

The Efficacy of Pelvic Intramedullary Nailing Combined with Sacroiliac Screws in the Treatment of Unstable Pelvic Fractures in Elderly Patients

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Abstract: *Objective:* The 1-year mortality rate of elderly pelvic fractures reaches 23%, and minimally invasive and effective fixation has become a research hotspot. Traditional plate and screw fixation carries risks of complications. This study compared the clinical efficacy of novel pelvic intramedullary nails combined with sacroiliac screws (IMN group) versus traditional plate-screw fixation combined with sacroiliac screws (plate group) in treating unstable pelvic fractures in elderly patients. *Methods:* A retrospective analysis was performed on 32 elderly patients (over 60 years old) diagnosed with unstable pelvic fractures admitted to our hospital from 2020 to 2024. The IMN group (n=13) received anterior ring fixation with intramedullary nails and posterior ring fixation with sacroiliac screws; the plate group (n=19) underwent anterior ring reconstruction plate fixation combined with posterior sacroiliac screw fixation. All patients were followed up for at least 1 year (average follow-up duration: 21 months). Observation indicators included 1-year survival rate, Majeed functional score, operation time, intraoperative blood loss, fluoroscopy frequency, fracture healing time (Matta criteria), and postoperative complications. *Results:* Three patients died within 1 year after surgery (1 in the IMN group, 2 in the plate group), all due to pulmonary infection. Compared with the plate group, the IMN group showed significantly shorter operation time (73.2 ± 13.4 min vs 106.2 ± 22.5 min, $P < 0.05$), drastically reduced intraoperative blood loss (52.4 ± 32.2 ml vs 381.6 ± 322.7 ml, $P < 0.05$), and higher Majeed functional scores (83.5 ± 8.6 vs 78.6 ± 9.2). No statistically significant intergroup differences were observed in fracture healing time (average 2.8–2.9 months), fracture reduction quality (18 cases with anatomical/satisfactory reduction in each group), or 1-year survival rate. No complications occurred in the IMN group, while 2 patients in the plate group developed subcutaneous effusion that resolved after debridement. The IMN group required more intraoperative fluoroscopy (63.6 ± 28.9 vs 35.7 ± 12.2). *Conclusion:* For elderly unstable pelvic fractures, pelvic intramedullary nailing combined with sacroiliac screws achieves equivalent fracture reduction quality, bone healing and 1-year survival rates compared with traditional plate-screw fixation. Meanwhile, this minimally invasive technique significantly shortens operation duration, cuts intraoperative blood loss and lowers complication rates, delivering

satisfactory clinical outcomes.

Keywords: Pelvic intramedullary nail; Sacroiliac screw; Elderly patients; Unstable pelvic fracture

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1. Research Background

Pelvic fractures represent severe injuries with high mortality and disability rates, with a global incidence of 20–37 per 100,000 people. In recent years, the epidemiological characteristics of pelvic fractures have shifted notably: the proportion of high-energy trauma has declined, while low-energy osteoporotic pelvic fractures among the elderly have risen sharply. The 1-year mortality rate of elderly pelvic fractures is as high as 23%, far exceeding the 14.7% mortality of hip fractures. Therefore, minimally invasive and reliable fixation for elderly pelvic fractures has become a key research focus.

Conventional fixation modalities for pelvic fractures include external fixators, reconstruction plates, channel screws and pelvic intramedullary nails. As an emerging fixation technique, pelvic intramedullary nails feature minimally invasive access and anatomical shaping. They deliver stable fixation while avoiding severe complications such as massive hemorrhage, intra-articular screw penetration and pelvic cavity injury frequently associated with traditional plates and channel screws.

This study compared two fixation strategies—pelvic intramedullary nails combined with sacroiliac screws versus conventional plate-screw fixation—in elderly pelvic fracture patients. Indicators including 1-year all-cause mortality, intraoperative blood loss and postoperative functional recovery were analyzed to evaluate the clinical efficacy of the combined intramedullary nail technique.

2. Materials and methods

2.1. Study design

A retrospective cohort study was conducted. Consecutive elderly patients with unstable pelvic fractures admitted between January 2020 and January 2024 were enrolled via the hospital electronic medical record system. This research was approved by the Medical Ethics Committee of our hospital, and informed consent was waived.

2.2. Case selection criteria

2.2.1. Inclusion criteria

- (1) Age ≥ 60 years old;
- (2) Tile classification B (B1–B3) or C pelvic fracture;
- (3) Diagnosis confirmed by preoperative pelvic three-dimensional CT reconstruction;
- (4) Treated with either IMN + sacroiliac screw fixation or reconstruction plate + sacroiliac screw fixation;
- (5) Complete clinical follow-up data for a minimum of 12 months.

2.2.2. Exclusion criteria

- (1) Pathological fractures (metastatic tumors, osteomyelitis, etc.);

- (2) Severe traumatic brain injury ($GCS \leq 8$) or ISS score ≥ 16 ;
- (3) Pre-existing walking dysfunction ($mRS \geq 3$);
- (4) Lost to follow-up or deaths unrelated to pelvic fracture injury.

2.3. Grouping protocols

- (1) IMN group ($n=13$): Anterior ring fixation using pelvic anterior column intramedullary nail system (Tianjin ZhengTian Medical Devices Co., Ltd.); posterior ring stabilized with 7.3 mm cannulated sacroiliac screws (Tianjin ZhengTian Medical Devices Co., Ltd.).
- (2) Plate group ($n=19$): Anterior ring fixation via reconstruction plates (Tianjin ZhengTian Medical Devices Co., Ltd.); posterior ring fixation identical to the IMN group.

2.4. Surgical techniques

2.4.1. IMN group surgical procedures

- (1) Position and fluoroscopic localization: General anesthesia with supine positioning; real-time C-arm fluoroscopy throughout the operation.
- (2) Anterior ring fixation: A 3 cm longitudinal incision was made 1 cm lateral to the anterior inferior iliac spine. Under fluoroscopic guidance, a guide wire was inserted into the pubic ramus medullary canal (on anteroposterior view, medial to the hip “teardrop” projection). After medullary reaming, an 8 mm titanium alloy intramedullary nail was implanted.
- (3) Posterior ring fixation: Seldinger technique for percutaneous insertion of S1/S2 channel sacroiliac screws; C-arm scanning performed intraoperatively to verify proper screw placement.

2.4.2. Plate group surgical procedures

- (1) Anterior ring fixation through modified Stoppa approach with 6–10 hole reconstruction plates for pubic symphysis stabilization;
- (2) Posterior ring fixation consistent with the IMN group.

2.5. Perioperative management

- (1) Intravenous cefuroxime 1.5 g administered 30 minutes preoperatively for antibiotic prophylaxis;
- (2) Surgical drains removed 24 hours postoperatively if placed;
- (3) Low-molecular-weight heparin anticoagulation maintained until ambulation;
- (4) Bedside rehabilitation training initiated on postoperative day 3.

2.6. Observation indicators

2.6.1. Primary outcome

1-year all-cause mortality (recorded up to 365 days postoperatively).

2.6.2. Secondary outcomes

- (1) Intraoperative surgical parameters: Operation time (from skin incision to wound closure), total blood loss (calculated via suction volume plus gauze weighing method), total fluoroscopy counts (automatically recorded by C-arm equipment).
- (2) Functional assessment: Majeed pelvic functional score (Excellent ≥ 85 , Good 70–84, Poor < 70).

- (3) Radiological assessment: Fracture healing criteria (continuous callus formation + VAS pain score <3);
Matta reduction grading (anatomical reduction defined as residual displacement ≤ 4 mm).

2.7. Statistical analysis

SPSS 26.0 software was used for statistical analysis. Normally distributed measurement data (verified via Shapiro-Wilk test) were expressed as mean $\pm$ standard deviation, and intergroup comparisons were performed using independent samples *t*-test. Count data were presented as case numbers (percentages), compared via chi-square test or Fisher's exact test. Kaplan-Meier survival analysis was applied for mortality data. $P < 0.05$ was defined as statistically significant.

3. Results

3.1. Baseline patient characteristics

A total of 32 patients were enrolled. Baseline intergroup comparisons showed balanced demographic and clinical data:

- (1) Age: IMN group (68.2 $\pm$ 5.4) years vs Plate group (70.1 $\pm$ 6.2) years ($t=0.893$, $P=0.379$).
- (2) Gender distribution: Males accounted for 53.8% (7/13) in IMN group and 57.9% (11/19) in Plate group ($\chi^2=0.063$, $P=0.802$).
- (3) Tile fracture classification (**Table 1**).
- (4) Comorbidities: No significant intergroup differences in hypertension ($P=0.672$), diabetes mellitus ($P=0.521$), or other chronic illnesses.

Table 1. Tile fracture classification of two groups

Fracture Type	IMN group (n=13)	Plate group (n=19)	<i>P</i> -value
B1	4 (30.8%)	6 (31.6%)	0.842
B2	5 (38.5%)	8 (42.1%)	0.791
C	4 (30.8%)	5 (26.3%)	0.913

3.2. Intraoperative surgical metrics (Table 2)

Table 2 compares intraoperative indicators between the IMN group (13 patients) and the Plate group (19 patients).

Table 2. Comparison of intraoperative indicators between two groups

Index	IMN group (n=13)	Plate group (n=19)	t/χ^2 value	<i>P</i> -value
Operation time (min)	73.2 $\pm$ 13.4	106.2 $\pm$ 22.5	4.832	<0.001
Intraoperative blood loss (ml)	52.4 $\pm$ 32.2	381.6 $\pm$ 322.7	3.971	<0.001
Fluoroscopy counts	63.6 $\pm$ 28.9	35.7 $\pm$ 12.2	3.562	0.021
Patients receiving blood transfusion	0 (0%)	5 (26.3%)	4.329	0.037

3.3. Postoperative follow-up outcomes

3.3.1. Survival analysis

- (1) 1-year cumulative survival rate: IMN group 92.3% (12/13) vs Plate group 89.5% (17/19) (Log-rank

$\chi^2=0.142$, $P=0.706$).

- (2) Mortality cases: All 3 deaths resulted from postoperative pulmonary infection. One patient in IMN group died 8 months after surgery; two patients in Plate group died at 5 and 11 months postoperatively respectively.

3.3.2. Functional recovery

- (1) Majeed functional score stratification (Table 3)
- (2) Postoperative ambulation time: IMN group (14.2 ± 3.1) days vs Plate group (18.7 ± 4.5) days ($t=2.874$, $P=0.039$).

Table 3. Majeed score grading of surviving patients

Grade	IMN group (n=12)	Plate group (n=17)	P-value
Excellent	8 (66.7%)	6 (35.3%)	0.032
Good	3 (25.0%)	9 (52.9%)	0.041
Poor	1 (8.3%)	2 (11.8%)	0.621

3.3.3. Radiological outcomes

- (1) Fracture healing time: No significant intergroup difference (IMN group 2.8 ± 0.7 months vs Plate group 2.9 ± 0.8 months, $P=0.712$).
- (2) Matta reduction grading: IMN group: 10 anatomical reductions (76.9%), 2 satisfactory reductions (15.4%), 1 unsatisfactory reduction (7.7%); Plate group: 12 anatomical reductions (63.2%), 6 satisfactory reductions (31.6%), 1 unsatisfactory reduction (5.3%) ($\chi^2=1.127$, $P=0.569$).

3.4. Postoperative complications

No complications including incision infection or nerve injury were observed in the IMN group. In the plate group, 2 patients (10.5%) developed subcutaneous wound effusion resolved by debridement; 1 patient (5.3%) presented lateral femoral cutaneous nerve palsy with spontaneous recovery within 6 months.

4. Discussion

The incidence of elderly pelvic fractures rises annually with population aging. Similar to hip fractures, pelvic fractures carry elevated mortality risks. Diminished physical reserve and immune function in elderly individuals increase perioperative adverse events, reducing survival rates and long-term quality of life. Rommens et al. proposed minimally invasive early fixation for fragility pelvic fractures (FFP) in elderly patients, prioritizing early mobility rather than perfect anatomical reduction—principles consistent with geriatric hip fracture management.

Advancements in minimally invasive anterior pelvic ring fixation have expanded clinical options. Vaidya first introduced the INFIX subcutaneous internal fixator technique. Lodde et al. compared five fixation modalities for unstable osteoporotic pelvic ring fractures and concluded that percutaneous retrograde pubic screws or S1/S2 iliosacral screws serve as effective minimally invasive alternatives to open plating. Hopf et al. reported minimal intraoperative and postoperative complications in 30 patients treated with percutaneous iliosacral screw fixation for posterior pelvic ring injuries, consistent with our finding of significant

postoperative pain relief across all surgical cohorts. Shetty et al. combined INFIX and percutaneous iliosacral screws to achieve optimal fracture stabilization with minimal complications and favorable functional outcomes. Domestic research by Li Zutao et al. confirmed that anterior pelvic intramedullary nails yield reliable minimally invasive outcomes with low complication rates for superior pubic ramus fractures, representing a preferred fixation strategy.

The superior pubic ramus features a curved cancellous bone channel extending from the pubic symphysis to the supra-acetabular iliac region. Its anatomical curvature complicates straight screw implantation and limits widespread adoption of conventional screw techniques. The dual-curve anatomical pelvic anterior column intramedullary nail matches the physiological curvature of Chinese pubic rami, providing concurrent reduction and mechanical stability. Implantation through cancellous bone avoids cortical penetration and intra-articular hardware malposition; the curved tip delivers directional safety and reduces iatrogenic tissue injury. The fixed, easily accessible entry point lowers the surgical learning curve compared with pubic ramus cannulated screws.

Our study demonstrates that despite increased fluoroscopy exposure, pelvic intramedullary nail combined sacroiliac screw fixation outperforms traditional plate-screw fixation in shorter operative duration, drastically reduced blood loss, fewer blood transfusions, higher postoperative functional excellence rates, and elimination of plate-related complications such as wound effusion and nerve palsy.

This research bears inherent limitations: it is a single-center retrospective case-control study prone to selection bias, with limited sample size and moderate follow-up duration.

5. Conclusion

In conclusion, pelvic intramedullary nailing combined with sacroiliac screws achieves equivalent fracture reduction quality, bone healing and 1-year survival rates versus conventional plate-screw fixation for elderly unstable pelvic fractures. This minimally invasive protocol significantly shortens surgery time, reduces intraoperative hemorrhage and lowers complication risks, delivering satisfactory clinical efficacy.

Disclosure statement

The authors declare no conflict of interest.

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