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Augmented Surgical Fixation of Pelvic Fractures in Elderly Patients. A prospective case series study from level one trauma centre in Upper Egypt

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Augmented Surgical Fixation of Pelvic Fractures in Elderly Patients. A prospective case series study from level one trauma centre in Upper Egypt

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Ethics approval

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethical Review Board of the Faculty of Medicine, Assiut University (IRB local approval number: 04-2023-200291).

Consent to participate

Informed consent to participate in the study was obtained from all participants prior to enrollment

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ‘Grammarly AI tool) in order to rephrase and refine the language of this manuscript, ensuring clarity and grammatical accuracy for publication. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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Conflict of interest

The authors declare that they have no conflict of interest.

Keywords

Pelvic fractures; Elderly; augmented Surgical fixation; Early mobilization; Functional outcome; Prognostic factors.

Abstract

Purpose: The purpose of this study was to evaluate functional outcomes after augmenting surgical fixation of pelvic fractures in elderly patients and to identify clinical and surgical factors influencing recovery, particularly the role of early mobilization.

Methods: This prospective case series was conducted at Assiut University Trauma Hospital, which is level 1 trauma center, between May 2023 and July 2024. This study included 15 patients aged ≥65 years with pelvic fractures treated surgically using minimally invasive augmented surgical fixation techniques. Preoperative evaluation included clinical assessment, pelvic radiographs, and CT scans, with fractures classified according to the Rommens classification and AO/OTA systems. Posterior stabilization was performed using transsacral screws, with additional anterior fixation using INFIX or locked symphyseal plating when indicated. The primary outcome was post surgery weightbearing pain assessed by the Visual Analog Scale (VAS), while secondary outcomes included functional evaluation using the Majeed's score and Merle d'Aubigné score, radiological union and implant loosening. Follow-up was performed up to one year.

Results: Fifteen patients were included (mean age 67.7 ± 3.2 years), with a predominance of males (86.7%). Most injuries resulted from low-energy trauma (60%). According to Rommens classifications, types II–III fractures were most common fractures to be included, while AO/OTA type B fractures predominated. Transsacral screw fixation was the most frequently used technique (60%), often combined with anterior stabilization methods. Median intraoperative blood loss was 30 ml and mean radiation exposure was 2.76 ± 0.87 mSv. Significant improvement was observed in clinical outcomes during follow-up, with VAS scores decreasing from 3.47 ± 1.25 at 3 weeks to 0.85 ± 0.90 at 1 year ($p < 0.001$) and Majeed scores improving from 58 ± 12 at 1.5 months to 89 ± 10 at 1 year ($p < 0.001$). Delayed weight bearing and higher early pain scores were strongly associated with poorer functional outcomes. Early postoperative pain was the only independent predictor of the 1-year Majeed score. One-year mortality was 13.3%, radiological union occurred in 92.3% of patients, and implant loosening occurred in 23% without requiring reoperation.

Conclusion: Augmented fixation techniques provide stable management of pelvic fractures in elderly patients, facilitating early mobilization and significant functional improvement. Early pain control and timely weight bearing appear to be key determinants of recovery.

Introduction

Pelvic fractures in the elderly represent a major clinical challenge associated with high morbidity, functional decline, and increased mortality. With the progressive aging of populations, the incidence of these injuries continues to rise, placing substantial demands on healthcare systems and rehabilitation services. Elderly patients with pelvic fractures frequently experience severe pain and prolonged immobility, which significantly compromise independence and quality of life. Due to advancements in healthcare, the elderly population has become more active, leading to increased functional demands and a higher exposure to high-energy trauma. Therefore, pelvic fractures in the elderly may result from either low-energy or high-energy mechanisms. Traditional methods for managing pelvic fractures in the elderly such as conservative treatment or applying the same principles and tools used in younger adults may delay weight bearing and adversely affect functional outcomes. (1-3)

Complications such as thromboembolism, pulmonary infection, pressure ulcers, and overall deterioration in function frequently result from delayed ambulation so achieving early mobilization is the main therapeutic objective (4,5). However, non-operative management often provides insufficient mechanical stability and pain control, leading to delayed rehabilitation and suboptimal outcomes. Consequently, surgical fixation has gained increasing importance as a means of restoring pelvic stability, reducing pain, and enabling safe early mobilization. On the other hand surgical fixation in elderly patients is challenging due to reduced physiological reserve, which limits tolerance for major surgical procedures. In addition, poor bone quality associated with osteoporosis restricts the available options for stable pelvic fixation. Therefore, minimally invasive augmented fixation techniques represent a rational and biomechanically sound approach, as they provide enhanced stability while minimizing surgical trauma. (6)

Recent advances in pelvic fracture classification, imaging, and minimally invasive fixation techniques have improved recognition of instability and broadened surgical options for elderly patients (7-9). Modern strategies emphasize percutaneous posterior and anterior ring stabilization, with

augmentation applied when necessary like INFIX, trans-sacral screws (TSS) with fully threaded screws, the use of multiple TSS, fixed-angle symphyseal plates, spinopelvic fixation and cement augmentation to enhance fixation in osteoporotic bone (10–12). Despite these advances, there remains limited prospective evidence identifying which clinical, surgical, and radiological factors most strongly influence functional recovery. This study hypothesizes that minimally invasive augmented fixation techniques offer enhanced biomechanical stability in elderly pelvic fractures, thereby promoting earlier mobilization, improving functional recovery, and minimizing postoperative complications. Specifically, it seeks to evaluate functional outcomes using the Majeed Pelvic Score, assess pain reduction through the Visual Analogue Scale (VAS), and identify early weight-bearing as a critical determinant of prognosis.

Patients and Methods

Study Design and setting

This prospective case series was conducted at Assiut University Hospitals which is a Level 1 trauma center, between May 2023 and July 2024. The study included 15 consecutive patients aged 65 years or older who sustained pelvic fractures and were managed surgically. Inclusion criteria were patients with radiologically confirmed pelvic fracture on plain radiographs and computed tomography, willingness to participate in the study, and to be treated by surgical fixation.. Patients with uncontrolled medical comorbidities precluding surgical intervention were excluded from the study.

Ethical considerations

The research was conducted exclusively by scientifically qualified and trained personnel in accordance with the ethical principles of the Declaration of Helsinki. Informed consent was obtained from all participants prior to enrollment, and all collected data were kept strictly confidential and used solely for research purposes. The study protocol was reviewed and approved by the Ethical Review Board of the Faculty of Medicine, Assiut University (IRB local approval number: 04-2023-200291). This study was prospectively registered at ClinicalTrials.gov under identifier NCT05837182 with a registration date 18th of May, 2023.

Outcomes

The primary outcome was post–weight-bearing pain intensity, measured using the Visual Analog Scale (VAS) at 3 weeks, 1.5 months, 6 months, and 1 year following surgery. Secondary outcomes included functional assessment using the Majeed score (13) and the Merle d'Aubigné score (14) at 1.5 months, 6 months, and 1 year. Radiological union, implant loosening, and one-year mortality were also evaluated.

Patient assessment

A detailed history was obtained including age, residence, occupation, pre-injury mobility assessed by the Parker Mobility Score (15), comorbidities using the age-adjusted Charlson Comorbidity Index (ACCI) (16), medication history, and mechanism of trauma. Pain location, post-injury weight-bearing ability, and any disturbance of consciousness were documented. Clinical evaluation included assessment of general condition, vital signs, systemic examination, screening for associated fractures, and local pelvic examination focusing on tenderness, soft tissue status, limb alignment, neurovascular integrity, and signs of deep venous thrombosis.

All patients underwent X ray pelvis views including anteroposterior (AP), inlet, outlet, lateral views and computed tomography for fracture assessment as shown in Figures 1 and 2. Fractures were classified using both the Rommens classification for Fragility Pelvic Fractures patients and the AO/OTA pelvic fracture classification system. Fracture stability, posterior ring involvement, and displacement patterns were documented for treatment planning. Preoperative CT imaging was also utilized to determine the appropriate screw length and to assess for pelvic dysmorphism that could influence the trans-sacral screw corridor.



Figure 1 A, B and C: AP, outlet and inlet views of case 1 of a male patient, seventy two years old with pelvic fracture, Rommens classification IIIB , AO classification 61B1

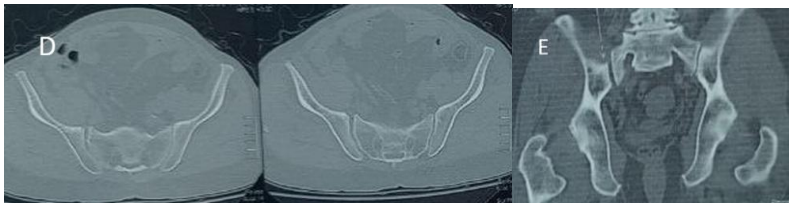


Figure 1 D and E: Preoperative imaging with CT scans showing widening of the right sacroiliac joint

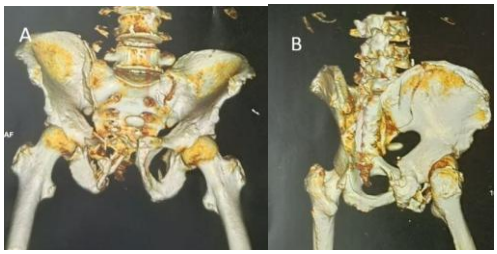


Figure 2 A and B: Preoperative 3D CT imaging of case 2 of male patient, 67 years old, Rommens classification IVC, AO classification 61C1

Surgical Techniques

All procedures were performed with the patient in the supine or prone position according to the technique being used on a radiolucent table to allow optimal fluoroscopic visualization. Either spinal or general anaesthesia was administered according to the patient's clinical condition and associated injuries. Standard fluoroscopic imaging was used throughout the procedure to obtain anteroposterior, inlet, outlet, and lateral views for accurate reduction and implant positioning. Indirect reduction techniques were primarily utilized under fluoroscopic guidance, and open anterior reduction was reserved for selected cases requiring direct visualization.

Transsacral screw fixation was planned preoperatively using CT-based corridor analysis to ensure safe screw trajectory within the sacral osseous pathway. Under multiplanar fluoroscopic control, a guidewire was inserted across the transsacral corridor, followed by placement of a cannulated 7.3-mm screw with a washer. Proper positioning was confirmed using AP, inlet, outlet, and lateral sacral views to avoid cortical breach or neural injury. Additional screws were inserted when required to enhance stability as shown in Figure 3. (17)

The anterior internal fixator (INFIX) was applied by inserting supra-acetabular screws from the anterior inferior iliac spine (AIIS) toward the

posterior superior iliac spine (PSIS). A pre-contoured subcutaneous rod was passed across the lower abdomen and connected to the screw heads, forming a stable anterior construct. Care was taken to avoid injury to the femoral nerve and the lateral femoral cutaneous nerve during insertion, as shown in Figure 4. (18)

Locked symphyseal plating was indicated for symphyseal disruptions and parasymphyseal fractures requiring rigid anterior stabilization. Exposure was achieved through a Pfannenstiel or modified Stoppa approach. After reduction, a contoured small-fragment locking plate was applied with long screw trajectories to maximize bone purchase, as shown in Figure 3.



Figure 3. Immediate postoperative pelvic radiographs of Case 1 after fixation with Trans-sacral screw and locked symphyseal plating (A) Anteroposterior (AP) view**,** (B) Outlet view and (C) Inlet view



Figure 4. Immediate postoperative pelvic radiographs of case 2 of male patient with seventy six years old, with pelvic fracture, Rommens classification IVC , AO classification 61B2 fixed with INFIX, Sigle Trans-sacral screw and right posterior LC2 screw, (A) Anteroposterior (AP) view, (B) Outlet view and (C) Inlet view.

Postoperative care

Postoperative care included neurovascular assessment and radiographic evaluation (AP, inlet, outlet, lateral sacral views). Prophylaxis with a first-generation cephalosporin, calcium, and vitamin D supplementation was administered. Reduction quality was graded using Lefaivre's rotational symmetry (19) , and Matta and Tornetta's vertical displacement criteria as shown in Figure 5. (20)

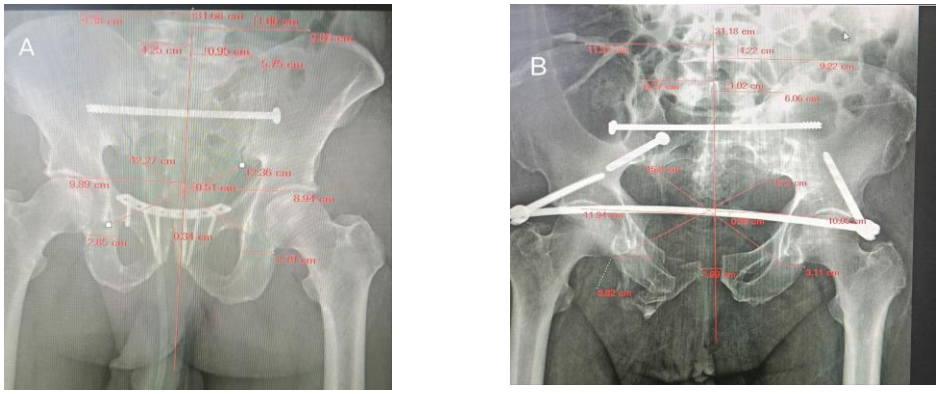
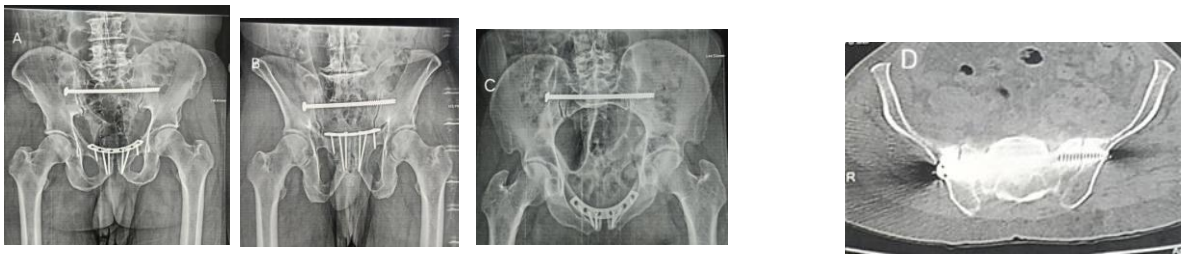


Figure 5. Radiographic assessment of reduction parameters following pelvic fixation (A) for Case 1 and (B) for Case 2

Assisted weight bearing was initiated as tolerated. All patients were instructed in range-of-motion and strengthening exercises.

Clinical follow-up was performed at 3 weeks, 6 weeks, 6 months, and 1 year with assessment of pain using the Visual Analogue Scale (VAS), assessment of functional outcome using Majeed score and Merle d'Aubigné score. Radiographs were obtained at each visit, with CT at 1 year to assess union, implant stability, and loosening, as shown in Figures 6 and 7.



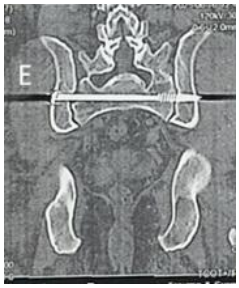


Figure 6. One-year follow-up of Case 1 showing maintained pelvic alignment and stable fixation on radiographs (A–C), CT images (D–E)

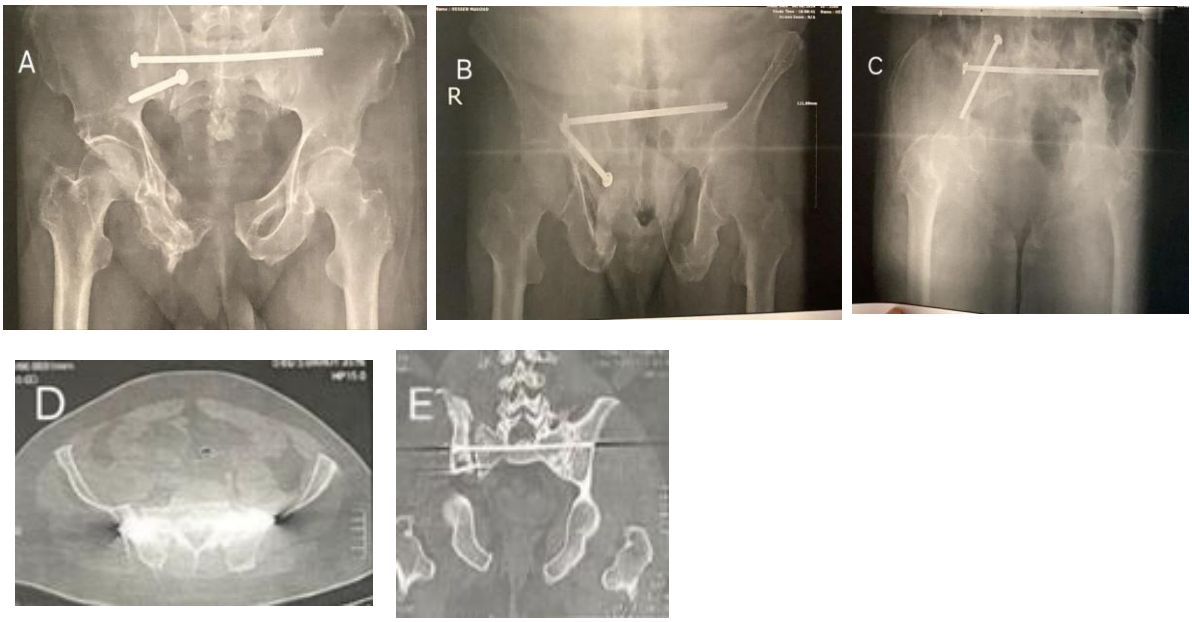


Figure 7: One-year follow-up of Case 2 after INFIX removal, with plain radiographs (A–C) and CT images (D-E).

Statistical Analysis

Data analyzed using SPSS v20. Repeated measures were tested by Friedman and Wilcoxon. Sign test for non-parametric comparisons. Spearman correlation for associations. $p < 0.05$ considered significant.

Results

Fifteen patients were included, where 2 females and 13 males were included, mean age was 67.7 ± 3.2 years, range was 65–76 years. The mean age-

adjusted Charlson Comorbidity Index [16] was 2.7 ± 0.7. Nine patients were having low-energy trauma, while the rest had high-energy trauma, as shown in Table 1.

Variable	Value
Total number of patients	15
Mean age (years)	67.7 ± 3.2 (65–76)
Sex	
– Male	13 (86.7%)
– Female	2 (13.3%)
Age-adjusted Charlson Comorbidity Index	2.7 ± 0.7, range: (2–4)
Median Parker Mobility Score (pre-injury)	7, range (2–9)
Mechanism of injury	
– Low-energy trauma	9 (60%)
– High-energy trauma	6 (40%)

Table 1 Baseline demographic data, comorbidity profile, and mechanism of injury of the study cohort, Data expressed as frequency ± SD, (percentage) and range

Most injuries were Rommens types II–III, with type IIC the most frequent (26.7%). By AO/OTA classification, type B fractures predominated, especially subtype B2.1 (26.7%), as shown in Table 2

Rommens Classfication	Frequency (percentage)	**AO/OTA Classification**	Frequency (percentage)
IIC	4 (26.7%)	B2	9 (60%)
IIIA	2 (13.3%)	B3	3 (20%)
IIIB	3 (20.0%)	C1	3 (20%)
IIIC	3 (20.0%)		
IVA	1 (6.7%)		
IVC	2 (13.3%)		

Table 2: Distribution of pelvic fracture patterns according to the Rommens–Hofmann and AO/OTA classification systems, Data expressed as frequency (percentage).

Transsacral screw fixation was the most common fixation method to be used (60%), followed by locked symphyseal plating (33.3%), iliosacral screws (26.7%), LC2 screws (20%), INFIX (20%), and HA-coated external fixation (13.3%). Combined constructs were frequently applied as shown in Table 3.

Fixation Type	Frequency (percentage)
Transsacral screws	9 (60%)
INFIX	3 (20%)
Locked symphyseal plate	5 (33.3%)
HA-coated Ex-fix	2 (13.3%)
LC2 screws	3 (20%)
Iliosacral screws	4 (26.7%)

Table 3: Types of fixation methods used in the study cohort. Data expressed as frequency (percentage).

According to the Matta grading system [20] for vertical displacement, anatomical or acceptable reduction (<10 mm) was achieved in the majority of cases (80%), while poor reduction (>10 mm) occurred in 20% of patients. Based on the Lefaivre grading system [19] for rotational deformity, none of the cases demonstrated severe rotational malreduction, with most of the patients showed anatomical, near-anatomical, or moderate alignment, as shown in Table 4.

Grading system	Quality of reduction	Frequency (percentage)
Matta (vertical displacement)	Anatomical (< 4 mm)	6 (40%)
	Imperfect (4–10 mm)	6 (40%)
	Poor (> 10 mm)	3 (20%)
Lefaivre (rotational deformity)	Anatomical (< 5 mm)	5 (33.3%)
	Near anatomical (5–10 mm)	5 (33.3%)
	Moderate (10–20 mm)	5 (33.3%)
	Poor (> 20 mm)	0 (0%)

Table 4: Quality of fracture reduction according to Matta and Lefaivre criteria. Data expressed as frequency (percentage).

Intraoperative blood loss and radiation exposure

The median intraoperative blood loss was 30 mL (IQR 10–170 mL), indicating minimal bleeding in most cases. The mean blood loss was higher

(86.3 ± 102.9 mL) due to a few cases with increased blood loss associated with open anterior ring fixation using locked symphyseal plates. The mean intraoperative radiation exposure was 2.76 ± 0.87 mSv (range 1.57–4.41 mSv).

Functional outcome

Median time to start painless weight-bearing was 11 days (range 1–45). Clinical and functional outcomes improved progressively throughout the follow-up period. Functional recovery assessed by the Majeed score showed an increase in score over time, while VAS scale showed a decrease over time, indicating gradual pain relief. In addition, the Merle d'Aubigné score showed further improvement between 6 months and 1 year. (13,14)

All Clinical and functional outcome measured during the follow-up period showed significant difference with p-value less than 0.05, as shown in Table 5.

Outcome	Time Points	Mean ± SD	Statistical Test	Test Value	p-value
VAS scale	3 weeks	3.47 ± 1.25	Friedman	$\chi^2 = 34.5$	<0.001*
	1.5 months	1.77 ± 1.17			
	6 months	1.23 ± 0.83			
	1 year	0.85 ± 0.90			
Majeed score	1.5 months	58 ± 12	Friedman	$\chi^2 = 14.81$	0.0006*
	6 months	84 ± 12			
	1 year	89 ± 10			
Merle d'Aubigné score	6 months	15.46 ± 2.18	Sign test	8 improved, 1 worsened, 4	0.039*

				unchanged	
	1 year	16.15 ± 1.91			

Table 5 Evolution of VAS, Majeed, and Merle d'Aubigné scores during follow-up. Data expressed as Mean ±SD with the corresponding P values . * Indicates statistical significance ($p<0.05$)

Correlation analysis showed strong negative associations between weight-bearing delay and Majeed scores ($r = -0.824$, $p < 0.001$) and between age and one-year Majeed ($r = -0.622$, $p = 0.023$). Early pain also correlated negatively ($r = -0.74$, $p < 0.001$), while Parker score, Charlson index, and radiological displacement were not significant, as shown in Table 6.

Factor	Majeed 1.5 months ρ (p-value)	Majeed 6 months ρ (p-value)	Majeed 1 year ρ (p-value)
Weight-bearing delay	-0.692 (0.006)*	-0.705 (0.007)*	-0.82(<0.001)*
VAS at 3 weeks			-0.74 (<0.001)*
Age	-0.409 (0.165)	-0.397 (0.180)	-0.622 (0.023)*
Parker mobility score	0.212 (0.488)	-0.009 (0.976)	0.108 (0.725)
Age-adjusted Charlson index	-0.333 (0.267)	0.194 (0.526)	0.063 (0.838)
Lefaivre rotational deformity	-0.131 (0.669)	-0.277 (0.359)	-0.250 (0.410)
Matta vertical	-0.159 (0.605)	0.024 (0.939)	0.026 (0.932)

displacement			

Table 6 Correlation between clinical and radiological factors and Majeed functional outcomes at different follow-up periods. Data in the table are expressed as Spearman's rank correlation coefficient (ρ) with the corresponding P values. * Indicates statistical significance ($p<0.05$)

Multiple linear regression analysis was performed to evaluate predictors of functional outcome at 1 year. The overall model was significant ($R^2 = 0.65$, $p = 0.019$). Among the evaluated variables, VAS score at 3 weeks was the only independent predictor of the Majeed score at 1 year ($\beta = -5.80$, $p = 0.006$), indicating that higher early postoperative pain was associated with worse long-term functional outcomes. Age and delay in weight-bearing were not independently associated with the final functional outcome, as shown in Table 7.

Predictor	β coefficient	p-value	Interpretation
VAS at 3 weeks	-5.80	0.006*	Significant predictor
Weight-bearing delay	-0.13	0.436	Not significant
Age	-0.006	0.992	Not significant

Table 7 Multivariable regression analysis identifying predictors of the Majeed score at one year. Data are expressed as unstandardized regression coefficients (β) with corresponding p-values. * Indicates statistical significance ($p < 0.05$).

Mortality and complications

Two patients (13.3%) died during follow-up, one at 3 months and another at 5 months postoperatively. At 1 year, radiological union was achieved in 12 patients (92.3%), while one patient (7.7%) developed nonunion but had a good functional outcome ,Majeed score at last follow up was 93, and required no intervention. Implant loosening was observed in three patients (23%), all of whom maintained favorable functional outcomes. No reoperations were required during the follow-up period.

Discussion

The present prospective study demonstrates that augmented minimally invasive fixation can provide reliable stabilization for pelvic fractures in elderly patients, resulting in progressive pain relief and meaningful functional recovery during the first postoperative year. Rather than focusing solely on fracture union, these findings reinforce the concept that restoring mobility and independence should be the primary objective of treatment in this patient population. This is further supported by the observation that early postoperative pain, rather than age or weight-bearing delay, independently predicted long-term functional outcome. (1,7,10)

Patient demographics and injury characteristics

The demographic and fracture characteristics reflect the heterogeneous nature of pelvic injuries encountered in elderly patients treated at trauma centers. Although fragility fractures are generally more common in women, the predominance of men in this cohort is likely explained by the inclusion of both low- and high-energy injuries. In many low- and middle-income countries, older adults frequently remain engaged in physically demanding occupations beyond retirement age because of socioeconomic factors, increasing their exposure to high-energy trauma. Consequently, the spectrum of pelvic fractures in these settings may differ from that reported in high-income countries, where elderly pelvic injuries are predominantly low-energy osteoporotic fragility fractures. Likewise, the predominance of Rommens type II–III and AO/OTA type B fractures in the present study highlights the importance of recognizing posterior pelvic ring instability, which is often underestimated on plain radiographs but has a major influence on treatment selection and subsequent functional recovery. (1,7,9,10)

The heterogeneity of the study population and inclusion of high-energy pelvic injuries represent study limitations. However, they reflect the real-world spectrum of elderly pelvic fractures encountered in tertiary trauma centers in many low- and middle-income countries, where older adults remain exposed to both low- and high-energy trauma.

Implant choice

The choice of fixation was individualized according to fracture morphology and bone quality rather than using a single implant for all patients. Trans-sacral screws were the most frequently used technique, often combined with anterior stabilization when necessary. This strategy is consistent with current concepts of pelvic fracture management, where construct stability is optimized by combining fixation methods to address both posterior and anterior ring instability. Such an approach is particularly valuable in osteoporotic bone, where improved mechanical stability may facilitate earlier mobilization while reducing the risk of fixation failure. (1,8,17)

Functional and pain outcomes

The primary objective of this study was achieved, with a progressive reduction in postoperative pain throughout the first postoperative year. This was accompanied by sustained improvements in function, reflected by significant gains in both the Majeed and Merle d'Aubigné scores. These findings suggest that augmented fixation provides sufficient mechanical stability to permit early rehabilitation while minimizing pain during recovery. Similar improvements have been reported following minimally invasive fixation of unstable pelvic fractures in elderly patients, where restoration of pelvic stability facilitated earlier mobilization and improved patient-reported outcomes. Improved postoperative pain likely resulted from the enhanced stability achieved by augmented fixation, allowing earlier mobilization and rehabilitation. (1-4, 17)

Although functional recovery was substantial, improvement continued beyond six months, indicating that rehabilitation after pelvic fractures in elderly patients is often prolonged. This observation emphasizes the need for continued physiotherapy and structured follow-up after fracture union, as functional restoration depends not only on bone healing but also on recovery of muscle strength, balance, and walking ability. (7,9,10)

Prognostic factors

One of the most important findings of the present study is the identification of factors associated with long-term functional recovery. Delayed weight bearing showed a strong negative correlation with Majeed scores throughout

follow-up, highlighting the importance of early mobilization after achieving stable fixation. Early mobilization is widely recognized as a cornerstone of geriatric fracture management because prolonged immobilization contributes to muscle wasting, thromboembolic events, pulmonary complications, and delayed functional recovery. Early postoperative pain demonstrated both a strong negative correlation with functional outcome and emerged as the only independent predictor of the one-year Majeed score in multivariable analysis. This finding suggests that early pain may represent an integrated marker of fracture stability, soft-tissue injury, and the patient's ability to participate in rehabilitation. Therefore, optimizing postoperative analgesia and achieving stable fixation should be considered complementary goals to maximize functional recovery. (1-4)

Increasing age was associated with poorer functional outcomes in the univariate analysis but lost significance after adjustment for other variables. This suggests that chronological age alone may be less important than postoperative recovery and rehabilitation in determining long-term function. Similarly, radiographic reduction quality was not independently associated with functional outcome, indicating that acceptable stability allowing early mobilization may be more clinically relevant than achieving perfect anatomical reduction in elderly patients.

Union, implant loosening and Complications

Radiological union was achieved in nearly all surviving patients, supporting the effectiveness of augmented fixation in providing sufficient stability for fracture healing despite compromised bone quality. This high union rate compares favorably with previously published series and may reflect meticulous preoperative planning, individualized fixation strategies, and the routine use of augmented posterior fixation constructs when indicated. Although implant loosening was observed in a proportion of patients, none required revision surgery and satisfactory functional outcomes were maintained. This finding indicates that radiographic loosening does not necessarily indicate clinical failure, particularly after fracture union. Nevertheless, it also highlights the persistent biomechanical challenges of

fixation in osteoporotic bone and the need for continued refinement of fixation techniques. (1,10)

Clinical Implications

The findings support augmented fixation of pelvic fractures as a reliable treatment option for selected elderly patients with unstable pelvic fractures. Stable fixation facilitates early mobilization, while early postoperative pain appears to be an important indicator of long-term functional recovery. These results emphasize the importance of combining stable fixation with effective pain management and structured rehabilitation to optimize postoperative outcomes.

Limitations and Future Directions

The strengths of this study include its prospective design, the use of validated functional outcome measures, comprehensive radiological assessment, and the inclusion of both low- and high-energy pelvic fractures. Unlike most published studies focusing exclusively on osteoporotic fragility fractures, this cohort better reflects the spectrum of elderly pelvic injuries encountered in tertiary trauma centers in many low- and middle-income countries, where older adults often remain occupationally active and continue to be exposed to high-energy trauma.

Nevertheless, several limitations should be acknowledged. The relatively small sample size and single-center design limit the generalizability of the findings, while the absence of a conservatively treated control group precludes direct comparison between treatment strategies. In addition, different fixation techniques were selected according to fracture configuration, limiting comparisons between individual implants. Finally, although the Majeed score is widely used for pelvic fracture assessment, some of its domains may be less applicable to elderly patients.

Future multicenter studies with larger cohorts and longer follow-up are required to validate these findings. Comparative studies evaluating different augmented fixation techniques, standardized rehabilitation protocols, and the

influence of frailty, bone quality, and cognitive status may further optimize the management of pelvic fractures in the elderly.

Conclusion

Augmented fixation of pelvic fractures in the elderly population provided stable fracture fixation, significant pain relief, and progressive functional recovery during the first postoperative year. Early postoperative pain was the strongest predictor of long-term functional outcome, underscoring the importance of stable fixation, adequate analgesia, and timely rehabilitation. Although the study cohort was heterogeneous, it reflects routine clinical practice in many tertiary trauma centers. Further prospective comparative studies are warranted to refine treatment strategies and optimize outcomes in this growing patient population.

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