Journal of Chemical Health Risks

www.jchr.org

JCHR (2026) 16(1), 2672-2679 | ISSN:2251-6727

Evaluation of Medial Cortical Reduction Pattern on Clinico-Radiological Outcome after Fixation of Intertrochanteric Fractures

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(Received: 05 December 2025 Revised: 15 January 2026 Accepted: 10 February 2026)

KEYWORDS

Unstable intertrochanteric fracture (AO31A2), Medial cortical reduction, PFNA2, Varus collapse, Modified Harris hip score.

ABSTRACT:

Background: Unstable intertrochanteric fractures in elderly patients are associated with high morbidity and mechanical complications. Medial cortical reduction pattern has been suggested as an important determinant of postoperative stability and functional recovery. This study aimed to evaluate the effect of medial cortical reduction patterns on clinico-radiological outcomes following proximal femur nail antirotation (PFNA2) fixation.

Methods: A prospective observational study was conducted in the department of orthopaedics at Integral institute of medical sciences and research (IIMS&R), Lucknow, over 18 months after approval from institutional ethics committee (IEC/IIMSR/2024/36). Sixty-two patients aged ≥60 years with unstable intertrochanteric fractures (AO31A2) treated with PFNA2 were included in the study. There were 33 males and 29 females, with a mean age of 71.9 ± 6.43 years (range 62–85 years). Based on the medial cortical reduction pattern on immediate postoperative radiographs, patients were categorised into 3 groups: positive (n=22), neutral (n=24) and negative (n=16). Radiological outcomes (fracture union, varus collapse, implant-related complications) and functional outcome using Modified Harris Hip Score (mHHS) were assessed at 6 months. Statistical analysis was performed using SPSS version 26.0, with $p<0.05$ considered as significant.

Results: Fracture union rates were highest in the positive reduction group (95.5%) compared to neutral (87.5%) and negative groups (62.5%) ($p=0.098$). Varus collapse was significantly more frequent in the negative group (37.5%) than in the positive (4.5%) and neutral groups (12.5%) ($p=0.020$). Mean mHHS was significantly higher in the positive group (87.7±3.7) compared to neutral (78.6±3.6) and

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JCHR (2026) 16(1), 2672-2679 | ISSN:2251-6727

negative groups (68.3±3.3) ($p<0.001$). Excellent functional outcomes were predominantly observed in the positive reduction group.

Conclusion: Positive medial cortical reduction is associated with superior radiological stability and functional recovery following PFNA2 fixation of unstable intertrochanteric fractures in elderly patients. Achieving positive medial cortical support should be emphasised to optimise surgical outcomes.

INTRODUCTION

Intertrochanteric fractures of the femur are among the most common fragility fractures encountered in the elderly population and constitute a major public health concern due to increasing life expectancy worldwide. These fractures account for nearly half of all hip fractures and are associated with substantial morbidity, mortality and socioeconomic burden, particularly in patients above 60 years of age [1,2]. Early surgical intervention aims to restore mobility, reduce complications related to prolonged immobilization and improve functional outcomes [3].

Unstable intertrochanteric fractures, particularly AO/OTA type 31A2, are characterized by posteromedial comminution and loss of medial cortical support, which significantly affects fracture stability and healing potential [4]. The integrity of the medial cortex plays a crucial role in load transmission across the proximal femur. Loss of medial buttress may lead to excessive collapse, varus malalignment, implant failure and compromised functional recovery [5].

Intramedullary fixation devices, especially proximal femoral nail antirotation (PFNA), have gained widespread acceptance in the management of unstable intertrochanteric fractures because of their biomechanical advantages, shorter lever arm and better control of rotational instability [6,7]. Despite advances in implant design and surgical technique, complications such as blade cut-through, backout, varus collapse and non-union continue to occur, particularly in unstable fracture patterns [8].

Recent literature emphasizes the importance of achieving optimal reduction quality during surgery. Among the various parameters of reduction, the medial cortical reduction pattern has emerged as a key determinant of mechanical stability. Positive medial cortical support, where the proximal fragment overlaps medially over the distal fragment, provides a buttress effect that enhances stability and promotes fracture union [9]. In contrast, neutral or negative reduction patterns may predispose to mechanical failure and inferior functional outcomes [10].

Although several studies have evaluated reduction quality in intertrochanteric fractures, limited data are available regarding the direct association between medial cortical reduction patterns and clinico-radiological outcomes following PFNA fixation, particularly in the elderly Indian population. Understanding this relationship is essential for optimizing surgical strategies and improving patient prognosis.

Therefore, the present study was undertaken to evaluate the effect of medial cortical reduction patterns (positive, neutral and negative) on radiological union, varus collapse, implant-related complications and functional outcome [assessed by the Modified Harris hip score (mHHS)] in elderly patients with unstable intertrochanteric fractures (AO type 31A2) treated with PFNA2.

MATERIALS AND METHODS

A prospective observational study was conducted in the department of orthopaedics at Integral institute of medical sciences and research (IIMS&R), Lucknow, Uttar Pradesh, India, over a period of 18 months. The study was initiated after obtaining approval from the institutional ethics committee (Reference No.: IEC/IIMSR/2024/36).

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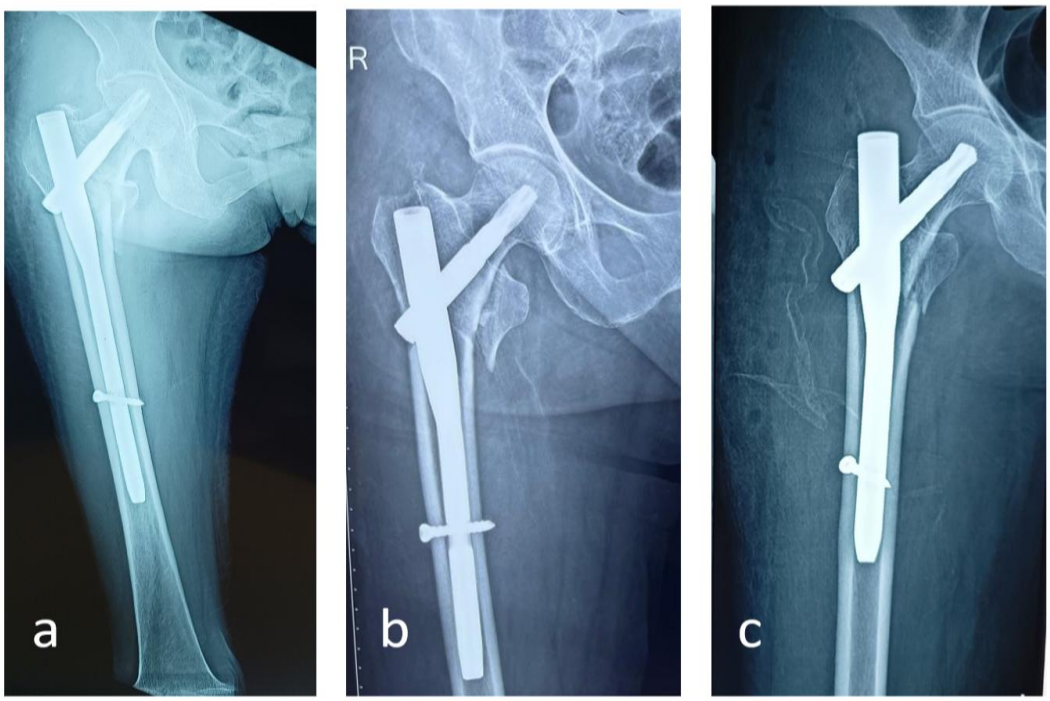
A total of 62 patients aged 60 years or more with unstable intertrochanteric fractures classified as AO31A2 were included in the study. All patients were managed surgically using proximal femoral nail antirotation II (PFNA2). Only those patients with a duration of fracture less than or equal to two weeks were considered eligible for inclusion. Patients with pathological fractures, open fractures, poly trauma, active infection, previous proximal femur surgery, congenital or acquired deformities of the ipsilateral hip, any spinal pathology, ipsilateral arthritis of the knee or ankle and those treated with extramedullary fixation for intertrochanteric fractures were excluded from the study. Written informed consent was obtained from all participants prior to inclusion in the study. Demographic data including age, gender and follow-up duration were recorded. All patients underwent a standardized rehabilitation protocol: immediate postoperative knee mobilization; non-weight bearing ambulation with walker for 6 weeks; partial weight bearing for the next 6 weeks and full weight bearing after 12 weeks.

Radiological evaluation was performed immediately postoperatively and at 6 months follow-up using plain radiographs (anteroposterior and lateral views of the hip with thigh). Based on the medial cortical reduction pattern observed on immediate postoperative radiographs, patients were categorized into three groups: **Group I -** Positive reduction; **Group II -** Neutral reduction; **Group III -** Negative reduction (Figure 1a, b, c).

Figure 1: Immediate postoperative xrays showing **(a)** Positive reduction **(b)** Neutral reduction **(c)** Negative reduction.



Radiological assessment at 6 months included: fracture reduction pattern (positive/ neutral/ negative); evidence of fracture union; varus collapse and implant-related complications (blade cut-through or backout) as shown in Figure 2 a, b and c.

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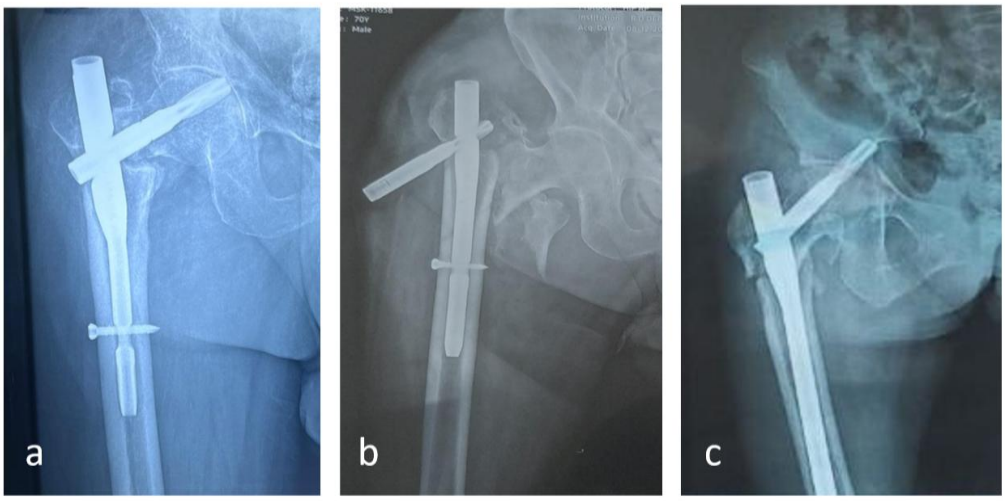
JCHR (2026) 16(1), 2672-2679 | ISSN:2251-6727

Figure 2: Postoperative follow-up xrays - (a) Varus collapse with blade cut-through. **(b)** Nonunion, varus collapse and blade backout. **(c)** Varus collapse and blade cut-through.



Functional outcomes were assessed at 6 months using the Modified Harris hip score (mHHS), which evaluates pain, gait, functional activities, hip range of motion and absence of deformity. The results were graded as: Poor (<70); fair (70–79); good (80–89) and excellent (>90).

Data was entered into microsoft excel and analysed using Statistical Package for Social Sciences (SPSS) version 26.0. Descriptive statistics were used to calculate frequencies and proportions for categorical variables. Continuous variables were expressed as mean ± standard deviation. Associations between sociodemographic, clinical, radiological variables and outcome measures were analysed using Analysis of Variance (ANOVA) and chi square test. A *p*-value < 0.05 was considered statistically significant. The association between medial cortical reduction patterns and clinico-radiological outcomes was analysed to achieve the study objectives.

OBSERVATION AND RESULTS

The study population consisted of 62 patients, 33 males and 29 females, with a mean age of 71.9 ± 6.43 years (range 62–85 years). The patients were distributed as 22 in group I (Positive), 24 in group II (Neutral) and 16 in group III (Negative) [Table 1].

Table 1: Distribution of patients in groups based on postoperative medial cortical reduction patterns.

Medial cortical reduction pattern	**No of patients**	**Percentage (%)**
Group I (Positive)	22	35.5%
Group II (Neutral)	24	38.7%
Group III (Negative)	16	25.8%

Age and gender distributions were comparable across the groups, with no significant differences ($p > 0.05$) as shown in Table 2.

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JCHR (2026) 16(1), 2672-2679 | ISSN:2251-6727

Table 2: Distribution of patients based on demographic characteristics among the three groups.

Demographic Characteristics		Group I (Positive) (n=22)	Group II (Neutral) (n=24)	Group III (Negative) (n=16)	Total (n=62)	p-value
Age (Years)	60-70	11 (50.0%)	13 (54.1%)	8 (50.0%)	32 (51.6%)	0.978*
	71-80	8 (36.4%)	7 (29.2%)	6 (37.5%)	21 (33.9%)	
	>80	3 (13.6%)	4 (16.7%)	2 (12.5%)	9 (14.5%)	
Mean Age (Years)		71.2 ± 6.58	72.5 ± 6.50	72.2 ± 6.43	71.9 ± 6.43	0.785#
Gender	Male	12 (54.5%)	13 (54.2%)	8 (50.0%)	33 (53.2%)	0.955*
	Female	10 (45.5%)	11 (45.8%)	8 (50.0%)	29 (46.8%)	

*Chi-square test; #Analysis of Variance (ANOVA) test.

Radiological assessments at six months evaluated fracture union, varus collapse and implant-related complications. Table 3 shows that **fracture union rates** were highest in the positive group (n=22), with 21 patients (95.5%) achieving union and only 1 patient (4.5%) experiencing non-union; the neutral group (n=24) showed union in 21 patients (87.5%) and non-union in 3 patients (12.5%), while the negative group (n=16) had the lowest union rate, with 10 patients (62.5%) achieving union and 6 patients (37.5%) developing non-union. No cases of malunion were observed in any group. Although a trend toward better union was seen in the positive group, the differences in fracture union rates across the three groups did not reach statistical significance (p = 0.098).

Table 3: Fracture union rates of patients among the three groups.

Variable	Group I (Positive) (n=22)	Group II (Neutral) (n=24)	Group III (Negative) (n=16)	p-value
Union Achieved	21 (95.5%)	21 (87.5%)	10 (62.5%)	0.098
Non-Union	1 (4.5%)	3 (12.5%)	6 (37.5%)	
Malunion	0 (0.0%)	0 (0.0%)	0 (0.0%)	

*Chi-square test

The incidence of **varus collapse** was lowest in the positive group (n=22), affecting only 1 patient (4.5%), compared to 3 patients (12.5%) in the neutral group (n=24) and 6 patients (37.5%) in the negative group (n=16) [Table 4]. The differences across the three groups were statistically significant (p = 0.020).

Table 4: Varus collapse incidence of patients among the three groups.

Variable	Group I (Positive) (n=22)	Group II (Neutral) (n=24)	Group III (Negative) (n=16)	p-value
Varus collapse	1 (4.5%)	3 (12.5%)	6 (37.5%)	**0.020**

*Chi-square test

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Postoperative implant-related complications (Table 5), primarily **blade cut-through or backout**, were lowest in the positive group (n=22), where no patients (0%) experienced such issues. The neutral group (n=24) had 3 patients (12.5%) with blade cut-through or backout. The negative group (n=16) showed the highest rate, affecting 4 patients (25.0%). Although a clear increasing trend in implant-related complications was observed from the positive to the negative group, the difference was not statistically significant (p = 0.053). There were no incidences of blade or nail breakage.

Table 5: Implant-related complications of patients among the three groups.

Implant-Related Complications	Group I (Positive) (n=22)	Group II (Neutral) (n=24)	Group III (Negative) (n=16)	p-value
Blade Cut-through	0 (0.0%)	2 (8.3%)	2 (12.5%)	0.268
Backout	0 (0.0%)	1 (4.2%)	2 (12.5%)	0.203

*Chi-square test

Functional outcomes at 6 months, assessed using the mHHS, were significantly better in the positive group (n=22), where 15 patients (68.2%) achieved excellent ratings, 6 (27.3%) good, 1 (4.5%) fair and none poor, with a mean score of 87.7 ± 3.7 [Table 6]. The neutral group (n=24) showed intermediate results, with no excellent ratings, 5 (20.8%) good, 14 (58.4%) fair and 5 (20.8%) poor, yielding a mean mHHS of 78.6 ± 3.6. The negative group (n=16) had the poorest outcomes, with no excellent or good ratings, 8 patients (50.0%) fair, and 8 (50.0%) poor and a mean score of 68.3 ± 3.3. These differences in both categorical distributions and mean mHHS across the groups were highly statistically significant (p < 0.001).

Table 6: Modified Harris hip score (mHHS) of patients at 6 months among the three groups.

Modified Harris hip score (mHHS) at 6 months	Group I (Positive) (n=22)	Group II (Neutral) (n=24)	Group III (Negative) (n=16)	p-value
Excellent (>90)	15 (68.2%)	0 (0%)	0 (0%)	**<0.001**
Good (80–89)	6 (27.3%)	5 (20.8%)	0 (0%)	
Fair (70–79)	1 (4.5%)	14 (58.4%)	8 (50.0%)	
Poor (<70)	0 (0%)	5 (20.8%)	8 (50.0%)	
Mean mHHS (Mean ± SD)	87.7 ± 3.7	78.6 ± 3.6	68.3 ± 3.3	**<0.001**

*Chi-square test; #ANOVA test

The components of the mHHS at 6 months revealed consistently superior results in the positive group, with mean scores of 40.2 ± 3.1 for pain (out of 44), 30.1 ± 2.8 for gait (out of 33), 12.8 ± 1.5 for functional activities (out of 14) and 4.9 ± 0.3 for range of motion (out of 5). The neutral group (n=24) demonstrated intermediate scores of 36.5 ± 4.0 (pain), 27.3 ± 3.2 (gait), 10.9 ± 1.8 (functional activities), and 4.5 ± 0.5 (range of motion), while the negative group (n=16) recorded the lowest values at 32.8 ± 4.5 (pain), 24.5 ± 3.9 (gait), 9.2 ± 2.1 (functional activities) and 4.1 ± 0.6 (range of

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motion). Statistically significant differences were observed across all four mHHS components among the groups ($p < 0.001$ for each) as shown in Table 7.

Table 7: Components of the Modified Harris hip score of patients among the three groups

mHHS Component	Group I (Positive) (n=22)	Group II (Neutral) (n=24)	Group III (Negative) (n=16)	p-value
Pain (Mean ± SD)	40.2 ± 3.1	36.5 ± 4.0	32.8 ± 4.5	**<0.001**
Gait (Mean ± SD)	30.1 ± 2.8	27.3 ± 3.2	24.5 ± 3.9	**<0.001**
Functional activities (Mean ± SD)	12.8 ± 1.5	10.9 ± 1.8	9.2 ± 2.1	**<0.001**
Range of motion (Mean ± SD)	4.9 ± 0.3	4.5 ± 0.5	4.1 ± 0.6	**<0.001**

[#]ANOVA test

DISCUSSION

Intertrochanteric fractures in the elderly remain a significant orthopaedic challenge due to poor bone quality, fracture instability and associated comorbidities. Achieving stable fixation that allows early mobilization is the primary goal of treatment [1,2]. In unstable fracture patterns such as AO/OTA 31A2, restoration of medial cortical support is considered crucial for maintaining mechanical stability and preventing varus collapse [4,5].

In the present study, patients with **positive medial cortical reduction** demonstrated superior clinico-radiological outcomes compared to neutral and negative reduction groups. The fracture union rate was highest in Group I (95.5%), followed by Group II (87.5%) and Group III (62.5%). Although the difference in union rates did not reach statistical significance ($p = 0.098$), a clear clinical trend was observed favouring positive medial cortical support. These findings are consistent with the biomechanical principle described by Evans [5], who emphasized the importance of medial buttress restoration in maintaining fracture stability.

Varus collapse was significantly more common in the negative reduction group (37.5%) compared to positive (4.5%) and neutral groups (12.5%) ($p = 0.020$). This supports the concept proposed by Chang et al. [9,10], who highlighted that positive medial cortical support acts as a mechanical buttress, reducing excessive sliding and preventing varus deformity. Loss of medial cortical integrity increases compressive and bending forces across the implant, predisposing to mechanical failure [8].

Implant-related complications such as blade cut-through and back-out were more frequently observed in neutral and negative reduction groups, although statistical significance was not achieved. Baumgaertner et al. [8] demonstrated that mechanical factors such as reduction quality and implant positioning strongly influence fixation failure. Poor medial cortical apposition likely contributes to excessive implant loading and secondary displacement.

Functional outcomes, as assessed by the mHHS, were significantly better in patients with positive medial cortical reduction. Group I had a mean mHHS of 87.7 ± 3.7, compared to 78.6 ± 3.6 in Group II and 68.3 ± 3.3 in Group III ($p < 0.001$). A majority (68.2%) of patients in Group I achieved excellent outcomes, whereas half of the patients in Group III had poor scores. These findings strongly correlate reduction quality with postoperative functional recovery. Similar observations were reported by Simmermacher et al. [6], who emphasized that stable fixation with intramedullary devices facilitates early rehabilitation and better functional outcomes.

The individual components of mHHS (pain, gait, functional activities and range of motion) were significantly superior in the positive reduction group ($p < 0.001$), indicating that restoration of medial cortical support not only enhances radiological stability but also improves pain relief and mobility.

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This is particularly relevant in elderly patients, where early return to ambulation reduces complications such as deep vein thrombosis, pneumonia and pressure sores [3].

Although the study demonstrated significant associations between medial cortical reduction patterns and functional as well as radiological outcomes, certain limitations must be acknowledged. The sample size was relatively small, and follow-up duration was limited to 6 months. Longer follow-up could provide further insight into late complications and long-term functional outcomes.

Overall, the findings of the present study reinforce the importance of achieving positive medial cortical support during fixation of unstable intertrochanteric fractures with PFNA2. Restoration of the medial buttress appears to be a key determinant of fracture union, prevention of varus collapse, reduction of implant-related complications and improved functional recovery.

CONCLUSION

This study demonstrates that the medial cortical reduction pattern is a critical determinant of outcome following PFNA2 fixation of unstable intertrochanteric fractures (AO31A2) in elderly patients. Positive medial cortical reduction was significantly associated with reduced varus collapse and superior functional outcomes at 6 months, along with a trend toward higher union rates and fewer implant-related complications.

Therefore, restoration of positive medial cortical support should be emphasised as an essential intraoperative goal to enhance mechanical stability and optimise clinico-radiological outcomes.

ACKNOWLEDGEMENT

The authors are grateful to IIMS&R, Integral University, Lucknow, for providing the manuscript communication number (MCN): IU/ R&D/ 2026-MCN0004375.

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