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Diagnostic Performance of Pelvic Radiography Compared with Computed Tomography Scan in Detecting Hip and Proximal Femur Injuries Following Blunt Trauma

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ABSTRACT

Objective: This study aimed to evaluate the diagnostic performance of pelvic radiography compared with computed tomography (CT) scan in detecting hip and proximal femur injuries following blunt trauma in the emergency department.
Methods: This retrospective study included 317 patients who presented with blunt trauma. Demographic data and imaging indications were recorded, and radiographic findings were compared with CT scan results, which served as the reference standard. Sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios, and kappa coefficient were calculated for various fracture and dislocation types.
Results: Intertrochanteric fractures were the most frequently identified injuries on radiography (30.6%). Radiography demonstrated the highest diagnostic accuracy for hip dislocations (sensitivity: 70%, specificity: 99%, kappa=0.74). For femoral neck and trochanteric fractures, radiography exhibited moderate sensitivity and high specificity, with a positive likelihood ratio >10 and a negative likelihood ratio <0.5, suggesting a strong ability to rule in and a reasonable ability to rule out these injuries. In contrast, intertrochanteric fractures were significantly underdiagnosed on radiography (sensitivity: 45.6%; kappa=0.28).
Conclusion: Pelvic radiography could be a valuable initial tool for diagnosing hip dislocations and specific femoral fractures. However, it has notable limitations in detecting intertrochanteric fractures. CT scan remains the reference standard for comprehensive assessment of blunt hip and proximal femur trauma, particularly when clinical suspicion is high or radiographic findings are inconclusive.

Keywords: Pelvic fracture; Pelvic radiography; CT scan; Blunt trauma

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Introduction

Blunt pelvic injuries are among the most common and severe forms of trauma, often associated with severe hemodynamic complications, massive hemorrhage, and damage to vital organs [1, 2]. These injuries typically result from high-energy mechanisms such as motor vehicle accidents, falls from a height, or severe crush injuries [3, 4]. Therefore, rapid and accurate diagnosis of pelvic injuries during the acute phase of trauma is critical, as delays in detection can lead to life-threatening consequences [5].

Imaging evaluation of the pelvis is a critical step in the management of trauma patients [6]. Plain pelvic radiography has long served as the initial screening modality for individuals with blunt trauma [7, 8]. Due to its wide accessibility, low cost, and rapid execution, it has consistently been widely applied in emergency settings [8]. However, the inherent limitations of plain radiography in precisely evaluating complex fractures, pelvic ring disruptions, and associated soft-tissue injuries compromise its overall diagnostic efficacy [9].

In contrast, computed tomography (CT) has gained a crucial role in trauma assessment due to its high diagnostic accuracy, capacity for three-dimensional reconstruction, and ability to simultaneously evaluate the pelvic skeleton and adjacent organs [7]. Numerous studies have demonstrated that CT is significantly superior to plain radiography in detecting subtle fractures, minor dislocations, and associated pelvic injuries [6, 10]. Nevertheless, the widespread utilization of CT has raised questions regarding the necessity of initial radiography and its diagnostic utility in the presence of advanced imaging modalities [11].

In recent years, various clinical guidelines have provided varying recommendations regarding whether to omit or retain pelvic radiography as the initial diagnostic step. Some studies suggested eliminating radiography when rapid CT is feasible, whereas others continue to emphasize its importance in hemodynamically unstable patients or in facilities lacking immediate CT access [8, 12, 13]. Accordingly, comparative studies evaluating the clinical indications and imaging findings of both modalities are essential to clarify their respective roles in diagnostic and therapeutic decision-making. The present study was designed to compare the indications and imaging findings of pelvic radiography and CT in patients with blunt trauma, aiming to assess the diagnostic value of each method and provide evidence to optimize imaging protocols in trauma care.

Materials and Methods

This retrospective study included patients with blunt pelvic trauma who presented to the emergency departments of teaching hospitals affiliated with Birjand University of Medical Sciences between March 2024 and March 2025.

Inclusion criteria comprised: (1) a history of blunt pelvic trauma, (2) completion of both pelvic radiography and pelvic CT scan during the emergency department evaluation, and (3) availability of complete medical and imaging records. Patients with incomplete records or lacking valid imaging reports were excluded from the study.

Demographic and clinical information, imaging indications, and imaging findings were extracted from hospital medical records and the hospital imaging information system. All included patients underwent both pelvic radiography and pelvic CT scan as part of their standard diagnostic evaluation, allowing direct comparison between the two modalities. CT findings served as the reference standard for assessing the diagnostic performance of radiography. Patients were evaluated with respect to the indications for pelvic radiography and CT, the type and number of imaging studies requested, and the imaging findings.

All plain pelvic radiographs were obtained using a SHIMADZU digital radiography system in the standard anteroposterior (AP) positions, with a tube-to-image receptor distance of 100–120 cm. All CT examinations were performed using a Toshiba 16-slice Activion multidetector CT scanner with patients in the supine position, acquiring 3- to 5-mm thick slices. Images were reconstructed using the scanner's specialized software and interpreted by a radiologist. By utilizing consistent imaging equipment for all patients, potential variability related to hardware was minimized.

Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarize the data. Fisher's exact test was applied to compare categorical variables. To assess the agreement between radiographic and CT findings, Cohen's kappa (κ) coefficient was calculated. Additionally, sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively), and positive and negative likelihood ratios were calculated for each type of fracture and dislocation to evaluate the diagnostic performance of radiography against the reference standard CT. Statistical analyses were performed using Stata version 12 (Stata Corp., College Station, Texas), and a two-sided $p<0.05$ was considered statistically significant.

Results

A total of 317 patients were included in this study. The mean age of the participants was 48.58±26.14 years, with 52.7% being male and 47.3% female. The majority of the patients (49%) were illiterate, and 66% resided in urban areas. On average, each patient underwent 3.78 radiographic examinations.

The majority of imaging requests were initiated by the orthopedics department (44.4%) and the emergency department (42.4%). The most common indication for imaging was localized tenderness (82.6%), followed by urethral injury (5.4%) and multiple trauma (4.4%) (Table 1).

Comparison of imaging findings demonstrated that CT scan identified a greater number of injuries than plain radiography across most categories. Femoral neck fractures were detected in 41.3% of patients on CT compared with 24.9% on radiography (Table 2). Similarly, intertrochanteric fractures were identified in 43.5% of patients by CT versus 30.3% by radiography. Hip dislocations were reported in 6.3% of CT examinations and 5.4% of radiographs. Cross-tabulation analysis revealed significant differences between CT and radiographic findings for all evaluated injuries (p<0.05). CT scans detected a substantial proportion of fractures missed by radiography, particularly intertrochanteric fractures. These findings indicated that radiography might underestimate the presence of certain injuries, thereby supporting the role of CT as the reference standard in patients with suspected traumatic hip and pelvic injuries. Regarding hip dislocations, despite overall moderate agreement between the two modalities, CT detected dislocations in 2% of cases that were missed by radiography (P<0.05; Table 3).

When comparing radiographic findings with CT scan as the reference standard, radiography demonstrated the highest accuracy for hip dislocations (sensitivity: 70%, specificity: 99%, Kappa=0.74). For femoral neck and trochanteric fractures, radiography exhibited moderate sensitivity and high specificity, with positive likelihood ratios >10 and negative likelihood ratios <0.5, indicating a strong ability to rule in and a reasonable ability to rule out these injuries. In contrast, intertrochanteric fractures were significantly underdiagnosed by radiography (sensitivity: 45.6%, Kappa=0.28), reflecting limited diagnostic accuracy. The kappa coefficient results indicated that the agreement between radiography and CT varied depending on the specific type of fracture or dislocation, highlighting the inherent limitations of radiography in certain indications (Table 4).

Discussion

This study aimed to evaluate and compare the indications and findings of pelvic radiography and CT scan in patients with blunt pelvic trauma. The results demonstrated that the diagnostic performance of radiography varies considerably depending on the type of injury. While radiography showed acceptable accuracy for certain conditions, such as

Table 1. Baseline and demographic characteristics of the study participants.

Variables		Mean/Frequency	Standard deviation (SD)/ Percentage (%)
Age (year)		48.58	26.14
SBP		118.91	14.16
DBP		74.63	10.20
RR		16.69	2.36
HR		83.97	12.92
SPO2		94.49	7.73
Number of radiography requests		3.78	2.07
Sex	Male	167	52.7
	Female	150	47.3
Education	Illiterate	153	49
	Primary	120	38.5
	Secondary	32	10.3
	Academic	7	2.2
Residence	Urban	206	66
	Rural	106	34
Requesting department	Emergency medicine	132	42.4
	Surgery	41	13.2
	Orthopedics	138	44.4

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; HR: Heart rate; RR: Respiratory rate; SPo_2; Oxygen saturation

Table 2. Indications and findings of radiography and CT scan in the study patients.

Variable	CT scan findings	Radiography findings	Total
Femoral neck fracture	131 (41.3%)	79 (24.9%)	210 (66.24%)
Intertrochanteric fracture	138 (43.5%)	96 (30.3%)	234 (73.81%)
Trochanteric fracture	11 (3.5%)	19 (6%)	30 (9.5%)
Hip dislocation	20 (6.3%)	17 (5.4%)	37 (11.68%)

CT: Computed tomography

Table 3. Comparison of findings between CT scan and radiography in the study participants.

Comparison of indications and findings			CT scan findings		Total	*p*-value
			Yes	No		
Radiography finding	Femoral neck fracture	Yes	72 (91.13%)	7 (8.87%)	79	0.001
		No	59 (24.78%)	179 (75.22%)	238	
		Total	131	186		
	Intertrochanteric fracture	Yes	63 (65.62%)	33 (34.38%)	96	0.001
		No	75 (33.93%)	146 (66.07%)	221	
		Total	138	179		
	Trochanteric fracture	Yes	6 (31.57%)	13 (68.43%)	19	0.002
		No	5 (1.67%)	293 (98.33%)	298	
		Total	11	306		
	Hip dislocation	Yes	14 (82.35%)	3 (17.65%)	17	0.01
		No	6 (2%)	294 (98%)	300	
		Total	20	297		

Table 4. Evaluation of sensitivity, specificity, and agreement between CT scan and radiography findings and indications

Findings	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	PLR	NLR	Kappa
Femoral neck fracture	54.96%	92.24%	91.14%	75.21%	14.60	0.47	0.54
Intertrochanteric fracture	45.65%	81.56%	65.62%	66.06%	2.48	0.67	0.28
Trochanteric fracture	54.55%	95.75%	31.58%	98.32%	12.84	0.47	0.37
Hip dislocation	70%	98.99%	82.35%	98%	69.30	0.30	0.74

PPV: Positive predictive value; NPV: Negative predictive value; PLR: Platelet-lymphocyte ratio; NLR; Neutrophil-lymphocyte ratio

hip dislocations, its sensitivity and agreement were low for other injuries, including intertrochanteric fractures. Therefore, relying solely on radiography to rule out hip and proximal femur injuries might result in missed diagnoses or delays in treatment.

In the present study, a substantial proportion of patients underwent at least three pelvic radiographs, highlighting the frequent need for imaging in trauma patients. The most common indication for pelvic radiography was localized tenderness. Other clinical signs that might indicate the need for radiography included abdominal tenderness, perineal or pelvic ecchymosis, deformity, scrotal hematoma, limb length discrepancy, blood at the urethral meatus, pelvic fluid on ultrasound, pelvic fracture findings on rectal examination, and pelvic instability on clinical assessment. In stable patients, tenderness over the pelvic bones, iliac crest, rami, sacrum, or coccyx, as well as sensory or motor deficits and absent pulses in the lower extremities, represent important indications for imaging. These findings underscored that pelvic imaging should be guided by careful clinical evaluation and suspicious findings to ensure timely identification of fractures and associated injuries [14-16].

Previous studies support these findings. For example, in studies of elderly patients with pelvic fractures, the overall sensitivity of radiography compared with CT was reported to be 48%, indicating that more than half of the fractures were not detected using plain radiography [17]. Other studies reported that radiography identified only 78% of fractures detected by CT [18]. This discrepancy could be attributed not only to the technical limitations of radiography but also to the complex anatomy of the pelvis, fracture orientation, fracture location (e.g., posterior pelvic ring, ilium, pubis, acetabulum), and the presence of stable fractures that might not be visible on plain radiographs. Even in centers with high standards, a significant proportion of fractures (e.g., involving the ilium, acetabulum, pubis) might be missed on radiographs [19]. Recent evidence has also confirmed the superior diagnostic performance of cross-sectional imaging for occult fractures, with CT demonstrating high diagnostic accuracy and magnetic resonance imaging (MRI) providing even greater sensitivity in selected cases [20, 21].

As noted in the literature, radiography might be ineffective in clinically stable patients with a high clinical suspicion for fracture, and accurate fracture diagnosis and classification require CT [22, 23]. Clinically, in emergencies where a patient is stable and CT is already planned, initial radiography might not be necessary. Some guidelines suggest omitting radiography in such cases to save time and reduce radiation exposure [24]. Conversely, in hemodynamically unstable patients, those with positive clinical findings, or those with suspected internal/vascular injury based on physical examination, radiography could serve as a rapid screening tool, although it should not replace CT.

Our findings indicated that for fractures such as femoral neck or trochanteric fractures, a positive radiograph, given the high positive likelihood ratio

and specificity, strongly suggested the presence of a fracture. However, a negative radiograph did not definitively rule it out, particularly for intracapsular or longitudinal fractures. For complex or occult fractures, particularly when clinical suspicion remained high despite negative radiographic findings, CT remained essential and could not be replaced by radiography. Importantly, even CT is not flawless. For example, in occult femoral neck fractures, CT sensitivity was reported to be 86%, and some cases might still be missed, for which MRI was recommended if feasible [25, 26]. Previous evidence demonstrated that limited MRI protocols could achieve near-perfect sensitivity for radiographically occult hip fractures, supporting MRI as a valuable complementary modality when CT findings remained inconclusive [27].

The agreement analysis further supported these clinical observations. The observed Kappa coefficients demonstrated variable levels of agreement between radiography and CT across different injury types, indicating that the reliability of plain radiography depends largely on the specific lesion being evaluated. Higher Kappa values for certain injuries suggested substantial agreement between the two modalities, whereas lower values indicated that radiography might fail to identify a considerable proportion of injuries detected by CT. In addition, likelihood ratios provide clinically meaningful information beyond sensitivity and specificity alone. The relatively high positive likelihood ratios observed for several fracture types indicated that a positive radiographic finding substantially increased the probability of true injury. However, the negative likelihood ratios were not sufficiently low to confidently exclude injury when radiographic findings were negative. Consequently, a negative radiograph should be interpreted with caution, particularly in patients with persistent symptoms or high clinical suspicion, and additional CT evaluation should be considered when clinically indicated.

These considerations highlighted the clinical significance of our study: trauma imaging protocols should involve judicious use of both radiography and CT, as reliance solely on radiography might lead to incomplete diagnosis, delayed treatment, or inappropriate therapeutic decisions. Although this study had notable strengths, including a relatively large sample size, assessment of multiple diagnostic indices (sensitivity, specificity, PPV/NPV, likelihood ratios, and Kappa), and emphasis on both indications and findings, it had some limitations. Fractures were categorized broadly (femoral neck, intertrochanteric, trochanteric), and other pelvic fractures (posterior ring, acetabulum, pubis, ilium) were not analyzed in detail, despite evidence showing these sites are most prone to radiographic misdiagnosis [17, 18, 28]. Furthermore, the study was limited to patients with blunt trauma who underwent CT examination, which might have introduced selection bias. In addition, due to the retrospective nature of the study and the routine clinical setting, radiologists were not blinded to the findings of the other imaging modality. Therefore, interpretation bias could not be completely excluded.

In conclusion, the results of this study indicated that plain pelvic radiography demonstrated variable performance in detecting hip and proximal femur injuries following blunt trauma. Radiography showed good diagnostic performance for hip dislocations and certain femoral neck and trochanteric fractures but demonstrated limited sensitivity for intertrochanteric fractures. These findings suggested that radiography alone cannot replace CT for the comprehensive evaluation of traumatic hip and proximal femur injuries, particularly in patients with persistent clinical suspicion despite negative radiographic findings. Furthermore, clinical indicators such as pelvic tenderness, perineal or pelvic ecchymosis, limb asymmetry, and pelvic instability remain important factors in imaging decision-making. Therefore, imaging strategies should be tailored according to clinical presentation, suspected injury type, and patient condition. When radiographic findings are inconclusive or clinical suspicion remains high, CT should be considered to improve diagnostic accuracy, facilitate timely management, and reduce the risk of missed injuries.

Declaration

Ethics Approval and Consent to Participate: The study was conducted in accordance with the ethical guidelines of the Research Ethics Committee of Birjand University of Medical Sciences (Ethical Approval Code: IR.BUMS.REC.1403.025). Written informed consent was obtained from all participants included in the study.

Consent for Publication: Written informed consent was obtained from all participants for the publication of their data and any accompanying images.

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Data Availability: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' Contributions: MRT and MF contributed to conceptualization, study design, literature search and resource collection, as well as writing, reviewing, and editing the original drafts. FS and MM contributed to study design, reviewing, and

editing the original drafts.

Declaration of Generative AI in Scientific Writing: AI tools were used solely for text paraphrasing and editorial purposes. All scientific content, reasoning, and conclusions presented in this manuscript are solely the responsibility of the authors.

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