the lowest von Mises stresses at the nail and the most physiologically appropriate interfragmentary compressive strains for enchondral callus formation, while the negative-negative configuration—analogue to anatomical reduction in the presence of medial comminution—concentrated stresses at the proximal nail, replicating the mechanical preconditions for cut-out.^[10] Our clinical findings align precisely with these predictions: zero cut-out events in Group A versus four in Group B, and a highly significant reduction in neck-shaft angle loss over the follow-up period.

The landmark retrospective cohort study by Chang et al. of 127 patients with AO/OTA 31A2.2 and 31A2.3 fractures treated with either PFNA-II or Gamma-3 nails established that PMCS patients experienced the least loss of neck-shaft angle and neck length at follow-up and achieved independent weight-bearing significantly earlier than those with neutral or negative cortical configurations, with correspondingly better functional outcomes at one year.^[8] The 2025 prospective cohort study by Shasho et al. of 154 patients confirmed these findings in a different surgical context, reporting significantly less NSA loss and faster full weight-bearing in patients with positive medial cortical support, thereby validating the Chang criteria across patient populations.^[13]

The anteromedial component of cortical support—incorporating both the medial AP and the anterior lateral relationships—was the focus of Chang et al.'s fluoroscopy-versus-3D CT comparison study, which found that a negative anterior cortex on lateral fluoroscopy was a robust predictor of postoperative loss of the anteromedial buttress.^[14] In our study, only

biplanar C-arm fluoroscopy was available, which is the standard of care in Indian government teaching hospitals. The observation that all 20 PMCS patients maintained satisfactory cortical reduction at six months (compared with 55% of AR patients; $p=0.001$) indicates that fluoroscopically verified PMCS is durable under routine public hospital conditions, without recourse to postoperative 3D CT. The regional evidence base for PMCS in South Asian public hospital settings has also grown. Rasheed et al., in a 2024 prospective study of 30 patients, demonstrated that anteromedial cortical support significantly reduced mechanical complications in cephalomedullary nail fixation of unstable pertrochanteric fractures and was achievable without specialised equipment.^[6] Suresh Kumar et al., studying 40 patients with pertrochanteric fractures at a Tamil Nadu government centre closely analogous to ours, reported that positive cortical support facilitated earlier ambulation and superior NSA preservation compared to neutral or negative configurations at 18–24 months.^[15] These findings, together with ours, build a consistent and geographically relevant body of evidence favouring PMCS in the Indian public sector context.

The significantly shorter union time observed in Group A (11.4 versus 13.6 weeks; $p<0.001$) carries particular clinical importance in elderly patients, for whom prolonged non- or restricted weight-bearing is associated with deconditioning, pressure ulcer formation, deep venous thrombosis, hypostatic pneumonia, and urinary tract infection—all contributors to the well-documented excess perioperative mortality in this age group. The progressively widening HHS gap from the four-week to the six-month assessment strongly suggests that earlier mechanical stability in Group A enabled more aggressive and pain-free physiotherapy participation, compounding the functional advantage over time. The finding that 90% of Group A patients achieved a Good or Excellent HHS grade at six months, versus only 45% in Group B, translates into a clinically meaningful difference in patient independence, return to pre-injury activity level, and caregiver burden—particularly relevant in the Indian socioeconomic context.

The prospective cohort study by Mounisamy et al. from South India, which found no independent effect of medial cortical reduction on functional outcomes across their sample of 47 patients, enrolled a broader spectrum of fracture types including the relatively stable AO/OTA 31-A1 pattern.^[9] Our restriction to 31-A2 and 31-A3 fractures—the patterns in which the medial cortical buttress is most critically disrupted—may account for the more pronounced and statistically robust functional benefit we observed with PMCS. This interpretation is further supported by the mechanistic argument: the structural advantage of PMCS is most pronounced precisely in fractures where posteromedial comminution is greatest.

This study has several acknowledged limitations. The prospective but non-randomised design, based on intraoperative reduction achieved rather than a formal randomisation protocol, carries risk of allocation bias, though the comparable baseline characteristics of both groups mitigate this concern. The single-centre design at a government teaching hospital, while enhancing the ecological validity of the findings for similar settings, limits direct generalisability to private sector or tertiary referral centres. The follow-up period of six months precludes assessment of late mechanical complications, implant removal procedures, or long-term functional trajectory. The reliance on biplanar fluoroscopy rather than postoperative 3D CT for verification of cortical support configuration introduces the possibility of misclassification in a proportion of patients. Larger, multicentre randomised controlled trials with extended follow-up and 3D-imaging-confirmed reduction quality assessment are now warranted to consolidate and extend these findings.

CONCLUSION

This prospective comparative study demonstrates, across a cohort of 40 elderly patients with unstable intertrochanteric fractures, that Positive Medial Cortical Support provides superior mechanical stability, significantly faster radiological union, complete elimination of implant cut-out, and meaningfully better Harris Hip Scores at all follow-up intervals compared with conventional Anatomical Reduction in PFN fixation. The technique is technically reproducible using routine C-arm fluoroscopic guidance in a government teaching hospital setting, requires no additional operative time or specialised equipment, and carries no demonstrable increase in patient risk. On the basis of these findings, PMCS should be established as the standard intraoperative reduction goal for AO/OTA type 31-A2 and 31-A3 intertrochanteric fractures, particularly in elderly patients with osteoporotic bone where the medial cortical buttress is inherently compromised and where anatomical reduction, even when achieved, cannot be relied upon to provide adequate mechanical stability through the pre-union period.

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