J Orthop Spine Trauma. 2026 August; 12(4): 179-84. DOI: 10.18502/jost.v12i4.22582

Research Article

Anterior-First Approach to Unstable Pelvic Ring Fracture Fixation: Functional Outcomes and the Importance of Anatomic Reduction

Reza Zarei[1], Alireza Manafi Rasi[2], Mojtaba Baroutkoub[1], Mahdi Ghasemi Nik[3], Seyed Shahab Aldin Vaziri[4], Ali Pourmojarab[1,*]

[1] Assistant Professor, Department of Orthopedic Surgery and Traumatology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2] Professor, Department of Orthopedic Surgery and Traumatology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3] Resident, Department of Orthopedic Surgery and Traumatology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4] Researcher, Department of Orthopedic Surgery and Traumatology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[*]Corresponding author: Ali Pourmojarab; Department of Orthopedic Surgery and Traumatology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Tel: +98-9141868187; Email: ali.pourmojarab@gmail.com

Received: 17 April 2026; **Revised:** 19 June 2026; **Accepted:** 21 July 2026

Abstract

Background: Unstable pelvic ring fractures are high-energy injuries with complex anatomy and significant morbidity. Surgical fixation is the standard treatment; however, there is still controversy over the optimal sequence of anterior and posterior stabilization. An anterior-first fixation may help stabilize the pelvis, facilitate posterior reduction, and improve functional outcomes.

Methods: We retrospectively reviewed patients with unstable pelvic ring injuries using a standardized "anterior-first" fixation protocol. Radiographic reduction was assessed using Matta and Tornetta criteria on anteroposterior (AP), inlet, and outlet views. Functional outcomes at a minimum of 12 months were measured using the Iowa Pelvic Score (IPS) and Majeed Pelvic Score (MPS). Clinical complications, including bleeding requiring transfusion, hematuria, and limb-length discrepancy (LLD), were recorded.

Results: The study included 20 patients with a mean age of 40.7 ± 16.3 years. Excellent or good reductions were achieved in most patients, with 45% and 60% of cases rated as "Excellent" on the AP and inlet views, respectively. Outlet views showed greater variability, with 40% fair reduction. Mean IPS and MPS scores were 84.2 ± 16.7 and 78.9 ± 16.0, respectively, and were strongly correlated with each other ($r = 0.82$, $P < 0.001$). Older patients (> 50 years) achieved functional outcomes comparable to younger cohorts. Clinically, bleeding requiring transfusion occurred in 45%, hematuria in 35%, and LLD > 1 cm in 35%. No catastrophic complications were observed.

Conclusion: In this small retrospective case series, anterior-first fixation was associated with acceptable radiographic reduction and favorable functional outcomes in selected patients with unstable pelvic ring injuries. Given the limited sample size and the absence of a comparator group, these findings should be interpreted with caution. Larger prospective comparative studies are needed to clarify the optimal fixation sequence.

Keywords: Fracture Fixation; Treatment Outcome; Retrospective Studies; Pelvic Bones

Citation: Zarei R, Manafi Rasi A, Baroutkoub M, Ghasemi Nik M, Vaziri SSA, Pourmojarab A. **Anterior-First Approach to Unstable Pelvic Ring Fracture Fixation: Functional Outcomes and the Importance of Anatomic Reduction.** *J Orthop Spine Trauma* 2026; 12(4): 179-84.

Background

Disruption of the pelvic ring constitutes a grave orthopedic emergency, representing a marker of high-energy trauma with substantial physiological burden (1). Historically, pelvic fractures often resulted in fatality due to uncontrolled hemorrhage. Improvements in damage-control methods and modern resuscitation have markedly reduced early mortality, shifting the current treatment focus towards optimizing functional and long-term outcomes (2, 3). As survival has improved, contemporary management has shifted its focus from life-saving measures toward optimization of anatomical restoration and long-term functional outcomes (4, 5). Given that pain-related disability significantly impacts quality of life (QoL) and work capacity in musculoskeletal conditions, patient-centered functional outcome assessment is essential (6).

Unstable pelvic ring injuries, including Tile type B or C fractures, as well as Young-Burgess anteroposterior compression (APC) type III, lateral compression (LC) type III, and vertical shear (VS) patterns, are characterized by the disruption of both anterior and posterior stabilizing structures (7, 8). Surgical stabilization is generally recommended for these injuries to restore pelvic stability, facilitate early mobilization, and reduce the risk of chronic pain, deformity, and disability (9-11). While the necessity of operative fixation is well established, the optimal surgical strategy remains controversial, particularly regarding the sequence of reduction and fixation (12).

Recent literature has primarily focused on determining which components of the pelvic ring require stabilization (e.g., posterior-only versus combined anterior-posterior fixation) (10), rather than the sequence of fixation procedures (13, 14). However, the order of fixation may have significant biomechanical and clinical effects, as it can affect the quality of intraoperative reduction, the stability of the construct, and the ease of posterior reduction (12). Stabilization of the anterior pelvic ring, either via plate fixation or retrograde transpubic screw, has been shown to enhance overall pelvic stability and may facilitate subsequent fixation of the posterior ring in fragility fractures of the pelvis (15). Even with these theoretical biomechanical advantages, clinical evidence on the radiological and functional outcomes of a standardized anterior-first fixation approach for unstable pelvic ring injuries remains limited.

This study aimed to describe the quality of radiographic reduction and functional outcomes after a

standardized anterior-first fixation protocol for unstable pelvic ring injuries, and to evaluate the association between anatomic reduction and patient-reported function. We hypothesized that prioritizing the anterior pelvic ring may facilitate subsequent posterior reduction, while acknowledging that comparative effectiveness cannot be established in this case series.

Methods

Study Design and Ethics: This retrospective case series included all patients with unstable pelvic ring fractures treated at our trauma center from January 2023 to December 2024. All procedures followed an anterior-first approach, in which the anterior ring was stabilized before the posterior ring was addressed. This study was approved by the Institutional Review Board of Shahid Beheshti University of Medical Sciences, Tehran, Iran (approval code: IR.SBMU.MSP.REC.1404.611). Given the retrospective design of the study, the need for informed consent was waived. Data collection and reporting were performed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria.

Patient Selection

Inclusion Criteria: Patients were included if they met the following criteria: 1) skeletal maturity (age ≥ 16 years); 2) radiographically confirmed unstable pelvic ring disruption (Tile type B or C, Young-Burgess LC-III, APC-III, or VS); 3) operative stabilization [open reduction internal fixation (ORIF), percutaneous fixation, or hybrid] performed within 7 days of injury; 4) availability of complete radiographic series [anteroposterior (AP), inlet, and outlet views] for grading; and 5) a minimum clinical follow-up of 12 months with completed functional scores.

Exclusion Criteria: Patients were excluded if they met any of the following criteria: 1) stable injuries managed non-operatively; 2) pathologic fractures (tumor, metabolic bone disease) or low-energy fragility fractures; 3) concomitant fractures of the lower limbs; 4) concomitant acetabular fractures requiring fixation; 5) pre-existing suprapubic catheter; 6) bladder rupture requiring surgical intervention; 7) history of prior subumbilical laparotomy; 8) presence of a bed sore at the intended surgical site; 9) severe traumatic brain injury [Glasgow Coma Scale (GCS) < 13 at discharge], preventing reliable functional assessment; and 10) incomplete medical records or missing data.

Management and Surgical Technique: All surgical procedures were performed by a single fellowship-trained orthopedic trauma surgeon in accordance with a standardized protocol. Emergency medicine and general surgery specialists performed initial management in accordance with Advanced Trauma Life Support (ATLS) guidelines (16). Hemodynamically unstable patients underwent prompt pelvic binding, angiography, or packing as indicated. For definitive fixation, patients were positioned supine on a radiolucent table. The anterior ring was first constructed using either a Pfannenstiel or a modified Stoppa approach. After exposure, the rectus abdominis moved from the pubic body to the retropubic area, and the corona mortis was identified and ligated if it was present. One or two precontoured reconstructive plates were used to reduce and stabilize the anterior ring. Then, the posterior ring was supported via percutaneous iliosacral screws under fluoroscopic guidance, utilizing the modified two-view technique described by Dehkhoda et al. to guide the screw insertion (17). The S1 foramen was first identified via the outlet view, and the guidewire was placed just above it. Then, the inlet view was employed to advance the guidewire toward the mid-S1 body in a slightly posterior orientation. Once both views showed satisfactory trajectories, the cannulated screw was moved over the guidewire.

All patients followed a standardized postoperative rehabilitation protocol under the supervision of the operating surgeon and a specialized physiotherapist. The protocol emphasized early mobilization and transfer training, range of motion (ROM) exercises, progressive strengthening, and gait training with appropriate assistive devices. Patients remained non-weight-bearing for the first 6 weeks, progressed to partial weight-bearing between weeks 6 and 12 based on radiographic healing, and then advanced to full weight-bearing as tolerated.

Outcome Assessment

Radiographic Evaluation: Reduction quality was assessed using postoperative AP, inlet, and outlet plain radiographs by two independent surgeons blinded to clinical outcomes. Disagreements were resolved by consensus or a third senior trauma surgeon. Displacement was evaluated using the Matta and Tornetta criteria (18), focusing on the highest residual gap or step-off identified on any view:

- Excellent: ≤4 mm
- Good: 5–10 mm
- Fair: 10–20 mm
- Poor: > 20 mm.

Functional Evaluation: At the final follow-up, functional outcomes were measured using two validated patient-reported outcome measures (PROMs):

1. Majeed Pelvic Score (MPS): Evaluating pain, standing, sitting, sexual function, and work capacity (19)
2. Iowa Pelvic Score (IPS): Assessing activities of daily living (ADL), pain, gait, work history, and cosmesis (20).

Clinical complications, including urogenital injury (hematuria), limb-length discrepancy (LLD) > 1 cm, and infection, were recorded as secondary variables.

Statistical Analysis: Data were analyzed using SPSS software (version 26.0, IBM Corporation, Armonk, NY, USA). Given the small sample size and the non-normality of some variables, nonparametric tests were used for group comparisons. We used the Mann-Whitney U test to compare functional scores between patients with anatomic reduction (Excellent/Good) and those with non-anatomic reduction (Fair/Poor). The association between IPS and MPS was assessed using Pearson's correlation (both treated as continuous outcomes). As a sensitivity analysis, Spearman's rank correlation was also calculated. Missing data were not imputed; instead, a complete-case analysis was performed. A P-value < 0.05 was considered statistically significant. Due to the small subgroup sizes, Mann-Whitney U comparisons were interpreted as exploratory and likely underpowered rather than confirmatory.

Results

Patient Demographic: This case series included 20 patients, of whom 19 (95%) were men and one (5%) was woman. The mean age at the time of surgery was 40.7 ± 16.3 years (range: 16-77 years). All patients sustained unstable pelvic ring disruptions secondary to high-energy trauma. The Young-Burgess classification indicated that 13 patients (65%) exhibited an APC-III injury pattern, while 7 patients

(35%) exhibited a VS injury pattern. The mean follow-up duration was 24.2 ± 7.6 months (range: 12-35 months), and all patients completed at least 12 months of follow-up.

Radiographic Outcomes: Radiographic reduction quality was assessed using the Matta and Tornetta criteria across three standard views (Figure 1).

Figure 1. Postoperative fracture reduction quality according to the Matta and Tornetta criteria, assessed separately on anteroposterior (AP), inlet, and outlet pelvic views

AP View: All patients achieved an acceptable reduction, with 9 patients (45%) graded as "Excellent" (≤ 4 mm) and 11 (55%) graded as "Good". No "Fair" or "Poor" results were observed on this view.

Inlet View: This view demonstrated the highest rate of anatomic reduction, with 12 patients (60%) graded as "Excellent" and 4 patients (20%) graded as "Good". The remaining 4 patients (20%) were classified as "Fair", with no "Poor" reductions observed.

Outlet View: This view showed the greatest variability in reduction quality, with one patient (5%) graded as "Excellent", 11 patients (55%) graded as "Good", and 8 patients (40%) graded as "Fair". No "Poor" outcomes were identified on this view.

Postoperative radiographs showed anatomical reduction of the posterior ring and symphysis pubis (Figure 2).

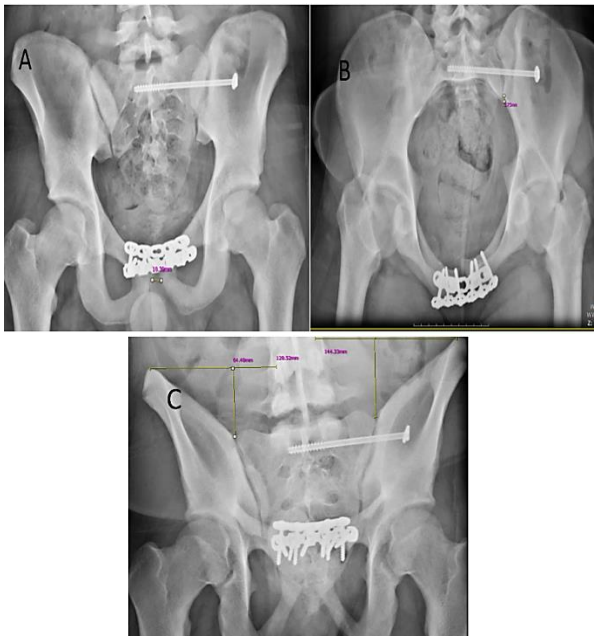

Figure 2. Pelvic radiographs of a 51-year-old woman demonstrating the injury pattern on standard views: A) Anteroposterior (AP); B) Inlet; and (C) Outlet

Pre- and Postoperative Clinical Complications: Bleeding was the most common clinical complication. Nine patients (45%) had bleeding requiring transfusion, whereas the remaining 11 patients (55%) had mild bleeding managed conservatively. Hematuria was recorded in 7 patients (35%). In addition, 7 patients (35%) had a clinically relevant LLD greater than 1 cm.

Functional Outcomes: At the final follow-up, patients demonstrated good overall functional recovery on both validated outcome measures. The mean IPS was 84.2 ± 16.7 (range: 51-99), and the mean MPS was 78.9 ± 16.0 (range: 50-100). A strong positive correlation was observed between IPS and MPS (Pearson's r = 0.82, P < 0.001), indicating consistency between the two functional scoring systems in this cohort (Figure 3).

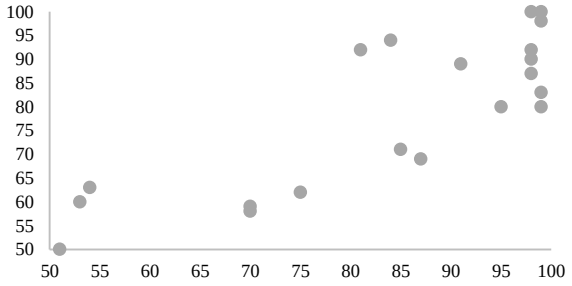

Figure 3. Correlation between Iowa Pelvic Score (IPS) and Majeed Pelvic Score (MPS) at final follow-up. The vertical axis represents MPS, and the horizontal axis represents IPS. A strong positive correlation indicates a high degree of agreement between the two validated functional outcome measures.

Age Subgroup Analysis: To examine the influence of age on functional recovery, the data were evaluated across three age categories. The highest mean functional scores were observed in patients aged 30-50 years (n = 7), with an IPS of 86.3 and an MPS of 81.9. Patients older than 50 years (n = 6) also showed good results, with average scores of 83.0 (IPS) and 82.0 (MPS), which were close to the overall cohort averages. The youngest group (< 30 years, n = 7) had a lower mean MPS of 73.1. This finding should be interpreted with caution, because detailed measures of injury severity and associated soft-tissue trauma were not available for subgroup comparisons (Figure 4).

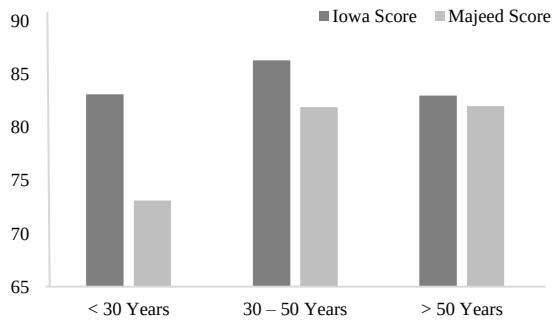

Figure 4. Mean Iowa Pelvic Score (IPS) and Majeed Pelvic Score (MPS) values for patients aged < 30 years, 30-50 years, and > 50 years. The figure provides a descriptive comparison of functional scores across age groups.

Discussion

Our findings suggest that using a standardized "anterior-first" reduction protocol may be a feasible approach in the surgical management of unstable pelvic

ring injuries. This protocol, which prioritizes early stabilization of the anterior ring, appears to help re-establish a stable foundation during surgery (21). Early anatomic restoration of the anterior pelvic ring may provide a stabilizing buttress against rotational forces, thereby facilitating subsequent posterior ring reduction and fixation (22).

In our study group, this strategy was associated with satisfactory clinical and radiological results, suggesting that restoring anterior stability may contribute to pelvic reconstruction and patient recovery in selected cases.

Standard orthopedic curricula and authoritative trauma textbooks, such as Rockwood and Green's Fractures in Adults, traditionally advocate for prioritizing posterior ring fixation in unstable pelvic fractures (23). Beyond the biomechanical advantages, many surgeons have traditionally prioritized posterior fixation, which often requires placing the patient in a prone position to access the sacroiliac joint or sacrum, followed by intraoperative repositioning to supine for anterior stabilization (12). Consequently, this strategy often requires staging the reconstruction across two separate surgical sessions or necessitates intraoperative repositioning to a supine posture for anterior stabilization. This requirement for staged procedures or intraoperative changes in the patient's position not only increases operative time and resource utilization but also poses risks of airway management complications, pressure sores, and loss of reduction during repositioning. In selected cases, the anterior-first approach may allow fixation of the entire pelvic ring in a single supine session without repositioning.

In this series, the anterior-first sequence was associated with satisfactory rotational alignment in most patients, with 60% achieving excellent scores on the inlet view. It is important to note that lower MPS and IPS in some patients may not solely reflect the surgical technique or fixation sequence; rather, they may reflect the severity of the initial trauma and its associated complications, such as significant bleeding or hematuria, which may affect early recovery and patient-reported outcomes. This observation is consistent with the literature describing the anterior ring's role in limiting external rotation (24, 25). In this study, vertical alignment showed more variability. We noted a fair reduction in the outlet view in 40% of cases, which was associated with a clinical finding of LLD > 1 cm at follow-up in the same group. Although the protocol appeared feasible for improving rotational deformity, the technique used did not consistently prevent residual vertical displacement in this small sample. Persistent vertical displacement remains a significant concern, underscoring the importance of determining the optimal sequence of anterior and posterior fixation in unstable pelvic fractures (26).

Patients aged 50 years and older demonstrated functional recovery comparable to the cohort average. In this small series, anterior-first treatment appeared to provide sufficient stability for rehabilitation in selected older patients; however, age-related conclusions should be interpreted with caution, given the limited sample size.

Many clinical and biomechanical studies have supported the role of anterior ring fixation as an important element in stabilizing unstable pelvic ring injuries. Zhang et al. indicated that combined anterior and posterior fixation preserved reduction better than posterior fixation alone in LC pelvic fractures, highlighting the mechanical significance of anterior ring stability in restoring pelvic integrity (10).

Moussa et al. reported that hip fractures treated with combined fixation strategies achieved markedly superior radiological alignment and functional outcomes compared with posterior-only fixation, underscoring the synergistic contribution of anterior fixation to overall pelvic stability (14). Moreover, biomechanical studies demonstrate that anterior pelvic fixation enhances resistance to rotational loads by minimizing construct displacement, thereby contributing to overall pelvic ring stability (21, 22).

In contrast, Petryla et al. reported no significant differences in functional outcomes or QoL between isolated posterior pelvic ring fixation and combined anterior-posterior fixation in patients with LC B2 pelvic fractures (27). Moreover, biomechanical evaluations of sacral and lumbopelvic fixation methods underscore the essential role of posterior-based structures in maintaining vertical stability and improving load distribution across the pelvic ring (26). The conflicting findings indicate that while anterior-first fixation might enhance rotational stability and facilitate reduction, its efficacy in vertically unstable injuries remains uncertain and should be tailored to the specific fracture morphology.

Some key limitations of our study warrant mentioning. With only 20 patients, our sample size was small, which limits the strength of some statistical comparisons. Although this is a common challenge in single-center studies of such complex injuries, consistency was maintained by using the same surgical protocol for all patients. While the follow-up period was adequate to assess fracture healing and early functional outcomes, it may not be long enough to identify later complications like post-traumatic arthritis. Certain variables, such as hematuria and LLD, were recorded in a binary (yes/no) format. Consequently, the severity of these conditions could not be quantified, limiting our ability to assess their specific impact on postoperative recovery. Furthermore, reliance on retrospective medical records resulted in incomplete data for certain variables such as smoking history or comprehensive medical conditions. This limitation is clinically significant, as smoking has been linked to markedly increased rates of nonunion, avascular necrosis (AVN), and revision surgery in other surgically managed high-energy fractures (28). These missing variables limited our ability to assess their potential effects on outcomes. Although all patients presented with high-energy, unstable fractures, there was still natural variation in the specific injury patterns and soft-tissue damage. Finally, because this was a single-center study restricted to patients treated via an anterior-first approach, we were unable to directly compare our results with a group treated with the more traditional posterior-first sequence. Therefore, no conclusion can be made regarding the superiority of one strategy over another. Due to these limitations, our analysis relied on traditional statistical methods. Future multicenter studies could leverage artificial intelligence (AI) and large-scale datasets to predict functional outcomes and complications in pelvic ring injuries, thereby creating more robust predictive models, as suggested in recent literature (29).

Additional limitations include the predominantly male cohort, the prevalence of APC-III and VS injury patterns, and the lack of a posterior-first or posterior-only comparator group. Therefore, the findings should not be generalized to all patients with unstable pelvic ring fractures, and the

statistical comparisons should be considered exploratory and hypothesis-generating.

Conclusion

In this small retrospective case series, anterior-first fixation followed by posterior stabilization was associated with acceptable radiographic reduction and favorable functional outcomes in selected patients with unstable pelvic ring injuries. These findings suggest that accurate anatomical restoration may contribute to functional recovery; however, the absence of a comparator group and the limited sample size preclude conclusions regarding superiority over other fixation sequences. Larger prospective comparative studies are required to establish the optimal surgical sequence for different unstable pelvic fracture patterns.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

None.

References

1. Hu S, Guo J, Zhu B, Dong Y, Li F. Epidemiology and burden of pelvic fractures: Results from the Global Burden of Disease Study 2019. *Injury*. 2023;54(2):589-97. doi: 10.1016/j.injury.2022.12.007. [PubMed: 36528424].
2. Stahel PF, Hammerberg EM. History of pelvic fracture management: A review. *World J Emerg Surg*. 2016;11:18. doi: 10.1186/s13017-016-0075-4. [PubMed: 27148396]. [PubMed Central: PMC4855448].
3. Langford JR, Burgess AR, Liporace FA, Haidukewych GJ. Pelvic fractures: part 1. Evaluation, classification, and resuscitation. *J Am Acad Orthop Surg*. 2013;21(8):448-57. doi: 10.5435/jaaos-21-08-448. [PubMed: 23908251].
4. Suzuki T, Shindo M, Soma K, Minehara H, Nakamura K, Uchino M, et al. Long-term functional outcome after unstable pelvic ring fracture. *J Trauma*. 2007;63(4):884-8. doi: 10.1097/01.ta.0000235888.90489.fc. [PubMed: 18090021].
5. Hermans E, Brouwers L, van Gent T, Biert J, de Jongh MAC, Lansink KWW, et al. Quality of life after pelvic ring fractures: Long-term outcomes. A multicentre study. *Injury*. 2019;50(6):1216-22. doi: 10.1016/j.injury.2019.04.002. [PubMed: 31029370].
6. Sabzghabaei A, Dolikhani M, Marivani M, Salehi S, Shakibamaram G. Effectiveness of Acupressure and Reflexology Combined with NSAIDs in Acute Low Back Pain: A Prospective Cohort Study. *J Emerg Pract Trauma*. 2025;11(1):e92622.
7. Alton TB, Gee AO. Classifications in brief: young and burgess classification of pelvic ring injuries. *Clin Orthop Relat Res*. 2014;472(8):2338-42. doi: 10.1007/s11999-014-3693-8. [PubMed: 24867452]. [PubMed Central: PMC4079881].
8. Gray A, Chandler H, Sabri O. Pelvic ring injuries: classification and treatment. *Orthop Trauma*. 2018;32(2):80-90. doi: 10.1016/j.mporth.2018.01.005.
9. Orthopaedic Trauma Research Group. Anterior and posterior fixation versus posterior fixation only of minimally displaced lateral compression type 1 pelvic ring injuries: A multicenter propensity-matched analysis. *Injury*. 2026;57(2):112964. doi: 10.1016/j.injury.2025.112964. [PubMed: 41500149].
10. Zhang BF, Shang K, Wang PF, Ke C, Han S, Yang K, et al. Comparison of posterior ring fixation with combined anterior and posterior ring fixation for the treatment of lateral compression type 2 pelvic fractures. *Int Orthop*. 2020;44(6):1187-93. doi: 10.1007/s00264-020-04512-1. [PubMed: 32125463].
11. Halawi MJ. Pelvic ring injuries: Surgical management and long-term outcomes. *J Clin Orthop Trauma*. 2016;7(1):1-6. doi: 10.1016/j.jcot.2015.08.001. [PubMed: 26908968]. [PubMed Central: PMC4735567].
12. Puchwein P, Sandersjöö G, Lindahl J, Eibinger N. Combined pelvic ring and acetabular fractures - strategies and sequence of surgery. State of the art. *Arch Orthop Trauma Surg*. 2024;144(10):4577-86. doi: 10.1007/s00402-024-05555-4. [PubMed: 39311940]. [PubMed Central: PMC11576877].
13. Papathanasopoulos A, Tzioupis C, Giannoudis VP, Roberts C, Giannoudis PV. Biomechanical aspects of pelvic ring reconstruction techniques: Evidence today. *Injury*. 2010;41(12):1220-7. doi: 10.1016/j.injury.2010.10.001. [PubMed: 21288466].
14. Moussa IS, Sallam AM, Mahmoud AK, Elzaher EH, Nagy AM, Eid AS. Combined anterior and posterior ring fixation versus posterior ring fixation alone in the management of unstable Tile B and C pelvic ring injuries: A randomized controlled trial. *Chin J Traumatol*. 2023;26(1):48-59. doi: 10.1016/j.cjtee.2022.06.003. [PubMed: 35750597]. [PubMed Central: PMC9912183].
15. Lodde MF, Katthagen JC, Schopper CO, Zderic I, Richards G, Gueorguiev B, et al. Biomechanical Comparison of Five Fixation Techniques for Unstable Fragility Fractures of the Pelvic Ring. *J Clin Med*. 2021;10(11):2326. doi: 10.3390/jcm10112326. [PubMed: 34073570]. [PubMed Central: PMC8199358].
16. Galvagno SM, Jr., Nahmias JT, Young DA. Advanced Trauma Life Support(®) Update 2019: Management and Applications for Adults and Special Populations. *Anesthesiol Clin*. 2019;37(1):13-32. doi: 10.1016/j.anclin.2018.09.009. [PubMed: 30711226].
17. Dehkhoda F, Manafi Rasi A, Zandi R, Abedi M, Ebadi SS. Percutaneous Sacroiliac Screw Fixation: A Modified Screw Insertion Method Using Just 2 Fluoroscopy Views. *Arch Bone Jt Surg*. 2024;12(8):574-9. doi: 10.22038/abjs.2024.77855.3589. [PubMed: 39211565]. [PubMed Central: PMC11353148].
18. Yu YH, Liu CH, Hsu YH, Chou YC, Chen IJ, Wu CC. Matta's criteria may be useful for evaluating and predicting the reduction quality of simultaneous acetabular and ipsilateral pelvic ring fractures. *BMC Musculoskelet Disord*. 2021;22(1):544. doi: 10.1186/s12891-021-04441-z. [PubMed: 34126982]. [PubMed Central: PMC8204573].
19. Majeed SA. Grading the outcome of pelvic fractures. *J Bone Joint Surg Br*. 1989;71(2):304-6. doi: 10.1302/0301-620x.71b2.2925751. [PubMed: 2925751].
20. Busso C, Cambursano S, Aprato A, Destefanis C, Gianotti A, Massazza G, et al. Algo-Functional Indexes and Spatiotemporal Parameters of Gait after Sacroiliac Joint Arthrodesis. *J Clin Med*. 2020;9(9):2860. doi: 10.3390/jcm9092860. [PubMed: 32899638]. [PubMed Central: PMC7563510].
21. Kumaran P, Wier J, Hasegawa I, Patterson JT, Gary JL. Stability before and after percutaneous anterior medullary fixation of lateral compression 1 and 2 pelvic ring disruptions: Should surgeons prioritize the anterior ring? *Eur J Orthop Surg Traumatol*. 2024;34(6):3103-8. doi: 10.1007/s00590-024-04037-y. [PubMed: 38965132].
22. Zhao Y, Ma Y, Zou D, Sun X, Cheng G, Lian W, et al. Biomechanical comparison of three minimally invasive fixations for unilateral pubic rami fractures. *BMC Musculoskelet Disord*. 2020;21(1):594. doi: 10.1186/s12891-020-03604-8. [PubMed: 32887595]. [PubMed Central: PMC7487546].
23. Bucholz RW, Heckman JD, Court-Brown CM, Rockwood CA, Green DP, Editor. Rockwood and Green's fractures in adults. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.
24. Yao F, He Y, Qian H, Zhou D, Li Q. Comparison of Biomechanical Characteristics and Pelvic Ring Stability Using Different Fixation Methods to Treat Pubic Symphysis Diastasis: A Finite Element Study. *Medicine (Baltimore)*. 2015;94(49):e2207. doi: 10.1097/md.0000000000002207. [PubMed: 26656353]. [PubMed Central: PMC5008498].
25. Moftakhari Hajimirzaei S, Bagherzadeh Cham M, Dolikhani M, Tabatabaee SM, Ebrahimpour A. The Impact of Vitamin C on Analgesic, Anti-inflammatory, and Hemostatic Outcomes After Total Hip and Knee Arthroplasty: A Systematic Review and Meta-Analysis. *Arch Bone Jt Surg*. 2025;13(11):676-92. doi: 10.22038/abjs.2025.89801.4070. [PubMed: 41509597]. [PubMed Central: PMC12777713].

26. Tripathi S, Nishida N, Soehnlen S, Kelkar A, Kumaran Y, Seki T, et al. Pelvic Ring Fractures: A Biomechanical Comparison of Sacral and Lumbopelvic Fixation Techniques. *Bioengineering (Basel)*. 2024;11(4):348. doi: 10.3390/bioengineering11040348. [PubMed: 38671770]. [PubMed Central: PMC11048038].
27. Petryla G, Uvarovas V, Bobina R, Kurtinaitis J, Puronaitė R, Kvederas G, et al. Comparison of One-Year Functional Outcomes and Quality of Life between Posterior Pelvic Ring Fixation and Combined Anterior-Posterior Pelvic Ring Fixation after Lateral Compression (B2 Type) Pelvic Fracture. *Medicina (Kaunas)*. 2021;57(3):204. doi: 10.3390/medicina57030204. [PubMed: 33652683]. [PubMed Central: PMC7996925].
28. Noorigaravand S, Yahyazadeh H, Amiri S, Zareie B, Sajedi S, Gharanizadeh K. Cephalomedullary Nail Versus Dynamic Hip Screw-plate Fixation: A Comparative Analysis of Ipsilateral Femoral Neck and Shaft Fracture Outcomes. *J Res Orthop Sci*. 2025;12(1):65-70. doi: 10.32598/JROSJ.12.1.2716.1.
29. Ebrahimpour A, Dolikhani M, Shakibamaram G. Artificial Intelligence (AI) as a Catalyst for Orthopedic Residency Training. *Arch Bone Jt Surg*. 2025;13(12):773-5. doi: 10.22038/abjs.2025.91837.4159. [PubMed: 41509057]. [PubMed Central: PMC12777714].